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HISTORY
OF THE
TOW MISSILE SYSTEM

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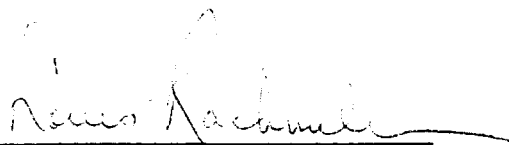
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HISTORY
OF THE
TOW MISSILE SYSTEM

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PREFACE

The TOW (Tube-launched Optically-tracked Wire-guided) Heavy Antitank/Assault Weapon (HAW) system now in the Army's arsenal of operational antitank weapons belongs to a family of advanced systems designed to cope with the enemy armor threat through the early 1980's. The TOW/HAW system became operational in September 1970, initially replacing the 106mm recoilless rifle and French ENTAC system, and later the helicopter adaptation of the French SS-11 system. Other members of the new generation of weapons were the M72 Light Antitank Weapon (LAW), which began replacing the Bazooka and antitank rifle grenade in 1963; the SHILLELAGH combat vehicle armament system, which reached the field in 1967; and the DRAGON Medium Antitank Weapon (MAW), which began replacing the 90mm recoilless rifle early in 1975.

This monograph traces the history of the TOW weapon system from the inception of predevelopment studies in mid-1958 through 1976. Except for the chapter dealing with project management, the story of the ground-based and airborne systems is related in basically chronological sequence. Unless otherwise indicated, the footnotes are unclassified.

19 October 1977

Mary T. Cagle

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CHAPTER I

(U) EVOLUTION OF ARMY ANTITANK REQUIREMENTS AND WEAPONS

The Advent of Tank Warfare

The present-day antitank missions and weapons of the United States Army evolved from the introduction of the armored tank during World War I. The British first developed the tank as a weapon to penetrate barbed wire entanglements and overwhelm enemy machine gun nests. The first British tank was a ponderous 27-ton vehicle developed by COL E. D. Swinton and associates of the Royal Engineers, who had obtained some of their ideas from American caterpillar farm tractors. It was first used in the Somme River area during September 1916 in an effort to break the deadlock on the Western Front.¹

Recognizing the tactical advantage of the armored tank, the French and Germans developed tanks of their own. The French concentrated their effort on small, fast assault tanks with a two-man crew, while the Germans built large, unwieldy contraptions that were singularly ineffective. By the time the United States entered the war against Germany in April 1917, virtually all of the belligerent nations had developed armored tanks of various descriptions and capabilities.

The unparalleled firepower, mobility, and endurance of these caterpillar-tread monsters in offensive warfare led to radical changes in defensive strategy and tactics. No longer could the existing guns and field artillery be relied upon to counter enemy tank onslaughts. It was necessary to devise a more powerful gun-projectile combination with armor-defeating capabilities. The first such weapon, developed toward the end of World War I, was a long, heavy antitank rifle fired in the prone position, its barrel supported by a tripod. At short ranges, its armor-piercing bullets of about .55-caliber could penetrate the 0.5-inch steel plate of contemporary tanks. A number of these rifles were ready by the end of the war, but they were not used in quantity until World War

¹(1) Lynn Montross, *War Through the Ages* (New York, 1960), pp. 722-23. (2) DA ROTCM 145-20, Jul 56, subj: American Military History 1607-1953, p. 335.

II, when the progressively increasing thicknesses of tank armor soon made them obsolete except for defense against lightly armored vehicles.

World War II Developments

Military interest in antitank weapons began to lag with the signing of the Armistice in November 1918 and was destined to remain so for over 20 years. Meanwhile, armor improvements proceeded so rapidly that available antitank weapons were soon found lacking in both penetration and range. At the outbreak of World War II, the Germans, whose tanks of the previous war were failures, possessed vast numbers of improved tanks with which they overran Poland in 1939 and northern France in 1940. The startlingly new tactical use of tanks in these blitzkriegs demanded a complete reconsideration of defensive measures, particularly of antitank weapons for the infantry. In case of a surprise attack or a sudden breakthrough by enemy tanks, it was essential that infantry troops be armed with light antitank weapons that could be carried into battle by individual soldiers or be so easily transported that they would comprise the principal antitank armament of platoons, companies, and battalions.

As the war progressed, many new antitank weapons with special ammunition were developed and put into the field in an attempt to stop the tanks of the German Panzer units. Among these were such innovations as the rocket-firing Bazooka; recoilless rifles; fast, heavily gunned motor carriages known as tank destroyers; towed antitank cannon; rifle grenades with shaped charges; antitank mines; high-velocity armor-piercing and armor-piercing-capped projectiles; and high explosive antitank shells with shaped charges for penetrating armor by chemical (jet) action.

The most popular antitank weapon introduced during the war was the 2.36-inch rocket-firing Bazooka which, for the first time, enabled the foot soldier to combat a tank single-handedly. The M6 fin-stabilized high explosive antitank (HEAT) rocket weighed 3.5 pounds, had a maximum range of 700 yards, and could perforate 3.5 inches of homogeneous armor at an obliquity of zero. Under the impetus of wartime programs, the initial M1 Bazooka launcher was superseded in December 1943 by the M9, which was slightly longer and 3 pounds heavier. In April 1945, the M9 was replaced by the M18, a two-piece aluminum launcher which weighed only 10.3 pounds. Efforts to improve the 2.36-inch HEAT rocket began in the summer of 1944 and were still in progress when the war ended.

Postwar Requirements and Developments

After World War II the defeat of armored vehicles was made progressively more difficult by steady increases in the thickness and obliquities of armor in hulls and turrets, development of better fabrication techniques, the curving of armored surfaces to defeat projectiles, and the introduction of new types of armor. Because of these improvements the weapon-ammunition combinations that could penetrate the armor of World War II tanks could seldom pierce the armor of later models. A radically new series of anti-tank weapons had to be developed. These improved weapons were to be capable of increased armor penetration, greater accuracy, and higher kill probabilities. In addition, it was essential that tanks be destroyed, not simply immobilized or put out of action by damage that could later be repaired. To obtain antitank weapons with these characteristics, effort was first concentrated on the improvement of existing conventional weapons, such as antitank guns, bazooka-type rocket launchers, recoilless rifles, and rifle grenades.

In October 1948, the Conference on Antitank Defense at Fort Monroe, Virginia, discussed at length the threat of enemy armor to airborne operations and agreed that two new antitank guns were needed to counteract it. These weapons were to be a 90mm self-propelled gun transportable in Phase I of airborne operations and a 76mm towed gun capable of being carried, with its prime mover, a three-man crew, and 15 rounds of ammunition, in an 8,000-pound-capacity glider and of being dropped by parachute. Army Field Forces Board Number 2 submitted detailed military characteristics for these weapons in April 1949.²

Official requirements for the M54 90mm cannon and the M48 76mm towed gun were established on an individual basis and summarized in the Army Equipment Development Guide (AEDG) of 1950. In addition to the 76 and 90mm guns, this edition of the AEDG specified an urgent requirement for (1) a manportable antitank weapon for front line units to replace the 2.36 and 3.5-inch rocket launchers and the 57mm recoilless rifle, and (2) an infantry division weapon capable of defeating at least 13 inches of armor at a range of 2,000 yards with a 75-percent probability of a first round hit. Pending development of the latter system, there was an immediate need for an antitank weapon capable of defeating at

²(1) *Ibid.*, pp. 335, 350, 416. (2) OCO TIR CD-5, Oct 60, subj: Dev of AT Wpns. RSIC.

least 11 inches of armor at a range of 1,000 yards.³

Advent of the Antitank Guided Missile

Once the guided missile was developed, its adoption as an antitank weapon was both logical and necessary. It was recognized that a properly controlled antitank guided missile (ATGM) would be an excellent weapon for use at ranges and under conditions that rendered conventional antitank fire either impracticable or ineffective. Despite steady improvements in conventional antitank weapons, they yet possessed a number of deficiencies that could only be overcome by the controlled or guided weapon.

Possibly the greatest single deficiency in conventional weapons stemmed from the fact that the trajectories of the projectiles they fired were fixed from the time of firing. Conversely, a guided missile could be directed or controlled throughout its flight and therefore intercept a maneuvering target regardless of the evasive action it might take. Another deficiency in conventional antitank weapons concerned their accuracy and range. To attain maximum accuracy they had to engage enemy armor by direct fire at comparatively short ranges, whereas the guided missile could be launched from behind a mask, or defiladed sites, and guided to a longer range target by either wire, radio, or a homing device. Also, the first hit probability of conventional weapons, although high at close range, diminished rapidly as the range increased, while the guided missile would have a potentially higher first-round hit probability at any range within its flight limits.

Although significant technological progress had been made in the development of guided missiles during the latter part of World War II, the possibility of front line troops using them against enemy armor was not seriously considered until early 1951, some 6 months after the Korean War started. Armor experiences early in the Korean War clearly demonstrated the need for an improved anti-tank weapon of minimum size and weight that would be capable of defeating the heaviest known enemy armor with pinpoint accuracy. There were a number of conventional weapons in combat use;* however,

* Namely, the rifle grenade with a range of 100 to 200 yards; the improved 3.5-inch Bazooka with a 300-yard range; and the 90 and 106mm recoilless rifles with ranges effective to 1,000 and 1,500 yards, respectively.

³ AEDG, 29 Dec 50, pp. 21-22, 82. RSIC.

their accurate range of application was limited to about 1,500 yards and their lethality was limited by projectile size. The most logical approach to overcoming these tactical deficiencies was the development of an antitank guided missile.⁴

Firm requirements for an antitank guided missile and certain general characteristics for such a weapon were established during a conference held at Fort Monroe, Virginia, in February 1951, to discuss land combat applications of infrared guidance techniques. The conferees concluded that infrared seekers had shown enough promise as homing devices for antitank guided missiles to warrant the establishment of a requirement for such a weapon. They recommended as a firm requirement a ground-launched antitank guided missile which would be of minimum size and weight, of very short range, and highly accurate, to attack armored tanks and other point targets, including artillery. The general characteristics outlined for the weapon system called for a 6,000-yard effective range and a kill probability of 0.9 against the heaviest known enemy tank.

The foregoing conclusions and recommendations were based primarily on the potential tactical application of the AN/DAN-3 infrared seeker, which had already been developed and successfully tested by the General Tire and Rubber Company, parent company of the Aerojet Engineering Corporation. The final engineering report, published in December 1950, described in some detail the tactical advantages of the infrared homing device which existed in actual hardware weighing less than 13 pounds, the entire unit being housed in a cylindrical shell 5 inches in diameter and 15 inches long.⁵ The characteristics and potentialities of the homing device were further confirmed in March 1951, when Aerojet completed a preliminary study of an antitank guided missile called the AeroSWAT*

* The code name originally suggested for this weapon was "SWAT," the acronym for Seeker Weapon Antitank; however, to distinguish it from other weapons of this type, it was called the AeroSWAT.

⁴ (1) OCO Booklet, Weapons for the Defeat of Armor, Vol. 4, AT Acft & ATGM's, Apr 53, pp. 6-7. RSIC. (2) RSA Tech Rept, Ord GM & Rkt Programs, Vol. VII - DART ATGM Sys, Inception thru 30 Jun 55, p. 3. HDF. (The latter report hereafter referred to as the DART Blue Book.

⁵ (1) Mins of Conf on IR Appls in Land Cbt, OCAFF, Ft Monroe, Va, 15-16 Feb 51. (2) General Tire & Rubber Co. Rept No. 2056, 22 Dec 50, subj: Final Engrg Sum Rept on the Dev of IR Homing Set AN/DAN-3 (XN-1). Both atchd as app to Rept of Study of Proj No. GM-451 - MC's for an ATGM, AFF Bd No. 4, Ft Bliss, Tex, 20 Nov 51. RSIC.

which used a modified version of the AN/DAN-3 seeker.⁶

In view of the findings and recommendations of the February 1951 conference and the promising results of Aerojet's studies, the Chief of the Army Field Forces (AFF), in April 1951, directed the AFF Board No. 4 to prepare detailed military characteristics (MC's) for an antitank guided missile to supplement the conventional weapons then in use. Nine months later, in November 1951, the board submitted a proposed statement of MC's, together with a supporting staff study.⁷

The Chief, AFF, in January 1952, recommended that the proposed MC's, as modified, be approved as the statement of Army requirements for an antitank guided missile, and that an investigative and design study project be initiated. The formal MC's, approved in May 1952, called for an antitank guided missile system with a maximum effective range of 6,000 yards (8,000 yards desired), a minimum range of 500 yards or less, and hit and kill probabilities of at least 0.90 against the heaviest known enemy tanks and other point targets. The missile was to be of minimum size and weight and be guided to the target by an infrared seeker or other type guidance, preferably automatic.⁸

Preliminary Studies and Investigations

The state of guided missile technology in 1952 was not considered adequate to support the development of an antitank system meeting all performance requirements of the MC's. It was considered feasible, however, to develop an interim system that would substantially fulfill the MC's, produce a tactically useful weapon, and pave the way for the ultimate weapon. The Ordnance Corps considered three guided missile systems for potential anti-tank use: The D-40 which was under development by the Department of the Navy, the French SS-10, and the proposed DART which was similar in structure to the SS-10.

⁶ Aerojet Rept No. 503, 16 Mar 51, subj: AeroSWAT - a Prelim Study of an AT Wpn. RSIC.

⁷ Rept of Study of Proj No. GM-451 - MC's for an ATGM, AFF Bd No. 4, Ft Bliss, Tex, 20 Nov 51, & App A thereto: Ltr, Chf, AFF, Ft Monroe, Va, to President, AFF Bd No. 4, Ft Bliss, Tex, 14 Apr 51, subj: MC's for an ATGM. RSIC.

⁸ Ltr, Chf, AFF, to ACofS, G4, Log, DA, 25 Jan 52, subj: Rept of Proj No. GM-451 - MC's for an ATGM, w incl. RSIC.

The D-40 Missile

Commonly known as the Cannonball missile, the D-40 was being developed by the Applied Physics Laboratory under a Department of the Navy contract with financial support from the Ordnance Corps. Unlike the torpedo-shaped bodies of its contemporaries, the D-40 was a spherical missile which measured about 24 inches in diameter. Also unlike the other missiles, it was guided by means of a radio-link system. The principal disadvantages of the D-40 were its great weight (300 pounds) and the vulnerability of its radio control system to enemy countermeasures. A lightweight version weighing about 150 pounds and using wire guidance was later developed and tested, but the antitank phase of the program was eventually dropped.⁹

The SS-10 Guided Missile System

The French SS-10 missile evolved from the German *Ruhrstahl*, or X-4, a single-wing, wire-guided, roll-stabilized missile originally developed as an air-to-air missile late in World War II. The Germans were ready to begin mass production of the X-4 early in 1945, but their plans were interrupted by costly delays in acquiring suitable solid-fuel rocket engines and by the relentless bombing of research and manufacturing centers by Allied planes. Recognizing the potentialities of the X-4 as a surface-to-surface antitank weapon, the French continued its development after the war ended.¹⁰ The resultant product was the SS-10, a ground-launched, cruciform-wing missile about 34 inches long with a 30-inch wing span. It had a gross weight of 34 pounds and carried an 8.9-pound shaped-charged warhead for an operational range of about 1,500 yards. Like the X-4, the SS-10 was an optically-guided, wire-controlled missile—features later incorporated in the DART guided missile system.¹¹

The Ordnance Corps became interested in the SS-10 as a potential antitank weapon late in 1951 and subsequently supported the development program with primary emphasis on procurement, test,

⁹(1) DART Blue Book, pp. 1-2. HDF. (2) OCO Booklet, Weapons for the Defeat of Armor, Vol. 4, AT Acft & ATGM's, Apr 53, p. 14. RSIC.

¹⁰*Ibid.*, p. 8.

¹¹RSA Tech Rept, Ord GM & Rkt Programs, Vol. IX - SS-10, Inception thru 30 Jun 55, p. 3. RSIC.

and evaluation of the system. Early in 1952, 500 SS-10 missiles and 3 sets of ground equipment were procured from the French Government for use in evaluation tests by the Ordnance Corps at Aberdeen Proving Ground, the AFF Board No. 3 at Fort Benning, Georgia, and the U. S. Marine Corps at Quantico, Virginia. The evaluation program began in December 1952 and continued until October 1953, when it was discontinued because of unfavorable test results. Members of the AFF Board No. 3 recommended that the SS-10 missile, in its current state of development, be considered unsuitable for use by the U. S. Army, and that future French development of the missile be carefully observed with a view to reconsideration of the weapon if an improved model should be produced before a comparable American weapon became available.¹²

The DART Guided Missile System

While the foregoing evaluations were in progress, the Ordnance Corps began an investigation to determine the feasibility of the new DART missile system, the initial proposal for which had been submitted by the Aerophysics Development Corporation in November 1951. From May to August 1952, Aerophysics conducted feasibility studies of the proposed DART system, which consisted essentially of a ground-launched, cruciform missile carrying a 20-pound shaped-charge warhead capable of penetrating 14 to 16 inches of armor within an effective range of 350 to 5,280 yards.

In structure, the DART missile would be similar to, but larger than, the SS-10. It would have an overall length of 64 inches, a wing span of 2.64 feet, and a launching weight of about 85 pounds. Unlike the SS-10, which would be guided by wire throughout its flight, the DART would use both wire control and an infrared homing device. Since the DART would have a much longer range than the SS-10, a forward observer would control its direction during much of its flight, either to guide it onto a target or to a point where the homing device could take over and complete the mission.

Conclusions of the feasibility study, submitted in August 1952, indicated that the DART missile system could be developed in a straightforward manner using the principles and techniques of the SS-10 which was already in the advanced development stage.¹³

¹² *Ibid.*, p. 26.

¹³ ADC Rept No. 106-5, 15 Aug 52, subj: FS of the DART AT Msl. RSIC.

Pending completion of the SS-10 evaluation then in progress, the Army Chief of Staff, in January 1953, authorized the establishment of a DART project limited to component studies and development.¹⁴ The promising results of these predevelopment studies, together with unfavorable results of the SS-10 evaluation, led to selection of the DART system to fulfill existing requirements for an antitank guided missile. The DART development project was officially established on 27 August 1953 with a 1A priority.¹⁵

Demise of the DART and Adoption of the SS-10

In its proposal of mid-August 1952, the Aerophysics Development Corporation optimistically predicted that the DART could be successfully developed in about 2 years and cost less than \$1,000 in large quantities.¹⁶ More than 6 years and \$47 million later, an acceptable DART system was yet to be developed and produced, causing a shift in user interest to the modified SS-10 system.

A dramatic demonstration of the improved SS-10 system in Paris, France, during June 1957, showed beyond any doubt that the French had indeed achieved a reliable wire-guided antitank missile. The results of this demonstration were confirmed in U. S. service tests of the SS-10 in mid-1958. In view of the stretchout in the DART development schedule, erosion of confidence in the ability of the contractor to solve basic technical problems, an escalation in program costs, and user statements favoring the improved SS-10 over the DART, the Department of Defense approved termination of the DART project in September 1958 and authorized the offshore procurement of sufficient SS-10 systems to meet interim antitank requirements of the U. S. armed forces.¹⁷

The SS-10 antitank missile system was classified Standard A in April 1959. Subsequent evaluations of the improved French SS-11 and ENTAC wire-guided missiles by the U. S. Army led to their procurement for employment as helicopter-mounted and ground-launched antitank systems. The ENTAC was classified Standard A in

¹⁴OTCM 34682, 9 Apr 53. RSIC.

¹⁵OTCM 34961, 27 Aug 53. RSIC.

¹⁶ADC Rept No. 126, 15 Aug 52, subj: The DART AT Msl - Pps1 for Dev, pp. 1-2. RSIC.

¹⁷For a complete history of the DART project, see Mary T. Cagle, *Development and Production of the DART Antitank Guided Missile System - 1952-1959* (ARGMA, 18 Jan 60).

April 1961. This was followed, in May 1961, by reclassification of the SS-10 to Standard B, and classification of the XM-22 (SS-11/UH-1B) armament subsystem as a limited production item. The latter was approved as Standard A on 23 July 1964.¹⁸

Toward a New Family of Army Antitank Weapons

Meanwhile, materiel requirements were established for a family of advanced weapons to counter the most formidable enemy armor anticipated on the battlefield into the 1970's. Among these were specific requirements for a direct-fire combat vehicle armament weapon using a missile with command guidance; a manportable, shoulder-launched light antitank weapon (LAW) to replace the 3.5-inch rocket-firing Bazooka and the antitank rifle grenade; a heavy antitank/assault weapon (HAW) to replace the 106mm recoilless rifle and the French wire-guided antitank systems; and a medium antitank weapon (MAW) to replace the 90mm recoilless rifle and bridge the range gap between the 300-meter LAW and the 2,000-meter HAW.¹⁹

One by one, these weapons took their place in the Army's arsenal of operational antitank systems, adding a major new dimension to tank warfare. The M72 LAW, consisting of a 66mm HEAT rocket and launcher, reached the field in 1963, followed by the SHILLELAGH combat vehicle armament system in 1967. The Tube-launched Optically-tracked Wire-guided (TOW*) heavy antitank/assault weapon became operational in September 1970, initially replacing the M40 106mm recoilless rifle and French ENTAC system, and later the helicopter adaptation of the French SS-11 system. The 750-meter DRAGON medium antitank/assault weapon began replacing the 90mm recoilless rifle early in 1975.²⁰

* The action authorizing the feasibility study phase of the project early in 1962 stated that the term "TOW" was an acronym for the HAW system rather than an approved name. (OTCM 38004, 22 Mar 62. RSIC.) The weapon system was never assigned a popular name, however, and it came to be known simply as the TOW.

¹⁸ (1) OCO TIR CD-5, Oct 60, subj: Dev of AT Wpns, pp. 31-32, & Suppl I, Oct 61, pp. 3-4. RSIC. (2) DF, AT/Acft Wpns Cmdty Ofc, MICOM, to Distr, 29 Jul 64, subj: Std A TCLAS of the M22 Armt Sys. HDF.

¹⁹ MICOM Staff Study, 9 Aug 65, subj: Exam of AT Devs. HDF.

²⁰ (1) *Ibid.* (2) Wpn Sys Hist Repts & Chronologies. HDF.

The TOW antitank weapon system is recognized as one of the most successful weapons ever developed by the Army Missile Command. Its effectiveness against tank and point targets was dramatically demonstrated in South Vietnam during the spring of 1972, when it became the first Army guided missile to be fired in combat by American soldiers. It is the development, production, and deployment of the TOW to which this study now turns.

CHAPTER II

(U) PREDEVELOPMENT STUDIES

Studies leading to the initiation of TOW/HAW development began in July 1958, just before termination of the DART project and offshore procurement of the French SS-10 system for interim use. Because the state of the art with respect to heavy antitank/assault weapons was not precisely known in 1958, the initial Qualitative Materiel Requirement (QMR) for the long range time period was written in general terms. The QMR, approved by the Chief of Research and Development on 11 July 1958, specified a need for a heavy antitank/assault weapon capable of providing a high first-round hit probability at all ranges up to 2,000 meters and of being operated from the ground, from a vehicle, or from a suitable Army helicopter. The HAW system would be organic to the combat group and be used primarily to defeat armor and other materiel targets and emplacements likely to be encountered in the battle area.¹ This initial QMR served as a general guide in subsequent preliminary studies and supporting research, but it lacked sufficient definition to provide the basis for specific system development.

Preliminary Studies of the HAW Problem

In the fall of 1958, after cancellation of the DART project, the Chief of Ordnance established an Ad Hoc Working Group to study the HAW problem and to recommend an orderly development program leading to system availability by the 1965-66 period. After an extensive investigation of the state of the art, the group concluded that there was no single weapon system whose feasibility was then established which could meet the HAW requirement. The Ad Hoc Working Group thus recommended that the development of a system to meet the HAW requirement be deferred for about 2 years, during which time the program would consist of vigorous supporting research of guidance schemes leading ultimately to homing systems, and field tests to evaluate performance of foreign man-guided

¹(1) CDOG, Para 237b(10), 11 Jul 58. (2) Ltr, CG, CONARC, to CRD, DA, 19 Mar 58, subj: QMR for HAW Sys(s). (3) Ltr, CRD, DA, to CG, CONARC, 17 Jul 58, subj: QMR for HAW. All in RSIC (CDOG File).

antitank guided missile systems.²

During the 1959-61 period, the U. S. Army evaluated a number of foreign antitank systems, including the French SS-11 and ENTAC, the German COBRA, the British VIGILANT and SWINGFIRE, the Swiss MOSQUITO, and the Swedish BANTAM. This effort led to selection of the SS-11 and ENTAC man-controlled, wire-guided missile systems for employment as helicopter-mounted and ground-launched antitank systems, respectively, during the mid-term period. These weapons, together with the 106mm recoilless rifle, would fulfill the anti-tank requirements of U. S. combat units pending availability of the long-term HAW system.³

The 2-year supporting research program, approved by the Chief of Research and Development on 25 June 1959, was accorded 1A priority. It provided for the full exploitation of principles and techniques necessary for the design and evaluation of various guidance and control schemes. Primary emphasis would be placed on the generation of design data relating to the detection of dissimilar military targets and the use of sensory devices in the determination and translation of intelligence to control missile mechanisms so that continual guidance would be provided from the point of launch to impact. The responsibility for supervision and direction of the program was assigned to the Ballistic Research Laboratories (BRL), Aberdeen Proving Ground, Maryland. The estimated cost of the program for FY 1960-61 was \$1.5 million.⁴

After an examination of the new guidance and control schemes investigated during the supporting research program, BRL concluded that all objectives of the HAW requirement could not be met, particularly with respect to an indirect fire capability and firing from an aircraft. It appeared, however, that there were several approaches to a tube launched, automatically optically tracked, wire command link missile (TOW) which gave sufficient promise of success and sufficient increase in performance over the mid-term weapons to warrant initiation of preliminary engineering design leading to system development. The mid-term or first generation antitank weapons (SS-11 and ENTAC) differed from

²BRL Memo Rept No. 1365, Sep 61, subj: A Study of HAW (Long Rg Time Period), p. 13. (This revised edition superseded BRL TN 1417 dated July 1961.) RSIC.

³(1) *Ibid.* (2) OTCM 38004, 22 Mar 62. RSIC. (3) OCO TIR CD-5, Oct 60, pp. 31-32, & Suppl I, Oct 61, pp. 3-4. RSIC.

⁴OTCM 37108, 25 Jun 59. RSIC.

the TOW concept in that they relied on human operator control and had smaller warheads, larger minimum ranges, and lower hit and kill probabilities. BRL therefore recommended that work be initiated on the engineering design of a new HAW system incorporating the basic features of TOW.⁵

Origin of the Infrared Command Guidance Concept

The automatic infrared command guidance concept on which the TOW/HAW system was based evolved from an in-house research effort begun at Redstone Arsenal in 1957. It was first suggested in January 1957 as a guidance approach for an armor-defeating missile in connection with Project WHIP (the popular name given to studies of an assault weapon system). The concept was then proposed in February 1957 as a solution to the DART capture problem, but the project was cancelled while consideration was being given to the new approach. The infrared command unit was again suggested in 1958 for the direct fire antitank weapon which later became the SHILLELAGH combat vehicle weapon system.⁶ The concept of automatic command guidance for antitank weapons had thus begun to take shape when preliminary studies of the HAW problem commenced in 1958.

It occurred to laboratory personnel that infantry antitank missiles, such as the SS-10 and SS-11, suffered in performance potential because they were manually tracked and guided and required highly skilled, highly trained operators. The infrared command unit, if successfully developed for the infantry antitank role, could perform automatically the missile tracking and command functions, leaving the operator the simpler task of target tracking. The Missile Electronics Laboratory of the Ordnance Missile Laboratories submitted the first formal proposal for automatic command guidance for an infantry antitank missile on 31 March 1959. This proposal contained a detailed concept for implementation and later served as the basis for a patent in the names of Nicholas J. Mangus, William B. McKnight, and Lonnie N. McClusky.⁷ It was

⁵BRL Memo Rept No. 1365, Sep 61, *op. cit.*, pp. 104-106, 108. RSIC.

⁶(1) ARGMA Rept, DOD Study Proj No. 97, 9 Aug 61, subj: The Role of ARGMA In-House Labs in Army Programs. HDF. (2) ARGMA Rept TR1F2R, 20 Nov 58, subj: A Review of IR Info Appl to Msl Guidn. RSIC. (3) SHIL GM Sub-Sys Plan, ARGMA MSP-7, 31 Aug 59. HDF.

⁷(1) Pps1 for Auto Comd Guidn, 31 Mar 59. RSIC. (2) U. S. Patent 3,366,346, Remote Msl Comd Sys, 30 Jan 68. HDF.

followed, in February 1960, by a proposal for development of the infrared command unit for wire-guided antitank missiles.⁸

Design and development of the automatic guidance system was initiated as an in-house program at the Army Rocket and Guided Missile Agency (ARGMA), Redstone Arsenal, Alabama, in February 1960. Feasibility flight tests of the unit began in November 1960, using breadboard hardware and SS-11 missiles. On 7 December 1960, ARGMA demonstrated the feasibility of the system at Redstone Arsenal for representatives of the Office, Chief of Ordnance (OCO), the Infantry Board, the Infantry School, the Aviation Board, the Armored Board, and other Ordnance installations. Later in December 1960, further presentations were made to OCO and DA Staff elements. The Ballistic Research Laboratories also followed the exploratory effort with much interest and, as noted above, subsequently judged that a very cost effective HAW system would result from the application of automatic command guidance technology to a new system, the essential characteristics of which would be a direct-fire missile that would be tube launched, optically tracked, and command guided by a wire link (TOW).

Briefly, the gunner's only task would be to train the cross-hairs of his optical sight on the target, then press the trigger to launch the missile. In flight, the missile would unreel two hair-thin wires from internal bobbins through which steering signals would be transmitted. Missile position with respect to the line of sight would be established after infrared signals from a source on the missile were received by a sensor at the launch site. Signals from the infrared sensor would be processed by electronic equipment and converted into azimuth and elevation data. The missile position would then be compared to the line of sight of the gunner's scope and appropriate pitch and yaw commands would be automatically transmitted to the missile over the wire link to bring the two together.⁹

Feasibility Studies of the TOW/HAW System

At the behest of the Army Chief of Research and Development,

⁸ ARGMA Rept TR1F5R, 25 Feb 60, subj: Pps1 for Dev of IR Comd Unit for Wire-Guided AT Msl. RSIC.

⁹ (1) ARGMA Hist Sums, 1 Jan - 30 Jun 60, pp. 157-58; 1 Jul - 31 Dec 60, pp. 145-46; & 1 Jan - 30 Jun 61, pp. 166-67. (2) MICOM Hist Sum, FY 63, pp. 146-47.

OCO submitted a plan, on 25 September 1961, calling for in-house and contractor studies to prove the feasibility of the TOW system before initiating a large and costly development program. The Assistant Secretary of the Army (R&D) and Secretary of Defense enthusiastically approved the plan on 16 October 1961 and authorized its implementation on a high priority basis.

In view of the urgency and top level interest associated with the TOW/HAW program, the Chief of Ordnance authorized certain deviations from normal procedure. Initial development would consist of several contractor competitive design programs and a parallel in-house effort, which would be evaluated at the end of 6 months in a system feasibility demonstration. Instead of naming one of the commodity commands as weapon system manager, the Chief of Ordnance assigned his Chief of Research and Development the responsibility for direction and supervision of both the contractor and in-house effort. These programs would be pursued on a competitive basis until the feasibility demonstrations, when the system proposals would be critically compared and a winner selected for completion of development and production. Indicating his intention to make maximum use of the total capabilities of the Corps for the in-house effort, LTC J. H. Hinrichs declared:

. . . This is indeed our opportunity to demonstrate to all the capabilities of the Ordnance Corps for orderly supervision of a priority program, as well as demonstrate our in-house technical capability. Time is short - - the competition is stiff - - let's establish a record in time, dollars and quality which will be a credit to the Ordnance Corps.¹⁰

An in-house effort in the TOW feasibility exercise was considered essential so that an independent yardstick would be available against which the contractor programs could be evaluated and so that in-house personnel would be able to provide informed technical supervision of the development program scheduled to begin in FY 1963. The in-house management group, established on 2 October 1961, was physically located at the Diamond Ordnance Fuze Laboratories and reported directly to the Chief of Research and Development, OCO. The management group consisted of four

¹⁰ (1) OCO Cir Ltr No. 408-61, CofOrd to CG, AOMC, *et al.*, 25 Oct 61, subj: HAW/TOW Dev Program. (2) Also see DF Cmt #2, CofOrd to CRD, DA, 10 Jan 62, subj: Pre-Awd Bfg on RDTE Contr - (TOW). Both in RHA Bx 13-168.

full-time members and one part-time member.¹¹

During a meeting held at BRL on 17 October 1961, 40 industrial firms were briefed on the TOW specifications and invited to generate, on an unfunded basis, complete concept systems and to propose programs leading to the development of their concepts. Eighteen proposals were received by 30 November 1961. From 11 December to 15 December 1961, the TOW evaluation panel met at BRL to review the proposals. The panel consisted of the following persons:

Dr. M. J. Zucrow, Chairman, Purdue University
Mr. David Hardison, Ballistic Research Laboratories
Mr. Harry Reed, Jr., Ballistic Research Laboratories
Dr. Anthony Ferri, Brooklyn Polytechnic Institute
Dr. Martin Goland, Southwest Research Institute
Dr. Glen Williams, Massachusetts Institute of Technology

The companies considered to have the best proposals, in the order of their ranking, were the Hughes Aircraft Company, the Martin Marietta Corporation, and the McDonnell Aircraft Company.¹² On 10 January 1962, each of these companies received a \$500,000 contract to design and fabricate, in a 6-month period, prototype hardware adequate for the flight demonstration of the technical feasibility of its proposed TOW missile concept. All costs in excess of \$500,000 were funded by the respective contractors. The parallel in-house effort was initially funded for \$500,000, but this was later raised to \$700,000. Each competitor was to deliver a minimum of four rounds for the feasibility demonstration at Aberdeen Proving Ground between 10 and 20 July 1962.

The preliminary plan for development called for completion of the feasibility study phase (four approaches) during the first quarter of FY 1963, completion of component development and engineering design (one approach) in the third quarter of FY 1964, conduct of the engineering service tests during the period January to December 1964, type classification of the system during the third quarter of FY 1965, and delivery of the operational system during the last quarter of CY 1965. The projected development

¹¹(1) Ord Opng Pro for Conduct of HAW Dev -- A Con Exper, 20 Sep 61. (2) OCO R&D Div Rept, 1 May 62, subj: In-House TOW. Both in RHA Bx 13-168.

¹²(1) MFR, LTC Roy E. Rayle, OCO R&D Div, 15 Dec 61, subj: Visit to BRL re TOW 14 Dec 61. (2) DF, Cmt #2, CofOrd to CRD, DA, 10 Jan 62, subj: Pre-Awd Bfg on RDTE Contr - TOW. Both in RHA Bx 13-168.

cost as of April 1962 was as follows:¹³

FY 1962	\$ 2,200,000
FY 1963	14,400,000
FY 1964	10,500,000
FY 1965	<u>2,000,000</u>
	\$29,100,000

The tentative technical characteristics for the TOW system, approved in March 1962, specified a requirement for a first-round hit probability of 0.9 at ranges of from near zero to 1,500 meters, and 0.75 from 1,500 to 2,000 meters, with a desired probability of 0.9 over the entire 2,000-meter range. A weapon system reliability of at least 95 percent was required. Three kinds of ammunition were to be provided: an antitank missile (with 5.95-inch diameter warhead weighing about 14 pounds), a soft-target round, and a chemical round. The tactical TOW system was to be capable of being mounted on and fired from a lightly armored tracked vehicle, an unarmored vehicle, the ground, or a helicopter, if feasible. The overall weight of the system was not to exceed 200 pounds, of which 160 pounds would be for the weapon, fire control system, and mount, and 40 pounds for the round of ammunition. The desired overall system weight, however, was 150 pounds.¹⁴

During the first meeting of the TOW Coordinating Group on 18 April 1962, the representative of the Office, Chief of Research and Development (OCRD), Department of the Army, requested OCO to investigate the effect of increasing the range of the TOW system. The Deputy Chief of Staff for Military Operations (DCSOPS) and OCRD appeared to favor an increase in the effective range, while OCO and the Infantry Board opposed the extension because of the possible increase in weight and complexity. A brief study indicated that a range extension from 2,000 to 3,000 meters would indeed result in a significant increase in both weight and complexity. For the McDonnell and in-house missiles, which used side thrusters, it was estimated that 8 pounds additional weight would be required for each 500 meters increase in range. For the Hughes and Martin missiles, which did not use side thrusters, it

¹³(1) Curr Sta of TOW Program, 20 Apr 62, by LTC Roy E. Rayle, OCO R&D Div, w Chart 1, TOW Dev Program, & Chart 2, Planned RDTE TOW Funds. (2) DF, Cmt #2, CofOrd to CRD, DA, 15 Jan 62, subj: Future HAW (TOW) Sys Dev Program. Both in RHA Bx 13-168.

¹⁴(1) AMC TIR CD-5, Suppl II, Nov 62, p. 2. RSIC. (2) Also see DF, CofOrd to CRD, DA, 8 Mar 62, subj: Revised QMR for HAW (Long Rg). RHA Bx 13-168.

was estimated that at least 5 pounds additional weight would be required for each 500 meters increase in range. This added weight stemmed from the need for a larger flare and larger battery to power the flare, 1 to 2 pounds of additional wire, a larger and heavier power source for control actuation, and additional motor propellant. The cited weight variations would be from a base weight of 40 to 55 pounds for the various TOW missiles under consideration. A final decision on the range increase would be made following the feasibility demonstrations.¹⁵

In May 1962, questions were raised regarding the priority of vehicles which might carry the TOW. Specifically, there was a question as to the relative priority between light wheeled vehicles more commonly used by infantry units and light armored vehicles more commonly used by armored units. Among the light wheeled vehicles, there was a question of relative priority of the standard 1/4-ton and 3/4-ton vehicles and the 1 1/4-ton vehicle then under development. Among the light armored vehicles, the question pertained to the M113, the M116, and the T114. Rather than advise the contractors that TOW must work equally well from all these vehicles, the Chief of Ordnance requested guidance on the matter of priority in case there were technical considerations under which one application must be favored over another. While it was considered premature to establish definitive vehicle requirements for mounting the TOW, DCSOPS ruled out the 3/4-ton wheeled vehicle and the M116 light armored tracked vehicle. For planning purposes, consideration would be given to the M151 1/4-ton or the new 1 1/4-ton wheeled vehicles and the M113 or T114 tracked vehicles. As to a preference between wheeled and tracked vehicles, DCSOPS indicated that both applications would be important, the tracked vehicles for use by armored forces in Europe and the wheeled vehicles for use by airborne troops anywhere.¹⁶

TOW Feasibility Demonstration

The primary objective of the TOW feasibility demonstration firings at Aberdeen Proving Ground (APG) was to collect ballistic

¹⁵(1) MFR, LTC Roy E. Rayle, OCO R&D Div, 23 Apr 62, subj: First Mtg of TOW Coord Gp, 18 Apr 62. (2) DF, CofOrd to CRD, DA, 4 May 62, subj: Effect of Increasing Rg of TOW. Both in RHA Bx 13-168.

¹⁶(1) DF, CofOrd to OCRD, DA, c. May 62, subj: TOW Use on Vehs. (2) DF, Cmt #2, DCSOPS to CofOrd, c. May 62, subj: same. (3) MFR, LTC R. E. Rayle, OCO R&D Div, 1 Jun 62, subj: Second TOW Coord Gp Mtg Held 28 May 62. All in RHA Bx 13-168.

flight data, tracker performance data, wire dispensing data, and overall system dynamics for use by the evaluation committee in selecting the most feasible missile system. The firings were considered as in-flight experiments rather than a shooting competition; that is, the principal data obtained was not the ability of the systems to hit a target, but rather data which gave the position of the missile throughout its flight path and some coverage of attitude angle.

Mr. Harry L. Reed, Jr., of BRL chaired the TOW evaluation committee which consisted of the following members:

T. Robert Bechtol	BRL
David Hardison	BRL
Robert Kreiger	BRL
William Otto	AOMC*
George Stiles	BRL
Arthur Thraikill	BRL

A panel of advisors, chaired by Dr. M. J. Zucrow of Purdue University, provided technical assistance to the evaluation committee. Among other personnel attending the demonstration flights were representatives from OCRD, OCO, the Continental Army Command, Canadian Army Staff, and British Army Staff.

The feasibility demonstration firings began at APG on 10 July and continued through 20 July 1962. Each contractor system included a launcher, an infrared tracker, test missiles, and the spare parts necessary to repair the system during the evaluation firings. Martin Marietta and Hughes Aircraft each delivered four test missiles with a 152mm smoothbore launcher, while McDonnell Aircraft delivered six missiles with a 152mm SHILLELAGH-type rifled launcher. Each contractor was responsible for setting up, checking out, loading, and aligning his system. Countdown procedures were coordinated between the contractor and personnel of APG's Development and Proof Services.

Although none of the contractor systems actually tested fully demonstrated the required flight performance, the evaluation committee concluded that either of the proposed concepts could, with adequate engineering, be developed into an acceptable system. Of the three contractor approaches, the one offered by the Hughes Aircraft Company was considered to have the best potential of being developed into an acceptable TOW system within a reasonable timeframe. In one component or another, each contractor had

* U. S. Army Ordnance Missile Command

underestimated weight; e.g., the valve in the Martin system and the motor case in the Hughes system. In view of this, it appeared that all the proposed TOW systems would be in the 50-pound class when considered with the 6-inch SHILLELAGH warhead. To approach the 40-pound limit imposed by the HAW requirement, it would be necessary to reduce the TOW system to a 5-inch warhead. The evaluation committee therefore recommended that the Hughes Aircraft Company be selected to develop a 5-inch TOW system based on their concept.

The in-house effort, unfortunately, never progressed to the stage where it could be considered as a competing system. Members of the in-house team concluded that their proposed technical approach would result in a low cost, reliable, and accurate missile; however, a minimum of 4 and a maximum of 12 to 18 months would be required to bring the system to a point where a short leadtime development program could be initiated. The actual cost of the in-house effort totaled \$610,000.¹⁷

Appointment of Weapon System Manager

While the TOW feasibility studies and demonstrations were in progress, the Department of the Army (DA) was undergoing a major reorganization which culminated in the creation of the Army Materiel Command (AMC), the abolishment of the Office, Chief of Ordnance (OCO), and the realignment and redesignation of the Army Ordnance Missile Command (AOMC) as the Army Missile Command (MICOM). The new AMC and MICOM organizations existed with skeleton staffs from 23 May 1962 to 1 August 1962, when they became operational. The Army Materiel Command absorbed the functions of the former OCO, and the Army Missile Command absorbed functions of the former AOMC.¹⁸ In one of his last official acts as the Chief of Ordnance, MG H. F. Bigelow, on 12 July 1962, designated the Commanding General of the Army Missile Command as the weapon

¹⁷ (1) Rept of the TOW Eval Com, 31 Jul 62, w incl: APG Firing Record R-3524, Ord Eval of the TOW Wpns Systems, 10 to 21 Jul 62. (2) OCO R&D Div Rept, 1 May 62, subj: In-House TOW. Both in RHA Bx 13-168.

¹⁸ (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) For a detailed history of the reorganization, see AOMC Hist Sum, 1 Jan - 30 Jun 62; MICOM Hist Sum, FY 63; & AMC Hist Sum, FY 63.

system manager for the TOW/HAW.¹⁹

Within MICOM, the TOW/HAW system was initially assigned to the Antitank/Field Artillery Weapons Systems Product Manager, Mr. Lloyd L. Lively, who was delegated full responsibility and authority for management of the weapon system under direction of the Deputy Commanding General (DCG) for Guided Missiles.²⁰ In a subsequent realignment of the MICOM project and product manager structure, in October 1962, the product managers were renamed commodity offices (managers), and the Antitank and Aircraft Weapons Commodity Offices were placed under the DCG for Land Combat Systems. Because of the similarity of weapon systems under the Antitank Commodity Office (TOW, ENTAC, SS-10, and SHILLELAGH) and the Aircraft Weapons Commodity Office (SS-11 and 2.75-Inch Rocket), these two offices were combined on 19 November 1962 to allow greater flexibility in the use of personnel skills and smoother phasing out from one system to a new system. Mr. Lloyd L. Lively was named manager of the Antitank/Aircraft Weapons Commodity Office.²¹

Commodity management was the technique employed in managing a weapon system not designated for vertical project management. The commodity manager's staff was relatively small (normally less than six people per weapon system). He exercised overall policy and interfunctional management, approved program plans, and made critical decisions affecting the program, while relying upon the functional directorates to accomplish the mission objectives of the project.²²

Extension of TOW Feasibility Studies

With the feasibility of the TOW and SHILLELAGH systems established for the infantry (HAW) role and combat vehicle weapon system (CVWS) role, respectively, the Army Chief of R&D, in mid-July

¹⁹(1) OrdC Order 102-62, 12 Jul 62, subj: Wpn Sys Mgt: HAW Sys (TOW). (2) Ltr, Chf, OCO R&D Div, to CG, AOMC, 24 Jul 62, subj: Mgt of Proj TOW. Both in RHA Bx 13-168.

²⁰(1) DF, Dep to DCG/GM, to Distr, 13 Aug 62, subj: Asgmt of Wpn Sys Mgt Resps for HAW (TOW). HDF. (2) AOMC GO 87, 30 Jul 62. (3) MICOM GO 15, 7 Aug 62.

²¹(1) MICOM GO 43, 3 Oct 62. (2) MICOM GO 54, 5 Nov 62. (3) MICOM GO 57, 19 Nov 62.

²²CR 10-2, 15 Mar 63.

1962, directed that feasibility studies be continued in both programs to determine whether either the TOW or SHILLELAGH could be adapted to fulfill both roles.²³ Earlier, Dr. Harold Brown, the Director of Defense Research and Engineering, had made it clear that if both the TOW and SHILLELAGH were successful and either could fill both antitank roles, only one of the weapons would be continued through development and production. He urged that every effort be made to reach a decision by mid-October 1962.²⁴

The Army Chief of R&D released \$6 million for the SHILLELAGH and TOW studies, \$1.5 million of which was allocated to the TOW. On 19 July 1962, the Chief of Ordnance sent AOMC \$1.3 million of the allocation to cover continuation of the TOW feasibility studies (\$1,250,000 for the contract and \$50,000 for in-house support). The remaining \$200,000 was allocated to the Aberdeen Proving Ground to cover various tests in support of the program. A Class Determination and Finding (D&F) was signed on 30 July 1962, authorizing sole source negotiation of a contract with the Hughes Aircraft Company for the TOW study effort during the period 15 August to 15 December 1962.²⁵

On 17 August 1962, MICOM awarded Hughes Aircraft a 60-day letter contract for \$625,000. Two months later, the letter contract was extended through 17 December 1962, increasing the total value to \$1,242,606 for the 4-month period. Pursuant to guidance from higher headquarters, primary effort during the first 2 months was to be focused on studies to determine the feasibility of using the TOW in both the HAW and CVWS roles. This requirement entailed the manufacture of experimental hardware for test firings to demonstrate the feasibility of pulling wire from a closed breech tube in the CVWS role and to determine gunner environment when firing from an open tube in the HAW role. Other work under the

²³DF, Cmt #3, LTG Dwight E. Beach, CRD, DA, to CofOrd, 13 Jul 62, subj: Funds for SHIL - TOW. RHA Bx 13-168.

²⁴(1) MFR, LTC R. E. Rayle, OCO R&D Div, 1 Jun 62, subj: Bfg of Dr. [Harold] Brown on TOW & SHIL, 31 May 62. (2) Also see MFR, LTC R. E. Rayle, 7 May 62, subj: Mtg 20 Apr 62 re Army Pos on TOW-SHIL Relationships. Both in RHA Bx 13-168.

²⁵(1) DF, Cmt #3, LTG Dwight E. Beach, CRD, DA, to CofOrd, 13 Jul 62, subj: Funds for SHIL - TOW. (2) TT 034, CofOrd to CG, AOMC, 19 Jul 62. (3) Ltr, Chf, OCO R&D Div, to CG, AOMC, 24 Jul 62, subj: Mgt of Proj TOW. (4) DF, Chf, Future Msl Sys Div, D/R&D, to Chf, DS (Guided) Wpn Sys Div, Asst Dir, Cmdty Ops, D/P&P, 2 Aug 62, subj: TOW Feas Dmstn Contr, w incl: Sum of TOW Program. All in RHA Bx 13-168.

contract included redesign of the missile around a 5-inch warhead as recommended by the TOW evaluation committee, provision of an integral boresight alignment capability in the infrared tracker-optical sight unit, and further refinement of the design of the complete weapon system.²⁶

The HAW/CVWS Decision

On 30 August 1962, MICOM advised AMC that conclusive evidence of the feasibility of using TOW in the CVWS role would not be available before December 1962, whereas the decision regarding the system(s) to be developed for the CVWS and HAW roles was scheduled for mid-October or earlier. In view of this and the cost involved in the TOW/CVWS feasibility demonstration, the Command recommended that it be authorized to delete the experimental effort from requirements placed on the contractor. The cost of the total CVWS investigation was about \$417,000, of which \$110,000 would be expended or committed by 30 September.²⁷ With AMC permission, MICOM, on 14 September 1962, directed Hughes to terminate all experimental effort on the closed breech (CVWS) launch, but to continue studies of the dual-role TOW system and submit a report by 12 October 1962.²⁸

In a preliminary report on its HAW/CVWS cost effectiveness study, the Ballistic Research Laboratories (BRL) concluded that the advantages which would result from having TOW in the HAW role and the SHILLELAGH in the CVWS role suggested that development of both systems was warranted. Although the TOW and SHILLELAGH very likely could be developed in a version which would be usable in both the HAW and CVWS applications, the selection of either one to fulfill both roles would mean the acceptance of less than the best system for one role or the other. This stemmed from the fact that the SHILLELAGH and TOW had specific limitations which were intrinsic to their respective concepts. The consequences of SHILLELAGH limitations were more pronounced in the HAW application

²⁶(1) *Ibid.* (2) Contr DA-04-495-AMC-3636, 17 Aug 62 (renumbered DA-04-495-AMC-12 by Mod #5). RHA Bx 13-168. (3) MICOM Hist Sum, FY 63, pp. 147-48.

²⁷SS AMSMI-R-530, D/R&D, 29 Aug 62, subj: Per to Delete Inves of TOW for CVWS, w incl: TT AMSMI-RFC-53, CG, MICOM, to CG, AMC, 30 Aug 62. HDF.

²⁸Ltr, Hughes Aircraft Co (HAC) to CG, MICOM, 9 Oct 62, subj: Second Monthly Rept Under Contr DA-04-495-AMC-3636 TOW. RHA Bx 13-168.

and the consequences of the TOW limitations were more pronounced in the CVWS application. For these and other reasons, BRL favored the development of both systems.²⁹

In its interim study report, submitted on 10 October 1962, the Hughes Aircraft Company indicated general agreement with BRL's findings. It concluded that a dual-purpose TOW missile could be designed to meet both the HAW and CVWS requirements; however, solutions to some of the engineering problems were yet to be proven. Moreover, there was some doubt that the economic and logistic advantages would offset the performance penalties inherent in such a system. Hughes therefore recommended that development of the single role TOW system be initiated.³⁰

As a result of the BRL and Hughes Aircraft studies, higher headquarters decided to proceed with development of the TOW for the HAW role and the SHILLELAGH for the CVWS role. Seven years later, however, the TOW/SHILLELAGH competition again surfaced and very nearly caused the cancellation of the TOW program.³¹

Description of the Proposed TOW/HAW System

The TOW weapon system proposed for development in November 1962 was designed to defeat all heavy tanks likely to appear on the battlefield in the 1965-70 timeframe. It would be effective against targets from point blank range (limited only by safe arming distance) out to 2,000 meters. The TOW missile would be boosted to a peak speed in excess of 1,000 feet per second, enabling it to reach maximum range less than 9 seconds after launch. The weapon's 5-inch, 9.2-pound warhead was expected to be only 5 percent less effective than the larger 12.5-pound XM-13 warhead against most heavy tank armor. The system's accuracy and high reliability would provide first-round hit probabilities of 90 percent at ranges up to 1,500 meters and 75 percent at ranges from 1,500 to 2,000 meters when fired against 7.5 by 7.5-foot targets.

²⁹(1) Ltr, CO, BRL, to CG, AMC, undated (c. early Sep 62), subj: TOW/SHIL -- Decn Concerning Initiation of Dev. RHA Bx 13-168. (2) Also see BRL Tech Note 1477, Sep 62, subj: A Feas, Effns, & Cost Study of a CVWS and a HAW Sys. RSIC.

³⁰HAC Rept, 26 Nov 62, subj: TOW Dev Pps1 - TP 268, p. 2. RHA Bx 13-168.

³¹See below, pp. 95-98.

When using the TOW system, the gunner was required only to superimpose crosshairs of the optical sight on the target from the time of missile launch until target impact. The guided missile, launched toward the target from a tube mechanically aligned with the optical sight, received automatic course corrections in the flight through the jam-proof wire link. With the aid of the infrared apparatus, the gunner, in effect, established a synthetic gun barrel from the launcher to the target by aiming the optical sight. The missile was automatically commanded to fly within this synthetic barrel to target impact.

The TOW missile was packaged in a shipping container that was used as a portion of the missile launch tube. This concept provided a rapid reload capability and enabled an average crew to engage up to three targets per minute from a single weapon position. The total weight of the missile and its container was 40 pounds. The launcher assembly, weighing about 120 pounds, was designed to be mounted on a variety of light vehicles and could also be demounted, mancarried short distances, and operated from a tripod for ground use. In most tactical situations, the TOW system would be installed on the M113 armored personnel carrier or the XM-561 1 1/4-ton (Gama Goat) vehicle.

As redesigned to accommodate the 5-inch, 9.2-pound warhead, the TOW missile was 5.85 inches in body diameter and 44.3 inches long, and had a prelaunch weight of 35.13 pounds.* It had a cruciform wing configuration with interdigitated tail control surfaces which were driven by pneumatic actuators and oscillated in a bang-bang mode at 15 cycles per second. The wing and control surfaces were folded into the missile body before launch and extended by springs and locked as the missile emerged from the launch tube. Roll was controlled by a gyroscope.

The missile was launched from a 152mm open breech tube to an exit velocity of 250 feet per second. It then coasted for about 40 feet to insure gunner safety, at which point a second boost achieved the maximum velocity of 1,060 feet per second about 1.4 seconds after launch. The missile coasted throughout the rest of its flight, reaching a terminal velocity of about 650 feet per second at maximum range. The time of flight to 2,000 meters was about 8.5 seconds.

* The original missile, with the 12.5-lb. XM-13 warhead, was 5.95 inches in diameter and 44.62 inches long, and had a prelaunch weight of 38.32 lbs. HAC Rept SSD 2300R, TOW/HAW Feas Dmstn Final Rept, Vol. 1, Jul 62, p. 2. RHA Bx 13-168.

The launch and flight motors were built for Hughes Aircraft by the Hercules Powder Company. The launch motor used multiperforated pellets of double-base propellant randomly loaded into the chambers. Potassium sulphate in an ethyl cellulose binder was used to suppress secondary burning and flash. A 2-inch-diameter blast tube, 8.75 inches long, extended from the aft closure to the nozzle. The flight motor, located near the missile center of gravity, used a head-end bonded ARP propellant grain. It exhausted through a pair of nozzles in the horizontal plane at 30 degrees to the longitudinal axis of the missile. This configuration eliminated wire link interference, directed the exhaust products away from the launcher, and minimized the center of gravity shift due to propellant burning. The propellant grain configuration was tubular with integral concentric end grooves providing extra burning surface at the aft end of the grain during the initial phase of motor operation. The high initial acceleration provided stability during the period of low aerodynamic forces.

Single strand, high strength wire for the command link was dispensed from two stationary 1.75-inch-diameter by 5-inch-long spools mounted on the aft baseplate of the missile. The two bobbins, each with 7,000 feet (2,135 meters) of wire, weighed 1.38 pounds. During boost, about 9 feet of armored leader was dispensed from a magazine in the wall of the shipping container/launch tube. When the missile left the launch tube, a release mechanism accomplished smooth transition to payout from the flight spools. The wire dispenser was designed for Hughes Aircraft by A. B. Bofors of Bofors, Sweden.

The 440-watt missile thermal battery supplied power to the infrared source, electronic circuitry, control actuator solenoids, rocket motor igniters, and warhead safety and arming device. Activation time was 0.5 to 0.6 second at 70°F, and 0.8 to 1.0 second at the minimum operating temperature of -65°F.

The infrared sensor mounted on the launch tube and collimated with the gunner's optical sight provided two discrete fields of view using components on a single optical axis. The gunner's optical sight had a double field of view with separate crosshairs. The upper half was at about 15x magnification and was used for precise tracking of targets at extended ranges. The lower half of the display was at about 3x magnification and was used for tracking short range targets having high crossing speeds.

The whole launcher assembly, including the gunner's sight, infrared sensor, electronic circuits, launch tube, and course and fine traversing mechanisms, was mounted on a tripod fitted with

spades, handles, and a wheel. The total weight of the ground mounted system, less missile, was 151 pounds. For vehicle installations, the tripod was discarded and the carriage mounted directly to the vehicle.³²

Proposed Development Plan

The proposed Hughes Aircraft plan for development of the TOW system embraced four phases: Component Development Phase (December 1962 - June 1963); Experimental Model Phase (July 1963 - March 1964); R&D Prototype Phase (April 1964 - September 1964); and R&D Prototype and Army Engineering Test/Service Test Phase (October 1964 - July 1965). The equipment to be built and tested included 2 experimental and 4 prototype launching systems, 37 experimental missiles, and 133 R&D prototype missiles. Test and evaluation of the system would be completed and the final design release effected by 1 August 1965. The cost proposal for the first 9 months of development effort was \$10,246,298, including a 9 percent fee of \$846,025.³³

The Hughes Aircraft Company offered to the TOW program the benefits of more than a decade of experience with military missile systems as a major defense contractor, an organizational and management structure of proven effectiveness in weapon system management, and a vast array of the latest, finest facilities in the country.

The company was organized on a decentralized basis to allow each group to concentrate its efforts on a specific area. The Aerospace Group—one of the three decentralized groups having its own design, engineering, manufacturing, and service functions—would be responsible for execution of the TOW program. The management focal point for the project would be the TOW Program Office (see Chart 1). The TOW Program Manager would report directly to the division manager and be assisted by a staff of highly qualified management personnel. This staff would draw upon the whole corporate organization for the capabilities needed to accomplish the

³²(1) HAC Rept, 26 Nov 62, subj: TOW Dev Pps1 - TP 268. (2) RDTE Proj Card, Proj No. 502-09-013, HAW Sys (TOW), 15 Sep 62. (3) HAC Repts SSD 2300R & SSD 2302R, TOW/HAW Feas Dmstn Final Rept, Vols. 1 & 3, Jul 62. All in RHA Bx 13-168.

³³HAC Rept, 26 Nov 62, subj: TOW Dev Pps1 - TP 268, pp. 17-19, 53. RHA Bx 13-168.

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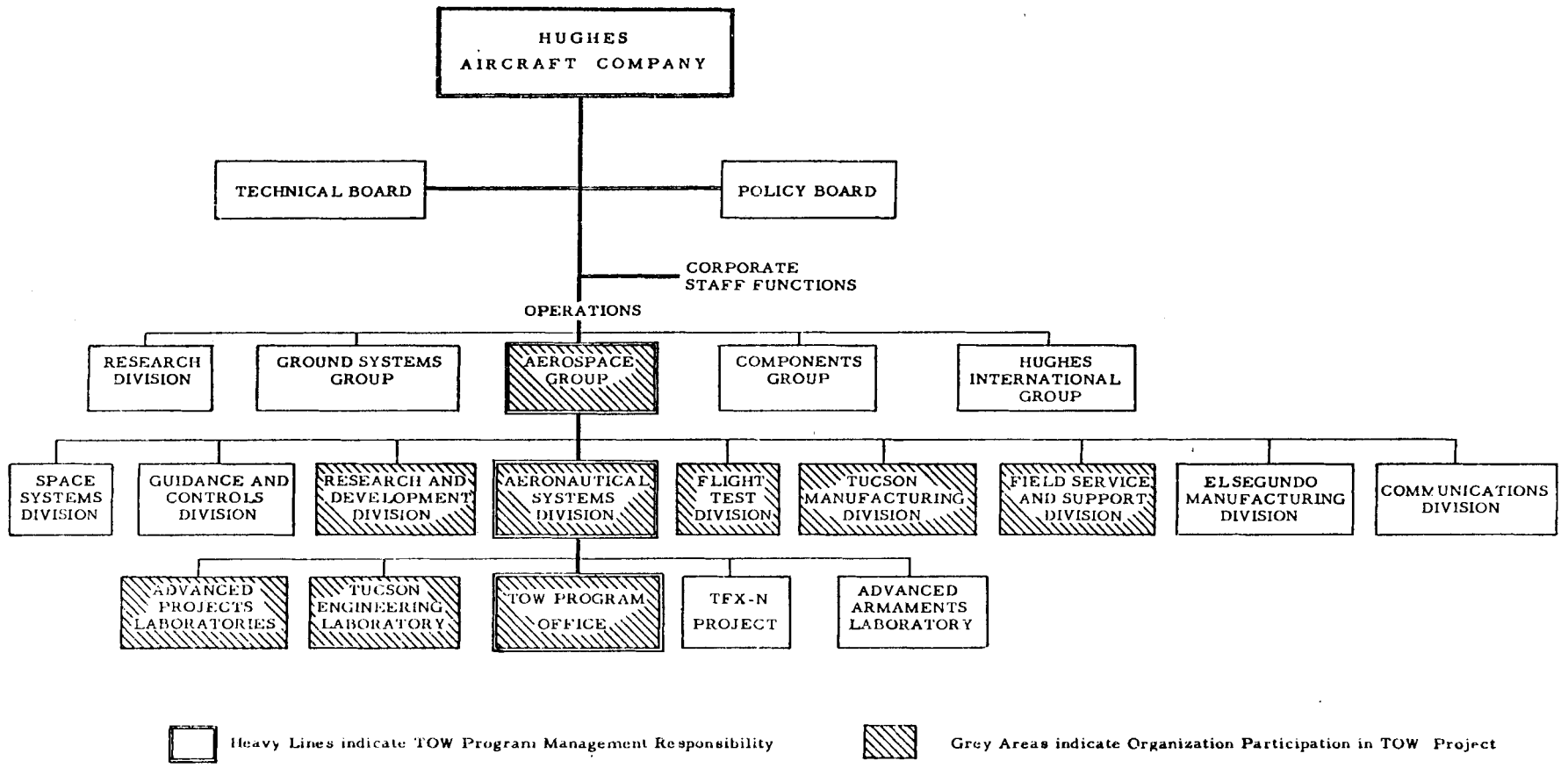


Chart 1. Hughes Aircraft Company Organization Chart.

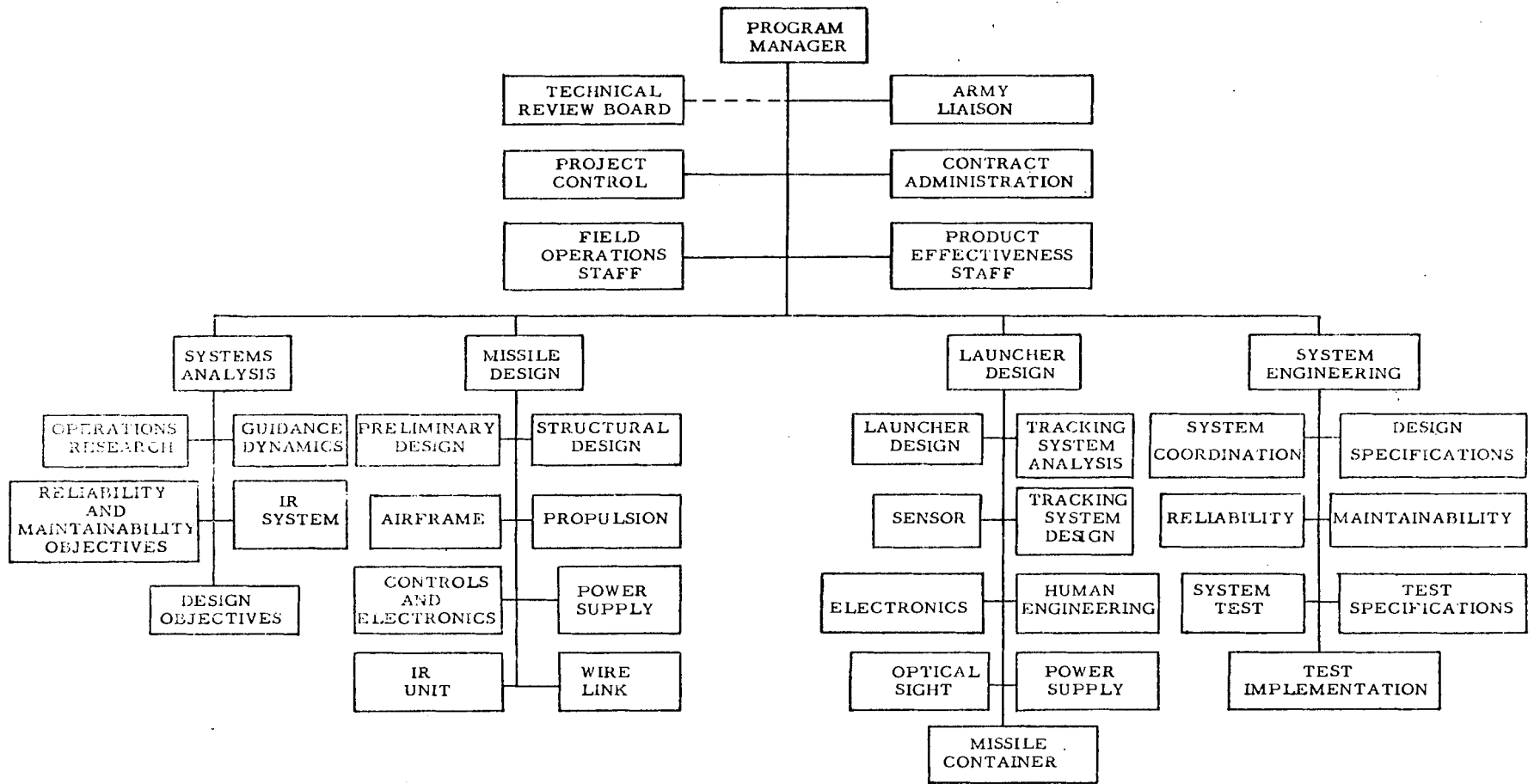


Chart 2. Proposed TOW Project Functional Organization Chart.

program, maintain communication with line activities, and work directly with the contracting agency to insure that the program objectives were met promptly, satisfactorily, and within the established cost limitations. The proposed TOW project organizational structure is shown in Chart 2.

A significant factor in Hughes' rapid growth was that virtually all company profits were used to expand company facilities which were valued at \$138,000,000 as of November 1962. Corporate facilities (land, buildings, machinery, and equipment) were valued at \$42,000,000 and company-leased facilities at \$64,000,000. In addition, the company occupied Government-owned facilities valued at \$32,000,000.

The cornerstone of the Hughes Aircraft Company was its facility at Culver City, California. Home of the executive offices, the Aerospace Group, and Flight Test Division, this modern complex of 1,305,441 square feet contained the finest research equipment and developmental and test facilities available in the electronics industry.

The El Segundo, California, plant of 674,058 square feet was devoted exclusively to the manufacture and production of advanced electronic weapon systems.

The Government-owned facility at Tucson, Arizona, was designed and equipped for the manufacture of entire missile systems. It contained 974,511 square feet, 566,280 of which were inclosed under one roof. This air-conditioned, dust-free factory reflected a uniquely successful approach to quantity missile and missile test equipment production.

The newly constructed Ground Systems Group facility at Fullerton, California, contained 731,800 square feet and was devoted to the development and production of ground surveillance radar data processing equipment and missile launching equipment.

The Inglewood, California, facility of 778,960 square feet in 27 buildings housed the Communications and Field Service and Support Divisions. The communications facility included space and equipment for research and development and production of advanced air and ground communications equipment. The field service and support facility included technical schools, an electronic equipment depot, and space and equipment to produce technical manuals.

The Costa Mesa, California, facility of 225,600 square feet was concerned with the development and manufacture of commercial

products, including semiconductors, tubes, and industrial systems and controls.

The Malibu, California, plant of 92,000 square feet housed the Hughes Research Laboratories. It contained the latest equipment for research in nuclear and gaseous electronics, solid state physics, infrared radiation, tubes, and data processing.

The Santa Barbara, California, facility of 34,608 square feet was devoted to research and development of infrared detectors and infrared search and tracking equipment.

The Hughes Aircraft Company had other facilities totaling 293,846 square feet at various locations in the United States. Included in these were special test sites and sales offices.³⁴

Original Program Cost Estimate

The first formal cost estimate of \$63.3 million, prepared in September 1962, covered a 34-month RDTE* effort, which was to be completed in July 1965 and provide an Initial Operational Capability (IOC) in December 1965. The Army Materiel Command advised the program director that, because of budgetary restraints, a program under \$50 million would be more favorably considered. The new cost estimate of \$49.5 million, also prepared in September 1962, was based upon a revised, austere plan which combined development and engineering service tests, reduced missile firings by 18 percent, and deleted funds for contingencies. It included the development of a non-guided companion round for the guided round, but did not include development of a night sight since no such requirement existed at that time. The revised cost estimate of \$49.5 million was still based upon a 34-month development effort to be completed in July 1965 and an IOC in December 1965.³⁵ With the \$2.1 million in RDTE funds appropriated for the FY 1962 pre-development studies, the total estimated TOW development cost was \$51.6 million.

* Research, Development, Test, and Evaluation

³⁴ *Ibid.*, pp. 43-46, 65-89.

³⁵ DA Study of Cost Growth in Acquisition of the TOW Wpn Sys (draft), 27 Jul 76, pp. 3, 6. TOW Proj Ofc.

Initiation of Development

The TOW development program began in January 1963 under a supplement to the letter contract with Hughes Aircraft. Pending a final decision on the FY 1963 funding level, the Department of the Army, on 7 December 1962, authorized the execution of a 60-day supplement to Hughes' letter contract for \$600,000. Under this supplement, issued on 17 December 1962, the contractor was to concentrate on completion of the final TOW system design using the 5-inch, 9.2-pound warhead. On 12 February 1963, additional letter authority was provided which remained in effect until 3 May 1963, when contract DA-04-495-AMC-12* was definitized. The cost-plus-incentive-fee (CPIF) contract for \$5.55 million (including a fee of \$415,000) covered the period of development through 19 September 1963.³⁶

The planned \$14.4 million in RDTE program authority for FY 1963 was never released. Instead, the funding level for that year was \$7,877,000. Follow-on funding to complete development and testing was estimated at \$41.4 million for the FY 1964-67 period, bringing the total projected program cost to \$51,377,000. Included in the program was \$5.2 million for development of the non-guided companion round. The RDTE funding requirements, by fiscal year, were as follows:³⁷

FY 1962	\$2,100,000
FY 1963	7,877,000
FY 1964	18,300,000
FY 1965	16,350,000
FY 1966	5,500,000
FY 1967	<u>1,250,000</u>
	\$51,377,000

The TOW Technical Development Plan issued by MICOM in March 1963 listed the following major milestones:³⁸

Component Development Complete	October 1963
Guided Firings Start	November 1963
Manned Firings Start	March 1964

* See footnote 26, p. 24.

³⁶ (1) TT, CG, AMC, to CG, MICOM, 7 Dec 62. RHA Bx 13-168.
(2) MICOM Hist Sum, FY 63, pp. 147-48.

³⁷ TOW TDP, 1 Mar 63, pp. I-3, IV-2, IV-3. RSIC.

³⁸ *Ibid.*, pp. I-4, II-5, II-6, II-22, VI-4, VI-5.

System Demonstration	May 1964
Preliminary Design Release	June 1964
Advance Production Engineering Starts	June 1964
Engineering Design Complete	February 1965
Interim Design Release	February 1965
Industrial Engineering Starts	March 1965
Type Classification - Limited Production	February 1965
Engineering Service Tests Start	February 1965
Engineering Service Tests Complete	September 1965
Final Design Release*	December 1965
Type Classification - Standard A	December 1965
Non-Tactical Deliveries Start	June 1966
Tactical Deliveries Start	February 1967

*Denotes design stability and completion of development effort, including correction of deficiencies.

As prime contractor, the Hughes Aircraft Company would be responsible for the complete system design and the fabrication of development hardware, with exception of the warhead and safety and arming system, which would be the responsibility of the Army Munitions Command. Design engineering of the missile system, less warhead and safety and arming device, and fabrication of the majority of experimental hardware would be performed at Hughes' Culver City, California, plant. The prototype hardware (and later production quantities) would be fabricated in the Government-owned Hughes-operated plant at Tucson, Arizona. The development flight tests would be conducted at MICOM and the engineering service tests by the Army Test and Evaluation Command at the White Sands Missile Range and other sites.³⁹

³⁹ *Ibid.*, p. I-5.

CHAPTER III

(U) PROJECT MANAGEMENT STRUCTURE

The Army Missile Command (MICOM) had full authority and responsibility for management, direction, and control of the infantry (ground-based) TOW weapon system, but only a technical support mission for the aircraft armament subsystems whose project managers were located at other headquarters. A brief summary of the TOW management structure follows.

As stated earlier, the Commanding General of MICOM was designated as the TOW Weapon System Manager in July 1962. He, in turn, delegated the authority and responsibility for overall program management and direction to the Antitank/Aircraft Weapons Commodity Manager, who relied upon the functional directorates to accomplish the mission objectives of his assigned projects.¹ With the commencement of TOW weapon system development in January 1963, primary responsibility for technical supervision and execution of the program was transferred from the Future Missile Systems Division to the Development Division of the Directorate for Research and Development. Within the Development Division, the project manager was Mr. Robert P. Whitley, who served as chief of the TOW Branch.²

The Aircraft Weaponization Project Manager was located at AMC Headquarters, and MICOM had a commodity manager for development support of the TOW armament subsystem. The project manager at AMC wanted a Project Manager Staff Officer (PMSO) appointed to act for him at MICOM. However, rather than designate another individual, MICOM selected the Antitank/Aircraft Weapons Commodity Manager for this role.³ MAJ Paul A. Pencola replaced Mr. Lloyd L. Lively as Antitank/Aircraft Weapons Commodity Manager on 11 March 1963 and served until 10 August 1963.⁴ COL Cyril D. Sterner took over

¹See above, pp. 21-22.

²DF, Chf, Future Msl Sys Div, to D/R&D, 10 Dec 62, subj: Trf of TOW Program to Dev Div, w concurrence notation, 17 Dec 62. RHA Bx 13-168.

³Anl Hist Sum, MICOM, FY 63, p. 25.

⁴(1) MICOM GO 21, 18 Mar 63. (2) Off Wkly Sta Rept, 15 Aug 63.

the post on 18 September 1963.⁵

Early in September 1964, near the end of the experimental model program, the Commanding General of AMC authorized the establishment of the TOW Project Manager's Office at MICOM Headquarters and designated LTC Ballard B. Small as Project Manager.⁶ The Missile Command activated the TOW Project Office on 1 October 1964, with personnel performing TOW/HAW functions being transferred from the Antitank/Aircraft Weapons Commodity Office and the functional directorates.⁷ Pending approval of the initial Table of Distribution (TD) on 22 January 1965, personnel were detailed to the TOW Project Office. The approved TD authorized the office 46 civilian and 3 military personnel spaces.⁸

In consonance with the vertical project management concept, the TOW Project Manager was delegated full line authority and responsibility for the ground-based TOW program and for all planning, direction, and control of the work and allocated resources. This included all phases of research, development, procurement, production, distribution, and logistical support to provide a balanced, expedited, economical, and effective system consistent with established program objectives. The TOW Project Manager reported to the Commanding General of AMC through the Commanding General of MICOM, and received full assistance of AMC staff and major subordinate commands in the accomplishment of his assigned mission.⁹ Major organizational elements of the office are depicted in Chart 3.

Mr. Robert P. Whitley, the Deputy TOW Project Manager, succeeded Colonel Small as Acting Project Manager on 1 July 1966.¹⁰ COL James N. Lothrop, Jr., was appointed TOW Project Manager on 26 September 1966¹¹ and served until 31 May 1968. Mr. Whitley again filled in as Acting Project Manager until the assignment of LTC Robert W. Huntzinger on 25 June 1968.¹²

⁵MICOM GO 89, 2 Oct 63.

⁶TT 9-4504, CG, AMC, to CG, MICOM, *et al.*, 8 Sep 64. HDF.

⁷(1) MICOM GO 76, 18 Sep 64. (2) MICOM GO 79, 6 Oct 64.

⁸Incl to Ltr, LTC Ballard B. Small, TOW PM, to CG, AMC, 19 May 65, subj: Proj Mgt Pers Staffing Plan. HDF.

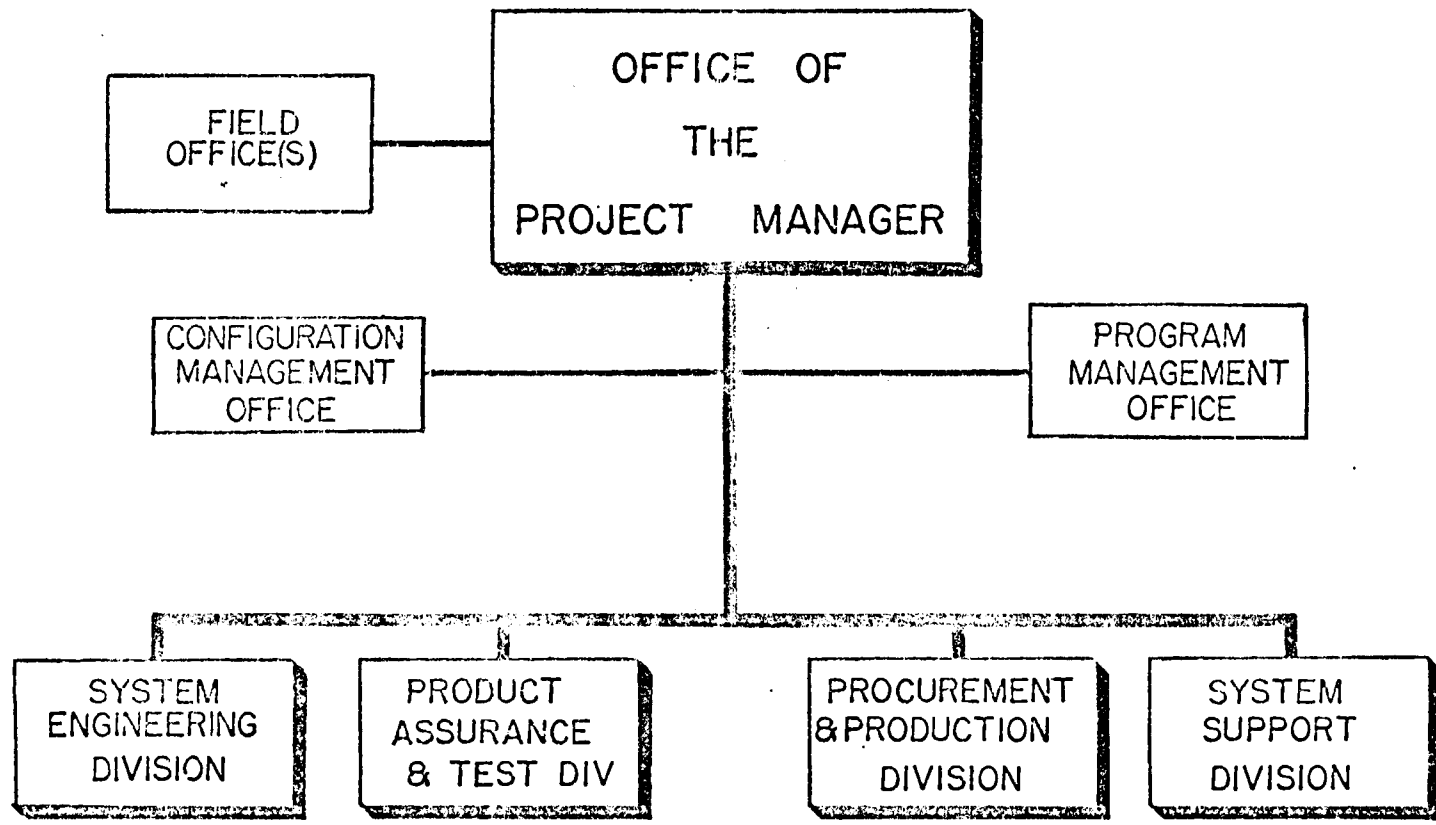
⁹TT 9-4504, CG, AMC, to CG, MICOM, *et al.*, 8 Sep 64. HDF.

¹⁰MICOM GO 77, 6 Jul 66.

¹¹MICOM GO 113, 5 Oct 66.

¹²(1) MICOM GO 39, 29 May 68. (2) MICOM GO 53, 8 Jul 68.

CHART 3
US ARMY MISSILE COMMAND
TOW PROJECT OFFICE



Management of the TOW aircraft armament subsystems (airborne TOW) remained a responsibility of the Antitank/Aircraft Weapons Commodity Office until 26 October 1964, when that office was discontinued and its functions and personnel were reassigned to the newly established Land Combat Commodity Office. COL Cyril D. Sterner, who had served as the Antitank/Aircraft Weapons Commodity Manager since September 1963, took over the dual role of Land Combat Commodity Manager and PMSO for the Aircraft Weaponization Project Manager located at AMC Headquarters.¹³

Four years later, on 16 October 1968, the Land Combat Commodity Office was discontinued and its functions were divided among three new management offices. Functions pertaining to the management of aircraft weapons (including the airborne TOW) were transferred to the new Aircraft Weapons Commodity Office. Mr. William C. Rotenberry, who had served as Acting Land Combat Commodity Manager since Colonel Sterner's departure on 16 November 1967, was named Acting Aircraft Weapons Commodity Manager. In that capacity, he served at MICOM as the PMSO for the Aircraft Weaponization and CHEYENNE Project Managers, both located at AMC Headquarters, and for the 2.75-Inch Rocket Project Manager then located at Munitions Command Headquarters, Picatinny Arsenal.¹⁴

On 5 April 1970, support functions pertaining to the airborne TOW systems were provisionally transferred from the Aircraft Weapons Commodity Office to the TOW Project Office. Personnel performing functions on the airborne TOW (four civilians) were detailed to the TOW Project Office pending finalization of personnel actions. The transfer of airborne TOW functions and personnel was made firm effective 4 January 1971.¹⁵

Airborne TOW support functions initially provided by the TOW Project Office were primarily concerned with work on the TOW/CHEYENNE interface which was continuing on a reduced level, and participation in studies of a TOW armament subsystem for the COBRA attack helicopter.¹⁶ The office supported the TOW/COBRA program under AMC Headquarters until establishment of the Product Manager, AH-1 COBRA Series Aircraft, at the Army Aviations Systems Command on 15 March 1972.¹⁷ The U. S. Army Materiel Development

¹³MICOM GO 88, 9 Nov 64.

¹⁴(1) MICOM GO 136, 16 Nov 67. (2) MICOM GO 109, 25 Oct 68.

¹⁵(1) MICOM GO 38, 2 Apr 70. (2) MICOM GO 20, 1 Mar 71.
(3) MICOM GO 23, 1 Mar 71.

¹⁶Hist Rept, TOW PM, FY 70, p. 10.

¹⁷(1) AMC GO 135, 5 Jun 72. (2) Also see below, pp. 177-98.

and Readiness Command* redesignated the Product Manager, AH-1 COBRA Series Aircraft, as the COBRA Project Manager effective 31 March 1976.¹⁸ Meanwhile, work on the TOW/CHEYENNE armament subsystem ceased with termination of the CHEYENNE program in August 1972.¹⁹

The TOW Project Manager's manpower authorization increased from 49 (3 military; 46 civilian) in June 1965, to 59 (4 military; 55 civilian) as of 30 June 1966. During the same period, his assigned strength went from 38 (2 military; 36 civilian) to 49 (2 military; 47 civilian). On 30 June 1968, shortly after release of the TOW for limited production, all 4 of the authorized military spaces and 50 of the 55 authorized civilian spaces were filled, for a total assigned strength of 54.

At the end of December 1970, following initial deployment of the ground-based TOW system, the Project Manager had a peak authorized strength of 61 (7 military; 54 civilian), with an assigned staff of 62 (5 military; 57 civilian). From that point on, his personnel staff gradually declined. As of 31 December 1976, there were 6 officers and 49 civilians assigned against an authorized strength of 6 officers and 47 civilians.²⁰ Thirteen of the 49 civilians had been with the TOW Project Office since its inception on 1 October 1964.

On 18 November 1976, COL Robert W. Huntzinger was guest of honor at a combination farewell party for him and the TOW Project Office's 12th anniversary. Colonel Huntzinger retired on 30 November 1976, after serving as the TOW Project Manager for 8 years and 5 months—the longest continuous tour of any project manager in the Department of the Army.²¹ Mr. Robert Q. Taylor, the Deputy TOW Project Manager, served as the Acting Project Manager until the arrival of COL James H. Brill on 3 January 1977.²²

* The U. S. Army Materiel Command (AMC) was redesignated the U. S. Army Materiel Development and Readiness Command (DARCOM) effective 23 January 1976. DA GO 1, 26 Jan 76.

¹⁸ DARCOM GO 83, 28 May 76.

¹⁹ (1) TT, AAH PM, AVSCOM, to DA, 5 Oct 72, subj: Cancellation of CTP for CHEYENNE. HDF. (2) AMC GO 165, 3 Jul 72.

²⁰ MICOM Pers Sta Repts, 1965-76. HDF.

²¹ *The Rocket*, 24 Nov 76.

²² TT, Cdr, DARCOM, to Cdr, MICOM, 30 Dec 76. TOW Proj Ofc.

CHAPTER IV

~~(S)~~ DEVELOPMENT OF THE TOW WEAPON SYSTEM (U)

(U) Although the TOW weapon system proposed by the Hughes Aircraft Company embodied technical concepts considered to be within the state of the art, its development proved to be much more difficult than originally anticipated. Major changes in qualitative system requirements and the accompanying component design changes, together with reliability and technical problems and a lack of adequate and timely funding support, led to a stretchout in the development and production schedules and an increase in development costs. The infantry (ground-based) TOW system was approved for limited production in April 1968, a slippage of 38 months from the February 1965 target date established in March 1963. A total of \$96,255,000 was obligated for TOW development during the FY 1962-68 period, and it was estimated that \$6,030,000 more would be required during the 1969-71 period, for a total projected development cost of \$102,285,000. This represented an increase of nearly 100 percent over the \$51,377,000 development cost projected in March 1963.¹

(U) This chapter traces the development of the infantry TOW system from January 1963 to the release for limited production in April 1968, and development of the TOW/UH-1B and TOW/CHEYENNE helicopter armament subsystems which were never released for production. The XM-65 TOW/COBRA helicopter armament subsystem, which was released for production in 1974, will be discussed in a later chapter. The infantry TOW system would replace the 106mm recoilless rifle and ENTAC antitank weapons, while the airborne TOW would supplant the M22 (helicopter-mounted SS-11) system.

Revision of the QMR and Technical Requirements

(U) The initial QMR and tentative technical requirements used in the predevelopment studies of the TOW system were revised early in the system development phase. Among the primary changes were the addition of a night firing capability, deletion of the unguided

¹(1) TOW PM₂P, 30 Jun 68, p. III.13.1. HDF. (2) Also see above, p. 33.

companion round, and an extension of the maximum range of the TOW missile.

(U) It will be recalled that the effect of increasing the range of the TOW missile was investigated during the feasibility study phase in 1962.² In February 1963, shortly after initiation of the component development phase, the Army Materiel Command requested the Army Missile Command to investigate the feasibility of increasing the range of the TOW missile from 2,000 to 3,000 meters, while maintaining the required accuracy and holding any increase in missile weight to less than 2 pounds. The results of this study indicated that the additional range could be achieved with a missile weight increase of about 1.4 pounds. The main area of concern was whether the infrared tracking loop would function past the 2,000-meter range.

(U) The Commanding General of the Army Materiel Command then amended the TOW specification to include a desired maximum range of 3,000 meters with the required maximum range remaining at 2,000 meters. The range extension, however, was not to delay TOW development, cause significant changes in the basic missile design, or degrade system performance at 2,000 meters.³ The assumption that these prerequisites could be met proved to be erroneous. Complications resulting from the range extension later led to significant design changes in the missile system, a delay in the program schedule, and an increase in development costs.

(U) Under the revision of TOW Technical Requirement No. 398, issued on 15 May 1963, the TOW system was to be capable of delivering accurate, effective fire against a variety of stationary and moving targets at all ranges from 100 to 2,000 meters, with a useful hit probability against both stationary and moving targets at 3,000 meters desired. The deviation from line-of-sight was to be no greater than 2 feet. First round hit probabilities on a 7.5 by 7.5-foot stationary or moving target was to be at least 90 percent at 1,500 meters and 75 percent at 2,000 meters. A firm hit probability for the extended range of 3,000 meters was yet to be established. The weight of complete ground equipment and one missile was not to exceed 200 pounds—42 pounds for the missile with its container and 158 pounds for the launcher and ground support equipment.⁴

²See above, pp. 18-19.

³(1) MICOM Hist Sum, FY 63, pp. 148-49. (2) Also see TOW TDP, 1 Mar 63, p. II-4. RSIC.

⁴TOW TR 398, Rev II, 15 May 63, pp. 3-1, 3-2. RHA Bx 7-58.

(U) On 14 May 1964, the Combat Developments Command prepared a proposed revision of the TOW/HAW QMR, which was approved by the Army Chief of Research and Development on 10 November 1964. Certain changes and additions were adopted in 1965 and incorporated into the basic QMR, which was recorded in AMC Technical Committee Item 6455 in November 1968. The TOW/HAW system was to replace the ENTAC antitank guided missile and the 106mm recoilless rifle, neither of which met existing and anticipated requirements for a suitable antitank/assault capability. It was to be capable of killing the most formidable enemy armor expected on the battlefield in the 1970-75 timeframe, and was to be available for field use during FY 1967. Major operational requirements and objectives of the weapon system are listed in Table 1. The complete QMR, as revised, is recorded in Appendix A.

Component Development

(U) The Hughes Aircraft Company conducted the component development phase of the TOW program under the definitized CPIF R&D contract (AMC-12), which covered the period through 19 September 1963.⁵ This phase consisted of the design, fabrication, testing, and demonstration of all individual components of the system. It ended with completion of the first experimental model in September 1963.

(U) Because of unforeseen technical problems relating to certain components and unanticipated difficulties in the fabrication and assembly of parts from the first experimental drawings, Hughes Aircraft reported, on 15 August 1963, that an additional \$555,000 would be required to carry the contract effort through 19 September 1963. Of the total contract overrun, \$395,200 was needed for added work on the design and fabrication of missile components, about \$192,400 of that amount being required to solve problems associated with the propulsion system. The initial launch and flight motor cases failed when subjected to hydrostatic tests and unexpected difficulties were encountered with the launch motor blast tube during static firings. The remaining portion of the overrun was distributed among tasks relating to the launcher, system analyses and engineering, field tests, and other work.⁶

⁵ See above, p. 33.

⁶ (1) Ltr, HAC to LAPD, 15 Aug 63, subj: Contr DA-04-495-AMC-12 - Art 101, Lmtn of Cost Clause. (2) HAC Rept to MICOM, 16 Aug 63, subj: TOW Overrun Sum. Both in RHA Bx 7-58.

TABLE 1--(U) TOW/HAW Qualitative Materiel Requirement

RANGE-----	Near 0 to 2000 meters required; 3000 meters desired
FIRST ROUND HIT PROBABILITY-----	<u>Fixed Targets (2.3 meters square [7.5 x 7.5 ft])</u> Required: .90 at 1500 meters; .75 at 1500-2000 meters Desired: .75 at 3000 meters <u>Moving Targets (2.3 meters square [7.5 x 7.5 ft])</u> .75 against 35-KPH targets essential (50 KPH desired) out to ranges of 2000 meters essential (3000 meters desired). <u>All Targets: .90 to 2000 meters desired.</u>
RELIABILITY-----	At least 95% essential; 99% desired.
RATE OF ENGAGEMENT-----	First hit 15 seconds after identification; 3 moving targets in 90° arc within 90 seconds essential, within 60 seconds desired.
COUNTERMEASURES & INTERFERENCE---	Weapon must be immune to enemy electromagnetic countermeasures and solar effects, and must not cause interference to, or be affected by, other equipment operating in the vicinity.
WEIGHT LIMITATION-----	Missile/Container: Not to exceed 42 lbs. (30 lbs. desired). Launcher/Ground Support Equipment: Not to exceed 160 lbs. (120 lbs. desired)..
PERSONNEL & TRAINING-----	Crew for each weapon not to exceed 4 men. Skills and time required for, and complexity of, training not to exceed that required for the 106mm Recoilless Rifle crew.
LAUNCH SIGNATURE-----	Less than that of recoilless rifles.
MOUNTS & TRANSPORTS-----	Tripod (Ground); M113 Armored Personnel Carrier; XM561 1 1/4-ton 6x6 Vehicle (GAMA GOAT); M274 1/2-ton Light Weapons Carrier (MULE); & M151 1/4-ton Utility Truck. Mounting on selected Army helicopters desirable. Weapon must be capable of parachute delivery in Phase I of airborne operations.
MAN-PORTABLE FOR SHORT DISTANCES	
ALL WEATHER & DAY-NIGHT CAPABILITY	

Funds allocated to cover the cost overrun increased the value of the contract from \$5,550,000 to \$6,105,000, with no change in the fixed fee which remained at \$415,000.⁷

(U) Effort during the component development phase was concentrated on critical areas of uncertainty, particularly flight dynamics of the missile and tracking dynamics of the launcher and guidance systems. Analog computer simulations conducted by the contractor indicated that the tracking accuracy necessary for a high hit probability was achievable. Deviations of the missile from the line of sight for the computer run were within the boundaries of the 7.5-foot square target for the entire flight to 2,000 meters.

(U) The missile external configuration, based on data from two previous wind tunnel tests, was designed to provide maximum performance at 2,000 meters, plus a useful capability to 3,000 meters. The extended range to 3,000 meters was obtained by providing an additional 1,000 meters of wire, cold gas for the control actuators for 5.5 more seconds of flight, and additional thrust to the launch motor to maintain launch velocity of the heavier missile at 250 feet per second. The total weight increment to provide this added capability was about 1.4 pounds. Other changes in the preliminary missile design were as follows: the missile length was increased by 0.28 inch; the wing pivot was moved forward; the wings were folded aft into the missile body; the wing area was increased 23 percent and the control surface by 51 percent; and the gyro was relocated.⁸

(U) Sled tests to evaluate the missile wire link were conducted at Holloman Air Force Base. These tests were interrupted in April 1963, when the wire pulling sled blew up right after reaching a maximum velocity of 1,035 feet per second. The sled left the rail, but the wire continued to pay out well for as much as 150 to 200 feet, giving a favorable indication of the pay out characteristics. This incident, together with the need to redesign the outrigger, increased the importance of doing additional turbine instrumentation work and associated data reduction and analyses.⁹ In subsequent sled tests at Holloman Air Force Base, wire was

⁷ Contr AMC-12, Mod 18, 22 Nov 63. RHA Bx 7-58.

⁸ (1) TOW TDP, 1 Mar 63, p. II-4. RSIC. (2) MICOM Hist Sum, FY 63, pp. 149-50.

⁹ (1) TOW Prog Rept, Struc & Mech Lab, D/R&D, 20 Mar - 20 Apr 63. (2) HAC Rept to MICOM, 16 Aug 63, subj: TOW Overrun Sum. Both in RHA Bx 7-58.

dispensed successfully from each of the two bobbins over a 10,000-foot course at 1,130 feet per second without breakage.¹⁰

(U) The Test & Evaluation Laboratory of the MICOM Directorate of R&D conducted the TOW launcher reaction tests, using a fixture with load cells for mounting the Hughes Aircraft test launcher and dummy missiles with prototype boost motors. The purpose of these tests was to determine reaction forces exerted on the launcher and missile tip-off rates during the boost phase. Failure of the launcher in the first test, on 15 April 1963, led to the suspension of firings pending modification of the test hardware. The tests were resumed on 27 June, with four flights conducted through 2 July 1963. All of the rounds functioned properly with exception of ignition delays in two of the firings, and there was no apparent damage to the launch tube or the missile. The data obtained from these tests would be used in designing the tactical launcher.¹¹

(U) Major problems were encountered in the design of a traverse mechanism that would meet requirements for smooth manual tracking throughout the complete range of tactical operating conditions. To achieve tracking accuracies of .1 to .3 mili-radians with a device weighing 50 pounds or less required a major advance in the state of the art. End dampers with silicone fluids were designed, built, and tested, along with rate sensors of a like sensitivity to provide missile flight corrections proportionate to the angular tracking velocities. The results of field and laboratory tests of the tracking capability of the traverse mechanism showed little difference in performance between experienced and inexperienced operators, indicating minimum training requirements for soldiers who would use the TOW system.

(U) The tripod designed for the ground mounted system weighed 27 pounds, including a 6-pound leveling device. The first lightweight, fiberglass/epoxy, honeycomb launch tubes to be manufactured and tested weighed about 30 pounds and could be mounted to the traverse mechanism within 5 seconds. A lightweight, expendable launch container was designed for protection of the missile from manufacture to the instant of firing. This container also formed the breech of the launcher from which the TOW was fired and the rear 48 inches of the 90-inch launch tube. The launch container protected the missile against all environmental stresses except

¹⁰TOW Prog Rept, Dev Div, D/R&D, 12 Sep 63 - 10 Oct 63. RHA Bx 7-58.

¹¹TOW Prog Repts, T&E Lab, D/R&D, Jan 63 - Aug 63. RHA Bx 7-58.

shocks and vibrations induced during transportation from the factory to the time of loading into a combat vehicle.¹²

(U) Protection of the missile and launch container against shocks and vibrations was provided by an overpack which contained two missiles. The overpack was designed, developed, and tested by the Package Research Laboratory of the MICOM Directorate of R&D, in conjunction with the Hughes Aircraft Company and Watertown Arsenal, and with full cooperation of the wirebound box and plastic industries. It consisted of a wirebound wooden box 58 by 20 by 11 inches, within which the missiles were supported by expanded polystyrene end pads and saddles.¹³

(U) In designing the kit for adapting the TOW system to the M113 armored personnel carrier, it became apparent that an elaborate, power-operated turret would be required, with a resultant gross modification of the vehicle, if the QMR was to be fully and literally met. Finding such an approach intolerable, the user expressed a willingness to trade off some weapon capability in return for a simple kit requiring a minimum alteration of the vehicle. Hughes Aircraft then designed and fabricated a simpler kit which consisted primarily of a pedestal unit mounted on double vertical rails which were pivoted at the vehicle floor under the main cargo hatch. The pedestal unit, traversing unit, leveling device, and sight/sensor unit were raised on the rails to an above-deck position, where the launch tube was attached and the weapon loaded for firing. In tests of the kit mounted on an M113 vehicle, a team of soldiers (two loaders and a gunner) prepared the TOW system for action in less than 30 seconds. Off-loading an empty container, after a simulated firing, and reloading took less than 10 seconds.¹⁴ The design of mounting kits for other carriers was begun later in the program.

Experimental Model Phase

(U) The experimental model phase of the development test program consisted of the integration, assembly, testing, and

¹²Hist Rept, Dev Div, D/R&D, FY 64, pp. 12-13.

¹³(1) *Ibid.*, p. 14. (2) Ltr, Dep Dir, D/P&P, MICOM, to CO, Watertown Ars, 15 Nov 63, subj: TOW Msl Sys Area of Resp. HDF. (3) DF, D/R&D, MICOM, to CO, Watertown Ars, 6 Jan 64, subj: TOW Overpack Suspension Concept. HDF.

¹⁴Hist Rept, Dev Div, D/R&D, FY 64, pp. 14-15.

demonstration of the experimental system. It commenced on 18 September 1963, with a series of six unguided flight tests. The experimental guided missile firings began on 27 November 1963, essentially on schedule, but were not completed until 17 December 1964, some 5 months behind schedule.¹⁵ As a result of this slippage, the preliminary design release for initiation of advance production engineering was moved from June to August 1964 and the commencement of R&D acceptance (prototype) firings was delayed to January 1965, with corresponding changes in other major milestones as follows.¹⁶

	<u>From</u>	<u>To</u>
Interim Release	Feb 65	Mar 66
Classification - Limited Production	Feb 65	Jun 66
ET/ST Start	Feb 65	Jun 66
Engineering Design Complete*	Feb 65	Sep 66
ET/ST Complete	Sep 65	Aug 67
Final Design Release	Dec 65	May 67
Classification - Standard A	Dec 65	Nov 67

*Experimental and R&D Prototype Phases

(U) As a result of continuing technical problems and the need for previously unprogrammed design and development effort, the projected RDTE cost for the FY 1962-67 period rose from \$51,377,000 as of March 1963 to \$86,228,000 as of May 1965. Following is a breakdown of the revised RDTE funding requirements.¹⁷

<u>FY</u>	<u>As of Mar 63</u>	<u>As of May 65</u>
1962	\$ 2,100,000	\$ 2,216,000
1963	7,877,000	7,873,000
1964	18,300,000	18,300,000
1965	16,350,000	22,034,000
1966	5,500,000	23,785,000
1967	<u>1,250,000</u>	<u>12,020,000</u>
Total:	\$51,377,000	\$86,228,000

¹⁵ (1) TOW Prog Rept, Dev Div, D/R&D, 12 Sep 63 - 10 Oct 63. RHA Bx 7-58. (2) Hist Rept, Dev Div, D/R&D, FY 64, p. 15. HDF. (3) TOW PM₂P, 30 Jun 65, pp. I.5.6 & I.5.7. HDF.

¹⁶ TOW TDP, 18 May 65, p. II-6. HDF.

¹⁷ (1) TOW TDP, 1 Mar 63. RSIC. (2) TOW TDP, 18 May 65, p. I-3. HDF.

FY 1964-65 Funding Program

(U) The RDTE program authority received for FY 1964-65 totaled \$40,319,000—\$18,300,000 for 1964 and \$22,019,000 for 1965. Of this sum, \$35,365,000 was allocated to the Hughes Aircraft Company and \$112,000 to other contractors. The remaining \$4,842,000 was distributed among Government agencies, most of it going to MICOM for technical supervision and development and qualification tests, and to the Army Munitions Command for warhead development.¹⁸

(U) An amendment to Hughes' R&D contract (AMC-12) on 25 August 1963 provided for continuation of the program from 19 September 1963 to 24 August 1964 at a cost of \$15,432,059 (including the incentive fee).¹⁹ This increased the value of the contract from \$6,105,000 to \$21,537,059. Subsequent amendments raised the contract value for the FY 1963-64 development effort to \$24,695,845, which included a net cost overrun of \$2,692,083.²⁰ Hardware procured through FY 1964 consisted of 42 experimental and 42 prototype missiles, 5 experimental launching systems, 3 prototype launching systems, and components for laboratory test.²¹

(U) Hughes Aircraft conducted the FY 1965 R&D effort under a new CPIF contract (DA-04-495-AMC-516) awarded on 25 August 1964. The original contract target cost of \$14,375,776 was increased to \$17,535,492, which included \$1,102,226 for an augmented reliability test program. The total cost overrun at the end of the fiscal year was \$3,376,642, of which \$1,586,596 was to be funded in July 1965.²²

(U) Meanwhile, in October 1963, MICOM requested program and project approval for Advance Production Engineering (APE), costing \$4,787,000, in support of the planned FY 1965 industrial production of the TOW system. The plan was to execute an APE contract with Hughes Aircraft in the amount of \$3,894,000 and reserve the remaining \$893,000 to cover the cost of in-house APE effort at

¹⁸TOW PM₂P, 30 Jun 65, p. I.10.2. HDF.

¹⁹(1) SS AMSMI-I-306, D/P&P, 30 Aug 63, subj: Req for Aprl of Awd. (2) Hist Rept, Dev Div, D/R&D, FY 64, p. 5. Both in HDF.

²⁰Hist Rept, TOW PM, FY 70, p. 1. HDF.

²¹Ltr, DCG/LCS thru CG, AMC, to ASA(I&L), 15 Jul 64, subj: Req for Aprl of D&F. HDF.

²²(1) TOW PM₂P, 30 Jun 65, p. I.5.7. HDF. (2) Hist Rept, TOW PM, FY 65, p. 11.

MICOM, Picatinny Arsenal, and Frankford Arsenal. To assure timely implementation of the APE effort, MICOM recommended that the required PEMA* funds be made available during the first quarter of FY 1965.²³

(U) In June 1964, the Army Missile Command submitted a request for approval of a D&F for authority to negotiate the FY 1965 APE contract in the amount of \$3,894,000. It was planned to award the contract by 30 September 1964, so that the APE effort would be conducted simultaneously with the FY 1965 R&D contract, under which 85 prototype missiles and 7 prototype launching systems would be procured for development tests. The data to be obtained under the initial APE contract would assure the orderly and expeditious transition of the TOW from the R&D phase to the production phase, provide for the establishment of component and system reliability, and reduce production and end item cost and leadtime.²⁴

(U) With the subsequent assignment of TOW field and depot test support to the Multisystem Test Equipment (MTE) program at MICOM, the TOW-peculiar MTE modules were deleted from the APE program, reducing the FY 1965 PEMA funding requirement by \$1,553,000 (from \$4,787,000 to \$3,234,000). The amount of the proposed FY 1965 APE contract with Hughes Aircraft was reduced to \$2,561,000, leaving \$673,000 for the in-house APE effort.²⁵

(U) A PEMA Program Change Proposal (PCP) submitted to AMC in September 1964 sought approval of the \$3,234,000 in FY 1965 PEMA funds for the APE effort and \$33 million for initial TOW procurement in FY 1966. Immediate approval of this PCP, particularly the FY 1965 APE funds, was essential in order to keep the TOW program on schedule. However, because of technical and reliability problems encountered in the experimental missile firings, the Army Materiel Command disapproved the PCP, and initiation of the advance production engineering effort was

* Procurement of Equipment and Missiles, Army.

²³ SS AMSMI-I-340, D/P&P to DCG/LCS, n.d., subj: APE Proj Just, FY 65, AMCMS 4930.1.82909 (TOW), w incl: Ltr, DCG/LCS to CG, AMC, 22 Oct 63, subj: same. HDF.

²⁴ Ltr, DCG/LCS to CG, AMC, 5 Jun 64, subj: Req for Apprl of D&F, as revised by Ltr, same to same, 15 Jul 64, subj: same. HDF.

²⁵ SS AMSMI-I-177-64, D/P&P, 24 Aug 64, subj: APE Proj Just, FY 65, AMCMS 4200.X.32909 (TOW), w incl: Ltr, DCG/LCS to CG, AMC, 17 Sep 64, subj: same. HDF.

ultimately deferred to the last quarter of FY 1966.²⁶

Experimental Flight Test Results

(U) Technical problems with the TOW missile set in with the unguided test firings begun at MICOM in September 1963 and continued throughout the 32-round guided missile firing program which ended in mid-December 1964. The design problems of prime concern involved the launch and flight motors, the wire link, the missile battery, the infrared source, and the gyroscope.

(U) The objectives of the six-round unguided flight test program were to obtain environmental and aerodynamic data on the missile and investigate launcher contributions to missile dispersions. In the first firing, on 18 September 1963, the launch motor blast tube failed while the missile was still in the launcher, destroying all of the aft section of the missile. Because of the launch motor's questionable safety, the pellet-type motor was cancelled in favor of one using six sticks of M7 propellant. The new motor would have a 2.1-inch outside diameter and allow more space in the aft end of the missile for guidance components. The Atlantic Research Corporation developed the alternate launch motor under a subcontract with Hughes Aircraft.

(U) Since the final fix on the launch motor had not been made, the propellant charge in the motor of the second test missile was reduced from 1.5 to 1.2 pounds, with a corresponding decrease in muzzle velocity from 250 to 200 feet per second. This round was fired on 4 October 1963 to evaluate operation of the wire pay-out system, flare, and flight motor. The xenon arc lamp ignited properly, the sensor picked up the flare signal, and the wire pay-out system operated satisfactorily until flight motor ignition at about 25 feet from the muzzle. At that point, the flight motor case failed and the round was destroyed in flight. An examination of the recovered debris indicated that the failure stemmed from a quality control problem; i.e., the headcap of the flight motor was not properly attached, only half of the threads being engaged. Because of the difficulties being experienced with the propulsion system, initiation of the rocket motor qualification test was postponed from March to June 1964.²⁷

²⁶ (1) Hist Repts, TOW PM, FY 65, p. 4, & FY 66, p. 6. (2) Ltr, TOW PM to CG, AMC, 9 Dec 64, subj: TOW PCP. HDF.

²⁷ (1) TOW Prog Rept, Dev Div, D/R&D, 12 Sep 63 - 10 Oct 63. RHA Bx 7-58. (2) Hist Rept, Dev Div, D/R&D, FY 64, pp. 10, 15-16. HDF.

(U) The third unguided missile, fired on 17 October 1963, was completely successful. During the remaining three unguided flights, conducted early in 1964, the flight motor experienced a resonant burning problem which was corrected by inserting baffles inside the motor case. Other known random failures occurred in the wire link, battery, and infrared source.²⁸

(U) The main objectives of the 32-round guided missile test program were to evaluate the data acquisition subsystems; analyze the guidance system missile capture transients; analyze guided missile dynamics during the boost and coast periods; and evaluate performance of tracking and command data links. The test program began at MICOM on 27 November 1963 and was temporarily suspended after the 14th firing on 26 May 1964, to allow a reliability evaluation of critical components. Ten of the 14 missiles failed to reach the target because of component malfunctions. There were known failures or partial failures in the missile aerodynamic surfaces, battery, sequencer, control wires, gyroscope, actuators, and infrared source. Only one of the unsuccessful flights was attributed to launcher performance and it involved a partial failure of the sight/sensor and error detector. The flight and launch motors performed to the experimental design requirements.

(U) The reliability evaluation, which continued until early July 1964, indicated that most of the component malfunctions stemmed from quality control and not from design problems. A major redesign of the guidance system was required, however, to overcome deficiencies in the transmission of guidance signals along the full 3,000 meters of the wire link. A design change in the xenon bulb eliminated some of the difficulty, and a change in the lamp modulator circuit showed promise of overcoming the remaining problems.²⁹ Changes in the guidance system resulted in a substantially more complex design which increased the number of electronic parts on the missile (from 136 to 591) and on the launcher (from 1,100 to 1,900).³⁰

(U) The TOW experimental firings were resumed in July 1964. Despite more stringent quality control procedures and improved engineering practices, reliability problems continued to plague the system. By 4 December 1964, 14 more guided rounds had been fired, only 7 of which reached their target. This brought the

²⁸ (1) *Ibid.* (2) AMC TIR CD-5, Suppl III, Dec 63, p. 2. RSIC.

²⁹ Hist Rept, Dev Div, D/R&D, FY 64, pp. 9-11, 16-17. HDF.

³⁰ DA Study of Cost Growth in Acquisition of the TOW Weapon System (draft), 27 Jul 76, p. 7. TOW Proj Ofc.

total experimental firings to 28, about 50 percent of which were successful or partially successful. Eleven of the missiles scored direct hits with a circular probable error of 1 foot against both moving and fixed targets at ranges required by the military characteristics. This demonstrated the adequacy and accuracy of the design, but did not reflect the high reliability expected in the prototype and production rounds. Design refinements in the R&D prototype would provide reliability improvements based upon the findings of the experimental test program. To support the increased reliability effort considered necessary for the prototype missile, the TOW Project Manager requested \$1.7 million in additional FY 1965 RDTE funds.

(U) It was because of concern over system reliability that the AMC Headquarters disapproved the TOW PCP submitted by MICOM in September 1964. The Procurement and Production Directorate of AMC insisted that the experimental missile firing program through 4 December 1964 was not sufficiently successful to justify approval of a PEMA program and that the remainder of the firings should be evaluated before any decision. At the same time, the AMC Research and Development Directorate, in a contradiction of AMC positions, questioned the need for an increased reliability program.³¹ The TOW Project Office later received \$1,177,000 in additional FY 1965 RDTE funds for an augmented reliability (product assurance) program, \$1,102,226 of which was allocated to Hughes' R&D contract.³² However, the FY 1965 APE funds requested in the PCP of September 1964 were never approved.

(U) As expected, the ratio of successes to failures was not significantly changed by the remaining four experimental firings, only two of which reached their target. The plan had called for a total of 34 experimental flight tests, but the program was terminated with the 32nd firing on 17 December 1964. The 32 guided missile firings resulted in 13 direct hits with a mean circular probable error of less than 1 foot; 1 near miss; 1 malfunction caused by range equipment failures; 1 launcher malfunction; 1 radio command receiver failure (a non-tactical experimental support item); and 15 unsuccessful flights caused by various component failures. Hits were scored on crossing targets traveling at a maximum rate of 30 mph, as well as stationary targets. Since missiles were controlled as far out

³¹(1) Ltr, TOW PM to CG, AMC, 9 Dec 64, subj: TOW PCP. (2) Ltr, TOW PM to Dr. A. E. Puckett, HAC, 9 Dec 64, n.s. Both in HDF.

³²(1) Hist Rept, TOW PM, FY 65, pp. 8, 11. HDF. (2) Also see above, p. 48.

as 3,450 meters, the ability of the TOW to reach the prescribed maximum range of 3,000 meters was successfully demonstrated.³³

R&D Prototype Test Phase

(U) The R&D prototype test program commenced on 6 January 1965 and ended on 20 June 1966, with a total of 62 firings. This phase of the program was characterized by continuing component reliability problems, a lack of timely decisions and funding guidance from higher headquarters, deferment of initial production from FY 1967 to FY 1968, a 1-year slippage in the Army Readiness Date from March 1968 to March 1969, and an escalation in system development costs.

Technical Management Review

(U) By January 1965, the TOW system had reached the point in the development cycle when production decisions were essential. While the overall results of the experimental firings indicated real progress toward meeting the development objectives, technical problems affecting system reliability had given rise to questions relative to the attainability of the existing military requirements within the published development schedule, and hence the propriety of releasing PEMA funds for production planning. To establish further confidence in the TOW development program, the Commanding General of AMC directed that MICOM appoint a TOW Program Review Group to conduct an in-depth technical management survey of the system and formulate a realistic master plan reflecting a valid availability date.³⁴ The survey began on 5 February and was completed on 29 March 1965.

(U) Members of the review group concluded that the TOW system concept was valid and that all components were within the state of the art, but that more emphasis was needed on the flight motor, infrared source, and launcher. The group stated in its report that the amount of time and quantity of R&D hardware in the existing program were inadequate to complete the development program. It estimated that an additional 11 months of development time would be required before starting engineering service tests, together with about \$15 million in additional RDTE funds (\$5 million in FY 1966 and \$10 million in FY 1967). In order to

³³TOW PM₂P, 30 Jun 65, p. I.5.6. HDF.

³⁴Ltr, CG, AMC, to DCG/ADS, MICOM, 28 Jan 65, n.s. HDF.

assure a logical and economical production program commencing early in FY 1967, the group emphasized that a minimum of \$1.2 million in FY 1965 APE funds would be required for the design and evaluation of production equipment and processes for the xenon source, bobbin winding, and flight motor nozzle. Funds required for the total APE effort were estimated at \$5.5 million, an increase of some \$2.3 million over the existing program. Subject to the timely release of the required FY 1965 APE funds and adequate RDTE funds for FY 1966-67, the group concluded that a limited production release date of June 1966 could be met, and that production deliveries could begin in September 1967.³⁵

Program Change Proposal

(U) A PCP, based on recommendations of the TOW Program Review Group, was approved by AMC Headquarters on 10 May 1965 and submitted to the Department of the Army. This PCP requested authority to proceed with TOW system development, production, and deployment as scheduled. Specifically, it requested authority to procure 110,430 HEAT missiles, 58,638 training missiles, 3,512 launch and guidance sets, and auxiliary equipment during the FY 1967-71 period at a total cost of \$296,838,000. It proposed a production go-ahead in August 1966 for an initial FY 1967 production increment of 8,192 HEAT missiles, 1,763 training missiles, 417 launch and guidance sets, and auxiliary equipment, at a total cost of \$53.2 million including \$1.7 million for advance production engineering.³⁶

(U) The TOW PCP included \$1.2 million for APE in FY 1965; \$4.1 million for APE in FY 1966; \$23,785,000 for RDTE in FY 1966; and \$12,034,000 for RDTE in FY 1967. It recommended immediate (June 1965) initiation of APE on three missile hardware items (wire bobbin, xenon source lamp, and flight motor nozzle) considered to be major obstacles to high-rate production. However, higher headquarters advised AMC that APE funds would not be released until approval of the PCP, which was not expected before mid-August 1965. This delay meant that handmade light sources and bobbins would continue to be used instead of the more reliable automated ones. It also prevented the use of the most reliable

³⁵ (1) Ltr, Chmn, TOW Program Review Gp, to CG, AMC, 4 Mar 65, subj: Interim Rept - TOW Program Review Gp. (2) Hist Rept, TOW PM, FY 65, pp. 4-5. Both in HDF.

³⁶ (1) TOW PCP A-5-038, cited in DOD Subject/Issue 363, 26 Nov 65. (2) TOW PM₂P, 30 Jun 65, pp. I.5.4 & II.14.2. Both in HDF.

hardware in engineering service tests.³⁷

(U) With the disapproval of the project request for \$1.2 million in FY 1965 APE funds, the TOW Project Office conducted new studies to determine the total FY 1966 funds necessary to complete the APE program by 1 August 1966. It was determined that a minimum of \$4.9 million would be required to complete the program. In the revised project request, submitted to AMC in late July 1965, the Commanding General of MICOM recommended that program approval and funds be made available no later than 15 August 1965, in order to assure an APE contract by 1 October 1965 and completion of the APE effort by 1 August 1966.³⁸

(U) The Department of the Army sent the TOW change proposal to the Department of Defense (DOD) on 31 July 1965, but a decision was not forthcoming until 26 November 1965. Despite the urgent need for the TOW and the improved reliability exhibited in the on-going prototype firings, DOD was not convinced that the weapon system had attained sufficient reliability to warrant its commitment to production. Because the TOW design was based on a "wooden round" concept which permitted no testing after production and before issue to troops, and because of the high unit cost of initial production units, it was considered essential that system reliability and integrity be proven before the release to production. The DOD decision paper stated that the TOW test firings to date had not provided this assurance, noting that 23 out of the total of 49 guided firings had been failures.* The DOD decision approved APE funds in the amount of \$4.9 million for FY 1966 and

* This conclusion was obviously based on a consolidation of experimental and prototype firings and therefore did not accurately portray the current development status of the system. At the time of the DOD decision on 25 November 1965, only 31 TOW prototype missiles had been fired. Twenty of these were fully guided (accuracy) firings against fixed and moving targets, and 11 were catcher and programmed ballistic firings. Fourteen of the 20 accuracy firings were successful with direct hits on targets at various ranges out to 3,000 meters. This yielded a sample reliability of 70 percent, in contrast to the 53 percent noted in the DOD decision paper. TOW PM₂P, Ch 3, 31 Dec 65, pp. I.5.7a, I.5.7b, & I.5.8. HDF.

³⁷ (1) *Ibid.*, pp. I.5.4 & I.5.5. (2) Ltr, DCG/LCS, MICOM, to CG, AMC, 29 Mar 65, subj: PEMA FY 65 APE Proj AMCMS 4220.X.32909 (TOW). HDF.

³⁸ Ltr, CG, MICOM, to CG, AMC, 23 Jul 65, subj: PEMA FY 66 APE Proj AMCMS 4290.X.32947 (TOW). HDF.

\$1.7 million for FY 1967, but deferred initial production until FY 1968. The FY 1966 APE funding requirement, however, was to be met by reprogramming within available Army resources.³⁹

(U) The delay in initiating the APE program was partially offset by allocating \$500,000 RDTE funds to the development of automated techniques for xenon lamp and wire bobbin manufacture. The Assistant Secretary of the Army (R&D) approved D&F authority for negotiating the contract for this work on 15 October 1965. Though DOD approved the FY 1966 APE project request for \$4.9 million, the funds were not immediately available from Army resources. Program authority for the APE contract was expected in January 1966, but was not forthcoming until April.⁴⁰

(U) The APE studies begun by Hughes Aircraft in April 1966 involved all phases of TOW system production, including the establishment of pilot lines for hardware considered to be major obstacles to high-rate production; i.e., bobbin winding, flight motor nozzles, and the infrared source lamp. Hughes Aircraft conducted the APE studies under Contract AMC-14824 issued on 15 April 1966 for \$864,578. On 1 May 1966, \$937,422 was sent to the Army Munitions Command (MUCOM) for APE effort at Picatinny Arsenal on the TOW warhead, launch motor, and flight motor propellant. This was followed on 30 June 1966 by the award of another contract (AMC-15537) to Hughes Aircraft for the balance of the FY 1966 APE program. The latter contract, in the amount of \$3,098,000, completed the obligation of \$4.9 million in authorized FY 1966 APE funds.

(U) Program authority for the FY 1966 RDTE effort was also delayed. To avoid excessive slippage of the development program while awaiting approval of the proposed FY 1966 funding, the TOW Project Manager extended the FY 1965 development contract (AMC-516) from 1 September to 27 November 1965. The costs incurred under this extension, including technical requirements revisions and product assurance provisions, increased the price of the FY 1965 contract by \$8,142,148. The final value of Contract AMC-516 was \$25,217,572, which included a net overrun of \$2,593,454 or 10.28 percent. On 28 November 1965, Hughes Aircraft

³⁹ DOD Subject/Issue 363, 26 Nov 65, atchd as incl to DF, Act C&DP, to TOW PM, *et al.*, 23 Dec 65, subj: PCP - TOW Msl Sys. HDF.

⁴⁰ (1) PM₂P, Ch 3, 31 Dec 65, p. I.5.5. (2) SS AMCPM-TO-1-66, TOW Proj Ofc, 7 Feb 66, subj: TOW APE, w incl: Ltr, CG, MICOM, to CG, AMC, 8 Feb 66, subj: TOW APE (Proj Req 4290.X.32947). (3) Hist Rept, TOW PM, FY 66, p. 6. All in HDF.

received a CPIF contract (AMC-13626) in the amount of \$12,674,886 for the balance of the FY 1966 development program, which included 108 missiles, 12 launchers, and components for laboratory testing. The total value of the FY 1966 contract was later increased to \$13,128,403.⁴¹

Realignment of Plans and Schedules

(U) With the deferment of initial production from FY 1967 to FY 1968, the TOW Project Manager prepared a revised program schedule which was approved on 28 May 1966. Changes in some of the major milestones were as follows:⁴²

	Schedule	
	<u>6/30/65</u>	<u>6/30/66</u>
Classification - Limited Production	Jun 66	Mar 67
Award 1st Production Contract	Aug 66	Aug 67
Award 2d Production Contract	Sep 67	Oct 68
Delivery of 1st Production Item	Sep 67	Sep 68
1st Unit Equipped	Mar 68	Mar 69
Army Readiness Date	Mar 68	Mar 69

(U) The stretchout in development effort, together with the added work in product assurance, led to a significant increase in development costs. A total of \$76,145,000 was allocated to TOW development through FY 1966, and it was estimated that \$19,600,000 more would be required during the FY 1967-69 period, for a total projected RDTE cost of \$95,745,000. This represented an increase of \$9,517,000 over the May 1965 estimate of \$86,228,000 for the FY 1962-67 period. The RDTE outlay for FY 1966 increased from \$23,785,000 to \$25,709,000, and the funding requirement for FY 1967 rose from \$12,020,000 to \$13,600,000. Projected requirements included \$5 million for FY 1968 and \$1 million for FY 1969.⁴³

Results of Prototype Test Firings

(U) The primary objective of the R&D prototype test phase was

⁴¹Hist Repts, TOW PM, FY 66, pp. 4, 6; FY 67, pp. 3-4. HDF.

⁴²(1) TOW PM₂P, 30 Jun 65, pp. II.20.3 - II.20.17. (2) TOW PM₂P, 30 Jun 66, Ch 5, pp. II.20.3 - II.20.13. (3) Hist Rept, TOW PM, FY 66, p. 6. All in HDF.

⁴³(1) TOW PM₂P, 30 Jun 66, Ch 5, p. III.21.2. (2) TOW TDP, 18 May 65, p. I-3. Both in HDF. (3) Also see above, p. 47.

to refine the system design to meet the complete physical and performance requirements set forth in the QMR. As a result of the system performance exhibited in the experimental firings, the prototype test program was directed toward greater component reliability and environmental testing.⁴⁴ Reliability problems, however, continued to plague the system.

(U) The TOW prototype missile, designated as the XBGM-71A, was 5.85 inches in diameter and 45.9 inches long, and weighed about 38.5 pounds. Its major components included the AN/TSQ-67 (XO-1) guidance set, XM-207 HEAT and XM-220 training warhead sections, XM-114 launch motor, and XM-113 flight motor. The missile was shipped in and fired from a spool-shaped, tubular, fiberglass container which, when loaded in the TOW launcher, served as the breech end of the launch tube. The container weighed 8.5 pounds and was 50.3 inches long and 8.6 inches in diameter. The prototype missile-container combination weighed 47 pounds, in contrast to the QMR objective of 42 pounds.

(U) The XM-151 TOW launcher consisted of a lightweight launch tube, tripod, traversing unit, sight/sensor unit and case, electronics unit, and battery. Its total weight of 166 pounds exceeded the QMR objective by 6 pounds.⁴⁵

(U) A total of 62 missiles of the Block I and Block II configuration were fired from 6 January 1965 through 20 June 1966. Six of these were "catcher" firings using missiles with inert flight motors, 6 were programmed flights against a point in space, and 50 were accuracy firings against fixed and moving targets. Forty-two of the 50 accuracy rounds were fired at Redstone Arsenal, with 11 failures and 31 successes for a sample reliability of 73.8 percent. The remaining eight accuracy rounds were fired in arctic tests at Fort Greely, Alaska, during January and February 1966, with two successes and six failures, bringing the sample reliability down to 66 percent. The results of the accuracy tests by type target were as follows:

Type Target	Range (meters)	Number of Firings		
		Successful	Unsuccessful	Total
Stationary	1,500-3,000	16	8	24
Moving (10-30 mph)	65-3,000	17	9	26
		33 (66%)	17	50

⁴⁴TOW TDP, 18 May 65, pp. II-4, II-5. HDF.

⁴⁵(1) TOW PM₂P, Ch 5, 30 Jun 66, pp. I.2.3 & I.3.2 - I.3.6. HDF. (2) AMCTCM Item 4467, 22 Feb 66. RSIC.

(U) Five of the 17 failures were attributed to wire breaks, 4 to malfunction of the infrared source lamp, 3 to malfunction of missile electronics, 2 to flight motor case burn-through, and the remaining 3 to malfunctions in the launcher programmer time, actuator squib, and gyro squib. The circular error probable (CEP) achieved in the R&D prototype firings was about 1.6 feet.⁴⁶

(U) A number of design changes were introduced in the course of the program to improve system performance and reliability. Improvements to the launcher electronics unit included an increased self-test capability and a new three-section power supply. Among changes and improvements to the TOW missile were (1) use of low air-drag joints on the Block II configuration; (2) change in the two-battery power supply to incorporate three identical thermal batteries; (3) change in the actuator gas supply to higher pressure helium; (4) development of a Block II infrared source using a new cylindrical lamp and a fixed duty cycle; (5) introduction of semi-automatic winding techniques for the wire bobbin; (6) replacement of the hot gas gyro with a cold gas (N₂) gyro; and (7) redesign of missile electronics to improve environmental operation relative to shock, vibration, and temperature.⁴⁷

Prototype In-Process Review

(U) The TOW Prototype In-Process Review (IPR) was held at MICOM 18-20 May 1966. The purpose of the IPR was to examine the prototype system design and determine its acceptability to the Army. Among the agencies represented were the Office, Chief of Research and Development; Assistant Chief Staff for Force Development; Army Materiel Command; Combat Developments Command; Continental Army Command; Army Test and Evaluation Command; Army Munitions Command; Army Tank-Automotive Command; Naval Training Devices Center; Ballistic Research Laboratories and Human Engineering Laboratory of the Aberdeen Proving Ground; Electronics Command; U. S. Marine Corps; Aircraft Weaponization Project Manager; General Purpose Vehicle Project Manager; Anniston Army Depot; and the Hughes Aircraft Company.

(U) A comprehensive review and evaluation of the TOW system design indicated that the overall weapon was progressing well

⁴⁶ (1) Hist Rept, TOW PM, FY 66, pp. 8-9. (2) TOW PM₂P, Ch 5, 30 Jun 66, pp. I.5.7a - I.5.7c, & I.5.8. Both in HDF.

⁴⁷ *Ibid.*, pp. I.5.3 & I.5.4.

toward meeting the QMR except in missile and launcher weight, which exceeded the objective by 11 pounds. An analysis of the prototype flight test firings through 10 May 1966 showed an overall flight reliability of 74 percent excluding the eight arctic firings. The flight success ratio was 85 percent for a 20-round moving average. It was concluded that the system had progressed sufficiently to enter the engineering service test with confidence and that an acceptable showing would be made.

System Weight Problems

(U) The QMR objective weight of 42 pounds for the encased missile was based on a 36-pound missile and a 6-pound launch container. The weight of the latest flight test missiles at Redstone Arsenal was 38.5 pounds. Some missile weight reductions had been introduced, but these were offset by necessary weight increases for the 3,000-meter range capability. Further weight reductions in the missile would not be possible without jeopardizing performance and reliability. The missile container weight ranged from the initial prediction of 6 pounds to the prototype weight of 8.5 pounds. By October 1965, it was realized that a container weight of less than 8.5 pounds could not be expected and still provide the required environmental protection for the missile.

(U) Meeting the QMR for a launcher weight of 160 pounds also appeared doubtful. The latest launcher configuration (System #16) weighed 166 pounds (13.7 for the tube; 19.8 for the tripod; 50.2 for the traversing unit; 29.2 for the sight sensor and case; and 53.1 for the electronics unit and battery). This increase in weight resulted from a general upgrading of the design to correct deficiencies revealed in environmental tests.

(U) Substantial weight reduction could be realized through design improvements and changes, such as microminiaturization and use of plastics or other lightweight materials; however, a price would be paid not only in dollars, but also in time needed to retest, requalify, and recertify system components before production deliveries could be made. In order to field the system within the scheduled timeframe, the design was therefore frozen.

(U) The reviewers recommended that no drastic measures be taken to reduce the system weight by the introduction of new, untried materials or redesign. Instead, development of the existing design would be continued, with every effort being made to reduce weight within the current design concepts and resources. They further agreed that the schedule for entering

the engineering service tests should be maintained as planned and that waivers to the QMR would be considered at a later date if the resulting system performance warranted.⁴⁸

Vehicle Adapter Kits

(U) Although the QMR did not specify which vehicle would be employed in certain units, it stated that adapter kits should be developed for the M113 armored personnel carrier, the M274 mechanical mule, the XM-561 Gama Goat, and the M151 jeep. By separate letter, the Department of the Army established that the basis of issue would require the M113 in the mechanized battalion, the M274 in airborne and airmobile battalions, and the XM-561 in infantry battalions. The M151 was to be used in air cavalry squadrons and possibly infantry battalions, depending upon the outcome of firing mount proposals for the XM-561. The QMR stated that a firing capability from the selected vehicle was desirable, but it should not degrade the ground mount capability.

(U) At the time of the TOW IPR, mounting kits had been developed for a firing capability from the M113 vehicle, the M151 1/4-ton jeep, and the M274 mechanical mule. The design of the M113 mounting kit had been approved and fabrication of engineering service test units was underway. The M151 adapter, approved in April 1966, was based on a two-jeep concept: the first or lead jeep would carry two crew members, a center-mounted firing pedestal, one complete launcher system, and two missiles; the second jeep would carry two crew members and six additional missiles. The MICOM R&D Directorate developed the M274 adapter kit to meet Army and Marine Corps* requirements. Except for the addition of an airdrop capability for the Army, the requirements were the same for both users. Four M274 adapter kits were being fabricated at MICOM for the engineering service test program.

(U) The Hughes Aircraft contract called for the development of a TOW firing capability from the XM-561 Gama Goat; however, no feasible firing platform had evolved for this vehicle. Dismounting and setting up the system on the ground could be done in about

*The Marine Corps supplied the Army \$2,248,000 in RDTE funds for M274 adapter kit hardware and 20 TOW missiles for test.

⁴⁸(1) Final Rept, TOW IPR, 18-20 May 66, pp. x - xii, xxiii, 60. HDF. (2) Also see AMCTCM Item 5005, 5 Jan 67, subj: Recording of Prototype IPR for TOW HAW, Proj 1X542409D336, AMCMS Code 5541.12.471. RSIC.

90 seconds. Since only a minimal gain in time could be expected by having a firing capability from the vehicle, and because a mount having a 360° firing capability and low silhouette was not possible, the reviewers recommended that only a stowage and transport kit be provided for the XM-561. They also recommended that consideration be given to changing the basis of issue from the 1 1/4-ton XM-561 to two 1/4-ton M151 vehicles for the infantry battalion, thus providing a vehicle firing capability.⁴⁹ With the subsequent approval of the proposed change in basis of issue, all adapter kit requirements for the XM-561 vehicle were cancelled.⁵⁰

Status of the TOW Night Sight

(U) Employment of the TOW system during hours of darkness required the development of a night sight that would permit the gunner to acquire a target, accurately aim the launcher, and see and track the target beyond the veiling glare of the flight motor plume and xenon beacon light. The Electronics Command Night Vision Laboratories (formerly Engineering R&D Laboratories) began feasibility studies of such a system in April 1965 with a basic budget of \$350,000. The original program consisted of a parallel approach of two concepts—one a hybrid passive system and the other a gated viewer, passive-active system. In August 1965, the Night Vision Laboratories solicited industry for new concepts of a night sight. Ten companies submitted proposals, but only one—from the Hughes Aircraft Company—met the criteria of being an improvement over the present effort, being within the state of the art, and being compatible with the required timeframe. The Hughes proposal was for a passive thermal imaging system using a scanned linear array of lead selenide detectors. On 6 May 1966, the Night Vision Laboratories awarded Hughes a \$150,000 contract for a feasibility model of the thermal night sight.

(U) Feasibility tests of the hybrid, gated, and thermal night sights were planned for the period 1 June to 15 July 1966. The objectives of these tests were to establish feasibility and to determine the extent to which the systems met the QMR. One of the three systems would be selected for engineering development by 20 August 1966. The development and procurement schedule,

⁴⁹ (1) *Ibid.* (2) Final Rept, TOW IPR, 18-20 May 66, pp. xix, xx, xxiii, xxiv, 9, 46, 61-62, 65, 93. HDF. (3) Also see PM₂P, 30 Jun 67, pp. I.2.4 - I.2.5. HDF.

⁵⁰ DA Msg 767632, OACSFOR to CG, AMC, *et al.*, 1 Jul 66, subj: TOW Veh Kits. Atchd as incl to AMCTCM Item 5005, 5 Jan 67. RSIC.

presented at the IPR by the Night Sight Commodity Manager, consisted of the following major milestones:

<u>Phase</u>	<u>Start</u>	<u>Finish</u>
Feasibility	Apr 65	Jul 66
Buy Engineering Design Units	Aug 66	Mar 67
Buy ET/ST Units	Jun 67	Oct 67
Engineering Design Test	Mar 67	Jun 67
LP Type Classification		Sep 67
ET/ST	Dec 67	Jun 68
Buy Field Units	Jan 68	Feb 69
Standard A Type Classification ..		Jan 69

(U) The reviewers concurred in the night sight program and recommended that development be continued at a rate that would keep pace with the TOW system development and allow concurrent fielding of the weapon system and night sight.⁵¹

Conduct of Fire Trainer

(U) The Office, Chief of Research and Development approved a Small Development Requirement (SDR) for the TOW Conduct of Fire Trainer (COFT) on 10 February 1966.* The COFT (later redesignated as the XM-70 Training Set) was required to provide realistic training with the TOW weapon system and to achieve maximum economy in the use of ammunition. To preclude excessive training costs with the TOW system, it was imperative that the COFT be made available concurrently with the weapon itself. It was estimated that \$1,115,000 in FY 1966-67 RDTE funds and 18 months' time would be required to complete development.⁵²

* The requirement stated in the SDR superseded the requirement for the optical elbow telescope device described in paragraph 14a of the DA-approved TOW QMR dated 7 December 1964. See Appendix A.

⁵¹ (1) Final Rept, TOW IPR, 18-20 May 66, pp. xxiv, 115-17, 119, 122-23, 138-39. HDF. (2) TOW PM₂P's, Ch 4, 31 Mar 66, pp. I.2.2 & I.5.6; Ch 5, 30 Jun 66, pp. I.5.6 & I.5.7. HDF. (3) Also see AMCTCM Item 3887, 18 Nov 65. RSIC.

⁵² (1) Ltr, OCRD, DA, to CG, CDC, & CG, AMC, 10 Feb 66, subj: Apprl of SDR for COFT for HAW & Proj Initiation. (2) Incl to Ltr, CG, CDC, to Distr, 24 Feb 66, subj: DA Apprd SDR for COFT for HAW (CDOG Para 27b[3]). Both atchd to AMCTCM Item 6165, 3 Jul 68. RSIC.

(U) During the IPR, a working committee was appointed for the purpose of deciding whether a standard type trainer for similar antitank weapons was feasible and practical, and whether the simple trainer planned for tactical units would be suitable for training centers and schools. The committee reaffirmed the need for a TOW COFT and agreed that it should be built against the SDR using the tactical TOW system as the basis. It concluded that the only possibility for trainer standardization would be in the target source, and that the same trainer would be issued to troop units and training centers.

(U) The reviewers concurred in the committee's report and recommended that development of the COFT be continued at a rate that would allow concurrent delivery with the TOW weapon system. They further recommended that the requirement for an indoor (25-meter) range employment of the TOW trainer be deleted and that the trainer be authorized for issue within the unit Table of Organization and Equipment (TOE) so that maintenance could be performed by the Combat Missile System Repairman (MOS 27C).⁵³

Land Combat Support System (LCSS)

(U) The LCSS design evolved from the Multisystem Test Equipment (MTE) project begun at the Missile Command in 1958. The change in title to LCSS was officially authorized on 20 January 1966, although the term began appearing in Command directory charts in September 1965. The LCSS consisted of tape-program-controlled automatic checkout equipment for providing a complete test and repair capability applicable to combat service support of the TOW, SHILLELAGH, LANCE, and other future Army land combat missile systems. It would be organic to direct and general support maintenance units and would be employed in the division, corps, field army, communications zone, and the Continental United States (CONUS). For the systems supported, it would eliminate about 90 percent of the requirement for system-peculiar equipment experienced with previously-developed missile systems.

(U) Funding for the TOW, SHILLELAGH, and LANCE support systems was approved in FY 1966. The equipment was expected to be available to meet the tactical support requirement of the TOW system; however, it would not be ready in time for the TOW engineering service tests. During these tests, the TOW would be

⁵³ Final Rept, TOW IPR, 18-20 May 66, pp. xvi - xviii, xxiv. HDF.

supported with maintenance and test equipment built and operated by the Hughes Aircraft Company.⁵⁴

Future Plans

(U) At the time of the prototype IPR in May 1966, TOW system documentation was nearing completion and was expected to be released and placed into formal Army change control with the commencement of engineering service tests in July 1966. Thirty-one Service Test Model (STM) missiles and 11 launcher systems were under contract and deliveries were in progress. The Hughes Aircraft Company was preparing a proposal for 342 additional STM's for the FY 1967 contracting period. With the 31 missiles already contracted, a total of 373 STM's would be built by August 1967, the date scheduled for award of the first production contract. Of these 373 missiles, 200 would be used for engineering service tests, 56 for the final phase of R&D test firings at Redstone Arsenal, 39 for various evaluation tests, and 58 for aging tests. The remaining 20 rounds would be delivered to the Marine Corps for evaluation tests with the M274 vehicle adapter kit.

(U) The Hughes Aircraft Company was building TOW R&D missiles in the U. S. Air Force Plant 44 at Tucson, Arizona, under a facilities contract finalized on 24 August 1965. The contractor was provided \$29.7 million worth of Government-furnished equipment (\$13.3 million in land and buildings and \$14.6 million in machinery and equipment). About \$5 million of the machinery and equipment would be used for production of the TOW system. The facilities contract provided for no-charge, noninterference use of Government-owned facilities in the performance of other DOD contracts. It was estimated that 21 months would be required for delivery of initial production equipment, this including 10 months of APE effort and 11 months of procurement leadtime.

(U) The missile items to be furnished by the Government included the tactical warhead (Iowa Army Ammunition Plant), the flight motor and igniter (Radford Army Ammunition Plant), and the launch motor and igniter (Picatinny Arsenal). The Army Electronics Command was to furnish the missile and launcher batteries through competitive procurement. The XM-151 TOW launcher was being built

⁵⁴(1) *Ibid.*, pp. xxiv, 161. (2) AMCTCM Item 4037, 20 Jan 66. RSIC. (3) Hist Rept, LCSS Div, Land Cbt Cmdty Ofc, FY 66, p. 1. HDF. (4) TOW PM₂P, Ch 5, 30 Jun 66, p. I.7.3. HDF.

and assembled at the Hughes plant in El Segundo, California.⁵⁵

Engineering Service Test Program

(U) The integrated engineering test/service test (ET/ST) program began in December 1966, some 22 months behind the time originally scheduled.* Flight test firings commenced on 1 March 1967 and continued until 1 May 1969. Overlapping these firings were engineering design flight tests of 69 STM missiles at Redstone Arsenal, from 9 July 1966 to 18 September 1968, which concluded the basic TOW R&D test program. The discussion which follows deals with the TOW development and test activities through approval of the limited production (LP) type classification in April 1968.

FY 1967-68 Funding Program

(U) The FY 1967 funds approved and released for the TOW program included \$14,040,000 in RDTE money for continued development and test of the system; \$7,441,000 in PEMA funds for the APE effort; and \$586,000 in OMA** funds for in-house technical supervision, depot maintenance and support, and personnel training.

(U) Hughes Aircraft received a CPIF contract (DA-AH01-67-C-0023) on 16 July 1966 for continuation of the R&D effort through 30 June 1967. The target cost of the contract was \$12,786,150; however, the value at the end of the year was \$15,084,864, including an interim cost overrun of \$1,675,600 (13.5 percent of the target cost). The FY 1967 contract covered the procurement of engineering service test hardware (220 STM missiles and 7 launchers) and test support, complete qualification testing of all system components less the missile container, demonstration of system capabilities through flight and operational tests, and complete documentation.⁵⁶

(U) The APE effort was continued during FY 1967 and extended

*See above, p. 47.

**Operations and Maintenance, Army.

⁵⁵(1) *Ibid.*, pp. I.10.3 & II.17.2. (2) Final Rept, TOW IPR, 18-20 May 66, pp. 60-61, 72, 233. HDF.

⁵⁶(1) Hist Rept, TOW PM, FY 67, p. 4. (2) TOW PM₂P, 30 Jun 67, pp. I.2.5 & I.2.6. HDF.

into FY 1968 by adding funds to the existing contracts. Hughes' APE contract AMC-15537, issued on 30 June 1966, was increased by \$2.5 million (from \$3,098,000 to \$5,598,000) and extended through August 1967, the date planned for award of the first production contract. The value of the initial APE contract (AMC-14824), issued in April 1966, was increased by \$119,427, from \$864,578 to \$984,005. Also, the Army Munitions Command (MUCOM) received an additional \$550,000 for APE effort on the warhead, and the Electronics Command was allocated \$1,500,000 for APE on the night sight.⁵⁷

(U) The FY 1968 RDTE funding program of \$5,908,000 supported development of the XM-70 trainer, "clean-up" development of the TOW system, contractor support of the engineering service tests, and conduct of the engineering service test program. The R&D program authority also included \$1,908,000 for a prior-year contract overrun. The FY 1967 R&D contract (DA-AH01-67-C-0023) was extended from 1 July 1967 to March 1968 to allow for the delivery of all hardware, increasing its value from \$15,084,864 to \$18,228,000. The FY 1968 R&D contract (DA-AH01-68-C-0007), awarded to Hughes on 1 July 1967 and definitized on 20 December 1967, provided for development and test of the XM-70 trainer, engineering support of the engineering service tests, and maintenance of hardware. The total contract price as of 30 June 1968 was \$1,995,429.⁵⁸

(U) The APE and production base support (PEMA 4290) funds programmed for FY 1968 totaled \$3,566,000; however, the project was limited to a \$596,000 production base support program for preparation of a TOW motor grain manufacturing facility at Radford Arsenal. The APE effort continued in FY 1968 with funds provided in FY 1967.

(U) The FY 1968 TOW production program suffered a serious setback. The plan was to initiate production in August 1967 with a program of \$53,837,000. A special IPR was held at the Army Missile Command on 12 April 1967 to obtain concurrence for the LP type classification of the TOW system. The Combat Developments Command nonconcurred in the action, preferring to wait until further engineering service test results were available. Final approval of the action was expected in time for the scheduled award of the first production contract; however, reliability

⁵⁷ Hist Rept, TOW PM, FY 67, pp. 4-5. HDF.

⁵⁸ (1) Hist Rept, TOW PM, FY 68, pp. 1-2. (2) TOW PM₂P, 30 Jun 68, p. I.2.6. Both in HDF.

problems and a failure in the missile container led to the suspension of the test program in August 1967.

(U) The Assistant Chief of Staff for Force Development (ACSFOR) then decided to delay approval of the LP release until a higher confidence level in system reliability could be established. The service tests were resumed at Fort Benning on 20 November 1967, and subsequent missile firings indicated a significant improvement in missile reliability. Although ACSFOR approved the LP type classification on 22 April 1968, initial production of the TOW system was deferred to FY 1969 and the Army readiness date (first unit equipped) was slipped from March 1969 to 30 September 1970. The revised schedule called for award of the first production contract on 30 November 1968, delivery of the first production items on 31 January 1970, and classification of the system as Standard A on 31 July 1970.

(U) The FY 1968 PEMA program, initially released for \$42.1 million, was reduced to \$11 million, which provided for engineering services only. Supplemental program authority of \$3,349,000 received during the year covered value engineering change proposals and design and fabrication of special acceptance inspection equipment. Hughes Aircraft initiated industrial engineering services on the TOW system in September 1967 under Letter Contract DA-AH01-68-C-0272, which was definitized for \$9,960,000 on 8 March 1968. This contract covered production and product engineering, product improvement, and maintenance of the technical data package. In June 1968, Hughes received another contract for \$3 million to complete the design and prototype fabrication of special acceptance test equipment.⁵⁹

ET/ST Objectives and Equipment

(U) The primary objective of the integrated engineering test/service test program was to conduct an independent evaluation of the TOW system to assess its readiness for release to production. The program was designed to answer two basic questions: (1) To what degree does the TOW system meet the QMR? and (2) Is the system reliable, accurate, effective, and safe when employed by troops?

⁵⁹ (1) Hist Repts, TOW PM: FY 67, pp. 9-10; FY 68, pp. 1-3. HDF. (2) TOW PM₂P's: 30 Jun 67, p. II.13.3; 31 Mar 68, p. I.2.4; & 30 Jun 68, pp. I.2.6, III.9.5 - III.9.7, & III.13.1. HDF. (3) AMCTCM Items 6166, 3 Jul 68, & 6363, 3 Oct 68. RSIC. (4) Ltr, ACSFOR to CG, AMC, 22 Apr 68, subj: LP Auth for TOW Wpn Sys. HDF.

(U) The tests were conducted by agencies of the Army Test and Evaluation Command (TECOM). The White Sands Missile Range (WSMR) served as the executive agency for all engineering service tests, and conducted the engineering test evaluation and tropic tests. The U. S. Army Infantry Board at Fort Benning, Georgia, conducted the service test evaluation and simulated combat tests, and provided military personnel for portions of other tests. Other TECOM agencies participating in the program were the U. S. Army Arctic Test Center, Fort Greely, Alaska; U. S. Army Tropic Test Center, Fort Clayton, Panama; Yuma Proving Ground, Arizona (desert tests); Aberdeen Proving Ground, Maryland (vehicle and warhead tests); and U. S. Army Airborne, Electronics, and Special Warfare Board, Fort Bragg, North Carolina (airdrop and air transportability tests). The integrated engineering design/engineering tests (ED/ET) were conducted at Redstone Arsenal.

(U) The equipment delivered for test consisted of encased STM missiles stored and shipped in an overpack container; the XM-151 launcher assembly with tripod for the basic ground-mounted system; the XM-233 mounting kit for the M113 vehicle; the XM-225 mounting kit for the M274 truck; and the XM-232 and XM-236 mounting kits for the M151A1 jeep. The night sight, XM-70 trainer, and Land Combat Support System (LCSS) were still under development and not available for test. In the absence of the latter, the TOW system was supported by maintenance and test equipment built and operated by Hughes Aircraft. The missiles delivered for test included the basic XBCM-71A round with the XM-207 HEAT warhead; the XBTM-71A with the XM-220 practice inert warhead and no fuzing; the XBEM-71A telemetry round with no warhead; and nonstandard rounds with flash-smoke (spotting charge) warheads.⁶⁰

Personnel Training

(U) The New Equipment Training (NET) program was a joint effort of Hughes Aircraft and the NET Division of the MICOM Supply and Maintenance Directorate. It included all training for the initial transfer of knowledge from the developer to establish a training base for the TOW weapon system in major commands.

(U) Staff Planner Orientation Courses. Seven TOW staff planner courses were presented: three by Hughes and four by MICOM

⁶⁰ (1) Final Rept, TOW IPR, 18-20 May 66, pp. 232-39. HDF.
(2) TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5200-01 (8-MI-000-TOW-005), Vol. I, Aug 69, subj: IE&ST of TOW HAW Sys. TOW Proj Ofc.

personnel. These courses covered an overall nontechnical familiarization of the system, including field deployment and logistical aspects. They were offered to all Army and Marine Corps personnel engaged in planning, budgeting, and approving programs for the development, production, and distribution of the system. A total of 146 personnel were trained in the seven courses—62 in the three courses at Hughes Aircraft in April 1966, and 84 in the four courses at MICOM during September and October 1966. Two of the latter were 14-hour courses presented exclusively for MICOM personnel. The other two courses for personnel of other commands were 18 hours long.

(U) Technical Training Courses. During the last quarter of FY 1966, Hughes Aircraft conducted technical training courses for TECOM personnel who were to perform the engineering service tests. The course was completed by 32 key operator, test and evaluation, and maintenance engineering personnel from TECOM, the U. S. Army Infantry Board, and MICOM. The engineer-level course of 1-week duration was presented in May 1966 at the Hughes' plant in Los Angeles. Hughes Aircraft conducted the operator-level course at Redstone Arsenal where adequate range facilities were available for tracking exercises. This training, completed in June 1966, included an introduction to the TOW system, theory of system operation, organizational and field maintenance, and system operational tasks. During the training, the operator-gunner tracked a truck equipped with a simulated TOW source. Readouts at the launcher indicated how well the gunner could track the light at varying ranges and target speeds. A blank shotgun shell, loaded in a special rig in the launcher, was used in place of missile slugs to simulate the launcher motor blast. This gave the gunner a feel for firing the weapon and prepared him for actual missile firings.⁶¹

Flight Test Summary

(U) Flight test firings of the ET/ST configuration missiles, representing the final phase of the TOW R&D test program, began at Redstone Arsenal on 9 July 1966. The nonfiring portion of the fieldability tests began at WSMR in December 1966, followed by flight test firings on 1 March 1967. The user-oriented service

⁶¹(1) Final Rept, TOW IPR, 18-20 May 66, pp. 217, 265. (2) TOW PM₂P, 30 Jun 66, pp. II.18.2 & IV.24.2. (3) TOW PM₂P, 31 Dec 66, pp. IV.25.1 & IV.25.2. All in HDF. (4) *Army Research and Development Newsmagazine*, Sep 66, p. 24.

test firings started at Fort Benning, Georgia, on 14 June 1967.

(U) All of the engineering design firings at Redstone Arsenal were conducted in the ground mode. Evidence of missile reliability problems showed up very early in the firings, four of the first six tests, completed in July 1966, ending in failure because of malfunctions in the xenon source lamp and wire assembly. By 20 July 1967, 29 missiles of the 100 and 200 series had been fired against fixed and moving targets at ranges of 500 to 3,000 meters. Only 19 of these were successful for a sample reliability of 65.5 percent.

(U) The results of the first 41 engineering service tests were equally disappointing. Thirty-two STM rounds were fired at WSMR from 1 March to 26 July 1967, and 9 rounds at Fort Benning from 14 June to 20 July 1967. Of the 41 rounds, 13 were fired at fixed targets at ranges of 2,000 to 3,000 meters, and 28 were fired against targets moving at speeds of 10 to 30 mph and at ranges from 200 to 3,000 meters. Twenty-eight of the rounds were fired from the ground mount, 7 from the M274 vehicle, 4 from the M151 jeep, and 2 from the M113 vehicle. One of the 41 firings was scored as no test, 13 were failures, and 27 were successful, yielding a sample reliability of 67 percent. Most of the failures were attributed to malfunctions in the xenon source lamp, wire assembly, and missile harness. There were also at least two failures of the flight motor.⁶²

(U) Because of recurring missile component failures, the engineering design and engineering service tests were suspended in August 1967 to permit an analysis of the problem areas and installation of corrective measures. In August and September 1967, MICOM personnel spent about 6 weeks at Hughes' plant working to improve missile reliability.⁶³ This effort resulted in the so-called "Golden 400" series missile which was later released for limited production.

(U) The engineering service test firings were resumed at Fort Benning on 20 November 1967 and at White Sands on 6 December 1967, following a special 10-round firing program at Redstone Arsenal from 2 October to 9 November 1967. By 30 June 1968, 35 of the

⁶²(1) TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5200-01 (8-MI-000-TOW-005), Vol. I & II, Aug 69, subj: IE&ST of TOW HAW Sys. TOW Proj Ofc. (2) TOW PM₂P, 30 Sep 67, p. I.2.7. HDF. (3) TOW Firing Data Furnished by Edwin E. Baker, TOW Proj Ofc.

⁶³TOW PM₂P, 30 Jun 68, p. I.2.7. HDF.

400 series missiles had been fired in engineering service tests—9 at WSMR and 26 at Fort Benning. One of these was scored as no test, 4 were failures, and 30 were successful, for a reliability of 88 percent. From 2 October 1967 through 1 May 1968, 20 STM missiles of the 400 series and 4 earlier series missiles were fired at Redstone Arsenal. Sixteen of these 24 firings were successful, yielding a sample reliability of 66 percent.

(U) Between 19 January and 20 February 1968, 10 missiles of the 400 series were fired in engineering design arctic tests at Fort Greely, Alaska. All of the missiles were fired in the ground mode against fixed targets at ranges of 1,900 to 2,000 meters. One was scored as no test for missile reliability because of a condensation trail, three were marred by missile component failures, and six were successful. All six of the reliable rounds scored accurate hits except one whose miss distance was excessive because of a gunner error.

(U) All told, 139 missiles were fired in engineering design and engineering service tests between 9 July 1966 and 30 June 1968—53 at Redstone Arsenal, 10 at Fort Greely, Alaska, 41 at WSMR, and 35 at Fort Benning, Georgia. Of the 76 engineering service tests, 59 were successful and 17 were failures, for an overall missile reliability of 77.6 percent. There were no ground support equipment failures in the ET/ST program.⁶⁴ A complete summary of these and subsequent firings in the integrated engineering service test program will be presented in the succeeding chapter.

(U) In addition to the 139-round Army test and evaluation program, a Marine Corps unit at Twentynine Palms, California, fired 20 TOW missiles from the M274 vehicle during February and March 1968. Aside from evaluating the M274 mounting kit and the TOW's effectiveness against moving tank targets, the Marines were interested in trying the missile's effectiveness against fortified ground targets and in testing untrained gunners in the use of the weapon. Ten of the rounds were fired against fixed targets (concrete fortifications, sandbag bunkers, and tank hulls) at ranges of 1,000 and 2,000 meters, and the other 10 against targets traveling at 20 and 25 mph at a range of 2,000 meters. The Marines were very impressed with the firepower and accuracy of

⁶⁴ (1) *Ibid.* (2) TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5200-01 (8-MI-000-TOW-005), Vol. I & II, Aug 69, subj: IE&ST of TOW HAW Sys. TOW Proj Ofc. (3) TOW Firing Data Furnished by Edwin E. Baker, TOW Proj Ofc.



TOW Firing from the M274 Mechanical
Mule at Twentynine Palms, California

the weapon, as the gunners scored direct hits on 9 of the 10 fixed targets and 8 of the 10 moving targets. A photographer who was given 30 minutes of instruction in use of the weapon scored a bullseye on a concrete wall three-fourths of a mile away.⁶⁵

Release for Limited Production

(U) As noted above, the Assistant Chief of Staff for Force Development approved the LP type classification of the TOW system on 22 April 1968, but deferred initial production to FY 1969. At the time of the type classification approval, development of the system was essentially complete, advance production engineering was complete, a technical data package was available, and all changes were under Government control. The engineering service tests were scheduled for completion by January 1969, except for arctic, desert, and tropic tests, which were expected to continue through June 1971.

(U) The results of the flight, laboratory, and field tests indicated that the system met most of the prescribed materiel requirements except for the deviations approved as a result of the prototype in-process review held in May 1966. The system still exceeded the QMR weight objective by about 12 pounds and the system reliability fell short of the 95-percent objective. Firings since introduction of the improved 400 series missile in November 1967 yielded a missile reliability of 85.7 percent. The achieved launcher reliability was 98.6 percent. First production estimate for reliability was 85 percent for the missile and 98 percent for the launcher. The predicted reliability for follow-on production was 96.1 percent for the missile and 99.1 percent for the launcher. The achieved hit probability, given a reliable round, exceeded the QMR objective against both fixed and moving targets at all ranges from 65 to 3,000 meters.

(U) The major items of the infantry (ground-based) TOW weapon system released for first-year sole source procurement in FY 1969, together with the quantities needed to meet Army requirements and the estimated unit cost, including tooling, are listed below. The second-year buy was expected to be under a Standard A classification.

⁶⁵(1) TOW Firing Data Furnished by Edwin E. Baker, TOW Proj Ofc. (2) *Huntsville Times*, 4 Sep 68.

<u>Federal Item Identification</u>	<u>Quantity</u>	<u>Unit Cost</u>
Guided Missile, Surface Attack, XBGM-71A (HEAT).....	4,500	\$ 8,908
Guided Missile, Surface Attack, XBTM-71A (Practice).....	1,050	9,379
Launcher, Tubular, Guided Missile, XM-151E1.....	211	83,402
Mounting Kit, Vehicle, GM System:		
XM-233 (M113/M113A1 APC).....	56	15,822
XM-225 (M274 Mechanical Mule).....	102	4,060
XM-232 (M151A1 Jeep).....	45)	8,482
XM-236 (M151A1 Jeep).....	45)	
Training Set, GM System, XM-70.....	77	20,127
Charger, Battery: PP-4884(XO-1)/T...	56	21,621

The only two major items of the basic system yet to be type classified for limited production were the Land Combat Support System (LCSS) and the night sight. TOW support items were to be tested in the LCSS ET/ST program and made available in final form before the Army readiness date. The night sight, however, would not be available in time for fielding with the TOW system because of a slippage in the development program at the Electronics Command.⁶⁶

(U) Feasibility tests of the hybrid, gated, and thermal night sights indicated that all three approaches met the minimum materiel requirements; however, the hybrid design was dropped from consideration because of superior performance by the other two systems. Instead of selecting one system for engineering development in August 1966, as originally planned, it was decided to continue parallel development of the gated and thermal systems until 1 March 1968. At the end of FY 1967, the night sight program schedule was compatible with that of the TOW system.⁶⁷ But subsequent technical problems caused major slippages in the schedule.

(U) Engineering design tests of the gated and thermal models began on 26 March 1968. The nonfiring tests, which were to have been completed in 2 weeks, required 4 weeks because of bad weather, test vehicle breakdowns, and failure of the night sights.

⁶⁶ (1) AMCTCM Item 6166, 3 Jul 68. RSIC. (2) Ltr, ACSFOR to CG, AMC, 22 Apr 68, subj: LP Auth for TOW Wpn Sys. HDF.

⁶⁷ (1) TOW PM₂P, 30 Jun 67, pp. II.10.2 & III.15.3. (2) Hist Rept, TOW PM, FY 67, p. 6. HDF. (3) Also see above, pp. 62-63.

Continuing night sight failures prevented the live missile firings and, on 19 April 1968, the hardware was returned to the contractors for further work to improve the mean time between failure. Resumption of engineering design testing was scheduled for early August 1968, and the selection of one system for the TOW was rescheduled from March 1968 to October 1968.⁶⁸ The results of the engineering design tests and subsequent developments in the program will be discussed later. For the moment, it will suffice to say that the gated night sight concept was selected for development in March 1969, but it was later dropped in favor of the thermal night sight which was yet to reach the field in late 1976.

The XM-26/UH-1B Helicopter Armament Subsystem

(U) Another major TOW materiel requirement yet to be met was the airborne firing capability. At the time of the TOW classification action in April 1968, the XM-26/UH-1B helicopter armament subsystem had undergone successful development tests; however, the program was halted short of service tests when the Army decided to redirect the effort to the TOW/CHEYENNE armament subsystem.

(U) One of the biggest problems involved in firing missiles from helicopters was stabilizing the line of sight from the chopper to point targets on the ground. The Army Missile Command (MICOM) chose the Hughes Aircraft Company, the TOW prime contractor, and the Aeronutronic Division of the Philco Ford Corporation, the SHILLELAGH prime contractor, to work on a solution to the problem. In December 1963, MICOM awarded contracts of \$1,380,000 each to Hughes and Aeronutronic to design, fabricate, and install on the UH-1B helicopter a stabilized sight/sensor that would be compatible with each company's antitank guided missile. The contracts also called for a preliminary design of the complete tactical weapon subsystem, designated as the XM-26, which was to replace the M22 (SS-11/UH-1B) subsystem by January 1969.

(U) Hughes and Aeronutronic delivered their stabilized sights and preliminary design packages on 2 September 1964. The Frankford Arsenal tested the competing sights under the direction of MICOM. At the same time, MICOM evaluated both contractor designs for the tactical subsystem. As a result of the evaluation completed in February 1965, MICOM concluded that both systems were superior to the M22 and that the Hughes stabilized sight/sensor was superior in performance to the Aeronutronic device. The

⁶⁸Hist Rept, TOW PM, FY 68, p. 3. HDF.

Aircraft Weaponization Project Manager then authorized MICOM to develop the XM-26 airborne subsystem using the Hughes stabilized sight and the TOW missile.

(U) On 8 October 1965, Hughes Aircraft received a CPIF contract for \$4.2 million covering the first 6 months of R&D effort. Negotiations for the remaining 21 months of the development program began on 18 April 1966 and were essentially completed by 17 June 1966. An increase in the contractor's cost estimate from \$12.3 million to \$18.6 million resulted in a revised scope of work written to reduce costs to an absolute minimum. This revision, together with final negotiation efforts, helped to pull the final negotiated target price down to \$15.3 million for the 21-month period. The total estimated R&D cost of the XM-26 program, including in-house support, was \$28 million. Advance production engineering (APE) was expected to cost \$3.6 million and production of 165 units about \$25.7 million, bringing the total estimated program cost to \$57.3 million.

(U) Upon completion of the contract negotiations in mid-June 1966, MICOM recommended to the Aircraft Weaponization Project Manager that the XM-26 program be terminated. The reasons were twofold: excessive costs and the projected availability of the advanced TOW/CHEYENNE system within 1 year after fielding of the TOW/UH-1B (XM-26). With the rejection of MICOM's recommendation, an R&D contract (DA-01-021-AMC-14688Z) for \$15,364,400 was awarded to Hughes on 30 June 1966, retroactive to 8 April.⁶⁹

(U) During FY 1967, the R&D program was hindered by funding problems. The development contract originally specified an interim design release in August 1967, and was incrementally funded. It had to be renegotiated in December 1966, because the Aircraft Weaponization Project Manager was unable to obtain funding in the negotiated amount. The renegotiated contract, which was to continue through 4 months of the ET/ST program, specified an interim release date of 1 March 1968. MICOM in-house funds paid for an overrun of \$650,000 to cover effort during June 1967. An additional \$506,000 from MICOM in-house funds was then included in the contract to cover effort through 17 July 1967, and \$3,613,953 more was needed to complete the development program. The Missile Command received \$1,576,000 to initiate a reduced APE program, but could not issue a contract because the Aircraft

⁶⁹(1) Anl Hist Sum, Acft Weaponization PM, AMC, Aug 64 - Aug 65, p. 25. (2) Hist Rept, Small Rkts & Acft Armts Br, D/R&D, MICOM, FY 66. (3) Hist Rept, Land Cbt Cmdty Mgr, FY 66. All in HDF.

Weaponization Project Manager had placed a hold on the award until 31 October 1967.⁷⁰

(U) The overall design configuration of the XM-26 subsystem was approved during the design characteristics review held at MICOM early in October 1966. As the result of a Tank, Antitank, Assault Weapons Requirement Study completed in February 1967, the Combat Developments Command recommended cancellation of the XM-26 program and transfer of the effort to the TOW/CHEYENNE (TOW/AH-56A) program. The Deputy Commanding General, Land Combat Systems, in an unexplained reversal of the previous MICOM position, later notified the Aircraft Weaponization Project Manager that he did not agree with this recommendation.⁷¹

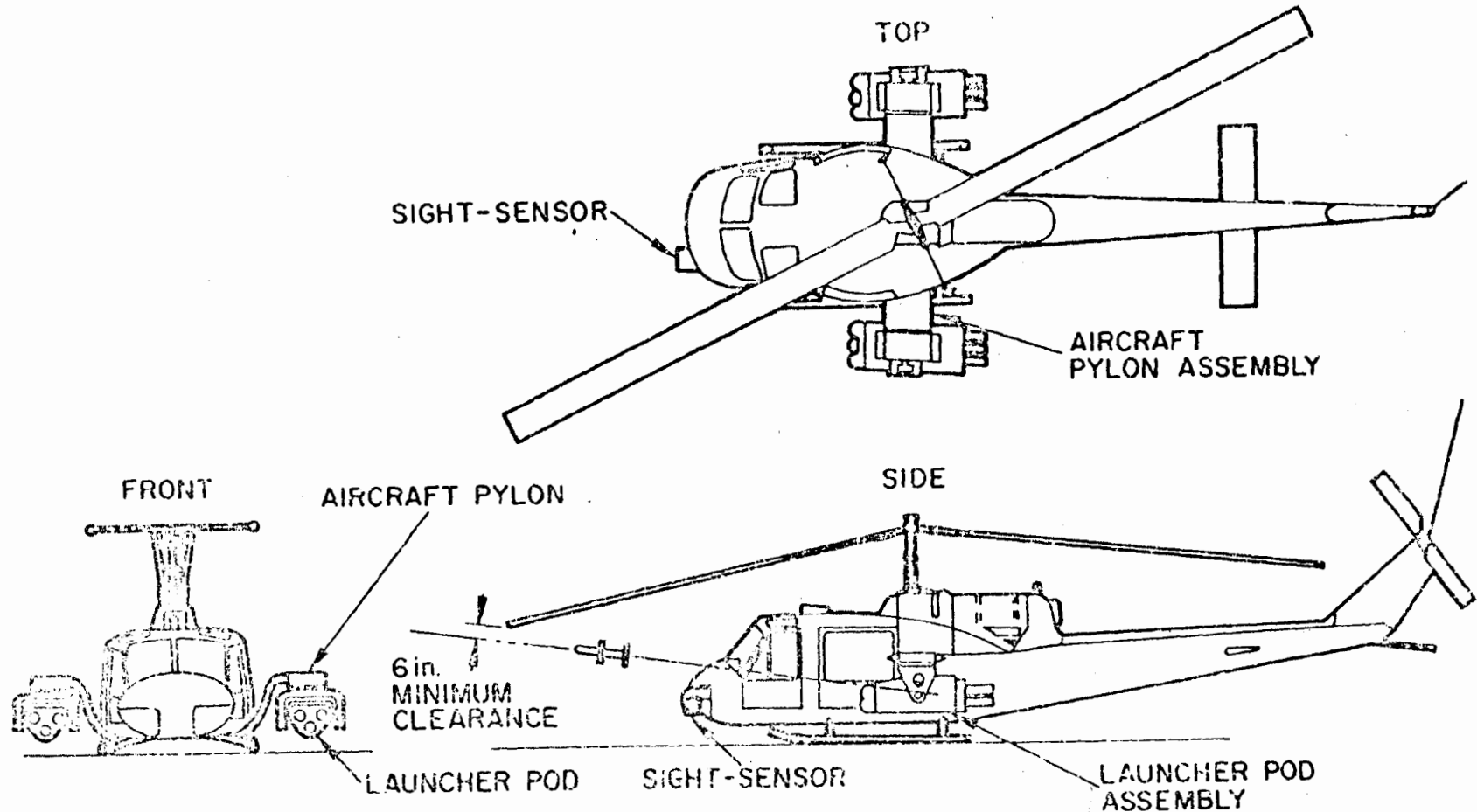
(U) The XM-26 armament subsystem consisted principally of two triangular three-missile pods, each mounted on an outboard pylon; a gyro-stabilized sight system designed to isolate the sight and sensor from helicopter motion and vibration; and three electronic units for stabilization, generation of missile signals, and regulation of electric power. The TOW missile, as used in the XM-26 subsystem, was identical to that developed for the ground-based system. When used in the XM-26, however, the missile was launched from its shipping container inclosed in the three-missile pod. Both pods were attached to MA-4A bomb racks containing electrical and mechanical jettison equipment. Both the pilot and gunner could jettison individual pods electrically, or both pods could be jettisoned at once by mechanical means. The missile pods could be attached to the pylons by two men in 5 minutes, and they could be reloaded without the use of special tools.⁷²

(U) The XM-26 development test program began with a series of 20 unguided ("slug") missile firings (10 ground and 10 airborne) from the experimental launcher in March, April, and May 1966, to verify launcher design and determine missile-helicopter reactions. The experimental subsystem was then modified to fire guided missiles, and design of the first Advanced Development Model (ADM)

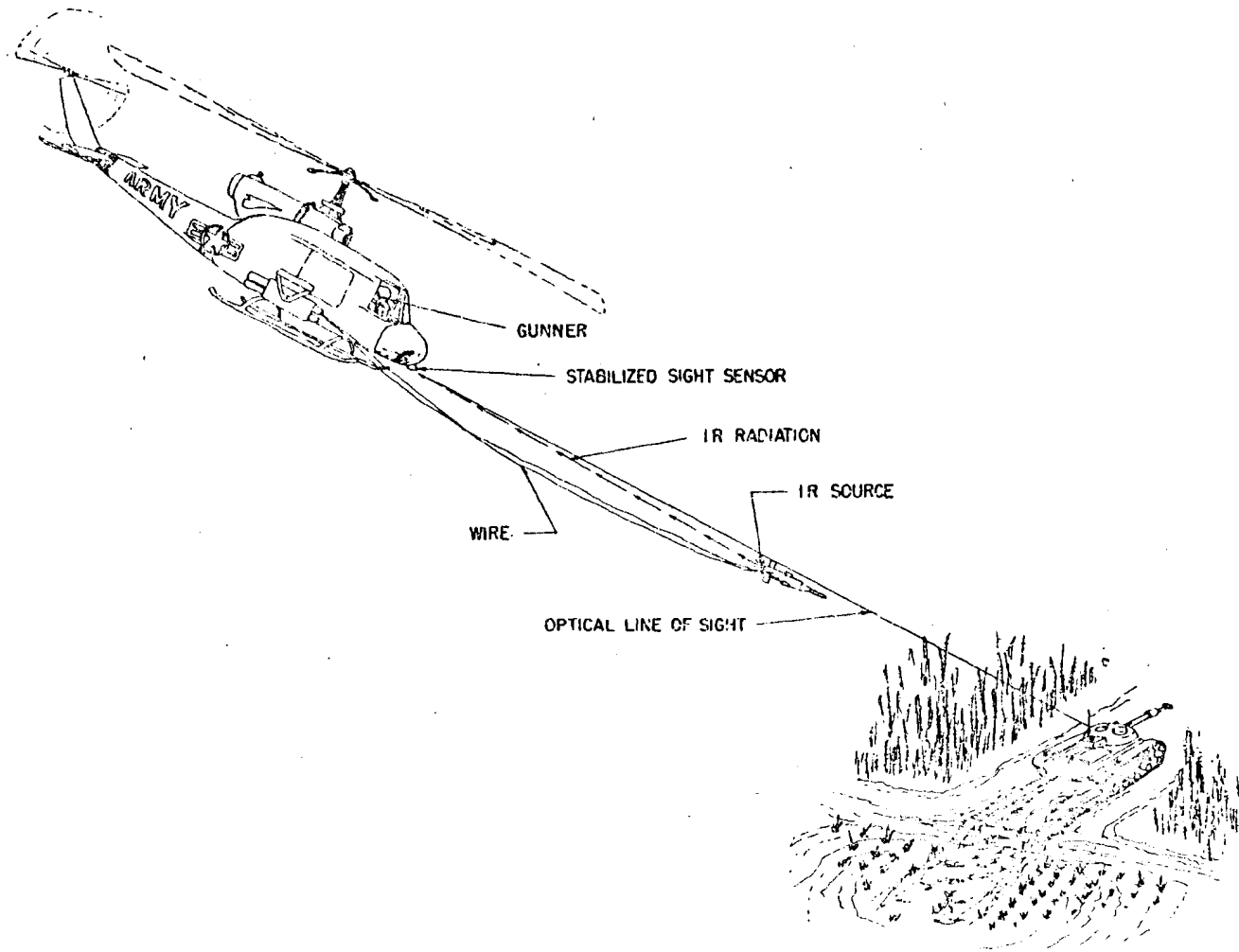
⁷⁰(1) SS AMSMI-I-130-66, D/P&P, 27 Oct 66, subj: Req for Apprl of D&F XM26, TOW/Hel. (2) Hist Rept, XM26 (TOW/Hel), Dev Div, D/R&D, FY 67, p. 1. (3) Hist Rept, LCCO, FY 67, pp. 1-2. All in HDF.

⁷¹(1) *Ibid.*, pp. 1-2. (2) AMCTCM Item 6535, 18 Dec 68, subj: Armt Subsys, Hel, GM Lchr: XM26 (TOW/Hel) - Apprl of Design Chars IPR, Proj DA1X164202D134 Task 05. RSIC.

⁷²AMC TIR 18.2.1.15, Jan 67, subj: GM Lchr Hel Armt Subsys, XM26. RSIC.



Three-View Drawing of XM-26 Helicopter Armament Subsystem



Drawing of the UH-1B Helicopter Firing the TOW Missile

subsystem was initiated.⁷³

(U) Guided flight tests from the helicopter-mounted experimental subsystem commenced at Redstone Arsenal on 29 July 1966 and continued through 13 July 1967, with a total of 32 firings including 12 wire integrity tests. The latter resulted in seven target hits, three missile failures unrelated to the XM-26 system, one wire break because of snagging in the trees, and one target miss because of gunner error. The other 20 firings yielded 12 target hits and 8 failures, 6 of which were attributed to the missile, 1 to the subsystem, and 1 to instrumentation.

(U) The first ADM subsystem was fabricated and installed on the UH-1B helicopter during June 1967. Test firings, however, were delayed until early October 1967 because of missile shortages and engineering changes.* The 30-round engineering design test program began on 5 October 1967 and continued through 28 February 1968. During the tests, the TOW missile successfully hit both stationary and moving targets with a high degree of accuracy while the helicopter was hovering, traveling at high speed, or flying a zig-zag course. Specifically, 22 of the 30 missiles fired scored target hits. Six of the eight failures were the result of design deficiencies later corrected, one was attributed to missile failure, and the other to an instrumentation problem. Excluding the round marred by instrumentation failure, which was scored as no test, 17 of the last 20 missiles fired hit their targets for a 20-round moving average of 85 percent.⁷⁴

(U) During the third quarter of 1968 and the first half of 1971, a total of 62 demonstration firings of the XM-26 airborne TOW were conducted in the Federal Republic of Germany. Fifty-seven, 92 percent, of the missiles scored direct hits. Two of the five misses were attributed to gunner errors and three to equipment failures.⁷⁵

(U) In addition to firings from the first ADM subsystem,

* As noted earlier, the basic TOW engineering design and engineering service tests were suspended in August 1967 because of missile reliability problems.

⁷³ (1) Hist Rept, LCCO, FY 66. (2) Hist Rept, Small Rkts & Acft Armts Br, D/R&D, FY 66. Both in HDF.

⁷⁴ (1) Hist Repts, LCCO, FY 1967-68. (2) Hist Repts, XM26 (TOW/Hel), Dev Div, D/R&D, FY 1967-68. (3) TOW Firing Data Furnished by Edwin E. Baker, TOW Proj Ofc.

⁷⁵ Abn TOW Fact Book. TOW Proj Ofc.

Hughes Aircraft conducted qualification tests using ADM Subsystem No. 2, MICOM performed reliability tests using Subsystem No. 3, and combined Government qualification and reliability tests were conducted on ADM Subsystem No. 4. The fifth XM-26 subsystem was built for service tests which were to have started in April 1968; however, these tests were cancelled when the Army decided to redirect the XM-26 effort to the TOW/CHEYENNE program. Subsequent effort was directed toward verification of the contractor-developed XM-26 documentation package and completion of advance production engineering on XM-26/CHEYENNE common items. The updated XM-26 package was retained at MICOM against future requirements for a TOW capability from the UH-1B or other rotary wing aircraft.⁷⁶

(U) The Army's investment in the XM-26 program (\$28,534,920 RDTE and \$1,396,000 PEMA/APE⁷⁷) paid handsome dividends. The TOW XM-26/UH-1B system not only fulfilled an urgent tactical requirement in Vietnam, but also provided the basis for development of an improved TOW armament subsystem for the COBRA attack helicopter. The XM-26 subsystem was removed from storage and rushed to South Vietnam in the spring of 1972, when the North Vietnamese swept across the Demilitarized Zone in an all-out tank-supported invasion.⁷⁸ The XM-65 TOW armament subsystem later developed for the AH-1 series COBRA helicopter was a functional upgrade of the XM-26 subsystem.⁷⁹

The TOW/CHEYENNE Program

(U) Shortly after the XM-26 TOW/UH-1B helicopter system reached Vietnam, development of the CHEYENNE advanced attack helicopter (AH-56A) was terminated because of high estimated production costs. Development of the CHEYENNE Advanced Aerial Fire Support System (AAFSS) had begun in 1963. Five years later, in September 1968, fire control and armament systems had been successfully integrated; there had been ground and air firings of the TOW missile, 7.62mm minigun, and 40mm grenade launcher; and 10 CHEYENNE prototypes had been completed and accepted by the Army.

⁷⁶(1) Hist Rept, XM26 (TOW/Hel), Dev Div, D/R&D, FY 68. (2) Hist Rept, Acft Wpns Cmdty Ofc, FY 69. Both in HDF.

⁷⁷Incl to Ltr, Cdr, AVSCOM, to ASA(I&L), DA, 10 Jan 73, subj: Req for Apprl of D&F for the Improved Armt Sys for the AH-1G Hel. TOW Proj Ofc.

⁷⁸For the story of the TOW in combat, see below, pp. 163-76.

⁷⁹See Chap VIII.

By mid-1972, however, the cost of the CHEYENNE had nearly doubled the original 1963 estimates. Moreover, tests conducted in 1972 showed that the machine lacked the vertical and lateral agility called for by the tactics developed in Vietnam. Specifically, increasing firepower from an enemy liberally equipped with automatic weapons and light antiaircraft guns had taught U. S. Army aviators that the helicopter would have to hug the ground if it was going to survive and fight effectively, taking advantage of available cover and darting into the open to use its weapons.⁸⁰

(U) In view of cost considerations and the shift in emphasis to a cheaper machine more closely tailored to the task, the Secretary of the Army directed termination of the CHEYENNE program on 9 August 1972.⁸¹ A total of 115 TOW missiles were expended in the TOW/CHEYENNE program: 62 in feasibility demonstration firings from mid-1967 through 1970, and 53 in developmental firings from January 1970 through July 1972. Thirty-four of the latter firings resulted in hits, 5 missed the target, and 14 were scored as no test.⁸²

(U) To fill the gap left by termination of the CHEYENNE program, the Army launched the Improved COBRA Armament Program (ICAP) in March 1972, and followed this with initiation of the Advanced Attack Helicopter (AAH) development program in June 1973. The object of the ICAP effort was to provide significant improvement in antiarmor firepower by mounting the TOW missile on the AH-1 series COBRA helicopter.⁸³ The TOW/COBRA program will be treated in appropriate detail in a later chapter.

⁸⁰(1) *Army*, Vol. 18, No. 11, Nov 68, p. 170. (2) *Army*, Vol. 23, No. 10, Oct 73, pp. 129-30.

⁸¹TT, AAH PM, AVSCOM, to DA, 5 Oct 72, subj: Cancellation of CTP for CHEYENNE. HDF.

⁸²Abn TOW Fact Book. TOW Proj Ofc.

⁸³(1) *Army Research and Development News Magazine*: Mar-Apr 73, pp. 17-18; and Jul-Aug 73, p. 2. (2) *Army*, Vol. 22, No. 10, Oct 72, p. 37. (3) *Army*, Vol. 23, No. 10, Oct 73, p. 133.

CHAPTER V

(U) THE TOW INDUSTRIAL PROGRAM (U)

(U) Procurement of the infantry TOW weapon system began with award of the first production contract in November 1968 and continued under LP classification authority until September 1970 when the major portion of the system was adopted as Standard A. Deployment of the TOW system commenced in September 1970, and production for the U. S. Army and Marine Corps and numerous foreign countries was still underway in 1976.

Initial Sole Source Procurement

(U) The FY 1969 funding program for the TOW missile system totaled \$78,527,000. The largest portion of the total, \$75,065,000, consisted of PEMA funds for initial production, production base facilities, and selected repair parts. RDTE funds released for continued research and development and test program support amounted to \$2,016,000. Providing maintenance support and central services required \$1,446,000 in OMA funds.¹ Of the \$75,065,000 in PEMA funds, \$2,600,000 was obligated for selected repair parts, \$307,000 for production base facilities, and the remaining \$72,158,000 for first-year sole source procurement of production hardware.²

(U) The initial production contract (DA-AH01-68-C-2141) was issued to Hughes Aircraft in June 1968 as a \$200,000 letter order. This early award, funded with FY 1968 RDTE money, was required to provide 163 missiles for the TOW/CHEYENNE qualification test program and 66 missiles for the TOW R&D test program. It was definitized into a 2-year multiyear CPIF contract on 29 November 1968, with a ceiling price of \$168,234,958. The first year of the contract covered initial PEMA hardware: 5,350 missiles, 211 launchers, 77 trainers, 56 XM-233 mounting kits, and 56 battery

¹TOW PMP, 30 Jun 69, p. III.12.1. HDF.

²(1) *Ibid.*, p. III.12.2. (2) AMCTCM 6166, 3 Jul 68. RSIC. (3) Also see AMCTCM 7402, 14 Jan 70. RSIC. (4) Also see Ltr, ACSFOR to CG, AMC, 22 Apr 68, subj: LP Auth for TOW Wpn Sys. HDF.

chargers. (The remaining 200 of the 5,550 missiles authorized for procurement in FY 1969 were later contracted with the Chrysler Corporation in an educational buy.) As of 30 June 1969, \$56,555,547 had been obligated. The Army Munitions Command (MUCOM) procured tactical warhead metal parts and crush switches by sole source negotiation with the Firestone Tire and Rubber Company, and safety and arming devices by award of a sole source contract to the Zenith Radio Corporation.³ Shipping and storage containers for the missile, launcher components, and sight/sensor were supplied to Hughes as Government-furnished property. The missile and launcher components were shipped in disposable wirebound wooden boxes, and the sight/sensor in a reusable metal container.⁴

(U) The terms of Hughes' production contract included "fly-before-buy" missile acceptance criteria to make sure the Army received a quality product for its money. Under this provision, a random sampling of production missiles would be selected each week for test firing before Army inspectors at Redstone Arsenal. If those missiles performed according to specifications, that particular lot would be accepted; if not, the contractor would have to produce an acceptable sampling before the Army would be obligated to buy. The Army Deputy Chief of Staff for Logistics approved \$307,000 in FY 1969 PEMA funds for preparation of the production acceptance test facilities at Redstone Arsenal.⁵

(U) The plan was to introduce competitive procurement for TOW missiles in FY 1971 between the prime contractor (Hughes Aircraft) and an alternate producer. The Army Missile Command solicited proposals for second source production from 63 prospective contractors. An evaluation of the proposals submitted led to the selection of the Chrysler Corporation Huntsville Division as the alternate producer. A \$2,943,550 contract for an educational buy of 200 TOW missiles was awarded to Chrysler on 10 January 1969. This contract (DA-AH01-69-C-0928) contained two options for an additional 2,685 missiles after the contractor successfully demonstrated his ability to produce an acceptable item. The cost of the two options was

³(1) Hist Repts, TOW PM: FY 68, p. 2; FY 69, as rev 29 Oct 69, p. 2; FY 70, p. 3. HDF. (2) TOW Adv Proc Plan No. 2. Atchd as incl to Ltr, MICOM Cofs, thru CG, AMC, to Dir of Mat Acq, OASA(I&L), 5 Mar 69, subj: Adv Proc Plan for TOW Wpn Sys. HDF.

⁴Hist Rept, TOW PM, FY 69, p. 7.

⁵(1) 2d Ind, DCSLOG, DA, to CG, AMC, 20 Feb 69, on Ltr, CG, MICOM, to CG, AMC, 16 Dec 68, subj: FY 69 Late-Start Proj 4291.-3692159, Acq of Fac for Pdn Acceptance Testing (TOW). HDF. (2) *Huntsville News*, 4 Jun 70, p. 2.

\$14,057,955, making a total of \$17,001,505 for the full quantity of 2,885 missiles.⁶

(U) Hughes Aircraft received a letter contract for FY 1969 industrial engineering services on 28 June 1968. Contract amendments on 5 August, 31 August, and 3 September 1968 preceded definitization into a cost-plus-award-fee (CPAF) contract on 25 November 1968, at a cost of \$11,559,159, which included a 3 percent base fee of \$336,674. This contract (DA-AH01-68-C-2155) was funded with \$3 million in FY 1968 funds and the balance with FY 1969 funds. It covered production and product engineering, product improvement, special acceptance inspection equipment, and maintenance of the technical data package.⁷

(U) During FY 1969, the total projected RDTE cost of the TOW system increased from \$102,285,000 for the 1962-71 period,⁸ to \$109,256,000 for the 1962-72 period.⁹ The Army Missile Command awarded Hughes Aircraft a CPIF R&D contract on 1 July 1968, covering the period from 1 July 1968 through 31 July 1969. The total target price, including fee, was \$901,752. This contract (DA-AH01-69-C-0004) provided program management, development engineering, qualification and reliability testing of any unqualified subassemblies, maintenance of TOW equipment, engineering support of ET/ST and XM-70 trainer test, and engineering service to correct deficiencies.¹⁰ On 25 February 1969, Hughes Aircraft received another R&D contract (DA-AH01-69-C-1084) for \$746,000 for redesign of the missile container which failed to meet design requirements for durability.¹¹

⁶(1) TOW PMP, 30 Jun 69, p. I.2.6. HDF. (2) Hist Rept, TOW PM, FY 69, p. 6. HDF. (3) TOW Adv Proc Plan No. 2. Atchd as incl to Ltr, MICOM CofS, thru CG, AMC, to Dir of Mat Acq, OASA(I&L), 5 Mar 69, subj: Adv Proc Plan for TOW Wpn Sys. HDF. (4) *Defense Industry Bulletin*, Apr 69, p. 25.

⁷(1) Hist Rept, TOW PM, FY 69, as revised 29 Oct 69. HDF. (2) SS AMSMI-I-160, D/P&P, 11 Oct 68, subj: Req for Pre-Awd Apprl of TOW FY 69 Engrg Svcs, DA-AH01-68-C-2155. HDF.

⁸See above, p. 40.

⁹TOW PMP, 30 Jun 69, p. III.12.4. HDF.

¹⁰(1) *Ibid.*, p. 1.2.6. (2) Hist Rept, TOW PM, FY 69, p. 5. HDF.

¹¹(1) *Ibid.*, pp. 2-3. (2) Also see below, pp. 90-91.

Conclusion of the ET/ST Program

(U) Engineering service tests of the basic TOW weapon system began in December 1966 and were completed in June 1969. Additional testing scheduled for completion by early 1972 included environmental (tropic, desert, and arctic) tests; ET/ST of the battery charger, trainer, land combat support system, and night sight; and countermeasures/radio frequency interference, nuclear vulnerability, and launcher equipment rough handling tests.

(U) The flight test phase of the program, begun in March 1967, consisted of 63 firings at White Sands Missile Range (WSMR) and 42 firings by the U. S. Army Infantry Board (USAIB) at Fort Benning, Georgia. Also included in the Army Test and Evaluation Command (TECOM) test report were 10 engineering design/engineering test firings at Fort Greely, Alaska, all of them fired from the ground mount against fixed targets. The ET/ST firings were conducted against fixed and moving targets at ranges from 65 to 3,000 meters. In addition, two missiles were fired at drones flying beyond the range capability of the system. Fifty-five of the 105 ET/ST rounds were fired from the basic ground mount, 22 from the M151 jeep, 17 from the M113 vehicle, and 11 from the M274 vehicle. Except for two remotely fired missiles, the engineering test rounds at WSMR were fired by a crew of eight military members and one civilian. The service tests at Fort Benning were conducted by a crew of 13 military personnel. Seven of these men had school training on the TOW and the other six had from 2 to 3 hours of field training. Seven out of nine rounds fired by the field-trained gunners scored direct hits.

(U) Fifteen of the 63 missiles fired at WSMR had been subjected to transportation tests on vehicles (M113, M151, and M274) and rough handling tests at Aberdeen Proving Ground. The Yuma Proving Ground conducted malfunction parachute drop tests on two missiles, and the U. S. Army Airborne, Electronics, and Special Warfare Board (USAAE&SWB) conducted normal airdrop tests using six missiles, a complete launcher system, and vehicles with TOW adapter kits. The latter six missiles were then fired by the Infantry Board as part of the 42 tests mentioned above. The launcher system and vehicles which had been airdropped were used for the service test. All six of the airdropped missiles scored hits on stationary targets at 3,000 meters.¹²

¹²(1) TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5400-01 (8-MI-000-TOW-005), Vol. I & II, Aug 69, subj: IE&ST of TOW HAW Sys. (2) USAIB Rept, ST of HAW (TOW), 30 Oct 68. Both in TOW Proj Ofc.

Reliability

(U) As stated in the preceding chapter, the TOW ET/ST program was suspended in August 1967 because of a low missile reliability figure of 67 percent for the first 41 firings. The flight tests were resumed at Fort Benning on 20 November 1967 and at White Sands on 6 December 1967, using the improved 400-series missile.¹³ By early May 1969, 74 missiles of the post-400 series had been fired, including 10 at the Arctic Test Center, Fort Greely, Alaska. Seven of these were failures, 2 were scored as no test (NT), and 65 were successful for a flight reliability of 90 percent. Indicative of the vast improvement in reliability was the fact that the last 45 missiles of the post-400 series were fired without a single failure. When considering only the 63 valid firings at White Sands and Fort Benning, the flight reliability of the post-400 series missile was 94 percent, just short of the 95 percent required by the QMR. The overall flight reliability for the 112 valid rounds of all series fired during the test program was 82 percent.¹⁴ Table 2 contains a tabulated summary of all rounds fired in the ET/ST program, together with an account of the failure modes for the 20 unreliable rounds.

Accuracy and Range

(U) Both pre- and post-400 series missiles fired with old and new configuration launchers were considered in the accuracy analysis because the hardware differences did not significantly affect system accuracy. Accuracy in firing was defined as the probability of the missile hitting a 2.3-meter square QMR target, given a reliable system. Only the rounds fired by gunners against a visible scoring target were considered in the overall analysis. Of the 115 rounds fired, 29 were scored as no test, 16 missed the target, and 70 (81.4 percent) were accurate.

(U) The results of the tests showed that firings against targets between 65 and about 150 meters and crossing at the QMR speed of 35 kph would not meet the accuracy requirement. At target angular rates higher than about 65 milliradians/second, accuracy would begin to deteriorate.

¹³ See above, pp. 70-72.

¹⁴ TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5400-01 (8-MI-000-TOW-005), Vol. I & II, Aug 69, subj: IE&ST of TOW HAW Sys. TOW Proj Ofc.

TABLE 2—(U) RELIABILITY OF ET/ST MISSILES

Agency	Pre-400 Series				Post-400 Series				All Series			
	Yes	No	NT	Total	Yes	No	NT	Total	Yes	No	NT	Total
WSMR	21 (65%)	11	0	32	30 (97%)	1	0	31	51 (81%)	12	0	63
USAIB	6 (75%)	2	1	9	29 (91%)	3	1	33	35 (87%)	5	2	42
Arctic	0	0	0	0	6 (67%)	3	1	10	6 (67%)	3	1	10
Total:	27 (67%)	13	1	41	65 (90%)	7	2	74	92 (82%)	20*	3	115

* Summary of TOW Failure Modes

	WSMR [#]	USAIB (Ft Benning)	Arctic Test Center	Total
Number of Unreliable Rounds	12	5	3	20
Failure Modes:				
Wire Link	2	1	1	4
IR Source	3	0	1	4
Missile Harness, Electronics, or Gyro Failure	8	4	1	13
Launcher Electronics	1			1

[#]More than one failure mode was noted on one missile.

SOURCE: TECOM/WSMR TOW Rept 13, USATECOM Proj 8-4-5400-01 (8-MI-000-TOW-005), Vol. I & II, Aug '69, subj: IE&ST of TOW HAW Sys. TOW Proj Ofc.

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(U) The accuracy required versus attained values was as follows:

<u>Required</u>	<u>Target</u>	<u>Attained</u>
0.90	65 to 1,500 meters, fixed	1.00
0.75	1,500 to 2,000 meters, fixed	0.95
0.75*	1,500 to 3,000 meters, fixed	0.97
0.75	65 to 2,000 meters, moving	0.75
0.75*	65 to 3,000 meters, moving	0.71
0.90*	65 to 2,000 meters, all	0.83

*Desired

Immunity to Interference

(C) The TOW could not be fired directly into the sun because of possible eye damage and guidance interference. Firings at sun angles of between 3° and 12° would cause guidance interference and some reduction in hit probability. Firings at sun angles of 12° or greater did not affect system performance. Electronic counter-measures testing was scheduled to be completed by December 1969. The TOW system was not susceptible to interference from radios organic to the TOW vehicles if the radios were at least 50 feet from the firing installation. Interference at distances less than 50 feet was dependent upon transmitter power level and frequency and would result in some reduction in hit probability, especially at longer ranges.

Lethality

(C) The requirement to defeat the quadripartite Type III heavy tank target was met; i.e., the TOW warhead could defeat a minimum of 16 inches of armor or 6 feet of reinforced concrete when fired at 0° obliquity. In the course of the ET/ST program, the safety and arming unit housing and the flight motor squib wire leads were insulated to eliminate premature warhead detonation, and the crush-switch lead was rerouted to eliminate unbalance of explosive loading in the warhead. Advance production engineering (APE) HEAT warheads (XM-207E1) were tested along with the older configuration XM-207 warhead.

Durability

(U) Overall durability of the ground launcher was satisfactory,

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but the vehicle adapter kits needed to be ruggedized. The pallet assembly latches were not durable, were difficult to operate, and came open when being transported. The flexible straps and springs had a tendency to rust, bend, and break, and the screws became loose and fell out. In addition, the leveler coupling on the tripod failed at the junction of the locking handle and the clamp. Many of the problems with the adapter kits were corrected in the course of the test program, but additional tests were required to confirm these corrections.

(U) With exception of its container, the missile generally met the design requirements for durability, but it would require careful handling and transportation to avoid possible damage from accidental drops on hard surfaces. The aft portion of the missile container was ruptured on two occasions causing a potential safety problem. An aluminum safety shield provided adequate protection for the remaining firings, but its use was not tactically feasible. The redesigned container was yet to be evaluated by the Test and Evaluation Command.

Weight and Portability

(U) The TOW system failed to meet the weight requirement specified in the QMR. The weight of the ground mount, traversing unit, sight/sensor, launch tube, and guidance set (including battery) was 173 pounds, which exceeded the QMR requirement by 13 pounds. The missile in its container (latest 400-series model) weighed about 50 pounds, which exceeded the QMR by 8 pounds. This additional weight, however, did not adversely affect the operational capability or portability of the TOW system. The weight and portability characteristics of the TOW system, compared with those of the M40 106mm recoilless rifle (RCLR), are shown below.

	<u>M40 RCLR</u>	<u>TOW System</u>
WEIGHT: Launcher System	480 lbs.	173 lbs.
1 rd Ammunition	<u>38 lbs.</u>	<u>50 lbs.</u>
Total	518 lbs.	223 lbs.
PORTABILITY: Time for 4 men to move launcher and one missile (or round) 3,218 meters (2 miles) over cross-country terrain	Crew exhausted after moving 100 meters in 30 minutes	About 90 minutes

Equipment Performance Reports (EPR's)

(U) In the course of the ET/ST program, a total of 200 EPR's were prepared by all TECOM test agencies. Thirty-three of these were originally classified as deficiencies* and the remaining 167 as shortcomings.** Most of the shortcomings were corrected during the test program. Many of the reported deficiencies were related to the same type of failure and some were reported more than once by different test agencies. A consolidation of similar deficiencies reduced the number from 33 to 12. Of these, three were closed out and tested, five were closed out but not tested, and four remained open. The open deficiencies consisted of the following: penetration of the launch container by propellant particles; failure of adapter kit pallet assembly latches; self-test and flight radio frequency interference from nearby radio transmission; and correction of the Preliminary Operating and Maintenance Manual (POMM) to indicate safe firing angles. With respect to the latter, the gunners experienced excessive launch overpressure when firing at an elevation greater than 20°, whereas the POMM stated that the system could be safely fired up to 30° elevation.

Conclusions.

(U) The test agencies concluded that the TOW weapon system was accurate, portable, easy to maintain, and simple to operate;

* A deficiency is a defect or malfunction discovered during the life cycle of an equipment that constitutes a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability. A deficiency normally disables or immobilizes the equipment, and if occurring during the test phases, will serve as a bar to type classification action. AR 310-25, 15 Sep 75.

** A shortcoming is an imperfection or malfunction occurring during the life cycle of equipment, which should be reported and which must be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the materiel or end product. If occurring during test phases, the shortcoming should be corrected if it can be done without unduly complicating the item or inducing another undesirable characteristic, such as increased cost, weight, etc. AR 310-25, 15 Sep 75.

that it provided a major improvement over the M40 recoilless rifle as an antitank weapon; and that it would be suitable for U. S. Army use in temperate environments when the deficiencies and as many as possible of the shortcomings were corrected.¹⁵

Development Acceptance IPR

(U) The purpose of the TOW development acceptance IPR, held at MICOM on 13-14 August 1969, was to present substantiating data that system conformance with the QMR was sufficient to justify continued production and a 1-year extension of the LP classification for FY 1970 procurement. The TOW system had been approved for LP on 22 April 1968 to cover only the FY 1969 first-year production buy.* The D&F approved by the Assistant Secretary of the Army (Installations and Logistics) in May 1968 authorized the negotiation of FY 1969 and 1970 buys. Under authority of this D&F and using the missiles and associated hardware contained in the approved FY 1969 program, MICOM had awarded Hughes Aircraft a 2-year multiyear contract, and the Chrysler Corporation a single-year contract for a small educational quantity to develop a second production source. In order to proceed with FY 1970 procurement, as visualized in the approved D&F, it was essential that the LP authority be extended and the second year's contract with Hughes be executed by 1 October 1969.

(U) The development acceptance IPR concluded that the TOW weapon system provided a major improvement over the 106mm recoilless rifle which it was to replace, and recommended that LP authority for FY 1970 procurement be extended from 1 October 1969 through September 1970. A review of the flight, laboratory, and field tests conducted through July 1969 showed that there were some deficiencies in meeting the existing QMR, but these were not considered a bar to fielding the system or continuing production. The reviewers agreed to change the QMR weight requirements to reflect current system characteristics, and several other requirements were either redefined or cited for further study and analysis before making a decision.

(U) The change in system weight requirement was to specify the

* LP authority for FY 1969 procurement was subsequently extended from April 1968 to 30 June 1969, thence to 30 September 1969.

¹⁵ (1) *Ibid.* (2) USAIB Rept, Svc Test of HAW (TOW), 30 Oct 68. TOW Proj Ofc.

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current weight (production missile, 54 lbs.; launcher, 173 lbs.) as acceptable and the original requirement (42 lbs. and 160 lbs., respectively) as desirable. Also, the QMR for ancillary night vision equipment then under development would be changed to reflect an acceptable weight of 58 lbs., with 45 lbs. desirable.

(C) Requirements relating to hit probability against crossing targets were redefined. The QMR specified a hit probability of 75 percent against 2.3-meter square targets moving at 35 kph from a minimum safe arming distance to 2,000 meters. The ET/ST results showed that this requirement could be met only at ranges beyond 150 meters; whereas tank size targets (2.3 meters by 4.6 meters) moving at 35 kph could be hit at all ranges. It was therefore agreed that the QMR for a crossing target should be defined as 2.3 meters by 4.6 meters.

(U) While the hardware reliability achieved in ET/ST (post-400 series missile 90%; launcher preflight 94%; launcher inflight 100%) fell slightly short of that specified in the QMR, the reviewers concluded that the fly-before-buy test program, together with a good contractor quality assurance program, should assure a fully reliable TOW weapon system in the Army inventory.

(C) System limitations stemming from susceptibility to electromagnetic countermeasures, solar effects, and radio frequency interference were to be further investigated with a view toward eliminating the problems or redefining existing requirements. The system design changes resulting from these and other deficiencies noted in the ET/ST report were to be confirmed by TECOM during the production validation tests scheduled to begin in November 1969.¹⁶

(U) The Office, Chief of Research and Development approved the development acceptance IPR on 19 September 1969.¹⁷ A week later, the Assistant Chief of Staff for Force Development extended the LP classification authority through 30 September 1970 for both the previously approved FY 1969 quantities and the following

¹⁶ (1) Mins of TOW Dev Acceptance (DEVA) IPR, 13-14 Aug 69. Atchd as incl to AMCTCM 7254, 25 Nov 69. (2) Ltr, DCG, AMC, to ACSFOR, 9 Sep 69, subj: Extension of LP TCLAS (LPTC) for TOW Wpn Sys. Atchd as incl to AMCTCM 7402, 14 Jan 70. Both in RSIC.

¹⁷ 1st Ind, OCRD, DA, to CG, AMC, *et al.*, 19 Sep 69, on Ltr, DCG for Mat Acq, AMC, to CRD, DA, 2 Sep 69, subj: TOW DEVA IPR. Atchd as incl to AMCTCM 7254, 25 Nov 69. RSIC.

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additional quantities for FY 1970 procurement:¹⁸

Guided Missile, Surface Attack, XBGM-71A	15,513 [*]
Guided Missile, Practice, XBTM-71A	3,929 ^{**}
Launcher, Tubular, Guided Missile, XM-151E2	350
Mounting Kit, Vehicle, XM-233 (M113)	360
Training Set, Guided Missile System, XM-70	49
Charger, Battery, PP 4884 (XO-1)/T	61

*1,748 funded in FY 1971

**937 funded in FY 1971

Revival of TOW/SHILLELAGH Competition

(U) The FY 1970-71 PEMA programs were threatened by a revival of the TOW/SHILLELAGH duplication syndrome. It will be recalled that the feasibility of using the TOW in both the HAW and Combat Vehicle Weapon System (CVWS) antitank roles was investigated in 1962 at the behest of the Director of Defense Research and Engineering (DDRE). The DDRE policy guidance at that time stated that if both the TOW and SHILLELAGH were successful and either could fill both antitank roles, only one of the weapons would be continued through development and production. The Ballistic Research Laboratories (BRL) study indicated that, while the TOW and SHILLELAGH very likely could be developed in a version that would be usable in both applications, the selection of either weapon to fulfill both roles would mean the acceptance of less than the best system for one role or the other. The Hughes Aircraft study concluded that a dual-purpose TOW missile could be designed to meet both the HAW and CVWS requirements; however, solutions to some of the engineering problems were yet to be proven and there was some doubt that the economic and logistic advantages would offset the performance penalties inherent in such a system. For these and other reasons, it was decided to proceed with development of TOW for the HAW role and the SHILLELAGH for the CVWS role.¹⁹

(U) In the fall of 1969, MICOM learned that higher headquarters was again giving consideration to replacing the TOW with the SHILLELAGH system. The Department of the Army reduced the TOW FY

¹⁸1st Ind, ACSFOR, DA, to CG, AMC, 27 Sep 69, on Ltr, DCG, AMC, to ACSFOR, 9 Sep 69, subj: Extension of LP TCLAS (LPTC) for TOW Wpn Sys. Atchd as incl to AMCTCM 7402, 14 Jan 70. RSIC.

¹⁹See above, pp. 22-25.

1970 PEMA program from \$156 million to \$142 million. The House Armed Services Committee (HASC) then deleted the entire program from the FY 1970 budget on 25 September 1969. The committee report pointed out that the range, accuracy, and lethality of the TOW and SHILLELAGH were virtually identical, but that TOW was twice as expensive. The committee suggested that the guidance and control elements of the SHILLELAGH could be repackaged so that SHILLELAGH could replace the more expensive TOW in its ground role.²⁰

(U) In a letter to Congressman L. Mendel Rivers in October 1969, the Secretary of the Army argued that, in full production, the cost of TOW would be about equal to the SHILLELAGH and that converting SHILLELAGH to the ground role would be expensive in terms of time and money.²¹ After review of an Aeronutronic proposal for adapting the SHILLELAGH missile to the HAW and air-borne antitank roles in place of the TOW, DDRE concluded that this adaptation might present potential cost savings to the Government. However, in view of the urgent requirement for the TOW and the 3-year delay involved in fielding an equivalent SHILLELAGH HAW system, he recommended that the TOW/HAW FY 1970 PEMA program be reinstated. He further recommended a reassessment of the TOW and SHILLELAGH for the helicopter antitank missile role.²²

(U) On 4 November 1969, a joint HASC and Senate Armed Services Committee (SASC) conference restored \$100 million to the FY 1970 TOW program with the agreement that TOW and SHILLELAGH would be reevaluated in both the air and ground roles.²³ This compromise bill later survived stiff opposition from Congressman Samuel S. Stratton (D-N.Y.) who called the TOW a "billion-dollar boo-boo" and a "wasteful duplication" of the SHILLELAGH missile which was already in production.²⁴

(U) Congressional opposition to the TOW was carried over into

²⁰(1) TOW PMP, 30 Jun 69, p. III.12.1. (2) TOW PMP, 31 Mar 70, p. I.2.4. Both in HDF. (3) DA Study of Cost Growth in Acq of the TOW Wpn Sys (draft), 27 Jul 76, p. 10. TOW Proj Ofc.

²¹*Ibid.*

²²Ltr, DDRE to Hon. John Stennis, Chmn, Com on Armed Svcs, U. S. Senate, 6 Apr 70. HDF.

²³(1) TOW PMP, 31 Mar 70, p. I.2.4. HDF. (2) DA Study of Cost Growth in Acq of the TOW Wpn Sys (draft), 27 Jul 76, p. 11. TOW Proj Ofc.

²⁴*The Huntsville Times*, 6 Dec 69, p. 1.

hearings on the FY 1971 budget. Early in April 1970, MICOM personnel went to Washington to brief AMC, DA, DOD (DDRE), and HASC on the results of the Army's detailed evaluation of Aeronutronic's proposal to use SHILLELAGH in lieu of TOW in the HAW role.²⁵ Following these briefings, DDRE advised the Chairman of the Senate Committee on Armed Services that he concurred with the Army's findings that procurement of the TOW for the HAW role should be continued.²⁶ In testimony before the House Armed Services Committee, GEN Bruce Palmer, Jr., the Army Vice Chief of Staff, reiterated the Army's conclusions that procurement of the TOW should be continued and that "we should discontinue our efforts to compare the TOW to the proposed SHILLELAGH ground system." The detailed studies, he said, showed that 4 years would be required to provide an acceptable SHILLELAGH/HAW system with no expectation that it would be better than the TOW and with no cost savings.²⁷

(U) The House Armed Services Committee still was not convinced, however. Its report with regard to the TOW/SHILLELAGH stated that the committee refused to approve the request for \$106 million for FY 1971 TOW missile procurement. Instead, \$106 million was approved for the HAW, with the stipulation that the Army (1) conduct tests, if necessary, to determine the adaptability of SHILLELAGH to the HAW role, and (2) solicit bids from TOW/SHILLELAGH producers. The low bid would determine which of the two missiles would fulfill the HAW role. Assuming that the final appropriations bill would contain language similar to that in the HASC report, the Assistant Secretary of the Army (Installations and Logistics) directed MICOM to proceed with the development of plans and schedules to minimize the impact. The results of the exercise showed, among other things, that it would cost \$1,435,785 to arrive at a HAW buy decision through the process imposed by HASC. The estimate for the 8-month program included a total of \$1,172,540 for Aeronutronic and Hughes to furnish contract definitions and \$263,245 for in-house support, excluding AMC costs.²⁸

²⁵ Trip Rept, 28 Apr 70, subj: TOW vs SHIL/HAW Cost Comparison. HDF.

²⁶ Ltr, DDRE to Hon. John Stennis, Chmn, Com on Armed Svcs, U. S. Senate, 6 Apr 70. HDF.

²⁷ DA Review of Pps1 for SHIL HAW Before HASC, FY 71. Atchd to Trip Rept, 28 Apr 70, subj: TOW vs SHIL/HAW Cost Comparison. HDF.

²⁸ (1) Ltr, ASA(I&L) to CG, AMC, 18 May 70, subj: Hv AT Wpn (HAW). (2) DF Cmt #2, D/P&P to Dep for Land Cbt Sys, 29 Apr 70, subj: HAW Proc. Atchd to SS AMSMI-I-71-70, 1 Jun 70, subj: Hv AT Wpn (HAW). Both in HDF.

(U) The TOW/SHILLELAGH controversy was partially settled in September 1970, when the Joint Session of Congress voted to continue with the TOW in the HAW role, and approved \$106,300,000 for FY 1971 procurement.²⁹ But the TOW/SHILLELAGH competition in the airborne role was yet to be resolved.

(U) An investigation of the merits of the TOW versus SHILLELAGH with the COBRA and CHEYENNE attack helicopters showed that total program costs were less for TOW in each case. For the COBRA, the comparison was \$240 million (TOW) versus \$268 million (SHILLELAGH); and for the CHEYENNE, \$99 million (TOW) versus \$129 million (SHILLELAGH), these figures including missile costs. The investigation considered the shorter development time necessary for TOW and the fact that TOW performance exceeded that of SHILLELAGH in certain instances, range when fired from hover and sun interference being two cases in point. The net results were program cost differentials of \$28 million (with COBRA) and \$30 million (with CHEYENNE), exclusively favoring TOW for use with both helicopters.³⁰

FY 1970 Procurement

(U) Funds released for support of the FY 1970 program totaled \$115,413,000. The largest share of the total, \$108,804,000, came from PEMA funds, \$100 million being programmed for production hardware and industrial engineering services, and \$8,804,000 for production base facilities and selected repair parts. RDTE funds amounting to \$2,102,000 provided for continued development and test programs. The remainder of the funds, \$4,507,000, consisted of OMA money for maintenance support and central services.³¹

(U) As a result of the cut in FY 1970 TOW production funds from \$156 million to \$100 million, missile production was reduced by 9,042, from 19,442 to 10,400, and launcher production from 350 to 174. The number of missiles programmed for procurement under the second year of Hughes' multiyear contract (C-2141) was reduced by 6,357 (from 16,757 to 10,400) and the 2,685 missiles scheduled for procurement under options to Chrysler's educational buy contract

²⁹Hist Rept, TOW PM, FY 71, p. 1.

³⁰Rept, Cost Benefit Economic Analysis—A Management Tool for Decision Making in AMC, Nov 71, p. 19. HDF.

³¹(1) Hist Rept, TOW PM, FY 70, p. 1. HDF. (2) TOW PMP, 31 Mar 70, pp. III.12.1 - III.12.5. HDF.

(C-0928) were deferred to FY 1971. With the decrease in FY 1970 production, the ceiling price of Hughes' multiyear contract was lowered from \$168,234,958 to \$142,031,360. The target price of the contract as of 30 June 1970 was \$120,983,146.

(U) The cost of Chrysler's educational buy contract for 200 missiles in FY 1969 increased \$456,450 (from \$2,943,550 to \$3,400,000). This cost growth was attributed to engineering changes and to a slip in schedule caused by late delivery of Government-furnished special test equipment. There was also a small increase of \$55,022 in the cost of the two options for 2,685 missiles (from \$14,057,955 to \$14,112,977). These increases raised the total cost of the 2,885 missiles from \$17,001,505 to \$17,512,977.³²

(U) The FY 1970 requirements for launchers (less tripod, launch tube, and battery assemblies), trainers, and a major portion of the repair parts were procured on a sole source basis from Hughes Aircraft under letter contract DA-AH01-70-C-0318 issued on 3 December 1969. This letter order was definitized on 1 June 1970 into a CPIF contract for 174 launchers, 18 trainers, and field service requirements for spares. The total value of the contract as of 30 June 1970 was \$16,400,000. A quantity of 244 XM-233 mounting kits, launcher tripods, and overpacks were procured by formal advertising from the Thompson International Corporation, G. W. Galloway Company, and Great Southern Wirebound Box Company, respectively.³³

(U) On 29 August 1969, Hughes received a notice of award for FY 1970 industrial engineering services. The letter order was definitized on 19 December 1969 into a \$9,185,848 CPAF contract (DA-AH01-70-C-0209) calling for the improvement, refinement, and maintenance of the TOW weapon system for the 12-month period beginning 1 September 1969. Work under this contract would be controlled by individual engineering service memoranda covering specific efforts.³⁴

(U) Hughes Aircraft initiated the FY 1970 research and development effort (Phase VIII) under a notice of award issued on 31

³²(1) Hist Rept, TOW PM, FY 70, p. 3. HDF. (2) MICOM An1 Hist Sum, FY 70, p. 41.

³³(1) Hist Rept, TOW PM, FY 70, p. 6. HDF. (2) Contr List, TOW Proj Ofc. HDF.

³⁴(1) Hist Rept, TOW PM, FY 70, p. 4. HDF. (2) TOW PMP, 31 Mar 70, p. I.2.7. HDF.

July 1969. The notice was definitized on 12 November 1969 into a combination CPIF and CPFF contract (DA-AH01-70-C-0097) with a performance period from 1 August 1969 through 31 July 1970. The CPIF portion provided for development of a solid state beacon and continuation of the counter-countermeasures effort. The CPFF part covered maintenance of R&D equipment and performance of special studies as directed by the technical supervisor. The total contract amount was \$1,304,718.³⁵

Initial Production Tests

(U) The first production milestone was met in August 1969 when Hughes Aircraft delivered 25 TOW missiles in accordance with the contract schedule. Beginning on 26 August and continuing through 22 December 1969, Hughes Aircraft fired 33 TOW missiles at Redstone Arsenal to verify the adequacy of the production processes for delivering reliable missiles. Fifteen of the 33 rounds were equipped with practice warheads, 14 with dummy (telemetry) warheads, and 4 with tactical (HEAT) warheads. Five of the rounds were fired against moving targets at ranges from 130 to 270 meters, and 28 against fixed targets at ranges from 2,000 to 3,000 meters. The first 21 rounds were fired from the R&D launcher and the remaining 12 rounds from the first production launcher which was delivered on 31 October 1969, along with the first battery charger. One of the firings was ruled as no test for missile reliability. Of the remaining 32 rounds, 29 were successful, yielding a missile reliability of 90.6 percent. Twenty-eight of the 29 reliable rounds scored accurate hits.³⁶

(U) The Army Test and Evaluation Command (TECOM) began initial production tests (IPT's) of the basic ground-mounted TOW system in January 1970 and completed the 98-round program in late April 1970. The firings were conducted at Redstone Arsenal under the direction of White Sands Missile Range. The objectives of the IPT program were to determine the suitability of production hardware for release to the field, to evaluate system performance against the QMR, to determine whether the deficiencies and shortcomings found during the ET/ST had been corrected, and to evaluate engineering changes made after completion of the ET/ST. Sixty-eight of the 98 IPT rounds were equipped with dummy (telemetry) warheads and 30

³⁵ (1) *Ibid.* (2) Hist Rept, TOW PM, FY 70, p. 3. HDF.

³⁶ (1) TOW PMP, 31 Dec 69, pp. I.2.4, I.2.9, & III.9.5. HDF.
(2) TOW Test Data Furnished by Edwin E. Baker, TOW Proj Ofc.

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with HEAT heads. All of them were fired from the ground-mounted tripod using the production launcher. Forty-four of the rounds were fired at moving (32 to 50 kph) targets located at various ranges between 65 and 3,000 meters, and 54 at stationary targets located between 350 and 3,000 meters from the launch site. Ten of the missiles were remotely fired and therefore were scored as no test for hit accuracy. Gunners for the remaining 88 rounds consisted of 1 civilian and 3 military personnel.

(U) The reliability and hit probability values demonstrated in the IPT's were about the same as those achieved in the post-400 series ET/ST firings. Of the 98 IPT missiles fired, 89 functioned and 9 were failures, yielding an overall reliability of 90.8 percent. The overall hit probability was about 80 percent. There were 19 no tests (including the 10 unmanned firings), 16 accuracy failures, and 63 target hits.

(U) The required accuracy (probability of hit, given a reliable system) versus attained values in IPT and ET/ST was as follows:

<u>Required</u>	<u>Target Conditions</u>	<u>Attained IPT</u>	<u>Attained ET/ST</u>
0.90	65 to 1,500 m., fixed	0.83	1.00
0.75	1,500 to 2,000 m., fixed	0.85	0.95
0.75*	1,500 to 3,000 m., fixed	0.94	0.97
0.75	65 to 2,000 m., moving	0.87**	0.75**
0.75*	65 to 3,000 m., moving	0.81**	0.71**
0.90*	65 to 2,000 m., all	0.86**	0.83**

* Desired

** Moving target IPT firings scored against QMR 2.3 x 4.6 m. target.
Moving target ET/ST firings scored against QMR 2.3 x 2.3m. target.

Although accuracy decreased at the extreme short and long ranges in IPT's, it decreased to an even greater extent at extreme ranges in ET/ST firings. The IPT improvement was attributed to the revised QMR allowing a wider moving target. Accuracy against IPT crossing targets at ranges of 65 to 132 meters almost met that specified in the QMR and, because of the low probability of engaging crossing targets in this range, no longer represented a significant problem. Accuracy against 3,000-meter moving targets met the desired QMR goal, whereas it did not in ET/ST firings.

(U) All but one of the deficiencies identified in the ET/ST firings had been corrected and one new deficiency occurred during the IPT program. Both of these deficiencies concerned serious

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environmental problems with the launcher system. The missile guidance set (MGS) was still sensitive to vibration and repeatedly failed to pass self test because of leakage to moisture in rain and immersion tests. The new deficiency involved the launcher traversing unit which also lacked waterproofness.

(U) All but 10 of the shortcomings found during ET/ST were corrected or did not recur and 52 new shortcomings were noted during the IPT program. Twenty-seven of the 62 shortcomings were associated with the missile and its overpack, 32 with the launcher, and 3 with the battery charger. The large number of shortcomings found during the IPT program indicated the need for further improvement in quality control procedures.

(/) In addition to the foregoing deficiencies and shortcomings, certain system limitations identified during ET/ST still existed. The TOW still could not be fired directly into the sun at angles of less than 7.3° without guidance interference and possible eye damage, and its accuracy could be adversely affected by gusty cross winds. The system was also susceptible to jamming by infrared radiation and to radio frequency interference.

(/) An analysis of the IPT results indicated that the basic ground-mounted TOW system met all essential characteristics of the QMR with exception of reliability, maintenance, and weight. The reliability of the system still fell short of the 95 percent requirement. Direct and general support maintenance evaluation using the Contact Support Test Set (CSTS) and/or Land Combat Support System was not conducted because a complete maintenance package was not available. The average weight of the initial production test launchers was 176 pounds, which exceeded the revised required weight by 3 pounds. The encased missile met the revised required weight of 54 pounds.

(U) The IPT report concluded that the production configuration TOW missile and launcher would be suitable for release to the field when the two launcher deficiencies and as many of the shortcomings as feasible were corrected. It recommended that correction of the launcher deficiencies be made a condition to type classification and that such corrections be verified by proof and acceptance tests.³⁷

³⁷ Ltr, CG, TECOM, to CG, AMC, & CG, MICOM, 22 Jun 70, subj: Partial Rept of IPT of HAW Sys, TOW, USATECOM Proj No. 8-MI-000-TOW-010, w incl: TECOM TOW Rept 16, Jun 70, IPT of TOW HAW Sys. TOW Proj Ofc.

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(U) Initial production tests of the vehicle mounting kits and battery charger were yet to be completed. Battery charger tests were suspended because of a capacitor failure. Test reports on the XM-232E1 (M151 jeep) and XM-233E1 (M113 APC) mounting kits were expected to be available by 28 August 1970. The TOW Project Manager had deferred initial production of the XM-225 (M274 MULE) and XM-236 (M151 resupply) mounting kits to FY 1971 pending a review of Army requirements. Tests of these kits were scheduled to begin upon receipt of the initial production units in August 1971 and continue through November 1971. Tests of production battery chargers and trainers were scheduled for completion in December 1970 and February 1971, respectively.³⁸

(U) Other TOW production tests conducted during FY 1970 included 35 New Equipment Training firings which began in November 1969 and 28 fly-to-buy firings. At the end of June 1970, a total of 286 production missiles had been fired in all phases of the production test program. The firings demonstrated a 93.6 percent reliability, with 3 firings counted as no test (1 R&D launcher failure and 2 Italian firings over water), 17 missile failures, and 1 production launcher failure. The hit probability, given a reliable system, was 95.1 percent, with one gunner no-test and 12 accuracy failures.³⁹

Production Validation IPR/SSE

(U) By August 1970, the basic design of the TOW weapon system, vehicle mounting kits, and all items of ancillary equipment except the night sight had been completed. The basic weapon system had undergone extensive flight, laboratory, environmental, and field testing, and had successfully completed the transition from development to production. Since the initiation of experimental firings in November 1963, a total of 611 TOW missiles had been fired in all phases of the flight test program, as follows:

³⁸ (1) *Ibid.* (2) Ltr, Chf, Sys Engrg Div, TOW PM Ofc, to CG, WSMR, 25 Feb 70, subj: TOW Veh Kits. HDF. (3) Ltr, TOW PM to CG, TECOM, 28 Apr 70, subj: Init Pdn Testing of TOW Veh Kits. HDF. (4) Incl to Ltr, TOW PM to CG, AMC, 30 Apr 70, subj: TOW DA Milestones Scd - AMC DASSO Feeder Prog Rept (1-30 Apr 70). HDF.

³⁹ (1) Hist Rept, TOW PM, FY 70, pp. 6-7. HDF. (2) Ltr, BG Arthur W. Kogstad, Chmn, TOW SSE, thru CG, AMC, to ACSFOR, DA, 19 Aug 70, subj: TOW PV IPR/SSE, w incl: Mins of TOW PV IPR/SSE, 12-13 Aug 70. Atchd as incl to AMCTCM Item 8176, 15 Dec 70. RSIC.

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<u>Test Phase</u>	<u>Nr. Rounds</u>
Experimental Firings	32
R&D (Ground & Vehicle Mounts)	157
UH-1B Helicopter Firings	61
ET/ST Program	106*
U. S. Marine Corps Firings	20
Demonstration Firings - Europe	4
CHEYENNE Helicopter Firings	3
Other System Demonstration Firings	24
Production Verification (Contractor)	43
Initial Production Tests	98
New Equipment Training (NET) tests	35
Production Acceptance (Fly-to-Buy)	28
	<u>611</u>

* 63 at WSMR; 42 at Ft Benning; 1 at Ft Knox.

(U) The Production Validation In-Process Review and System Status Evaluation (IPR/SSE) for the TOW weapon system was held at MICOM on 12-13 August 1970. The objectives of this meeting were to determine the acceptability of the TOW production missile and launcher for field use and type classification as Standard A, and to recommend an extension of the limited production (LP) classification for the mounting kits and ancillary items.

(S) After a review of the IPT results, members of the committee agreed that the TOW missile and launcher were suitable for type reclassification from LP to Standard A, and that certain changes should be made in the QMR. Specifically, they recommended that the required kill probability, assuming a hit on a vulnerable area, be decreased from 90 to 85 percent, and that the overall weight of the launcher system (ground mount, launcher, fire control group, and power supply) be increased to 180 pounds essential (160 pounds desirable). The demonstrated production configuration reliability of 94 percent versus the 95 percent specified in the QMR, was considered to be acceptable. Recognizing that the existing radio frequency interference limitation was undesirable, the committee recommended the earliest practicable reduction of the restriction to permit full-time operation of radios organic to infantry battalions without interfering with the TOW system. In addition, it recommended that technology be developed to eliminate the system's susceptibility to jamming by infrared radiation. Other system limitations, such as sun interference, cross wind effect, low temperature performance, and missile flight time, were considered to be minor in nature and not a bar to type classification. To assure maximum system availability and operational readiness, the committee recommended that continued emphasis be

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placed on hardware quality assurance, particularly the missile guidance set and battery.

(U) The battery charger, training set, and mounting kits were later in development than the TOW missile and launcher, and therefore were later in completing engineering test/service test (ET/ST) and production acceptance tests. Members of the IPR committee recommended that the limited production classification for these items be extended 20 months, from 1 October 1970 through 31 May 1972. This extension would permit completion of ET/ST and initial production tests of the items involved. Adequate quantities of all ancillary items had already been approved for limited production except for the XM-233E1 (M113 APC) mounting kit. An additional quantity of 152 of these kits would be required for the period through FY 1971. Other items required only an extension of time. The forecast for type classification as Standard A was as follows: XM-232E1 and XM-233E1 mounting kits - January 1971; XM-225 and XM-236 mounting kits - May 1972; battery charger - May 1971; and XM-70 trainer - December 1971.

(U) The night sight was not expected to be ready for type classification and field use until the fall of 1974, some 4 years after initial deployment of the TOW weapon system. The contact support set (formerly known as the Contact Support Test Set—CSTS) with its test and measurement equipment and manuals was being tested and would be available for deployment with the TOW weapon system. It had been type classified for limited production under a separate action approved by the Assistant Chief of Staff for Force Development on 16 June 1970. The Land Combat Support System (LCSS) and LCSS-TOW interface equipment would be tested in November 1970. The test, measurement, and diagnostic equipment and manuals of the LCSS would be available to support the TOW weapon system in March 1971.

(U) The TOW major items procured in FY 1969 and 1970 and the requirements for FY 1971 procurement, together with the worldwide asset position (WWAP) as of 30 June 1970, were as follows:⁴⁰

⁴⁰(1) *Ibid.* (2) Ltr, DCG, AMC, to ACSFOR, 4 Sep 70, subj: TOW Wpn Sys TCLAS Ppsls, w incls: Tech Subcom Rept U-1677 (Type Reclas of Msl & Lchr fr LP-U to Std A) & Tech Subcom Rept U-1674 (Extension of LP-U TCLAS on Ancillary Items). Atchd as incl to AMCTCM Item 8176, 15 Dec 70. RSIC.

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<u>Item</u>	<u>Procured</u>		<u>Rqrd</u>	<u>WWAP</u>
	<u>FY 1969</u>	<u>FY 1970</u>	<u>FY 1971</u>	<u>6/30/70</u>
Guided Missiles				
BGM-71A (HEAT)	4,465	9,543	13,595	1,934
BTM-71A (Practice)	<u>1,085</u>	<u>857</u>	<u>2,090</u>	
	5,550	10,400	15,685	
Launchers, M151	211	174	350	109
Mounting Kits				
XM-233 (M113 APC)	56	244	268	48
XM-225 (MULE)	0	0	86	0
XM-232 (M151 Jeep)	45	0	0	42
XM-236 (M151 Resupply)	0	0	45	0
Trainers, XM-70	77	18	7	62
Battery Charger	56	0	7	36

Type Classification and Initial Deployment

(U) The Assistant Chief of Staff for Force Development (ACSFOR) approved the findings and recommendations of the TOW Production Validation IPR/SSE on 30 September 1970, at which time the following items were reclassified from LP to Standard A:

Guided Missile, Surface, Attack, BGM-71A
Guided Missile, Practice, BTM-71A
Guided Missile, Surface, Attack, Telemetry, BEM-71A
Launcher, Tubular, Guided Missile, M151 (XM-151E2)

The LP classification for mounting kits and ancillary items was extended as follows:⁴¹

<u>Item</u>	<u>Expiration Date</u>
XM-233 & XM-232 Mounting Kits	31 March 1971
XM-225 & XM-236 Mounting Kits	30 June 1972
XM-70 Training Set	31 March 1972
Battery Charger	30 June 1971

(S) The initial distribution and deployment of the TOW weapon system were based on the approved procurement of 735 launchers

⁴¹AMCTCM Item 8176, 15 Dec 70, w incls: Ltr, ACSFOR, DA, to CG, AMC, *et al.*, 30 Sep 70, subj: TOW Wpn Sys, and Ltr, same to same 8 Oct 70, subj: same. RSIC

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during the FY 1969-71 period. Of these, 608 were allocated for support of the tactical Army Authorized Acquisition Objective (AAO) and 127 for support of nontactical programs. The Anniston Army Depot was officially assigned as the TOW mission depot during 1970, and the installation of maintenance facilities was completed in November 1971.⁴²

(U) The CONUS TDA training base was equipped in August 1970 and three training battalions became operational in September 1970. Launchers and ancillary equipment were distributed to the U. S. Army Infantry School (USAIS), Fort Benning, Georgia; U. S. Army Armor School, Fort Knox, Kentucky; U. S. Army Missile and Munitions Center and School (USAMMCS), Redstone Arsenal, Alabama; the U. S. Army Training Center (USATC) Infantry, Fort Jackson, South Carolina; and the U. S. Army Ordnance Center and School (USAOC&S), Aberdeen, Maryland.

(U) Resident training on the TOW began during the first quarter of FY 1971. Familiarization and orientation training was integrated into several courses for commissioned and noncommissioned officers at the USAIS, Fort Benning, Georgia, by 31 August 1970. The first class of TOW gunners graduated from the USATC, Infantry, Fort Jackson, on 13 September 1970. The first class in the TOW repairman resident course graduated from the USAMMCS, Redstone Arsenal, on 4 December 1970. The 1st Battalion, 29th Infantry, and the 1st Battalion, 58th Infantry, 197th Infantry Brigade at Fort Benning, and the 4th Battalion, 54th Infantry, 194th Armored Brigade at Fort Knox were equipped and operational after undergoing training at Fort Benning.

~~(S)~~ Distribution of launchers to U. S. Army, Europe (USAREUR) began in September 1970, and the first unit was equipped by 13 November 1970. A combined training/equipage program provided for the equipage of three battalions per month as each was cycled through a training program at the Seventh U. S. Army Combined Arms School and concurrently issued their TOE equipment. Twenty-four divisional battalions were equipped with six launchers each by the end of the year. A second round of an additional six launchers per battalion was to follow in July 1971.⁴³

(U) The TOW missile did not require any tests, checkouts, or

⁴² (1) Mins of TOW PV IPR/SSE, 12-13 Aug 70, *op. cit.*, p. 6. (2) Hist Rept, TOW PM, FY 71, p. 6. (3) TOW RECAP by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 8 Jan 74, p. 50. HDF.

⁴³ Hist Rept, TOW PM, FY 71, pp. 4-6. HDF.

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repair prior to firing. Minimum maintenance and repair parts would be required to support the launcher, the XM-70 training set, and auxiliary TOW equipment. The launcher had self-test features which provided fault isolation to the major assembly level. The Land Combat Support System (LCSS) began supporting the deployed TOW system on 1 March 1971.⁴⁴

(U) Initial production tests of the XM-233E1 (M113A1) and XM-232E1 (M151A1 Lead Jeep) mounting kits were successfully completed in July 1970, and these assemblages were reclassified from LP to Standard A on 20 August 1971. The estimated program unit cost of these items in quantity procurement was as follows:⁴⁵

Mounting Kit, M233 (Unmounted)	\$4,667
M113A1 APC with M233 Mounting Kit Installed	40,569
Mounting Kit, M232 (Unmounted)	6,589
M151 Truck with M232 Mounting Kit Installed	11,015

(U) A breakdown of the battery charger equipment during high voltage tests, together with the long leadtime required on repair parts to modify the equipment for complete retest, necessitated an extension of the LP classification from 30 June 1971 to 30 June 1972. The LP classification for the XM-70 training set was also extended, from 31 March 1972 to 30 June 1972.⁴⁶

(U) The XM-70 training set was reclassified from LP to Standard A on 18 November 1972, following an IPR in September 1972. The estimated program unit cost of this item in quantity procurement was \$22,300. The M70 trainer consisted of an instructors console which monitored the gunner's performance in dry firing exercises and provided a visual display of the results; a target source with a power supply modulator to simulate the infrared source in the missile; a target board that served as an aimpoint reference for the gunner; and the missile simulation round for handling and firing familiarization. The missile simulation round was identical

⁴⁴ (1) Mins of TOW PV IPR/SSE, 12-13 Aug 70, *op. cit.*, p. 7.
(2) DF, Prod Mgr, LCSS, to CG, MICOM, 2 Mar 71, subj: Attainment of TOW Spt Milestone by LCSS. HDF.

⁴⁵ AMCTC Item 9503, 19 Jul 72, & incl thereto: 1st Ind, ACSFOR, DA, to CG, AMC, 20 Aug 71, on Ltr, Chmn, AMCTC, to ACSFOR, DA, 17 Mar 71, subj: Type Reclas fr LP-U to Std A of the XM232E1 & XM233E1 Mounting Kits for the TOW Msl Sys. TOW Proj Ofc.

⁴⁶ (1) SS AMCPM-TO-11-71, TOW Proj Ofc, 23 Mar 71, subj: TOW Wpn Sys, w incls. (2) 1st Ind, ACSFOR, DA, to CG, AMC, 22 Nov 71, subj: TCLAS LP-U for TOW Btry Charger & XM-70 Tnr. Both in HDF.

in external configuration, weight, and center of gravity to the encased missile. A blast simulation device was contained in the round.⁴⁷

(U) The battery charger was reclassified from LP to Standard A on 4 October 1972. The estimated program unit cost of the PP-4884 (XO-1)/TT battery charger in quantity procurement was \$6,891.⁴⁸

(U) The XM-236 and XM-225 mounting kits, initial procurement of which had been deferred to FY 1971, were reclassified from LP to Standard A on 26 September 1972 and 24 October 1972, respectively. The estimated program unit cost of these items in quantity procurement was as follows:⁴⁹

Mounting Kit, M236 (Unmounted)	\$3,248
M151A1 Truck with M236 Mounting Kit Installed	5,375
Mounting Kit, M225 (Unmounted)	1,924
M274 MULE with M225 Mounting Kit Installed	4,991

Development Cost Through Type Classification

(U) From the inception of the basic TOW project in FY 1962 through initial production test and type classification of the

⁴⁷ (1) Mat Sta Rec 0173623, 18 Nov 72. (2) Incl 6 to Ltr, CG, MICOM, to CG, AMC, 12 Sep 72, subj: Type Reclas of the Tng Set for the TOW Wpn Sys. Both in HDF.

⁴⁸ Mat Sta Rec 017621, 25 Oct 72, w incl: 2d Ind, ACSFOR, DA, to CG, AMC, 4 Oct 72, on Ltr, CG, MICOM, to CG, AMC, 28 Jun 72, subj: Type Reclas of the Btry Charger for the TOW Wpn Sys. TOW Proj Ofc.

⁴⁹ (1) Mat Sta Rec 0173620, 25 Oct 72, w incl: 1st Ind, ACSFOR, DA, to CG, AMC, 26 Sep 72, on Ltr, CG, AMC, to ACSFOR, 13 Jun 72, subj: Type Reclas of the [M151A1] Trk, GM Assemblage for the TOW Wpn Sys. (2) Ltr, CG, AMC, to ACSFOR, 4 Aug 72, subj: Type Reclas fr LP-U to Std A: The [M274] Trk GM Equip Assemblage (M225) for the TOW Wpn Sys, & Incl 7 thereto, AMCTC Subcom Rept U-1800. (3) Ltr, Chf, Msl Sys Div, Rsch, Dev, & Engrg Drte, AMC, to AMC Tech Com (AMCTC), 6 Nov 73, subj: Mat Sta Rec Sbm. Atchd as incl to 1st Ind, Chf, Msl Sys Div, Rsch, Dev, & Engrg Drte, AMC, to Cdr, MICOM, 6 Nov 73, on Ltr, TOW PM to Cdr, AMC, 26 Oct 73, subj: Type Reclas of the Trk, GM Equip Assemblage [M225] for the TOW Wpn Sys. All in TOW Proj Ofc.

last major items in FY 1973, Army RDTE funding support totaled \$104.1 million, more than double the projected cost of \$51,377,000 for the FY 1962-67 period. In addition to the Army's investment, the U. S. Marine Corps furnished \$3,348,000 in RDTE funds during the 1965-69 period, bringing the total obligation to \$107,448,000 as of 30 June 1973 (see Table 3). The stretchout in development time and a large portion of the indicated cost growth were attributed to technical problems associated with the missile infrared source lamp and guidance wire subsystem; difficulties in meeting the required system reliability and other elements of the QMR; the inability of the contractor to perform within the contract target prices; and the supplemental effort necessary to correct design deficiencies noted in the ET/ST program.⁵⁰

Table 3
(U) Projected vs Actual TOW RDTE Cost - FY 1962-73
(in millions)

FY	Projected Mar 63	Actual		Total
		Army	USMC	
1962	\$ 2.100	\$ 2.200		\$ 2.200
1963	7.877	7.900		7.900
1964	18.300	18.500		18.500
1965	16.350	22.300	\$.200	22.500
1966	5.500	25.600	.398	25.998
1967	1.250	14.100	.950	15.050
1968		6.000	.700	6.700
1969		2.100	1.100	3.200
1970		2.200		2.200
1971		1.400		1.400
1972		1.100		1.100
1973		.700		.700
	\$ 51.377	\$104.100	\$3.348	\$107.448

SOURCE: (1) TOW TDP, 1 Mar 63. RSIC. (2) TOW TDP, 1 Jan 72. (3) TOW SAR's, 1971-73. TOW Proj Ofc.

⁵⁰(1) TOW TDP, 1 Mar 63. RSIC. (2) TOW TDP, 1 Jan 72. TOW Proj Ofc. (3) TOW SAR's, 1971-73. TOW Proj Ofc. (4) Cost Growth Info fr P&P Div, TOW Proj Ofc, 27 Aug 70. HDF. (5) Intvw, M. T. Cagle w Gary K. Smallwood, TOW Program Mgt Ofc, 22 Jun 76.

(U) About \$87.6 million or 81.6 percent of the \$107,448,000 RDTE investment went to Hughes Aircraft, the TOW system prime contractor. Increases in the value of Hughes' R&D contracts also accounted for most of the development cost growth. As shown in Table 4, the contract overruns and cost increases resulting from changes beyond the control of the contractor totaled \$35.1 million.

(U) The follow-on development and product improvement effort consisted primarily of countermeasures studies (solid state track link), the commonality night sight program, an extension in maximum missile range to provide an increased protective standoff for helicopters, and design of the under armor TOW for gunner protection. These and other aspects of the product improvement effort will be dealt with following a summary of the TOW procurement and production program and description of the standard weapon system.

Procurement and Production Summary

(U) The TOW industrial program got underway with award of the initial engineering services contract on 28 June 1968, followed by the first mass production contract on 29 November 1968. Seven and a half years later, the TOW was still in production for the U. S. Army and Marine Corps and foreign military sales of the weapon continued to soar. So great was the international demand for the TOW that the Army was often hard-pressed to keep enough in the inventory to meet its own requirements.

Army and Marine Corps Procurement

(U) As stated earlier, MICOM planned to introduce competitive multiyear buyout procurement for TOW missiles in FY 1971 between the prime contractor, Hughes Aircraft, and the alternate producer, the Chrysler Corporation Huntsville Division. Having been selected as the alternate producer, Chrysler was awarded a contract in January 1969 for an educational buy of 200 missiles, plus two options for an additional 2,685 missiles. These options were later exercised after Chrysler demonstrated its ability to produce an acceptable item. Hughes' initial production contract was a 2-year multiyear CPIF pact for FY 1969-70 missile requirements.⁵¹

(U) Instead of the planned multiyear buyout competition for the FY 1971 buy of 15,685 missiles, contract negotiations were

⁵¹See above, pp. 84-86, 99.

TABLE 4--(U) TOW R&D Contracts with Hughes Aircraft Company

<u>Contract Number</u>	<u>Date</u>	<u>Original Value</u>	<u>Total Cost Growth</u> ^{a/}	<u>Final Value</u> ^{b/}	<u>Source</u>
DA-04-495-AMC-12	Aug 62)				
DA-04-495-AMC-516	Aug 64)				
DA-01-021-AMC-13626	Nov 65)	\$ 48,568,218 ^{c/}	\$ 34,726,263 ^{c/}	\$ 83,294,481 ^{c/}	1
DA-AH01-67-C-0023	Sep 66)				
DA-AH01-68-C-0007	Jun 67)				
DA-AH01-69-C-0004	Jul 68	901,752	291,879	1,193,631	2
DA-AH01-69-C-1084	Feb 69	746,000	126,535	872,535	3
DA-AH01-70-C-0097	Jul 69	1,304,718	23,664	1,328,382	4
DA-AH01-71-C-0062	Jul 70	417,500	(104,712)	312,788	5
DA-AH01-72-C-0052	Jul 71	392,000	75,539	467,539	6
DA-AH01-72-C-1116	Jun 72	200,000	---	200,000	7
DA-AH01-73-A-0020	Dec 72	<u>d/</u>		<u>d/</u>	
		\$ 52,530,188	\$ 35,139,168	\$ 87,669,356	

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^{a/} Includes contract overruns, added support, and price adjustments; system performance, quantity, engineering, schedule, economic, estimating, and unpredictable changes; and added tasks.

^{b/} As of latest date of available source documents.

^{c/} Total for contracts, August 1962 through June 1967.

^{d/} Fixed Price Basic Ordering Agreement - R&D. No price shown in contract.

SOURCES:

1. Contr Perf Eval - Cost Growth - Analysis, atchd as incl to Ltr, TOW PM to CG, AMC, 4 Feb 70, subj: Contr Perf - Cost/Tech/Scds.
2. (1) Hist Rept, TOW PM, FY 69. (2) MICOM Contr Listings, 1 Jul 73 (Final Payment Feb 72).
3. (1) Hist Rept, TOW PM, FY 70. (2) MICOM Contr Listings, 1 Apr 74.
4. (1) Hist Rept, TOW PM, FY 70. (2) MICOM Contr Listings, 1 Apr 74.
5. Contract 71-C-0062.
6. Contract 72-C-0052.
7. MICOM Contr Listings, 1 Jul 72 & 1 Apr 74.

based on a high-low quantity mix whereby the low bidder would receive the greater quantity and the high bidder the lesser quantity. This revised contractual procedure not only allowed Chrysler to gain more experience before competing for the remaining program multiyear buyout, but also saved the Government some \$6.5 million in missile costs. First set at \$106.3 million, PEMA funds for FY 1971 were later reduced to \$99.8 million by the savings realized in contract negotiations.⁵²

(U) In the FY 1971 competitive split missile buy, Hughes Aircraft submitted the low bid and won the contract for the larger quantity, leaving Chrysler with the contract for the lesser quantity. Bidding for the multiyear buyout in FY 1972 would be on a "winner-take-all" basis. The FY 1971 missile contract with Hughes (DA-AH01-71-C-0994) was signed on 29 April 1971 for \$24,324,100. At the same time, Chrysler received a \$16,680,000 contract (DA-AH01-71-C-0995) for 4,000 missiles. This was the single largest Missile Command contract ever awarded to a Huntsville-based company, and the TOW became the first Army missile to be completely produced and fired in the Huntsville community. The Huntsville Division of the Thiokol Chemical Corporation, using facilities at Redstone Arsenal, assembled the TOW missiles, including explosives loading, under contract to Chrysler. Both the Hughes and Chrysler contracts were firm fixed price pacts and included "fly-before-buy" missile acceptance criteria. All of the production acceptance firings were conducted at Redstone Arsenal.⁵³

(U) The MICOM effort to develop a second source missile producer, which began in January 1969, culminated in a "winner-take-all" competition in FY 1972 between Hughes Aircraft and Chrysler. In this competition, Hughes Aircraft won a multiyear contract for production of TOW missiles over a 4-year period beginning in FY 1972 and ending in FY 1975. The competitive firm fixed price (FFP) contract (DA-AH01-72-C-0418), awarded on 19 November 1971, reduced the missile unit price some 42 percent below previous costs and resulted in a total savings of about \$25 million. The contract provided a specific economical, predetermined price for TOW missile deliveries during the 4-year period, thus avoiding costly and time-consuming follow-on

⁵²(1) Mins of TOW PV IPR/SSE, 12-13 Aug 70. Atchd as incl to AMCTCM Item 8176, 15 Dec 70. RSIC. (2) Hist Rept, TOW PM, FY 71, as amended Oct 71, p. 1.

⁵³(1) *Ibid.*, pp. 2-3. (2) *The Rocket*, 2 Dec 70.

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contract negotiations.⁵⁴

(U) During FY 1975, with foreign military sales of the TOW weapon system continuing to spiral, the Army Missile Command again invited the Chrysler Corporation to enter competition with the Hughes Aircraft Company for the multiyear production contract beginning in FY 1976. The objectives of this second dead-on competition were to determine the cost of setting up a second-source producer as an insurance policy, and to bring down the cost of building the TOW missile.⁵⁵ The Hughes Aircraft Company again won the competition and received a new multiyear contract (DA-AH01-75-C-0626) on 28 February 1975 for production of 57,229 missiles at a cost of \$142.6 million. As of 30 June 1975, the multiyear missile production contracts awarded to the Hughes Aircraft Company in FY 1972 and 1975 were worth over \$271.3 million.⁵⁶

(C) As of 30 June 1976, 88,887 TOW production missiles had been delivered (82,912 for the Army and 5,975 for the Marine Corps) against a total procurement of 134,210 during the FY 1969-76 period. Planned missile production during FY 1977-78 totaled 23,113, for a procurement objective of 157,323. Aside from 660 production missiles bought with RDTE money, the procurement objective included an authorization of 134,249 missiles for the Army and 22,414 for the Marine Corps.⁵⁷

(C) From the beginning of initial production tests in August 1969 through 4 June 1976, a total of 6,347 TOW production missiles were fired at Redstone Arsenal and other test sites, 5,215 of which were manned and 1,132 unmanned. Included in the unmanned firings were 941 fly-to-buy (production acceptance) tests at Redstone Arsenal—107 by Chrysler and 834 by Hughes Aircraft. The overall results of the production firings are shown below:⁵⁸

⁵⁴ (1) Hist Rept, TOW PM, FY 72, p. 2. (2) Hist Rept, D/P&P, FY 72. Both in HDF. (3) TOW SAR, 19 Jan 72, p. 2. TOW Proj Ofc Files. (4) Ltr, CG, MICOM, to Dir, D/P&P, 7 Feb 72, subj: Ltr of Commendation. HDF. (5) *The Rocket*, 25 Nov 71, p. 1.

⁵⁵ *The Huntsville Times*, 7 Mar 75.

⁵⁶ (1) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 10. (2) Hist Rept, TOW PM, FY 75, p. 1. Both in HDF.

⁵⁷ Info furnished by Robert U. Biss, TOW Proj Ofc.

⁵⁸ Info furnished by Edwin E. Baker, TOW Proj Ofc.

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Rounds Fired	6,347
Functioned (Reliable)	5,810
Hits	4,260
No Test (Reliability)	37
No Test (Accuracy)	1,132
Reliability	92.1%
Accuracy (Manned) (Hit Probability given a reliable system)	89.2%

(U) The TOW launcher system (less tripod, launch tube, and battery assemblies) was procured sole source from Hughes Aircraft through FY 1971. A multiyear launcher procurement contract was awarded competitively for the first time in March 1972. After solicitations to 35 firms evoked 7 technical responses, the Emerson Electric Company of St. Louis, Missouri, was selected to receive the 3-year contract (DA-AH01-72-C-0611) with a total multiyear value of \$22,746,380. The savings under the multiyear Firm-Fixed-Price (FFP) contract were estimated at \$7,549,000 for the first-year (FY 1972) procurement of 350 launchers; \$10,153,000 for the second-year (FY 1974) quantity of 1,618 units; and \$9,627,000 for the third-year (FY 1975) procurement of 1,041 units. There were no launchers procured in FY 1973.⁵⁹

(U) On 28 February 1975, a new multiyear competitive contract (DA-AH01-75-C-0628) was awarded to the Emerson Electric Company for additional Army and Marine Corps launchers. Under this FFP contract, Emerson was to build 2,349 launcher sets and spares for \$55.5 million. As of 30 June 1975, the multiyear launcher production contracts awarded to Emerson in FY's 1972 and 1975 were valued at more than \$108 million.⁶⁰

(U) By the end of FY 1976, 3,693 TOW production launchers had been delivered (3,322 for the Army and 371 for the Marine Corps) against a total procurement of 5,637 during the FY 1969-76 period. Planned launcher production for the FY 1977-78 period totaled 1,747, for a procurement objective of 7,384.⁶¹

(U) The actual and planned procurement of major TOW line items and the distribution of equipment between the U. S. Army and Marine Corps are depicted in Table 5.

⁵⁹ (1) Hist Rept, TOW PM, FY 72, p. 3. (2) Hist Rept, D/P&P, FY 72. (3) Also see Table 5.

⁶⁰ (1) Hist Rept, TOW PM, FY 75, p. 1. (2) MICOM Anl Rept of Maj Actvs, FY 75, p. 47.

⁶¹ Info furnished by Robert U. Biss, TOW Proj Ofc.

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TABLE 5— TOW Weapon System Procurement - U. S. Army & Marine Corps (U)
As Of 30 April 1976

ITEM	ACTUAL									PLANNED				TOTAL ACT/PLN
	FY 1969	FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	TOTAL	FY 1977	FY 1977	FY 1978	TOTAL	
Missiles														
BGM-71A (Tactical)	4,465	9,543	13,595	11,760	11,578 ^{a/}	20,479 ^{b/}	28,583 ^{c/}	19,203	119,206	2,287	11,188	1,510	14,985	134,191
BTM-71A (Practice)	1,085	857	2,090	240	722 ^{a/}	3,094 ^{b/}	1,808 ^{c/}	5,108	15,004	328	1,863	5,937	8,128	23,132
Total Missiles:	5,550	10,400	15,685	12,000	12,300	23,573	30,391	24,311	134,210	2,615	13,051	7,447	23,113	157,323
Launchers, M151	211	174	350	350	0	1,618	1,041	1,893	5,637	0	882	865	1,747	7,384
Mounting Kits														
M233 (M113 APC)	56	244	268 ^{d/}	350	0	716	514	0	2,148	0	0	0	0	2,148
M225 (M274 MULE)	0	0	85 ^{d/}	0	9	0	345	0	439	0	0	0	0	439
M232 (M151A2 Jeep)	45	0	0	0	204	1,293	1,337	0	2,879	0	674	46	720	3,599
M236 (M151A2 Jeep)	0	0	45	0	198	1,148	1,145	245	2,781	0	485	27	512	3,293
Trainers, M70	77	18	0	71	19	144	161	0	490	0	156	0	156	646
Battery Chargers	56	0	7	64	49	191	43	157	567	0	0	0	0	567

^{a/} Includes 300 production missiles bought with RDTE money.

^{b/} Includes 148 production missiles bought with RDTE money.

^{c/} Includes 212 production missiles bought with RDTE money.

^{d/} Excludes first article delivered for initial production test.

DISTRIBUTION

Item	U. S. Army			U. S. Marine Corps			USA + USMC		
	Actual	Planned	Total	Actual	Planned	Total	Actual	Planned	Total
Missiles									
BGM-71A (Tactical)	109,573	7,642	117,215	9,633	7,343	16,976	119,206	14,985	134,191
BTM-71A (Practice)	12,395	5,299	17,694	2,609	2,829	5,438	15,004	8,128	23,132
Total Missiles:	121,968	12,941	134,909	12,242	10,172	22,414	134,210	23,113	157,323
Launchers, M151	5,207	1,691	6,898	430	56	486	5,637	1,747	7,384
Mounting Kits									
M233 (M113 APC)	2,148	0	2,148	0	0	0	2,148	0	2,148
M225 (M274 MULE)	439	0	439	0	0	0	439	0	439
M232 (M151A2 Jeep)	2,449	618	3,067	430	102	532	2,879	720	3,599
M236 (M151A2 Jeep)	2,536	485	3,021	245	27	272	2,781	512	3,293
Trainers, M70	450	144	594	40	12	52	490	156	646
Battery Chargers	525	0	525	42	0	42	567	0	567

SOURCE: (1) Robert U. Bliss & Louis E. Nevels, TOW Proj Ofc. (2) AMCTCM Item 8176, 15 Dec 70.

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PEMA Investment

(C) As of 30 June 1976, the U. S. Government had invested \$838,800,000 in the TOW industrial program. Planned procurement for the FY 1977-81 period amounted to \$442,900,000, for a total projected investment of \$1,281,700,000 (see Table 6). The DOD Military Assistance Program (MAP) of \$13.5 million was authorized for Jordan and Turkey (2,068 missiles and 88 launchers for the former and 780 missiles and 56 launchers for the latter). TOW equipment for the Republic of Vietnam (3,220 missiles and 141 launchers) was supplied from Army-funded production.⁶²

(U) A cost growth of about 10.7 percent was reported for the Advance Production Engineering (APE) and Industrial Engineering Services (IES) effort at Hughes Aircraft. The total value of the two APE contracts (AMC-14824 and AMC-15537) increased from \$3,962,578 to \$6,551,724. Most of the \$2,589,146 cost increase was attributed to problems with the original wire winding machine which had to be redesigned. The total value of IES contracts covering the FY 1968-76 period increased from \$58,864,326 to \$62,999,069, for a net cost growth of \$4,134,743. The major portion of the IES cost increase stemmed from engineering changes to tooling, supplemental funding for value engineering, and the contractor's inability to perform within original target costs.⁶³ The APE and IES contracts with Hughes Aircraft are listed in Table 7.

Foreign Military Sales (FMS)

(U) The TOW's combat and cost effectiveness, versatility, and simplicity made it one of the Army's most popular commodities. Foreign interest in the weapon system began to burgeon at the time of its service availability in 1970. By July 1976, the NIKE HERCULES had recorded the greatest number of foreign sales cases and the HAWK the greatest dollar volume, but the TOW held the record for sales to the greatest number of foreign nations.⁶⁴

⁶² (1) TOW SAR, 30 Jun 76. (2) PEMARS Scd D, 31 May 76. (3) Sum, FMS/MAP Cases, 30 Jun 76, compiled by Mildred H. Whitlock. All in TOW Proj Ofc.

⁶³ (1) Incl to Ltr, TOW PM to CG, AMC, 4 Feb. 70, subj: Contr Perf - Cost/Tech/Scds. (2) Cost Growth Data furnished by P&P Div, TOW Proj Ofc, 27 Aug 70. Both in HDF.

⁶⁴ *The Rocket*, 16 Jun 76, p. 16.

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Table 6
 (U) TOW PEMA Funding Program (Actual & Projected)
 (in millions of dollars)

Fiscal Year	PBS	Army	USMC	DOD/MAP	TOTAL
1966	4.9*				4.9
1967	7.4*				7.4
1968	.6	15.1			15.7
1969	.4	81.8			82.2
1970	.1	107.0			107.1
1971	.1	97.3			97.4
1972		55.6			55.6
1973		44.9		.7	45.6
1974		111.7	22.4	4.2	138.3
1975	.8	98.8	32.4		132.0
1976		140.2	3.8	8.6	152.6
TOTAL ACTUAL:	14.3	752.4	58.6	13.5	838.8
Projected:					
1977T		6.6	2.8		9.4
1977		88.8	35.7		124.5
1978		116.0	16.7		132.7
1979		75.8			75.8
1980		67.8			67.8
1981		32.7			32.7
TOTAL PROJ'D:		387.7	55.2		442.9
GRAND TOTAL:	14.3	1,140.1	113.8	13.5	1,281.7

*Advance Production Engineering (APE). Other Production Base Support (PBS) funds for facilities.

SOURCE: (1) TOW Selected Acquisition Report, 30 Jun 76.
 (2) PEMARS Scd D, 31 May 76 (DOD/MAP Funds).

TABLE 7--(U) TOW APE and IES Contracts with Hughes Aircraft Company

<u>Contract Number</u>	<u>Date</u>	<u>Original Value</u>	<u>Total Cost Growth^{a/}</u>	<u>Final Value^{b/}</u>	<u>Source</u>
DA-01-021-AMC-14824	Apr 66)	\$ 3,962,578 ^{c/}	\$ 2,589,146 ^{c/}	\$ 6,551,724 ^{c/}	1
DA-01-021-AMC-15537	Jun 66)				
DA-AH01-68-C-0272	Sep 67	9,960,000	948,467	10,908,467	2
DA-AH01-68-C-2155	Jun 68	11,559,159	840,320	12,399,479	3
DA-AH01-70-C-0209	Aug 69	9,185,848	515,896	9,701,744	4
DA-AH01-71-C-0122	Sep 70	10,488,392	---	10,488,392	5
DA-AH01-72-C-0138	Aug 71	3,778,058	98,706	3,876,764	6
DA-AH01-72-C-1056	Jun 72	3,932,159	688,433	4,620,592	7
DA-AH01-74-C-0261	Oct 73	2,931,377	761,825	3,693,202	8
DA-AH01-75-C-0218	Oct 74	3,442,564	281,096	3,723,660	9
DA-AH01-76-C-0252	Oct 75	3,586,769	---	3,586,769	10
		\$ 62,826,904	\$ 6,723,889	\$ 69,550,793	

^{a/} Includes contract overruns, added support, and price adjustments; system performance, quantity, engineering, schedule, economic, estimating, and unpredictable changes; and added tasks.

^{b/} As of latest date of available source documents.

^{c/} Total for 2 APE contracts (performance period 15 Apr 66 to 30 Jul 68).

SOURCES:

1. Contr Perf Eval - Cost Growth - Analysis, atchd as incl to Ltr, TOW PM to CG, AMC, 4 Feb 70, subj: Contr Perf - Cost/Tech/Scds.
2. (1) Hist Rept, TOW PM, FY 68. (2) MICOM Contr Listings, 1 Apr 74 (Final Payment Nov 73).
3. (1) Hist Rept, TOW PM, FY 68. (2) MICOM Contr Listings, 1 Apr 74.
4. (1) Hist Rept, TOW PM, FY 70. (2) MICOM Contr Listings, 1 Apr 74.
5. MICOM Contr Listings, 1 Jul 72 & 1 Apr 74.
6. (1) MICOM Contr Listings, 1 Jul 72. (2) D/P&P Computer, 3 Aug 76.
7. Contract 72-C-1056.
8. Contract 74-C-0261 (Mod. 9, 2 Dec 74).
9. Contract 75-C-0218 (Mod. 15, 12 Jul 76).
10. Contract 76-C-0252.

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(C) As of 30 June 1976, a total of 22 foreign countries had acquired the TOW weapon system for their armed forces: Canada, Denmark, Ethiopia, Federal Republic of Germany, Greece, Iran, Israel, Italy, Jordan (MAP), Korea, Kuwait, Lebanon, Luxembourg, Morocco, NATO Maintenance & Supply Agency (NAMSA), Netherlands, Norway, Oman, Pakistan, Saudi Arabia, Turkey (MAP), and Republic of Vietnam (MAP). In addition to these, Sweden was in the process of evaluating the TOW with the potential of adoption, and eight other countries (Taiwan, Japan, Kenya, Spain, Belgium, Australia, United Kingdom, and Switzerland) had expressed varying degrees of interest in acquiring the system. The NAMSA Depot was officially opened on 24 September 1975 to support NATO (North Atlantic Treaty Organization) customers, and depot capabilities were being established in Iran and Israel.

(U) Firm TOW sales (exclusive of MAP cases) as of 30 June 1976 were as follows:

Missiles	76,770
Launchers	2,247
Mounting Kits:	
M233 (M113 APC)	1,011
M232 (M151A2 Jeep)	1,003
M236 (M151A2 Jeep)	972
Trainers	242
Battery Chargers	131

The estimated value of these sales was \$458 million. About \$69.2 million or 15.1 percent of the sales total was being returned to the U. S. Treasury as recovery of investment, thus reducing the cost of the TOW for U. S. Forces. The recoupment of nonrecurring (RDTE and PEMA) costs was a proration against the total FMS/DOD missile quantity. The initial proration of \$358 per round was raised to the existing level of \$551, and a further increase to \$820 per round was under consideration.⁶⁵

Description of the Standard Weapon System

(U) The standard TOW Heavy Antitank/Assault Weapon (HAW) was designed to satisfy a qualitative materiel requirement established

⁶⁵ (1) TOW SAR, 30 Jun 76. (2) TOW DAPR, 10 Jun 76. Both in TOW Proj Ofc. (3) Intvw, M. T. Cagle w Louis E. Nevels, TOW Proj Ofc, 30 Jun 76. (4) Intvw, M. T. Cagle w Jerry H. Wise, TOW Proj Ofc, 12 Jul 76.

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in July 1958 and revised in December 1964, as well as a requirement set forth in subparagraph 273b(10) of the Combat Development Objectives Guide. Initially deployed in September 1970, it was capable of delivering first round accurate, effective fire against targets from 65 to 3,000 meters. In its primary antitank role, the TOW was used to destroy formations of armored vehicles before the enemy armor could be brought to bear effectively. In the assault role, it was employed against vehicles, field fortifications, and emplacements. The TOW system was made organic to infantry, mechanized infantry, airborne, air mobile, and tank battalions, and armored cavalry squadrons. The TOW missile was also designated as the point target weapon on helicopters of selected aviation units. The basic weapon system had a four-man crew and could be fired from a ground tripod or from specifically adapted vehicles.⁶⁶

(U) The TOW ground system was programmed to replace the wire-guided ENTAC antitank missile system and the M40A1 106mm recoilless rifle on a one-for-one basis. In anticipation of this, the Army had completed phaseout of the ENTAC when the TOW was standardized on 30 September 1970. As the 106mm recoilless rifle was replaced by the TOW, it was redistributed to the reserves and depot stocks.⁶⁷ Among the benefits of TOW over the M40A1 106mm recoilless rifle were a reduction in gunner error, simplified gunner training, and a greatly increased hit capability against moving targets at all ranges from 65 to 3,000 meters. Other benefits included an increased maximum effective range from 1,100 to 3,000 meters, and a reduction of several hundred pounds in launcher system weight.⁶⁸

(U) Major elements of the standard TOW weapon system were the guided missile subsystem, launcher subsystem, vehicle mounting kits, training set, battery charger, and contact support set (CSS). A brief description follows.

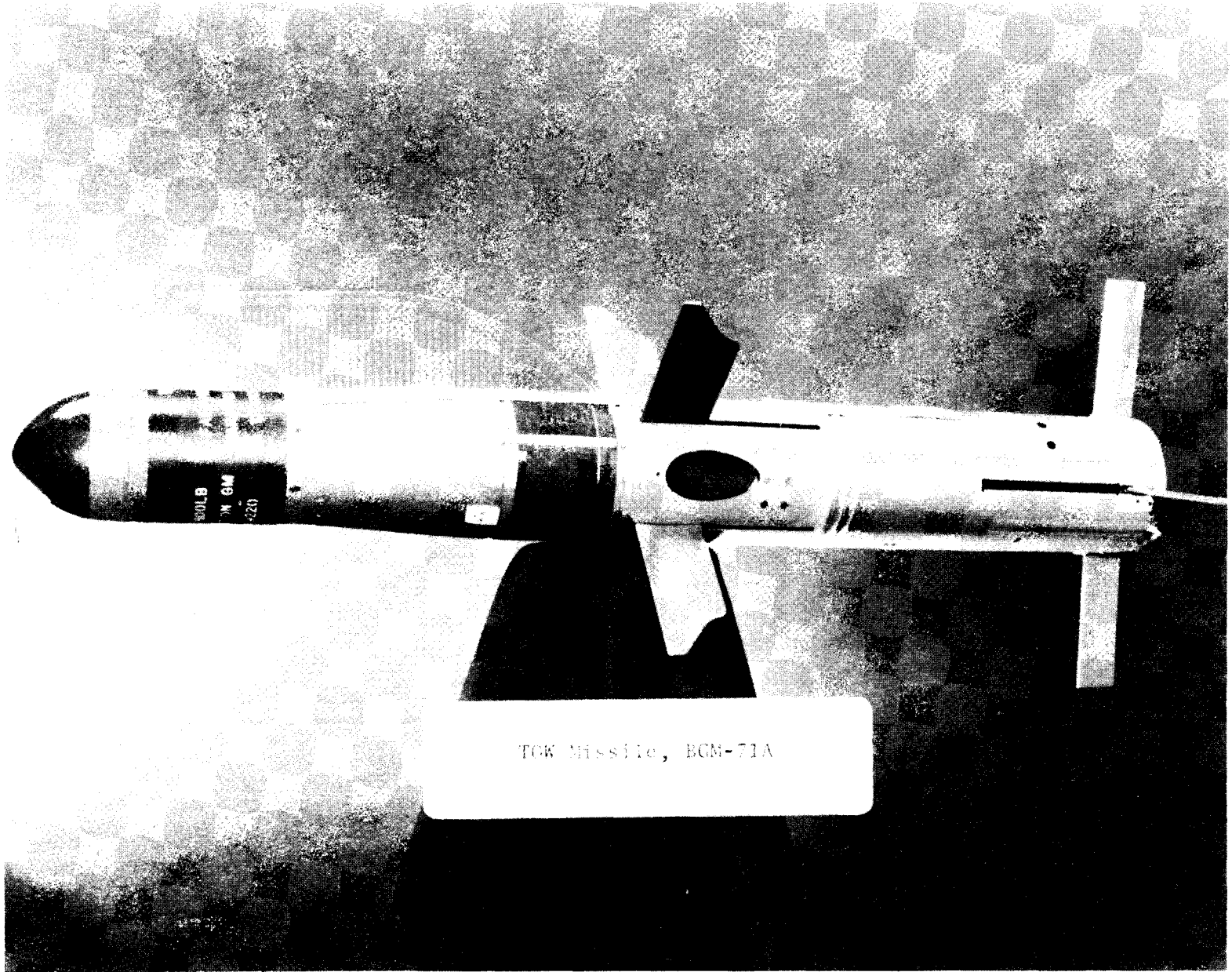
Guided Missile Subsystem

(U) The guided missile subsystem was comprised of the missile

⁶⁶(1) TOW/HAW New Materiel Introductory Ltr, revised Jul 76. TOW Proj Ofc. (2) AMC TIR 24.1.8.1(2), Feb 68, subj: HAW Sys (TOW), p. 1. RSIC.

⁶⁷AMCTCM 8176, 15 Dec 70, w incls. RSIC.

⁶⁸TOW/HAW New Materiel Introductory Ltr, revised Jul 76. TOW Proj Ofc.



TOW Missile, BGM-71A

and its container. There were two basic types of missiles: the BGM-71A tactical missile with a high explosive antitank (HEAT) warhead and the BTM-71A practice missile with an inert warhead. The missile was sealed in a tubular, fiberglass, epoxy container at the factory and was transported, handled, and fired without being removed from the container which served as the breech end of the launch tube. The encased missile was shipped from the factory in a wooden overpack containing contoured cushioning material to absorb shocks from transportation, vibration, and drops.

(U) Major components of the standard missile were the warhead section, electronics unit, gyroscope, thermal batteries, launch motor, flight motor, four control surfaces, four wings, two wire dispensers, infrared source, and aluminum airframe. The final missile was 5.8 inches in diameter and 46.5 inches long, and weighed 42 pounds. The encased missile (missile plus container) was 50.5 inches long and weighed 56 pounds. The encased missile in overpack weighed 86 pounds.

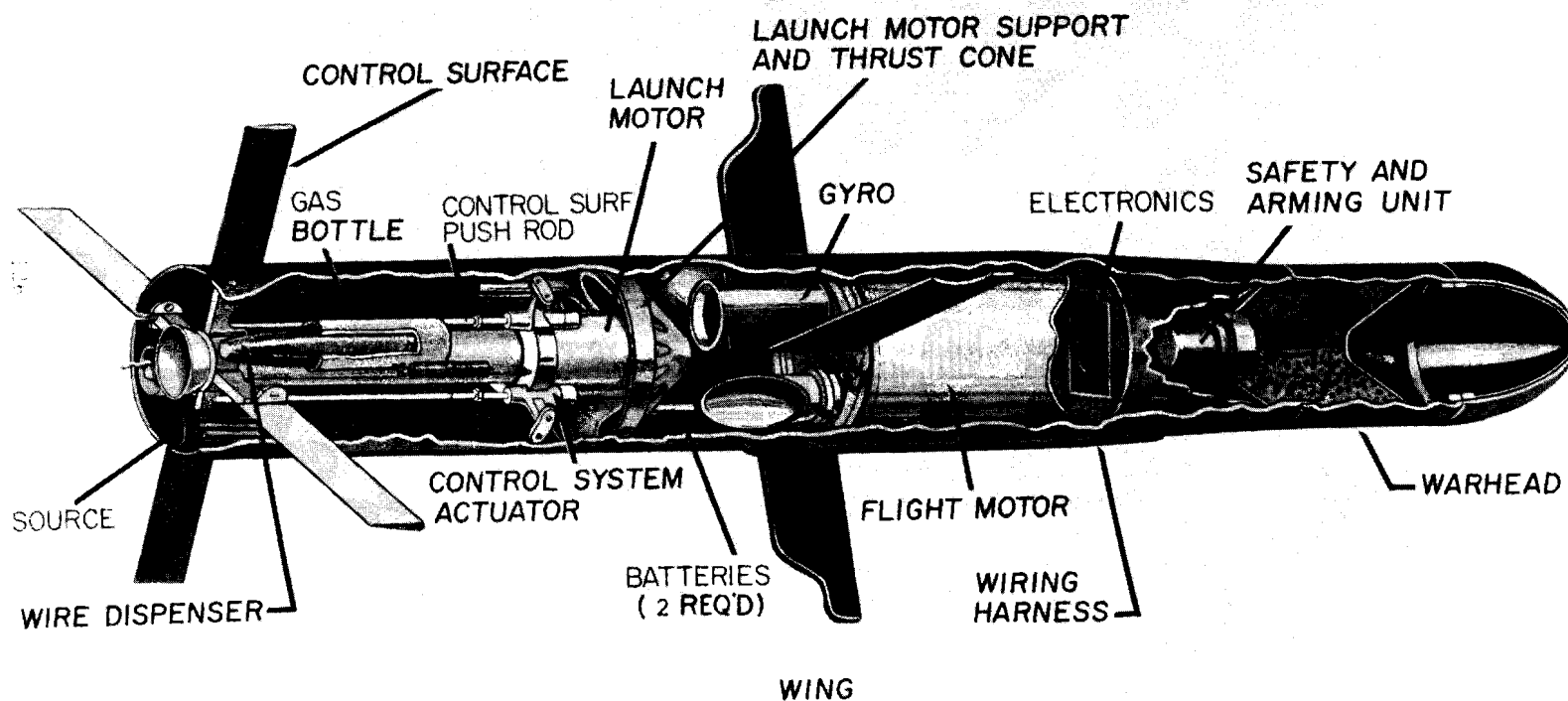
(U) The M154 shaped charge HEAT warhead was 5 inches in diameter and weighed 8 pounds, including 5.3 pounds of Octol. The M812 fuze system consisted of the nose crush switch assembly and the safety and arming device. The fuze was armed in no less than 30 meters and no more than 65 meters from the launcher. The M220 inert warhead had the same weight and dimensions as the HEAT warhead.

(U) The M114 launch motor, which completed burning before the missile left the launch tube, was 15 inches long, had an outside diameter of 2.1 inches, and contained four single perforated sticks of M-7 double-base solid propellant weighing 1.25 pounds. It had a muzzle velocity (end of boost) of 220 feet per second.

(U) The M113 flight motor had an outside diameter of 5.8 inches, was 7.5 inches long excluding nozzles, and contained 5.7 pounds of double-base solid propellant which achieved a nearly smokeless and flameless burn. It ignited about 12 meters forward of the launch tube and burned about 1.5 seconds, accelerating the missile to a maximum velocity of about 1,025 feet per second.

(U) The missile electronics unit received corrective guidance signals from the launcher through the wire command link, and yaw and roll error signals from the missile gyroscope. These signals were processed into commands which operated the solenoid valves of the control surface actuators.

CUTAWAY VIEW OF
TOW MISSILE



(U) The wire subsystem consisted of two bobbins of wire mounted in the aft end of the missile. Correcting commands were transmitted during flight over the wire link from the launcher to the missile. A single 0.005-inch diameter strand of wire, having a tensile strength of 530,000 pounds per square inch and coated with insulation, was wound onto each of the tapered bobbins. For the basic TOW missile, each bobbin contained about 3070 meters of wire.

(U) The infrared source on the aft end of the missile supplied a beam of modulated energy from the missile to the infrared sensor on the launcher for precision tracking of the missile. The infrared source consisted of an xenon arc lamp, an electronic modulator, and beam-forming optics. The modulator provided energy to the lamp to start the arc and then maintained the arc with a modulated signal. The optics consisted of a reflector and a simple lens to form a concentrated beam of radiated energy from the lamp. The lens was coated to filter out most of the visible radiation.⁶⁹

Launcher Subsystem

(U) The standard launcher subsystem, designated as the M151 guided missile tubular launcher, weighed 173 pounds when assembled and was manportable. The individual assemblies and their weights were as follows:⁷⁰

Missile Guidance Set (with Battery Assembly)	53 lbs.
Battery Assembly	24 lbs.*
Optical Sight	32 lbs.
Traversing Unit	54 lbs.
Launch Tube	13 lbs.
Tripod	21 lbs.

*Spare battery assembly not included in the total launcher weight.

(U) As implied by its name, the missile guidance set provided the system automatic guidance. It received and processed missile inflight position signals from the optical sight and transmitted appropriate corrective guidance signals to the missile during flight. Housed in a portable, all-weather case, the missile guidance set contained six printed circuit boards designed for

⁶⁹ *Ibid.*

⁷⁰ DA Tng Cir 23-23, Jul 70. TOW Proj Ofc.

rapid fault isolation and replacement.

(U) Power for the launcher was provided by a rechargeable battery assembly carried in the missile guidance set. The assembly was a three-section nickel-cadmium-potassium hydroxide design containing one 24-volt and two 50-volt sections. A spare battery assembly was issued with each missile guidance set to provide for recharging.

(U) The purpose of the optical sight was to establish the gunner's line of sight and to detect the deviation of the missile from this line. The unit consisted of 13-power optics for tracking the target and a dual-field infrared sensor—a wide field of view for missile acquisition and a narrow field for achieving the required accuracy at long range. The optical sight was attached to the traversing unit by a mechanism that permitted rapid mechanical and electrical connection. The sensor was activated by trigger action and operated until the missile container was removed from the launcher. The optical sight also provided a mounting surface for the night sight.

(U) The traversing unit provided for the required target tracking accuracy, served as the mounting fixture for the launch tube and optical sight, and provided for the electrical connection between the missile, the optical sight, and the missile guidance set. Launcher slew provided azimuth positioning; elevation positioning was obtained by rotating the control knobs.

(U) The function of the launch tube was to position the encased missile in the launcher, provide missile stability during the initial period of travel, and protect the gunner from launch motor exhaust. To accommodate the missile container, which served also as a rear extension of the launch tube, the diameter of the breech was larger than that of the rest of the tube. A quick release latch secured the launch tube to the traversing unit.⁷¹

Vehicle Mounting Kits

(U) Vehicle mounting kits were provided to mount the TOW weapon system on the M113A1 APC, the M151A2 1/4-ton truck, and the M274A5 1/2-ton truck (mechanical mule). The tripod was carried on each firing vehicle. All kits were designed for rapid dismount of the weapon for ground deployment.

⁷¹TOW/HAW New Mat Introductory Ltr, revised Jul 76. TOW Proj Ofc.

(U) The M233 kit for the M113A1 APC provided for stowage of the TOW launcher, 10 missiles, and the four-man TOW crew within the vehicle. For operation, the launcher was raised through the roof hatch to the firing position above the vehicle. This could be done within 10 seconds. Once raised to the firing position, the weapon operated in the same manner as on the ground tripod. The vehicle was capable of limited cross country travel with the launcher in the raised position. The APC/TOW was designed primarily for use by mechanized infantry.

(U) Two vehicles, each with an adapter kit, were required when employing the TOW with the M151A2 1/4-ton jeep. The firing vehicle, with the M232 mounting kit, carried the complete TOW launcher, two missiles, and two of the crew. The second vehicle, with the M236 kit, carried six missiles in racks, the remaining two crewmembers, and the section's individual equipment. The jeep/TOW was designed for use by infantry battalions and separate infantry brigades.

(U) The M274 vehicle with the M225 mounting kit carried the complete TOW weapon and six encased missiles. Firing from the vehicle was accomplished by the gunner standing alongside the firing platform. The 1/2-ton/TOW was designed for use by airmobile and airborne battalions.⁷²

Training Set

(U) The M70 training set consisted of the instructors console, missile simulation round, target source, target board, power supply modulator, and associated cables. The target source, target board, power supply modulator, and two of the three cables were also used for training with the DRAGON weapon system. The missile simulation round, provided on the basis of one per launcher, was used for training in TOW handling, loading, tracking, firing, and unloading. In operation, the missile simulation round was placed in the launcher in lieu of the encased missile. A blast simulation device connected into the aft end of the simulation round produced effects which were representative of the TOW missile blast.

Battery Charger

(U) The TOW-peculiar battery charger was provided for charging the batteries used in the missile guidance set and

⁷²(1) *Ibid.* (2) DA Tng Cir 23-23, Jul 70. TOW Proj Ofc.

instructors console. This semi-automatic charger was capable of charging two TOW batteries simultaneously or independently. Once a battery was connected and the charger started, the remaining sequence was automatic. The maximum time for the complete discharge-charge cycle was 6.5 hours.

Shop Equipment, Contact Support Set

(U) The contact support set (CSS) provided a highly mobile, manual fault isolation capability in direct support of TOW. It could also support the DRAGON weapon system. The set consisted of a standard military electronics shelter equipped with battery power multimeter and oscilloscope, breakout boxes, and inter-connecting cables. Mountable on the M715 1 1/4-ton truck, the shelter was equipped with heater, fan, exhaust blower, lights, and electrical outlets. Electrical power was provided from the truck.

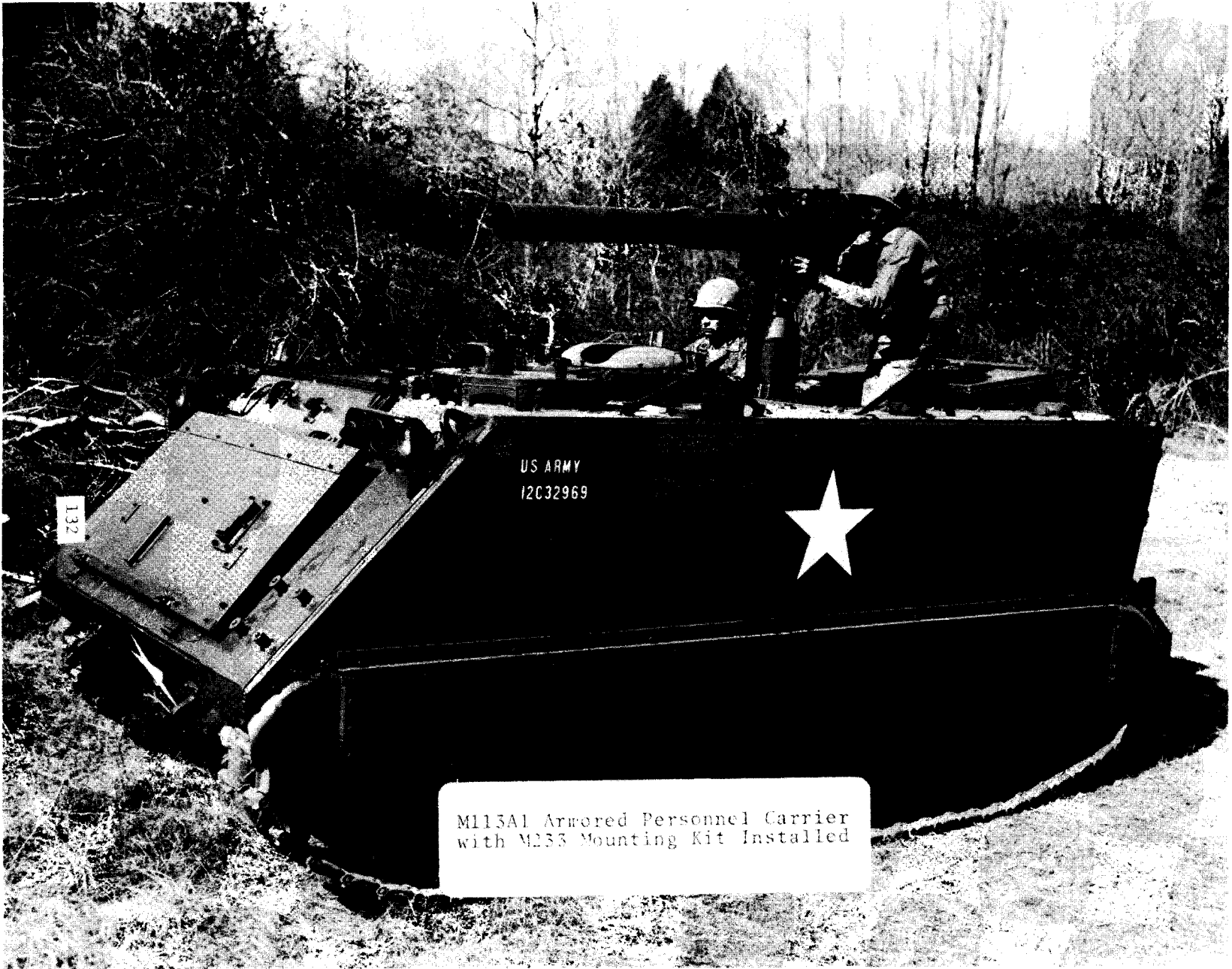
Land Combat Support System (LCSS)

(U) The LCSS was a multisystem unit capable of supporting the TOW, LANCE, DRAGON, and SHILLELAGH missile systems, as well as self-test support of its own components. It was comprised of two major items: the AN/TSM-93 test station, guided missile system, and the AN/75M-94 shop equipment, guided missile. Mobility for the shop equipment was provided by a 5-ton, M55 truck with an extra long wheel base.⁷³

⁷³TOW/HAW New Mat Introductory Ltr, revised Jul 76. TOW Proj Ofc.



TOW Weapon System - Ground Launcher



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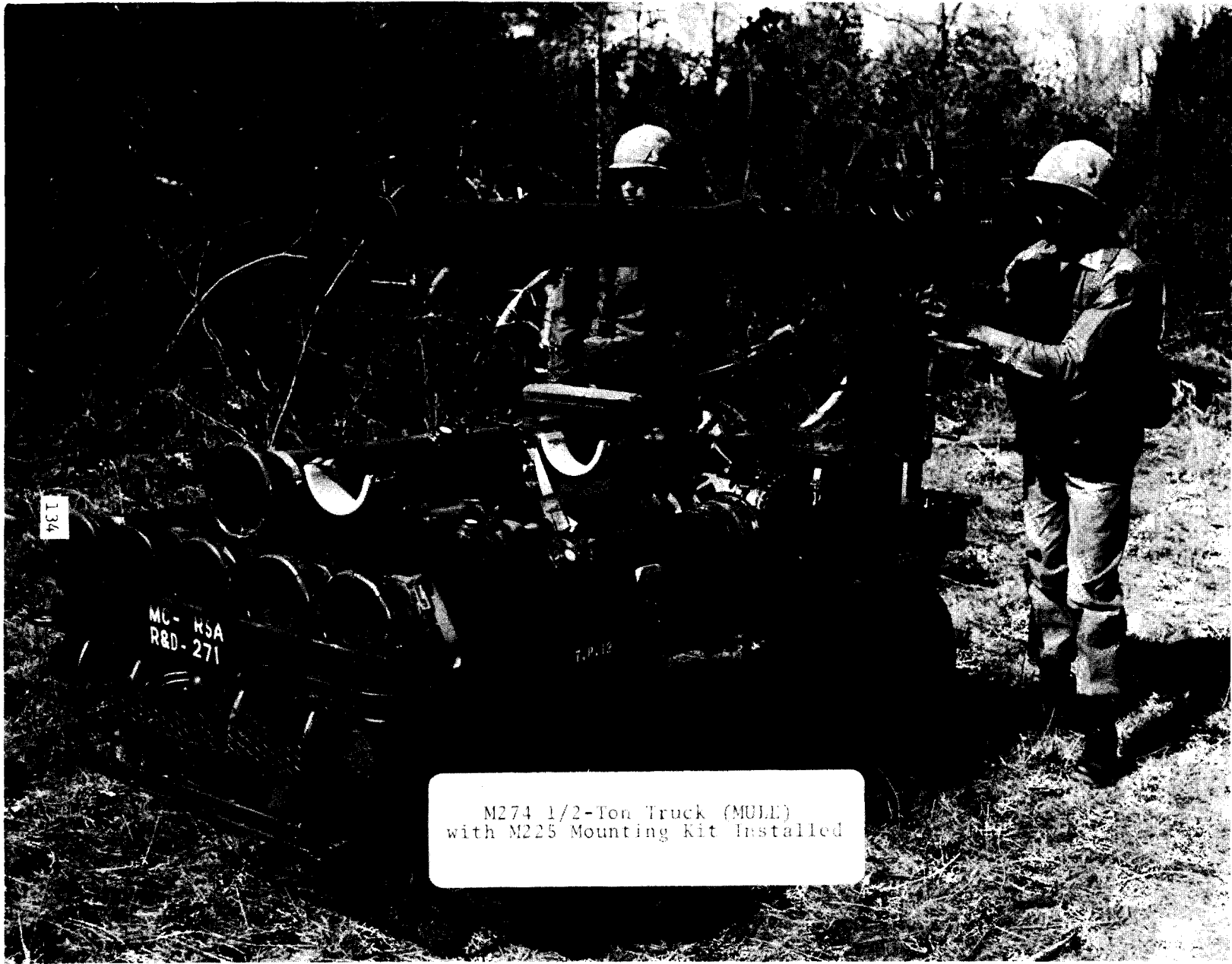
US ARMY
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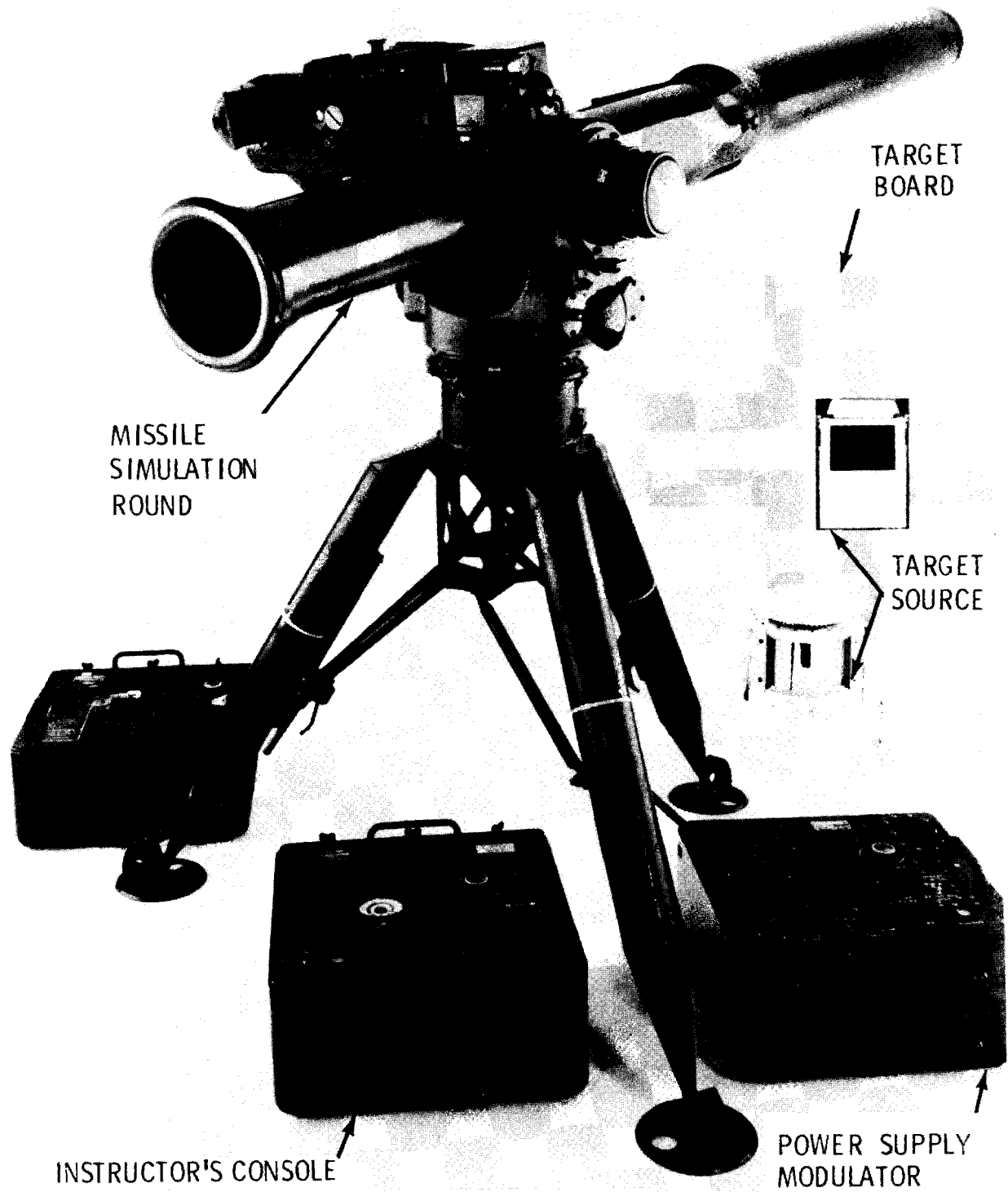
M113A1 Armored Personnel Carrier
with M253 Mounting Kit Installed



M151A2 1/4-Ton Truck
with M232 Mounting Kit Installed

M151A2 1/4-Ton Truck
with M236 Mounting Kit Installed





INSTRUCTOR'S CONSOLE

M70 Training Set

POWER SUPPLY MODULATOR



Land Combat Support Set

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CHAPTER VI

~~(S)~~ PRODUCT IMPROVEMENT PROGRAM (U)

~~(C)~~ Although the TOW weapon system committed to the field in September 1970 provided a major improvement over the 106mm recoilless rifle, it possessed several operational limitations which needed to be eliminated. Chief among these were the lack of an adequate night firing capability, susceptibility of the system to radio frequency and infrared interference, and the adverse effect of gusty cross winds on system accuracy. Among other product improvements addressed after standardization of the basic system were an extension of the maximum missile range to provide an increased protective standoff for helicopters, and development of the under armor TOW for protection of the weapon system and gunner against artillery round fragments.

Continuation of the Night Sight Program

(U) As stated earlier in this study, the Electronics Command (ECOM) Night Vision Laboratories began feasibility studies of the night sight in April 1965. At the time of the TOW prototype IPR in May 1966, the night sight program was continuing at a rate consistent with the TOW development and deployment schedule. However, subsequent technical problems delayed engineering design testing of the gated and thermal night sight concepts, and the selection of one system for the TOW was rescheduled from March 1968 to October 1968. When the TOW system was classified as Standard A in September 1970, the night sight had fallen 4 years behind schedule, its availability for field use having been extended to the fall of 1974.¹ For reasons noted below, the field availability date was subsequently slipped 5 more years to March 1979.

(U) The Night Vision Laboratories (NVL) of ECOM completed engineering design testing of the thermal and gated night sights in September 1968, and submitted their report and recommendations to the TOW Project Manager in October. On 18 March 1969, after an evaluation of the concepts, the TOW Project Manager announced

¹See above, pp. 62-63, 75-76, 105.

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that the gated night sight had been selected for continued development. Although NVL had negotiated a development contract with Electro-Optical System, Inc., signing of the contract was delayed pending firm FY 1970 RDTE funding guidance. The contract was finally signed on 19 March 1970, following DA approval of the night sight program on 27 February 1970. It provided for engineering documentation and hardware for completion of testing through ET/ST and for a small pilot production line quantity. The night sight was to be deployed with tactical TOW units in 1974.²

(U) Engineering development of the gated night sight continued through FY 1971, and engineering service tests commenced at White Sands Missile Range (WSMR) in 1972. The ET/ST program was halted in mid-1972, when the Department of the Army (DA) directed that the night sight hardware be shipped to the Republic of Vietnam (RVN). The sights were evaluated while deployed with RVN units from August 1972 through February 1973. By the end of FY 1973, the gated night sight program had been terminated in favor of the thermal concept being developed for the DRAGON medium antitank weapon system. Twenty gated night sights had been built at a total cost of \$10 million, which was paid by NVL as part of the general night vision program.

(U) Compatibility tests, including night firings, had disclosed that both the DRAGON gated and thermal night sights were compatible with the TOW system. After the DRAGON Project Office selected the AN/TAS-3 thermal night sight for follow-on development, the TOW Project Manager received guidance to use it as an interim night sight for the TOW.

(U) During FY 1973, DA approved the Materiel Need (MN) for a TOW thermal night sight and accorded the program Priority I. The MN requirements included range capabilities under clear air conditions of 2,500 to 3,000 meters target detection, 1,500 to 2,000 meters target recognition, and 500 to 750 meters target identification. The TOW thermal night sight, designated as the AN/TAS-4, would replace the DRAGON thermal night sight (AN/TAS-3) designated for interim TOW use.

(U) Like the gated night sight, the interim AN/TAS-3 thermal sight was developed but never released for production and field use. Parallel TOW/DRAGON design and operational tests of the AN/TAS-3 were successfully completed; however, members of the development acceptance IPR recommended that the unit not be type

²(1) Hist Repts, TOW PM: FY 69, p. 8; FY 70, p. 8. (2) TOW PM2P, 30 Jun 69, p. I.2.5. HDF.

classified and procured. Consequently, the plan to use the AN/TAS-3 as the interim night sight for TOW was cancelled.³

(U) Meanwhile, the TOW thermal night sight (AN/TAS-4) program was begun in FY 1973, with competition among the Philips Broadcast Equipment Corporation (the DRAGON night sight developer), the Hughes Aircraft Company, and the Texas Instruments Company. Philips offered a moderate performance system which was basically the DRAGON night sight with a larger objective lens. The Hughes and Texas Instruments night sights were high performance systems. Competitive evaluation of the three prototypes was completed in June 1973 and the validation IPR was held at NVL on 19 July. The review participants recommended that engineering development be initiated on the high performance concepts. Award of the contracts, however, had to await a DA decision on the night sight commonality program.⁴

(U) The Army Materiel Command had taken action to insure commonality of night vision devices or components, in accordance with a directive issued by the Office of the Chief, Research and Development (OCRD) in February 1971. The Night Vision Laboratories of ECOM was designated as the U. S. Army Lead Laboratory for developing night vision devices. Further, under the aegis of the Joint Logistic Commanders, a Joint Technical Coordinating Group (JTTCG) was established for coordination, elimination of duplicative efforts, and achievement of procurement economics based on component commonality. Composed of representatives of the three services and chaired by the director of the Army NVL, the JTTCG was charged with implementing a DOD-wide thermal imager standardization program which was expected to reduce development and production costs by 50 percent. The objective was a basic set of building block components that would meet commonality of parts goals in designing systems to meet specialized requirements of each of the military services.

(U) A study completed in January 1973 by the Office of the Director of Defense Research and Engineering (DDRE) revealed that the Army, Navy, and Air Force collectively had at least 200 far-infrared (thermal) systems, using 30 different designs, either in

³(1) Hist Repts, TOW PM, FY 1972-75. HDF. (2) DA Study of Cost Growth in Acquisition of the TOW Wpn Sys (draft), 27 Jul 76, p. 12. TOW Proj Ofc.

⁴(1) Hist Rept, TOW PM, FY 74. (2) TOW RECAP Presn by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 22 Aug 73, pp. 10, 34. Both in HDF.

inventory or under development. A subsequent Army review of on-going programs revealed that commonality of far-infrared systems/components was feasible among missile night sights and tripod and vehicular mounted systems. The Deputy Commanding General for Materiel Acquisition, AMC, on 16 July 1973, recommended approval of actions to implement the adoption of standard modules for certain thermal imaging applications.⁵

(U) The Deputy Chief of Research and Development approved the concept of standard modules for thermal imaging applications on 21 September 1973. Because of weight, power, and performance constraints, complete universality of components was not practical. The concept of standard modules embraced two general families of thermal imaging systems: manportable and vehicular/aircraft applications. Within each of these families, common modules or subsystems would be developed to reduce costs and lessen logistics. The manportable family encompassed applications for the TOW and DRAGON night sights, the Night Observation Device, Long Range (NODLR), and the Ground Laser Locator Designator (GLLD). The vehicular/aircraft mounted family, requiring higher performance and power, included the M60 tank thermal sight, the CHAPARRAL target acquisition aid, and sights for the new XM-1 battle tank and helicopters.⁶

(U) Approval of the validation IPR recommendations for engineering development of the high performance concepts eliminated the Philips system from competition. The Department of the Army directed development of the high performance thermal night sights proposed by Hughes Aircraft and Texas Instruments. Engineering development of the manportable thermal night sights finally got underway with the award of contracts to Texas Instruments and Hughes Aircraft on 18 December 1973.⁷ The contracts, as initially awarded, required delivery of TOW night sight prototypes for R&D acceptance tests (RDAT) which were to begin in February 1975. In June 1974, the contracts were modified to include delivery of DRAGON, GLLD, and NODLR hardware. The plan was to carry both

⁵(1) Ltr, DCG, Mat Acq, AMC, to HQ DA, 16 Jul 73, subj: Commonality in Far IR Systems. HDF. (2) *Army Research and Development News Magazine*, Vol. 15, No. 3, May-Jun 74, p. 16.

⁶(1) Ltr, Dep CRD, DA, to Cdr, AMC, 21 Sep 73, subj: Commonality in Far IR Systems. (2) Hist Rept, TOW PM, FY 74. Both in HDF.

⁷(1) *Ibid.* (2) TOW RECAP Presn by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 8 Jan 74, pp. 10, 14. HDF.

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contractors in a competitive prototyping situation through the qualification and RDAT phase of engineering development, then select one contractor for Development Test/Operational Test II (DT/OT II) hardware and follow-on full-scale development.

(U) Early in FY 1975, both contractors notified the Army of sizable projected cost overruns. To continue the program within available funds, the contracts were restructured by reducing requirements and converting to fixed price. The night sight prototypes were delivered in February 1975, and the RDAT program was successfully completed on schedule in early June 1975. The evaluation included missile firings, target acquisition range tests, and vehicle road tests.⁸

(U) During FY 1975, there was considerable pressure by higher headquarters to accelerate the TOW night sight field availability date of March 1979. The final plan for accomplishing the acceleration called for procurement of the night sights with a contract award concurrent with continuation of the development program and for fielding of the units with contractor logistic support. In June 1975, however, the U. S. Army, Europe (USAREUR) rejected this plan, electing to wait for fielding until all development testing had been completed and the Army logistic support plan had been finalized.⁹

(U) Requests for quotation for the DT/OT II and Low Rate Initial Production (LRIP) phases were issued to Texas Instruments and Hughes Aircraft in May 1975.¹⁰ The source selection conference held in September 1975 resulted in the award of a contract to Texas Instruments on 17 October 1975 for DT/OT II hardware and follow-on full-scale development of the manportable common thermal night sights. Texas Instruments successfully completed the DT II contractor tests in March and April 1976, and sent the sights to NVL for baseline examination before shipment to White Sands Missile Range. The DT II tests at White Sands were to be conducted by TECOM during the period June 1976 to March 1977. The OT II tests by USAREUR were scheduled to begin in September 1976 and continue through November 1976. The TOW night sight was expected to be ready for production and type classification as Standard A in

⁸ Hist Rept, TOW PM, FY 75. HDF.

⁹ (1) TT, Cdr, MICOM, to Cdr, AMC, 1 Aug 74, subj: Commonality Night Vision Devices. (2) Hist Rept, TOW PM, FY 75. (3) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, pp. 15, 27. All in HDF.

¹⁰ Hist Rept, TOW PM, FY 75. HDF.

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FY 1977, DT/OT III in 1978, and release for deployment with units in USAREUR in March 1979.¹¹

(U) Pending availability of the TOW night sight, the night firing capability for the tactical weapon system was provided by standard Army flares and searchlights. The night sight under development by Texas Instruments incorporated the latest thermal imaging techniques (detecting and displaying the difference in heat radiated between a target and its background). It was expected to provide a capability of engaging targets in darkness out to ranges nearly equal to TOW's daylight capability. Weighing less than 18 pounds, the night sight would be mounted on the bracket on top of the TOW optical sight, as shown in the accompanying photograph.¹²

(U) The manportable common thermal night sight family consisted of the AN/TAS-4 for the TOW and GLLD, the AN/TAS-5 for the DRAGON, and the AN/TAS-6 for the NODLR. The plan was to procure 3,370 AN/TAS-4 night sights for the TOW during the FY 1977-81 period at an estimated cost of \$68.8 million.¹³

Electronic Countermeasures

(U) Electronic countermeasure testing on the TOW confirmed that the weapon system was susceptible to radio frequency and infrared interference. To eliminate interference from radios organic to the TOW vehicles, radio frequency interference (RFI) filter pins were added to the missile guidance set and optical sight. System improvements, using gallium arsenide components for an improved infrared countermeasure capability, were proof tested in FY 1970. The capabilities provided by these improvements would defeat any known U. S. or enemy infrared countermeasures. The existing enemy threat was a tungsten infrared searchlight which presented no problem for the TOW.¹⁴ Texas Instruments, Inc., conducted a TOW countermeasure study under a \$67,776 contract (DA-AH01-71-C-1090) awarded in April 1971.¹⁵

¹¹TOW Wpn Sys DAPR, 10 Jun 76. HDF.

¹²TOW Wpn Sys New Materiel Introductory Ltr, revised Jul 76, p. 1. TOW Proj Ofc.

¹³TOW Wpn Sys DAPR, 10 Jun 76. HDF.

¹⁴(1) Hist Rept, TOW PM, FY 70, p. 7. HDF. (2) MICOM Hist Sum, FY 71, p. 55.

¹⁵MICOM Contr Listings, 1 Jul 72. HDF.

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AN/IAS-4 Night Sight Mounted on the TOW Optical Sight

(S) Development of the solid state track link to harden the TOW system against a postulated threat was to have begun in FY 1972, but funds to support the effort were not available.¹⁶ The Department of the Army approved a development program for the solid state track link during the first half of FY 1974. The request for proposal for the electronic counter-countermeasure (ECCM) program, released to industry on 15 February 1974, brought responses from Texas Instruments and Hughes Aircraft. A thorough evaluation of the competitive proposals resulted in the award of a \$3,546,944 development contract (DA-AH01-74-C-0868) to Texas Instruments on 31 May 1974. This expedited 30-month development effort was to conclude with delivery of a fully tested and approved engineering change proposal by 30 November 1976.¹⁷

(U) The solid state track link was to include a coded tracker and associated solid state beacon. The coded tracker would be designed to fire and track the standard production missile or a production missile retrofitted with a solid state beacon. The planned 64-round ECCM test program consisted of 34 standard missiles and 30 modified production missiles. All firings would use the hardened ground launcher.

(S) In May 1975, the contractor conducted the first four development firings (two modified and two standard missiles). Three of the firings were successful and one failed because of a beacon malfunction.¹⁸ Solid state track link firings were later started at MICOM, but the tests were suspended after 11 firings because of excessive noise in the guidance channels. As a result of the noise problem and the need for design refinement, the development effort was expected to require 6 months more than originally planned. DT/OT II testing at White Sands was scheduled to start in January 1977. An IPR was slated for February 1977, followed by award of the first production contract in May 1977. Delivery of production modification kits would start in July 1978, and the first tactical units would be equipped by 31 March 1979.¹⁹

¹⁶Ltr, DCG, MICOM, thru CG, AMC, to ASA(R&D), 17 Mar 71, subj: Req for Apprl of FY72 D&F for TOW Sys (R&D), w incl, & 1st Ind, CG, AMC, to CG, MICOM, 8 Jun 71. HDF.

¹⁷(1) TOW RECAP Presns by COL R. W. Huntzinger, to DCG, Mat Acq, AMC: 8 Jan 74, p. 10; 26 Mar 74, p. 10; & 9 Jul 74, p. 11. HDF. (2) Contr DA-AH01-74-C-0868. TOW Proj Ofc.

¹⁸TOW RECAP by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 14. HDF.

¹⁹TOW DAPR, 10 Jun 76. TOW Proj Ofc.

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(U) As of 4 August 1976, the two R&D contracts with Texas Instruments were worth \$6,275,740, representing a total cost growth of \$2,664,020. Technical problems and delays encountered in the solid state track link program increased the value of contract 74-C-0868 by \$2,661,720, from \$3,546,944 to \$6,208,664.²⁰ The value of the countermeasure study contract (71-C-1090) was increased by \$2,300, from \$64,776 to \$67,076.²¹

Reduction in Cross Wind Effect

(U) Gusty cross winds affected both the TOW gunner and launcher. Because the gunner must continuously keep the launcher crosshairs aligned with the target, wind disturbance to the launcher or the gunner could contribute to inaccuracy and cause some degradation in hit probability at longer ranges. The effect of gusty cross wind was substantially reduced by shortening the launch tube by 24 inches, from 66 to 42 inches. The wind effects could be further reduced or eliminated by placing the launcher behind a wind screen, such as vehicles or bushes. The final weight of the TOW launcher was 171 pounds, 2 pounds less than the original Standard A system.²²

Extended Range TOW

(C) The requirement for an extended range TOW missile for the airborne role materialized in 1972. Combat experience in Vietnam had shown that the range of the standard 3,000-meter TOW missile made the helicopter and crewmen susceptible to fire from radar-controlled antiaircraft guns such as the ZSU-23-4 and the SA-7 missile. To improve the survivability of the helicopter against the threat posed by the present-day battlefield, MICOM recommended that the range of the airborne TOW be extended to 3,750 meters. Preliminary studies and laboratory tests indicated that the additional range could be obtained by adding 750 meters of wire to each of the two spools carried aboard the TOW missile. To accommodate the additional wire on the spools, the thickness of

²⁰ (1) Contr DA-AH01-74-C-0868. TOW Proj Ofc. (2) D/P&P Computer, 4 Aug 76.

²¹ MICOM Contr Listings, 1 Jul 72 & 1 Apr 74. HDF.

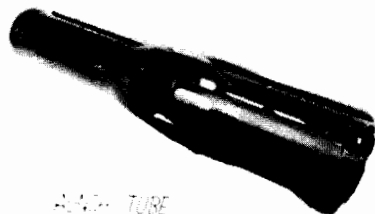
²² (1) DA Tng Cir 23-23, Jul 70. (2) New Mat Introductory Ltr, TOW/HAW, revised Jul 76. Both in TOW Proj Ofc.

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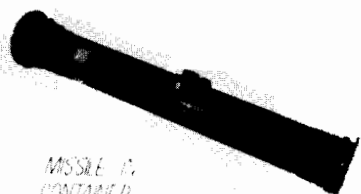


TOW WEAPON SYSTEM

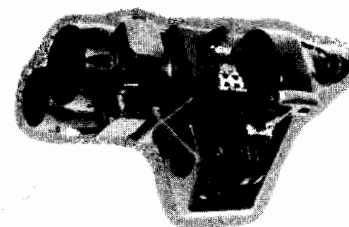


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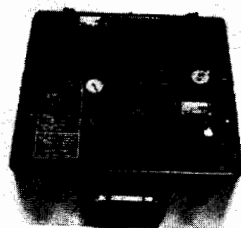
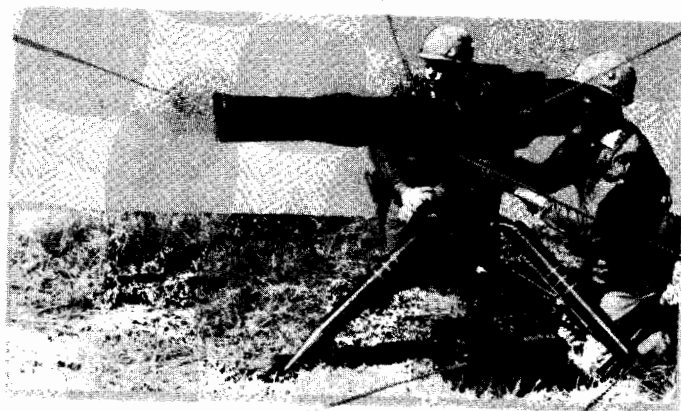
LAUNCH TUBE
(11 lbs.)



MISSILE IN
CONTAINER
(56 lbs.)



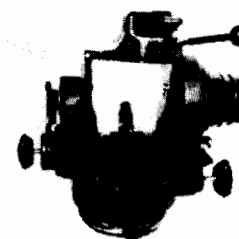
OPTICAL SIGHT
(32 lbs.)



MISSILE GUIDANCE SET
(54 lbs.)



TRIPOD
(21 lbs.)



TRAVERSING UNIT
(53 lbs.)

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the insulation on the copper coated, steel wire was reduced.

(2) The TOW's extended range capability was successfully demonstrated in a series of flight tests at Redstone Arsenal in May and June 1973, using the XM-26 subsystem installed on a UH-1M helicopter. Thirteen missiles were fired in the TOW helicopter automatic track program, with 12 target hits. A computer simulation, based upon the tracking accuracy of these firings, indicated a hit probability of 98 percent at 3,750 meters. The results of laboratory and field experiments revealed that the wire with the thinner insulation was superior in pack stability, dispense reliability, and storage over the thicker insulated wire. The new wire would be inferior when fired over water from the ground level, but this would not affect the helicopter application.

(3) Although the added wire would increase the missile weight by about 1 pound, this was not expected to decrease the system hit probability in the ground or air role. The conventional ground or vehicle launchers would be able to fire the extended range missiles, but would not be able to take maximum advantage of the extra 750 meters of wire because of the electronic programming of the missile guidance set. While conventional launchers could successfully guide the extended range missile to 3,000 meters, the hit probability beyond that would be reduced. The standard ground system with no changes was expected to have a hit probability of 80 percent at 3,500 meters.²³

(4) Having completed the investigative program for the extended range TOW, MICOM forwarded a Required Operational Capability to AMC on 21 August 1973.²⁴ Approval of the Engineering Change Proposal, however, was not forthcoming until 9 June 1975. Initial production of extended range missiles began in January 1976. Beginning in June 1976, all missiles produced were of the extended range design. The per unit cost increase was about \$45.²⁵

²³(1) TOW RECAP Presn by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 22 Aug 73, p. 10. HDF. (2) Table A (Abn TOW Extended Rg Firings), XM65 Abn TOW Msl Sys Msl Firing Sum, Mar 76, HAC. TOW Proj Ofc. (3) ROC for an Extended Rg TOW Wpn Sys, dtd 8 Aug 73, atchd to Ltr, Drte, Plans & Anal, MICOM, to Cdr, AMC, 21 Aug 73, subj: Ppsd ROC for an Extended Rg TOW Wpn Sys. HDF.

²⁴*Ibid.*

²⁵(1) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 10. (2) Hist Rept, TOW PM, FY 76/7T, p. 3. Both in HDF. (3) TOW/HAW New Materiel Introductory Ltr, revised Jul 76, p. 9. TOW Proj Ofc.

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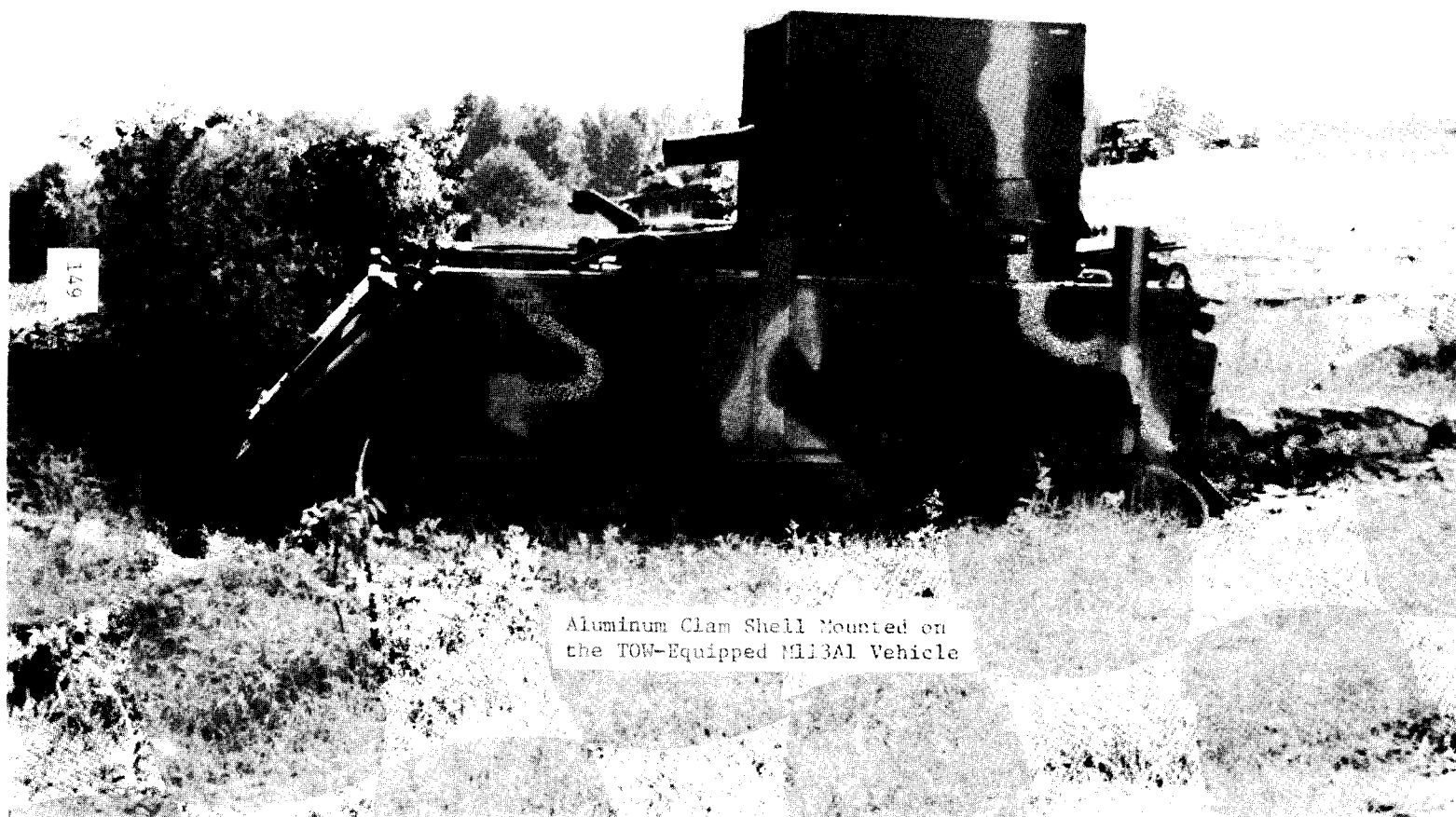
Under Armor TOW

(U) The immediate objective of the under armor TOW program was to provide interim armor protection for the crew and weapon system pending development of the Improved TOW Vehicle (ITV). When mounted on the standard M113A1 vehicle, neither the weapon system nor the gunner had armor protection. To overcome the deficiency, protection was required against artillery round fragments penetrating the gunner and weapon station. The most probable threat was the variable time and point detonating fuzes of the 152mm high explosive round bursting above and around the gunner and weapon system during target acquisition, firing, and tracking operations. The system also needed protection against direct fire small arms. The blanket-type TOW CAP (Cover, Artillery Protection) adopted for interim use on the M113A1 vehicle evolved from the aluminum tunnel or clam shell concept developed and evaluated during FY 1975.

Evolution of the TOW CAP

(U) Early in FY 1975, the U. S. Army Infantry School asked the TOW Project Manager for costs and schedule to provide prototypes of under armor TOW concepts previously submitted to the Army Materiel Systems Analysis Agency (AMSAA) for inclusion in TOW survivability studies. The schedule indicated that there could be a short term solution and an intermediate term solution. The TOW Project Manager provided mockups of the most promising short term solutions for evaluation by the Infantry School. In a joint meeting, Army Missile Command (MICOM) and Infantry School personnel selected the tunnel or clam shell version for immediate development, with the turret and elevated concepts to be considered in a Phase II effort.

(U) Using funds provided by the Army Training and Doctrine Command (TRADOC), MICOM, under direction of the TOW Project Manager, designed and fabricated a prototype of the clam shell concept of under armor TOW for the M113A1 armored personnel carrier (APC). The clam shell assembly was made of 1 1/2-inch aluminum and added 2,200 pounds to the basic TOW-equipped APC. Open on the vehicle front and rear ends, the squared tunnel-type cover was 51 inches high, 56.5 inches wide, and 60 inches long. The modified M113A1 APC, called the Under Armor TOW (UAT), was 10 feet 3 inches high with the clam shell in raised position, and 7 feet 3 inches with the shell lowered. The total weight of the UAT was 26,650 pounds



Aluminum Clam Shell Mounted on
the TOW-Equipped M113A1 Vehicle

(U) The tunnel prototype was delivered to the Infantry School early in May 1975 after safety testing at Redstone Arsenal. The Army Infantry Board conducted extensive OT I tests of the UAT from 7 May to 15 July 1975. Two TOW crews of four military personnel each comprised the basic test unit. The feasibility test/concept evaluation included crew training, firing accuracy, field of fire, rate of fire, transfer and erection times, signature effects, mobility, safety, and human factors. The Infantry Board concluded that the clam shell concept was feasible; however, the test item reduced to some degree the performance of the weapon system. It was recommended that the UAT design be refined to enhance system performance and crew protection; that the noted shortcomings be corrected and suggested improvements be made; and that the effects of the added weight on system reliability, availability, maintainability, and mobility be further evaluated.²⁶

(U) In view of the reported disadvantages of the aluminum clam shell design, the DA, TRADOC, and Infantry School, on 21 August 1975, requested that the Army Materiel Systems Analysis Agency (AMSAA) investigate the feasibility of a cheaper and lighter cover made of ballistic nylon. AMSAA, in turn, tasked the Human Factors Laboratory at Aberdeen Proving Ground to provide a feasibility prototype of the ballistic nylon cover, which became known as the TOW CAP.

(U) The TOW CAP prototype was delivered on 30 September 1975 for evaluation by the Infantry School and MICOM. As a result of the DT/OT I program, the ballistic nylon blanket was selected for interim use on the M113A1 vehicle in place of the aluminum clam shell. Engineering development of the TOW CAP began at the Natick Development Center (now Natick Research and Development Command) on 4 November 1975 and was completed within 20 weeks.

(U) The TRADOC Required Operational Capability (ROC) Review Board approved the requirement for the TOW CAP on 12 December 1975 and sent it to AMC on 31 December 1975. The Army Infantry Board was then directed to conduct the TOW CAP OT II, using the first preproduction prototype which was delivered on 1 February 1976. In view of the previous TOW CAP field tests, and because of the time constraints on development and fielding of the system, the OT II program was conducted on an abbreviated scale during February and March 1976.

²⁶(1) Hist Rept, TOW PM, FY 75. (2) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 13. Both in HDF. (3) USAIB Rept, Feasibility Test/Concept Eval of Crew Protection for TOW on M113A1, Jul 75. TOW Proj Ofc.

(U) The TOW CAP was approved for production during a program review held at the Army Infantry Center on 23 March 1976. In the plan, the Government was to produce the initial quantity of kits, which would be used to support the training base and three USAREUR battalions. Initial Operational Capability (IOC) for the first battalion was scheduled for January 1977. A follow-on competitive contract production from two sources was planned to provide the remaining quantity of kits. Installation of all kits was slated for completion by December 1977. This schedule was predicated on the availability of production funds by 23 April 1976.

(U) The Department of the Army, however, did not release the production funds until 21 May 1976, and the production schedule had to be reevaluated to determine how the January 1977 IOC could be attained. Instead of the Government producing the initial quantity of kits, the program was reoriented to award a competitive contract.

(U) The technical data package was finalized and the invitation for bid was released in June 1976. Natick awarded the initial production contract to Regent Jack Manufacturing Company of Downey, California, on 26 August 1976. This contract covered the first 216 production units to be delivered within a 90-day period beginning in December 1976, plus an option for an additional 120 units to be delivered in March 1977. The Natick contractual cost estimate for the initial 216 TOW CAP units was \$928,800. However, after competition, the award was for \$426,980, with a resultant savings of \$501,820. The exercise of the option was expected to result in an additional savings of \$278,789. The Fire Preclude Devices required for the TOW CAP modification were procured in a separate competitive contract. This effort resulted in a savings of \$77,067.

(U) The plan was to procure 1,067 TOW CAP units in FY 1977, bringing the total production to 1,403. Of these, 803 were allocated to USAREUR units, 472 to CONUS units, and the remainder to the training base and spares.²⁷

(U) The TOW CAP design not only added less weight to the TOW-equipped APC, but also provided the crew and weapon system more protection than the clam shell. It consisted of a tubular steel

²⁷(1) Hist Rept, TOW PM, FY 76/7T, pp. 4-7. (2) TOW Wpn Sys DAPR, 10 Jun 76. (3) TOW CAP Chronology, 8 Aug 76, compiled by Frank H. Case, Jr., TOW Proj Ofc. (4) Proc Milestones for TOW CAP Buy, 17 May 76. All in HDF. (5) *DARCOM News*, Vol. 4, No. 9, Jul 76, p. 6.

frame covered with four layered sections of the same 48-ply ballistic nylon fabric used for the infantryman's armored vest. The fabric was sewn into blankets, which were then bolted together to form multilayered protective panels. Four of these panels were hooked together and manually raised on metal rings over a curved frame to form the sides and roof. There was also a front panel below the TOW launcher which provided some frontal protection. The TOW CAP was 56 inches high, 67 1/4 inches wide, and 60 inches long. It weighed 573 pounds, compared to 2,200 pounds for the aluminum clam shell. The modified TOW-equipped M113A1 APC weighed 25,023 pounds and was 10 feet 8 inches high with the TOW CAP in the raised position. When not in use, the cover was folded into two long, low storage sections on the deck of the vehicle. Two men could erect the cover in less than 2 minutes. The entire TOW CAP system could be dismounted from the carrier and mounted in the ground mode.²⁸

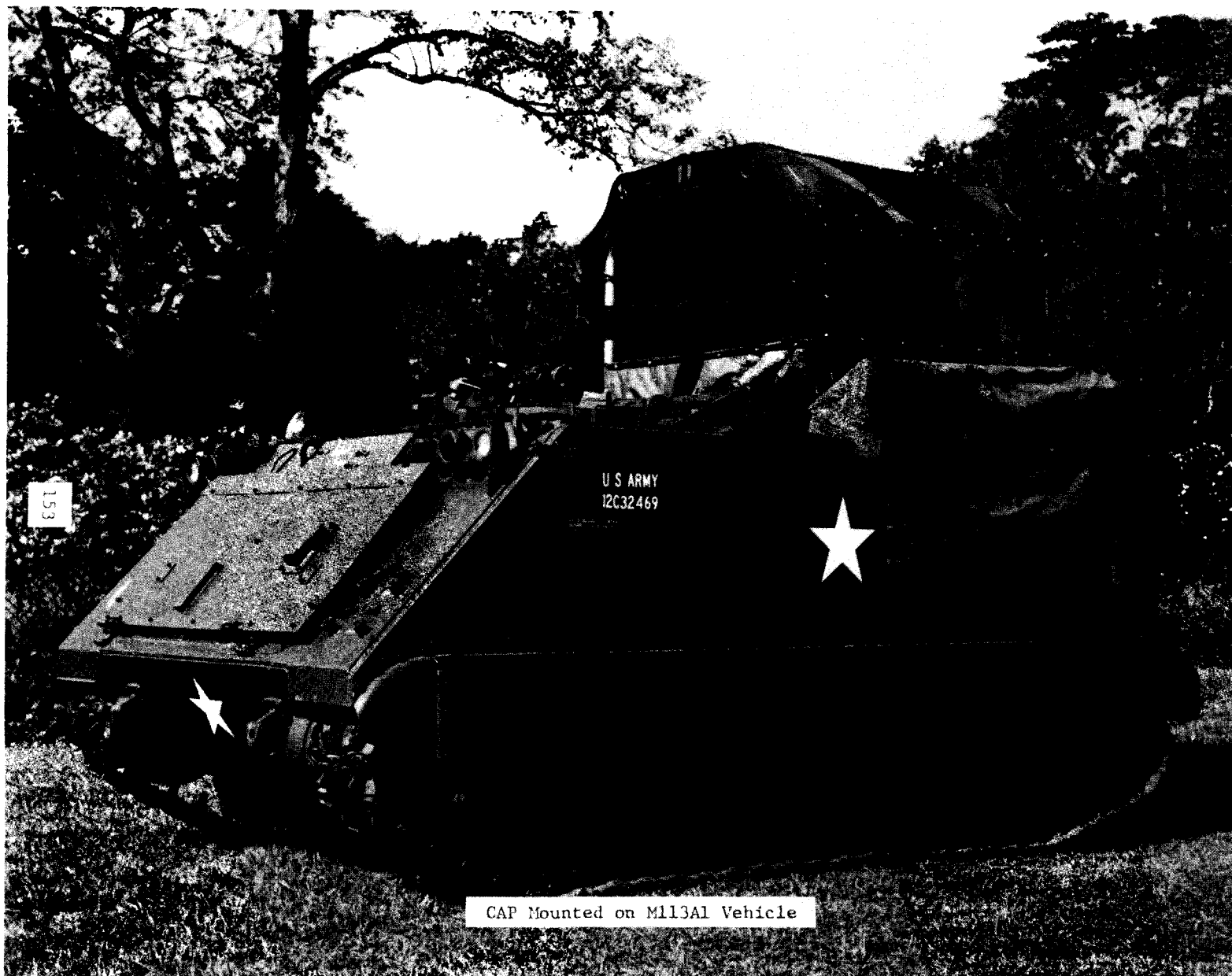
Improved TOW Vehicle Program

(U) The TOW CAP was to be an interim under armor system pending availability of the Improved TOW Vehicle (ITV). The Army Tank-Automotive Command (TACOM) began the ITV program, in coordination with the TOW Project Manager and TRADOC, early in FY 1976. The ITV system, as finally developed, would be procured as a production kit to modify the M113A1 APC to the ITV configuration.

(U) In view of the urgent need for the ITV system, the Department of the Army directed that acquisition be compressed as much as possible. Accordingly, the initial solicitation was issued only to those firms known to have the necessary knowledge, background, and capability to meet the program objectives in the time required. Request for Proposal DAAE 07-76-R-0046, issued by TACOM on 6 January 1976, brought responses from the Chrysler Corporation, Emerson Electric Company, Northrop Corporation, Pacific Car and Foundry Company, and the FMC* Corporation and Hughes Aircraft Company which submitted a combined proposal. After an evaluation of the proposals, TACOM, in April 1976, awarded competitive prototype validation contracts to the Chrysler Corporation, the Emerson Electric Company, and the Northrop Corporation. Chrysler's proposal was based on the turret concept, while Northrop offered an articulated elevated concept and Emerson

* Formerly Food Machinery Corporation, now known by initials only.

²⁸ (1) *Ibid.* (2) TOW/HAW New Materiel Introductory Ltr, revised Jul 76, p. 28. TOW Proj Ofc.



CAP Mounted on M113A1 Vehicle



TOW CAP in Stored Position

a combination of both concepts.²⁹

(U) The ITV competitive shoot-off (DT/OT I) commenced on 1 September 1976, with the TOW Project Office providing all of the Government-furnished TOW equipment and the necessary technical and logistical support. Upon completion of the 3-month DT/OT I program, one of the three contractors would be selected for an Engineering Development/Producibility Engineering and Planning (ED/PEP) contract, coupled with the negotiation of a priced option for initial production of about 550 ITV kits.

(U) Meanwhile, two other systems were added to the under armor TOW family: the Mechanized Infantry Combat Vehicle (MICV) and the Combat Support Vehicle (CSV). Intended as a complement to, rather than a replacement for, the ITV, the MICV consisted of two major programs: the Infantry Vehicle and the TOW-Bushmaster Armored Turret (TBAT) Scout Vehicle. As of 30 September 1976, the MICV had begun the OT II phase, and the TBAT was in the advanced development phase. The Required Operational Capability (ROC) for the Combat Support Vehicle, calling for an initial operational capability in the fourth quarter of FY 1979, was yet to be approved; however, the Department of the Army had concurred in the proposal to use the new XR-311 as the basic vehicle.³⁰

(U) Officials of the Army Missile Command got their first close look at the versatile XR-311 early in February 1976, when a prototype of the vehicle equipped with a TOW launcher was checked out by COL R. W. Huntzinger, TOW Project Manager, Robert Q. Taylor, Deputy Project Manager, and LTC Ben Bedford, Assistant Project Manager for Logistics. Designed by the FMC Corporation of San Jose, California, the advanced XR-311 vehicle extended the mobility of the wheeled vehicle into regions normally limited to tracked vehicles. This new concept in all-terrain combat mobility provided high speed, durability, low noise, low silhouette, low operational cost, and multimission adaptability. Powered by a 187-horsepower V8 gasoline engine coupled to a three-speed automatic transmission, the XR-311 "dune-buggy" had a maximum road speed of 80 mph. According to the contractor, it could easily

²⁹(1) Chrysler Ppsl D-0080, ITV Sys Competitive Prototype Validation Ppsl, 6 Feb 76. (2) Northrop Ppsl 76Y020, Design & Adv Dev of an ITV, 6 Feb 76. (3) Emerson Rept NB861-008-3, Ppsl for ITV ML13/TOW Turret Concept, 6 Feb 76. All in TOW Proj Ofc. (4) Intvw, M. T. Cagle w Frank H. Case, Jr., 9 Aug 76. (5) Hist Rept, TOW PM, FY 76/7T, pp. 7-8. HDF.

³⁰*Ibid.*, p. 8.

climb and descend slopes greater than 60 percent, negotiate side slopes greater than 50 percent, ford streams up to 30 inches deep, and plow through mud, snow, sand, and dense vegetation. The rugged four-wheel independent suspension system and heavy-duty shock absorbers allowed the vehicle to move quietly and quickly over extremely rough terrain and climb obstacles up to 20 inches high while providing an amazingly smooth ride.³¹

Follow-On Development Cost

(U) Excluding the ITV program which was funded through TACOM, the cost of the follow-on development effort during the FY 1974-76 period totaled \$21.5 million, increasing the actual obligation to \$128,948,000 as of 30 June 1976. The projected estimate for the FY 1977-79 period was \$4.4 million. The latter funds, if appropriated, would bring the total RDTE cost of the TOW program to \$133,348,000, as shown below.³²

<u>Phase</u>	<u>FY</u>	<u>RDTE Cost</u>	
Basic System Development:	1962-73		\$107,448,000
Product Improvements:	1974	\$5,700,000	
	1975	7,400,000	
	1976	<u>8,400,000</u>	21,500,000
Total Cost FY 1962-76:			<u>\$128,948,000</u>
Projected Estimate:	197T	\$1,500,000	
	1977	900,000	
	1978	1,500,000	-
	1979	<u>500,000</u>	<u>4,400,000</u>
Estimate at Completion:			\$133,348,000

³¹ (1) *The Rocket*, 11 Feb 76, p. 8. (2) Intvw, M. T. Cagle w Robert Q. Taylor, Dep TOW PM, 20 Aug 76. (3) FMC Brochure on XR-311 Veh. HDF.

³² (1) TOW SAR's, 1974-76. TOW Proj Ofc. (2) Intvws, M. T. Cagle w Gary K. Smallwood, 22 Jun 76 & 12 Aug 76. (3) Also see Table 3, p. 110.



LTC Ben Bedford, Assistant Project Manager for Logistics,
Checks Out a 10W-Equipped XR311 Combat Support Vehicle.

CHAPTER VII

~~(S)~~ WEAPON SYSTEM DEPLOYMENT (U)

(U) From the inception of its deployment in September 1970, the TOW weapon system continued to increase in density and reputation throughout the free world. One of the most difficult problems faced by the TOW Project Manager concerned the distribution of limited assets among a spiraling number of U. S. and foreign claimants. Procurement and distribution planning was subject to constant revision as changes occurred in worldwide priorities and force structures. The TOW was successfully deployed on an unprogrammed, urgent basis to the 82d Airborne Division in December 1970, to South Vietnam in both the ground and helicopter applications in May 1972, and to Israel in October 1973. To meet these unprogrammed requirements, available assets were diverted from scheduled U. S. deployments and a quantity of launchers were borrowed from tactical units in Europe. Despite an increase in the launcher production capacity at Emerson Electric, only 22 percent of the scheduled U. S. deployments was complete as of early January 1974. Deployments were still underway in September 1976 and were scheduled to continue on a time-phased basis through 1980.

Logistic Support

(U) The compilation of logistic support management information began with the initiation of the ET/ST program in December 1966. Supply support commenced in September 1970. The maintenance plan was prepared in September 1965 and continually refined and updated until November 1971, when the Anniston Army Depot became fully responsive to the TOW maintenance support mission. The TOW support and test equipment was identified in August 1968. Contractor support with R&D type test equipment was used for TOW deployments until the Land Combat Support System (LCSS) became available on 1 March 1971.

(U) The TOW system was designed for ease of maintenance. At the organizational level, maintenance was limited to keeping the equipment clean, inspecting for damage, and performing a launcher self-test. The latter was required after emplacement, daily when emplaced, and at 4-hour intervals during operation. The launcher had self-test features which provided fault isolation to the major

assembly level. Faulty components could be replaced by direct exchange using a minimum of tools. The TOW missile remained sealed in its container and required no tests, checkout, or repair before firing.

(U) Direct support contact teams made on-site repairs by replacement of faulty TOW assemblies. The two-man teams were equipped with the TOW Contact Support Set (CSS) which had an increased fault isolation capability over the launcher self-test. Assemblies requiring maintenance actions beyond the capability of the CSS were returned to the general support unit for repair with the Land Combat Support System. Technical assistance personnel were available to assist with fault isolation, maintenance, and data collection.

(U) As the maintenance support depot for the TOW weapon system, the Anniston Army Depot provided the following services: receipt, storage, and issue of end items and allocated vehicles; depot maintenance, repair, overhaul, and rebuild of designated end items, assemblies, subassemblies, and repair parts; receipt, installation, and checkout of vehicle adapter kits; receipt, assembly, and checkout of designated contact support test set components; fabrication of designated TOW component hardware; and scheduled depot surveillance of the TOW inventory.¹

Basis of Issue

(U) Under the original plan, all infantry TOE units were allocated 6 TOW systems (launchers) per battalion, except the U. S. Army, Europe (USAREUR) NATO-oriented mechanized battalions which were authorized 12 launchers each.² On 1 March 1975, the TOE was changed to reflect an increase in launcher density to 12 for each airborne battalion and 18 for each infantry, mechanized infantry, and airmobile battalion and armored cavalry squadron. On 7 March 1975, the authorized launcher density for USAREUR mechanized battalions and prepositioned forces was increased from 18 to 22. At the same time, the Department of the Army authorized the addition of four TOW launcher systems

¹(1) TOW/HAW New Mat Introductory Ltr, revised Jul 76. TOW Proj Ofc. (2) TOW RECAP Presn by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 8 Jan 74, p. 50. HDF.

²(1) AMCTCM Item 8176, 15 Dec 70. RSIC. (2) Also see above, p. 107.

for each USAREUR tank battalion.³

(U) The authorized basic load of TOW missiles per launcher was 20 each for mechanized infantry, armored cavalry, and tank units; 16 each for infantry and airborne units; and 12 each for airmobile units. The initial unit conversion training allowance of one HEAT and two practice missiles per launcher was authorized for selected units only. The TOW missile training allowance for annual service practice was one missile per launcher per year for selected units. Blast simulation devices were authorized and required for initial TOW gunner qualification and crewmember unit training.

(U) The DA-approved basis of issue for other items of the system was as follows:⁴

Battery Charger: 1 per battalion equipped with TOW
2 per division maintenance battalion
1 per independent brigade maintenance unit

Training Set: 2 per battalion equipped with TOW (except
units with less than 12 launchers)

Truck, GM Equipment (MULE): 18 per airmobile battalion

Truck, GM Equipment (Jeep) & Truck, GM, Missile Carrier
(Jeep): 12 per airborne battalion
18 per infantry battalion

Carrier, GM Equipment (APC): 22 per mechanized battalion
(NATO-oriented units)
18 per mechanized infantry
battalion

Shop Equipment, GM System, Contact Support: Issued to
direct support units on basis of 1 per TOW battalion
supported.

Tool Kit, GM Maintenance: 1 per MOS 27E Repairman

Tool Kit, GM Maintenance, Special: 1 per direct support
Maintenance Base Shop

³(1) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, pp. 8, 12. HDF. (2) Also see TOW/HAW New Mat Introductory Ltr, revised Jul 76, p. 3. TOW Proj Ofc.

⁴*Ibid.*, pp. 3-4.

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CONUS Training Base

(U) Except for changes in the TOW gunner training site, elements of the CONUS training base remained essentially the same as previously recorded.⁵ Gunner training was transferred from Fort Jackson, South Carolina, to Fort Polk, Louisiana, in July 1973,⁶ thence to Fort Benning, Georgia, in June 1976.⁷ The distribution of equipment to CONUS training agencies was completed in August 1976, with delivery of four launcher systems to the School Troop, 4th Battalion/31st Infantry, Fort Sill, Oklahoma. The training agencies and their equipment authorization are listed below.

<u>Training Agency</u>	<u>Systems Auth</u>
USAIS, Fort Benning, Ga.	48*
USAMMCS, Redstone Arsenal, Ala.	12
USAOC&S, Aberdeen Proving Ground, Md.	1
USA Armor School, Fort Knox, Ky.	3
USAMICOM, Redstone Arsenal, Ala.	7
Electronic Warfare Lab, Fort Monmouth, NJ	1
Contractor Equipment (Support of ITV Program)	6
Sch Trp, 4th Bn/31st Inf, Fort Sill, Okla.	4
	<u>82</u>

*Includes 16 systems transferred from Ft Polk, La.

Tactical Army Deployments

(U) Tactical deployment of the TOW weapon system commenced in September 1970 with equipage of the 197th Infantry Brigade at Fort Benning and the 194th Armored Brigade at Fort Knox.⁹ As of

⁵ See above, p. 107.

⁶ TOW RECAP Presn by COL R. W. Huntzinger, to DCG, Mat Acq, AMC, 22 Aug 73, p. 12. HDF.

⁷ MFR, LTC Ben C. Bedford, Asst PM, Log, TOW Proj Ofc, to TOW PM, 7 Jun 76, subj: Trf of Tng Equip fr Ft Polk to Ft Benning. TOW Proj Ofc.

⁸ TOW Mat Fielding Plan Part II (Dplmt), 15 Aug 76. TOW Proj Ofc.

⁹ TOW/HAW New Mat Introductory Ltr, revised Jul 76, p. 3. TOW Proj Ofc.

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15 August 1976, 1,882 TOW launcher systems had been deployed with active Army units in Europe, Korea, and CONUS, against a total TOE authorization of 2,230. The remainder of the authorized systems were to be deployed on a time-phased basis through March 1978. In addition to the 2,230 systems authorized for active Army units, 270 were programmed for roundout National Guard units and 2,058 for National Guard/U. S. Army Reserve (USAR) units. Deployment of these systems was scheduled to begin in September 1976 and continue through 1980.¹⁰

(C) Deployments to USAREUR began in November 1970 and were completed in February 1976 after a break in shipments to meet other urgent requirements. In October 1973, during the Mideast war, 81 launchers and 2,010 missiles were rushed to Israel under Project 9DD. At DA's direction, 26 of the launchers were deployed from CONUS assets and 55 were withdrawn from tactical units in Europe. The latter systems were paid back in 1975, and equipping of the remaining authorized tactical units was resumed. Delivery of the last 138 systems in February 1976 completed the U. S. 7th Army's TOE authorization of 760 systems, including 2 for the training center at Grafenwohr, Germany.¹¹

(C) Deployment of the TOW weapon system to the 2d Infantry Division, U. S. 8th Army, Camp Casey, Korea, commenced in March 1975 and was completed in June 1975. The 2d Infantry Division received 126 launcher systems, enough to equip 7 battalions.¹²

(C) The U. S. Army Forces Command (FORSCOM)/CONUS active units were slow in receiving their authorized TOW systems because of the diversion of available assets to meet urgent, unprogrammed requirements arising during the 1970-73 period. The first two CONUS units (the 197th Infantry Brigade and 194th Armored Brigade) were equipped in September 1970, but subsequently released their systems for use elsewhere. As of 31 December 1975, 270 systems had been distributed among 6 FORSCOM/CONUS units, enough to complete the TOE authorization of the 82d Airborne Division and to

¹⁰ TOW Mat Fielding Plan Part II (Dplmt), 15 Aug 76. TOW Proj Ofc.

¹¹ (1) *Ibid.* (2) TOW/HAW New Mat Introductory Ltr, revised Jul 76, p. 3. TOW Proj Ofc. (3) TOW RECAP Presns by COL R. W. Huntzinger, to DCG, Mat Acq, AMC: 8 Jan 74, pp. 2, 10; & 9 Jul 74, p. 10. HDF. (4) TOW DAPR, 10 Jun 76. TOW Proj Ofc.

¹² (1) TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 12. HDF. (2) TOW Mat Fielding Plan Part II (Dplmt), 15 Aug 76. TOW Proj Ofc.

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provide the other five units with a part of their authorized systems.¹³

Three battalions of the 82d Airborne Division had been equipped with the TOW system in December 1970 under an accelerated delivery schedule. These units were initially authorized the MULE-mounted version of TOW, but received the M151 Jeep-mounted system until the MULE became available. In the fall of 1974, the 82d Airborne Division switched back to the Jeep-mounted system and the MULE vehicles were returned to the depot. As of December 1975, the 82d Airborne was equipped with a full complement of 114 launcher systems.¹⁴

From 1 January to 15 August 1976, 726 more TOW systems were distributed among FORSCOM/CONUS units, increasing the number deployed to 996 against a total authorization of 1,344. The remaining 348 systems were scheduled for deployment during the period September 1976 to March 1978 (see Table 3).¹⁵

The TOW in Vietnam

(U) One of the urgent, unprogrammed requirements for the TOW weapon system materialized on 30 March 1972, when the North Vietnamese swept across the Demilitarized Zone in an all-out offensive supported by substantial numbers of heavily armored Russian and captured American tanks. To counter this new threat, the Department of the Army, on 14 April 1972, directed MICOM to rush two UH-1B (Huey) gunships equipped with the XM-26 armament subsystem and a load of TOW missiles to the battlefield. This was followed on 30 April by orders to deploy the ground-based TOW system with instructors to train U. S. and South Vietnamese crews to operate the weapon.

(U) The order to have the experimental airborne TOW system on the way to Vietnam, ready to fight, in 7 days sparked one of

¹³ (1) *Ibid.* (2) TOW/HAW New Mat Introductory Ltr, revised Jul 76, p. 3. TOW Proj Ofc. (3) Intvw, M. T. Cagle w CPT Jack D. Conway, TOW Proj Ofc, 17 Sep 76.

¹⁴ (1) TOW RECAP Presns by COL R. W. Huntzinger, to DCG, Mat Acq, AMC: 8 Jan 74, p. 2; & 8 Oct 74, p. 11. (2) Hist Rept, TOW PM, FY 71, p. 6. All in HDF. (3) TOW Mat Fielding Plan Part II (Dplmt), 15 Aug 76. TOW Proj Ofc.

¹⁵ *Ibid.*

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TABLE 8
Tactical Army Deployments - Actual & Projected (U) *

<u>Unit</u>	<u>Lchrs Auth</u>	<u>Dpld AO 8/15/76</u>	<u>Deployments Scd</u>
USAREUR (U. S. 7th Army)	760 ^a	760 ^b	
Korea (U. S. 8th Army)	126	126	
FORSCOM/CONUS Active Army:			
82d Abn Div, Ft Bragg, NC	114	114	
1st Inf Div, Ft Riley, Kan	90	90	
3d Armd Cav Regt, Ft Bliss, Tex	54	54	
2d Armd Div, Ft Hood, Tex	126	126	
1st Cav Div, Ft Hood, Tex	72	72	
101st Ambl Div, Ft Campbell, Ky	168	168	
9th Inf Div, Ft Lewis, Wash	144	144	
25th Inf Div, Schoefield Bks, Hi	108	108	
4th Inf Div, Ft Carson, Colo	144	114	30 - Sep 76
194th Armd Bde, Ft Knox, Ky	18	6	12 - Dec 76
197th Inf Bde, Ft Benning, Ga	36	0	36 - Oct 76
7th Inf Div, Ft Ord, Calif	108	0	108 - Jan-May 77
24th Inf Div, Ft Stewart, Ga	108	0	108 - Feb77-Mar78
5th Inf Div, Ft Polk, La	54	0	54 - Sep76-Sep77
Total FORSCOM/CONUS Units:	(1344)	(996)	(348)
Roundout Natl Guard Units	270	0	270 - Sep76-Dec78
Natl Guard/USAR Units	2058	0	2058 - 1977-80
GRAND TOTAL:	4558	1882	2676

^aIncludes two systems for the 7th U. S. Army Training Center at Grafenwohr, Germany.

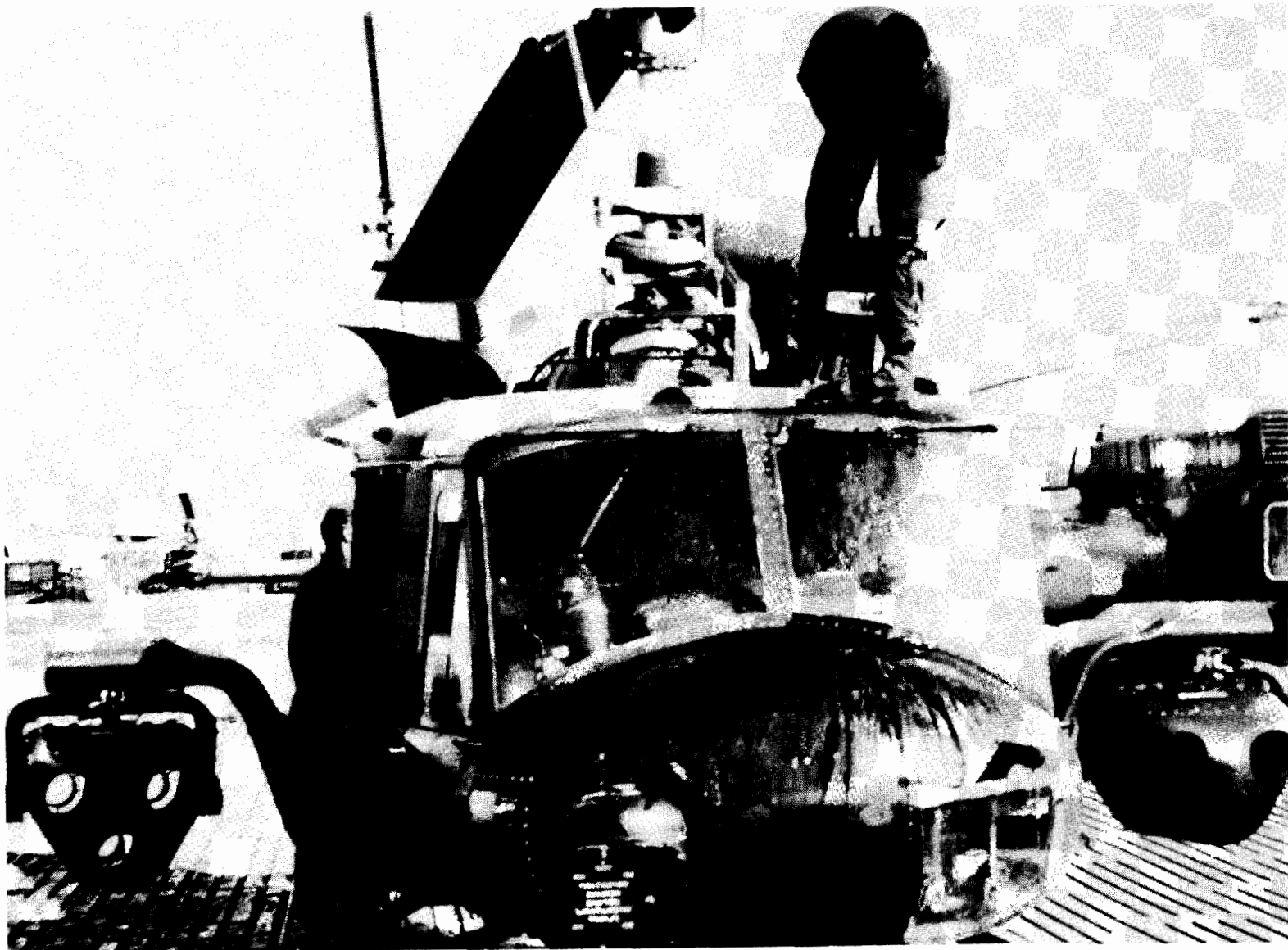
^bPlus one launcher issued over TOE authorization which was to be turned in to field service stock as excess.

SOURCE: TOW Mat Fielding Plan Part II (Deployment), 15 Aug 76.

the most unique deployments ever accomplished by the Army. It was indeed a monumental task done in record time through a well-coordinated team effort headed by COL Robert W. Huntzinger, the TOW Project Manager. The two UH-1B gunships originally modified and used in the XM-26 airborne TOW development tests at Redstone Arsenal were located at Fort Lewis, Washington, where they were being used in tracking tests by the Combat Developments Command Experimentation Center. Only a part of the XM-26 equipment was installed on the helicopters, the remainder having been placed in storage at the Hughes Aircraft plant in Culver City, California. The TOW-peculiar hardware was removed from the helicopters and flown to Culver City, where the complete XM-26 subsystems were assembled, checked out, and packed for pickup at El Segundo, California. Maintenance was begun on the two helicopters at Fort Lewis as they were readied for airlift. TOW missiles were taken from production lots at Hughes' plant in Tucson and assembled for pickup by a C-141 aircraft at Davis Monthan Air Base.

(U) Realizing that this was no time to break in new men, Colonel Huntzinger handpicked the technical support team that would go with the equipment to Vietnam. Heading the team was Hughie J. McInnish, who spearheaded development of the TOW airborne system at Redstone Arsenal. Included on the team were an expert on the UH-1B helicopter from Bell Aircraft and two engineers and two technicians from Hughes Aircraft, all of them experts on the TOW and its airborne guidance and control equipment. The aviators who had been flying the hueys in tests at Fort Lewis volunteered to deploy with the gunships to Vietnam. Members of the flight team, commanded by LTC Patrick L. Feore, Jr., were CWO's Scott E. Fenwick, Carroll W. Lain, and Edmond C. Smith, SFC Boyce A. Hartsell, Sp5 Ronald G. Taylor, and Sp4 David W. Lehrschall. CWO Lester Whiteis of the Aviation Systems Command, a qualified test pilot, instructor, and maintenance officer, was added to complete the crew.

(U) On 21 April 1972, exactly 7 days after MICOM got the word to go, three C-141 aircraft were enroute to Vietnam with the two gunships, two sets of the XM-26 subsystem, missiles, crews, and other equipment. On the morning of 24 April, the planes landed at Tan Son Nhut outside Saigon, where the gunships were readied for flight with the XM-26 systems. Since none of the Army aviators had ever fired a TOW missile from the UH-1B helicopter, the support team gave them a cram course on the XM-26 system. The crews checked out in cockpit procedures, held tracking drills to familiarize themselves with the stabilized missile sight and its controls, and, as a graduation exercise, fired two missiles each from airborne helicopters.



Readying one of the TOW-armed UH-1B gunships for combat action.

(U) At first it appeared that the TOW-equipped choppers would be committed to combat in the action then in progress at An Loc. The day the TOW package arrived in Vietnam, however, the North Vietnamese had overrun Tan Canh northwest of Kontum and there had been numerous actions at firebases guarding the northern and western approaches to the city. North Vietnamese armor, including Soviet-made T-54 medium and PT-76 amphibious tanks, was known to be in the area. Also, the North Vietnamese had captured a number of American M-41 tanks and were using them against the South Vietnamese units falling back to Kontum, a provincial capital north of Pleiku. On 28 April, with a major enemy attack on Kontum imminent, the helicopter crews and support team were ordered north to Camp Holloway near Pleiku in the Central Highlands. The gunships flew up that day while the remainder of the group and equipment were airlifted by C-130 aircraft.¹⁶

(U) As the airborne group at Pleiku prepared to take the TOW into action as soon as suitable targets were located, preliminary planning was underway at MICOM for deployment of the ground-based TOW. This deployment operation, much larger than the first, involved 87 TOW launcher systems, about 2,500 missiles, maintenance support personnel and equipment, repair parts, trainers, and instructors to train U. S. and South Vietnamese crews to operate the weapon. On 5 May 1972, just 5 days after MICOM received movement orders, the first aircraft landed in Vietnam. All had arrived by the following day, and training began soon thereafter. MAJ Dale F. Norton of the TOW Project Office was named logistics officer for the ground system and deployed with it, along with Jesse Rich, a civilian missile maintenance technician from MICOM's Directorate for Maintenance.¹⁷

(U) In addition to the above ground-based TOW equipment, the Army of the Republic of Vietnam (ARVN) was supplied with the following equipment under the Military Assistance Service Funding (MASF) program: 3,220 missiles, 141 launchers, 14 trainers, 39 M232 jeep adapter kits, 35 M236 jeep adapter kits, 13 battery chargers, and 6 contact support sets.¹⁸

(U) In yet another TOW deployment exercise, an 82d Airborne

¹⁶ (1) *The Rocket*, 26 Jul 72. (2) *The Rocket*, 6 Sep 72.

¹⁷ (1) *Ibid.* (2) *The Huntsville Times*, 26 May 72. (3) Hist Rept, TOW PM, FY 72, p. 6. HDF.

¹⁸ Intvw, M. T. Cagle w LTC Robert C. Dawes, TOW Proj Ofc, 26 Aug 76.

Division antitank task force headed by 1LT David R. Haskett was airlifted to Vietnam with 24 jeep-mounted launchers, 500 missiles, and 2 3/4-ton trucks for the maintenance contact team. The task force consisted of a 48-man crew plus a maintenance contact team of 10 personnel from the 763d Ordnance Company (now Company E, 782d Maintenance Battalion). In Vietnam, units of the task force were attached to the 3d Brigade, 1st Cavalry Division, whose personnel were trained to operate the TOW weapon system.¹⁹

(U) Meanwhile, the TOW airborne system had gone into action. The first TOW combat launches on the morning of 2 May 1972 resulted in the destruction of four captured American M-41 tanks, one artillery gun, and one truck at the site of one of the abandoned firebases near Kontum. CWO Carroll W. Lain probably took no note of it at the time, but he made history that morning, when a TOW missile he fired struck the first tank, marking the first American-made guided missile to be fired by U. S. soldiers in combat.* In the next several weeks, the two Huey gunships flew numerous sorties in the area around Kontum, knocking out tanks, armored vehicles, trucks, artillery pieces, and other point targets.

(U) The North Vietnamese launched the expected attack on the provincial capital of Kontum before dawn on 26 May 1972. Tactical air strikes pounded enemy forces within a mile of the city, but were hampered by the closeness of the enemy force to the defenders in the house-to-house battle underway inside the city. The two Huey gunships went into action at 0640 and before the morning ended flew several sorties apiece. They expended 21 missiles during several hours of continuous operation and scored nine tank kills—every one they found—as well as destroying other targets, including a machine gun on a water tank.

(U) In the ensuing days, there were other battles and other

* The first combat firings of Army missiles occurred during the Six Day War in 1967 when the Israelis downed several Egyptian jets with the HAWK missile. HAWK missiles were deployed in Vietnam, but were never fired in combat. Early in the Vietnam war, U. S. soldiers fired some French-developed ENTAC wire-guided missiles. MICOM-developed helicopter rocket launchers, firing the 2.75-inch rocket, and the Light Antitank Weapon had been widely used in Vietnam for several years.

¹⁹ (1) Stmt by SSG Tom R. Sutton, Cbt Spt Co, 1st Bn/508th Inf, Ft Bragg, NC, 6 Sep 76. HDF. (2) FONECON, M. T. Cagle w SSG Tom R. Sutton, Ft Bragg, NC, 5 Oct 76.

tank kills, but the opportunities for helicopter-tank engagements gradually diminished. During May and June 1972, the months spent in Vietnam by the temporary duty (TDY) team, the two helicopters fired a total of 94 TOW missiles in combat engagements, scoring 81 hits on a variety of targets, including 24 tanks, 9 trucks, 4 armored personnel carriers, 3 bunkers, 2 machine gun emplacements, 2 artillery pieces, 2 ammunition dumps, a bridge, and a rocket launcher. According to Warrant Officer Lester Whiteis, neither of the gunships was hit by enemy fire. They encountered considerable machine gun fire, but avoided most of it by staying high. Before leaving Vietnam, the TDY team trained replacements from the 1st Aviation Brigade. The XM-26 airborne TOW system remained in Vietnam until late January 1973.

(U) Between 30 April 1972 and 11 January 1973, the two Huey gunships fired a total of 199 TOW missiles—37 in training and 162 in combat engagements. The 37 training firings began on 30 April 1972 and continued through 7 August 1972. BG William J. Maddox, Jr., the Director of Army Aviation, fired one of the training rounds on 21 May 1972, during a 10-day visit to Vietnam, and scored a hit on a previously destroyed M-41 tank.

(U) Of the 162 airborne TOW missiles fired in combat engagements, 151 (93 percent) were reliable and 124 (82 percent) of the latter scored hits on a variety of targets. Among the targets destroyed were 27 tanks, 21 trucks, 5 armored personnel carriers, 3 artillery pieces, 1 antiaircraft gun, 1 122mm rocket launcher, 5 machine guns, 2 57mm guns, 5 caves, 8 bunkers, 2 bridges, 2 mortars, 2 ammunition storage dumps, 2 TOW jeeps (1 with launcher and 1 with missiles), and 1 house. Eleven of the missiles fired malfunctioned and four misses occurred when the gunner fired the missile at a range in excess of 3,000 meters and lost it when the guidance wire ran out.²⁰

(U) Nevertheless, the superior tactical value of the airborne TOW had been dramatically demonstrated. BG William J. Maddox, Jr., in confirming TOW's use in Vietnam, said he had been strongly impressed with two major lessons: "The Army attack helicopter has played a key role in the current campaign which began 30 March. . . . The Army has fielded for the first time, a highly effective

²⁰(1) Fact Sheets: XM-26 Sys Test & Tng Firings, 18 Sep 72; XM-26 Operational Firings, 14 Feb 73; & XM-26 Results in Vietnam (Tactical Firings), 14 Feb 73. TOW Proj Ofc. (2) *The Huntsville Times*, 26 May 72. (3) *The Huntsville Times*, 2 Jul 72. (4) *The Rocket*, 26 Jul 72. (5) *The Rocket*, 6 Sep 72.



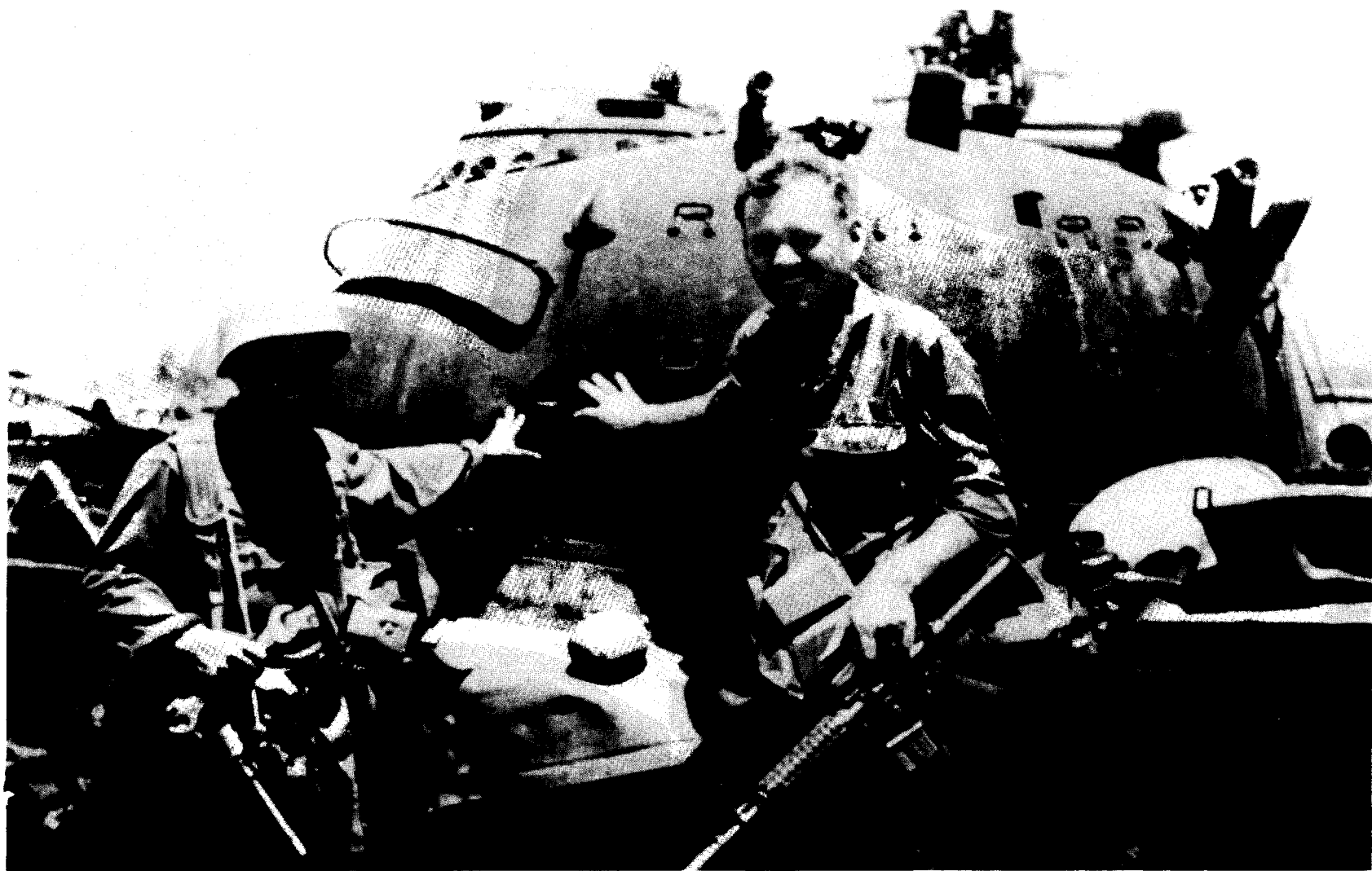
Hughie J. McInnish with one of the two TOW-armed UH-1B helicopters which scored 27 kills, including 17 tanks, during May and June 1972.



McInnish takes a look at the burned-out hull of a T-54 tank knocked out by a TOW on 27 May 1972.



This Soviet tank sought shelter in a building but found a deadly TOW missile instead.



McInnish and an ARVN soldier inspect a T-54 Soviet tank knocked out by a TOW missile.

aerial anti-tank weapon. This is the TOW missile. . . ." Summarizing what he had observed of the role of Army aviators and their attack helicopters in supporting the South Vietnamese, General Maddox said:

"A major new dimension has been added by their now proven combat effectiveness using the TOW missile against modern tanks as well as against other important point targets. With so few having proven so effective in Vietnam, it is now possible to visualize more clearly, the great anti-tank potential which far larger numbers of modern attack helicopters and TOW missiles would bring to a modern American division."²¹

(U) Performance of the ground-based TOW was equally impressive. As stated earlier, new equipment training for U. S. and South Vietnamese crews began upon arrival of the MICOM TDY team early in May 1972. Twenty-eight TOW missiles were expended in training personnel of the 82d Airborne Division and the 3d Brigade/1st Cavalry Division through 21 May 1972.²² Gunners of the 82d Airborne task force fired 12 training rounds against an artillery bunker at a range of about 2,800 meters and scored 12 direct hits.²³ Gunners of the 3d Brigade/1st Cavalry Division fired 16 training rounds, with 1 missile malfunction, 9 target hits, and 6 misses because of poor lighting conditions. Training for personnel of the ARVN Marine Corps began on 10 May and continued through 22 July 1972, with a total of 163 TOW missile firings.²⁴ It was in the course of the latter training program that the first ground-based TOW system was fired in actual combat. Following is an eyewitness account of that battle as described by Marine CPT Phillip C. Norton, an advisor with the South Vietnamese Marines, in a letter to *Infantry Magazine* at Fort Benning:

"The TOW really works! Especially against the Russian-made T-54 tank.

"Around 19 May 72 U. S. Army Sergeant Bill L. Tillman, weapons instructor with the First Regional Assistance Command, Republic of Vietnam, was assigned

²¹*The Rocket*, 5 Jul 72, p. 4.

²²Fact Sheet, TOW Gnd Results, 18 Sep 72. TOW Proj Ofc.

²³(1) *Ibid.* (2) Stmt by SSG Tom R. Sutton, Cbt Spt Co, 1st Bn/508th Inf, Ft Bragg, NC, 6 Sep 76. HDF.

²⁴Fact Sheet, TOW Gnd Results, 18 Sep 72. TOW Proj Ofc.

to Brigade 369 of the Vietnamese Marine Corps to instruct Marines on the Tube-launched, Optically-sighted, Wire-guided missile.

"After two days of classes the TOW was called upon to fire against a live enemy T-54 tank. On the morning of 22 May the 369 Brigade CP was attacked by a combined tank-infantry force consisting of 9 tanks and approximately 200 troops. Sgt Tillman quickly manned his weapon and sighted in on a T-54 at a range of 900 meters. Seconds later there was the unfamiliar roar of the TOW, followed by a victorious cheer, more akin to gridiron than to the battlefield, as the T-54 was engulfed in a bright orange ball of fire. The battle ended 2 hours later with all 9 tanks destroyed and 117 enemy confirmed dead.

"I know that this was the first kill recorded by the TOW in the Vietnamese Marine Corps, possibly the first kill in actual combat. In any case it was a fine job done by Sgt Tillman with a fine new weapon—the TOW."²⁵

(U) Meanwhile, the 82d Airborne Division task force, having completed in-country training and received an intelligence briefing on the enemy's armor tactics, were moved by C-130 aircraft from Bien Hoa to Pleiku. Four TOW squads were then rushed to positions around Kontum, just as the enemy tank assault began. PFC Angel Figueroa scored the Division's first tank kill with the ground-based TOW on or about 26 May 1972. Through the optical sight, he saw the missile hit the Russian tank and observed a secondary explosion. About a week later, the 48-man task force turned their TOW equipment over to the 3d Brigade/1st Cavalry Division and returned to the United States. The maintenance contact team remained in Vietnam until 1 August 1972.²⁶

(U) By 19 August 1972, a total of 23 TOW missiles had been fired in combat engagements, destroying 11 tanks and 6 bunkers. On 12 July, 78 TOW missiles were destroyed by enemy fire at Phu Bai, and 16 others were destroyed at Fire Support Base Ross on

²⁵Ltr, CPT Phillip C. Norton to Editor, *Infantry Magazine*, USAIS, Ft Benning, Ga, 30 May 72. HDF.

²⁶(1) Stmt by SSG Tom R. Sutton, Cbt Spt Co, 1st Bn/508th Inf, Ft Bragg, NC, 6 Sep 76. HDF. (2) FONECON, M. T. Cagle w SSG Tom R. Sutton, Ft Bragg, NC, 5 Oct 76.

19 August 1972.²⁷ Information on subsequent TOW combat actions involving U. S. units could not be located. Virtually all of the TOW equipment furnished South Vietnam was eventually captured or destroyed.²⁸

²⁷ Fact Sheet, TOW Gnd Results, 18 Sep 72. TOW Proj Ofc.

²⁸ TOW RECAP Presn by COL R. W. Huntzinger, to AMC, 1 Jul 75, p. 12. HDF.

CHAPTER VIII

(U) THE TOW/COBRA PROGRAM (U)

(U) The XM-65 TOW/COBRA development program begun in FY 1972 was a functional upgrade of the developmental XM-26 (TOW/UH-1B Huey) armament subsystem. The object of this product improvement effort was to provide significant improvement in antiarmor firepower by mounting the TOW antitank missile on the AH-1G COBRA helicopter.

(U) The AH-1G COBRA was an outgrowth of the UH-1 Huey helicopter of the 1950's. Developed by the Bell Helicopter Company and deployed by the U. S. Army to Southeast Asia in 1968, the COBRA was the first attack helicopter to be introduced into combat and the first to be designed expressly as a weapons carrier. It was designed to perform in the low air defense threat battlefield of Southeast Asia. Its missions required takeoff with a maximum number of rockets, flight at relatively high speed and over 1,500 feet altitude to the target area, and then a high speed diving attack for rocket delivery. The AH-1G COBRA significantly improved the firepower of the ground forces and, during low-intensity conflict, performed admirably as the Army's attack helicopter. However, in areas of increased altitudes and high temperatures, such as the highlands of South Vietnam, its effectiveness was curtailed by limitations in payload and agility.

(U) During the early years in Vietnam, the attack helicopter was allowed to operate relatively unthreatened at low altitude in performing ground support. In the late stages of the war, however, the air defense threat escalated, driving the flight envelope to tree skimming altitudes. This experience, coupled with that from the Mideast wars, made clear the need to fly attack helicopters in the nap-of-the-earth (NOE) environment, using terrain and vegetation to mask their presence. In this flight regime, the low, slow, and hovering pop-up maneuvers demanded greater helicopter power, agility, and performance. The AH-1G COBRA was too big to do the kind of maneuvering required for NOE flight, and, when broadside to the enemy, it offered too much target area. If not shot down when hit, it still usually required extensive repairs to become flyable again. Or, to put it another way, a bullet that cost the enemy a few cents could do damage that cost thousands of dollars to repair.

Moreover, the COBRA could not carry enough ordnance for prolonged combat, and the weapon systems available had neither the accuracy nor the punch for a good first-round tank kill probability.

(U) Pending availability of the Advanced Attack Helicopter (AAH) to fill the gap left by termination of the CHEYENNE program,* the Army/Bell team undertook a two-phased COBRA improvement effort to adapt it to the high-threat battlefield. In the first phase, known as the Improved COBRA Armament Program (ICAP), the AH-1G COBRA was equipped with the XM-65 TOW armament subsystem, the modified version then becoming the AH-1Q. The next phase, known as the Improved COBRA Agility and Maneuverability (ICAM) program, entailed the upgrading of engine and dynamic components of the AH-1Q. The resultant model, designated as the AH-1S, would provide the performance margin needed for most battlefield environments until the AAH became available in the early 1980's.¹

Improved COBRA Armament Program (ICAP)

(U) Studies leading to development of the XM-65 TOW armament subsystem for the AH-1 series COBRA helicopter began in FY 1970.² Concurrently with these studies, the Army Aviation Systems Command (AVSCOM) formulated a preliminary TOW/COBRA program calling for award of the prime development contract to the Bell Helicopter Company. Under the proposed management concept, the Hughes Aircraft Company would design and develop the TOW armament subsystem under subcontract to Bell, and the TOW Project Manager at MICOM would provide technical support to the program under direction of the Project Manager, Advanced Aerial Weapons Systems (CHEYENNE/COBRA**) at AVSCOM.

(U) Drawing upon experience with the TOW/CHEYENNE program, which had a similar management structure, MG Charles W. Eifler, Commanding General of MICOM, argued that such an arrangement would

* See above pp. 82-83.

** With the subsequent phaseout of the CHEYENNE project in 1972, AMC established the Product Manager, AH-1 COBRA Series Aircraft, at AVSCOM. See above, pp. 38-39.

¹ (1) Rept, Army/Bell AH-1S, by Bell Helicopter Div of Textron, Inc., undated. TOW Proj Ofc. (2) *Army*, Nov 68, p. 168. (3) *Army*, Mar 73, pp. 17-18. (4) *Army*, Aug 73, p. 22.

² Hist Rept, TOW PM, FY 70, p. 10. HDF.

be unwise both from an economical and managerial standpoint. Assuming successful completion of the preliminary effort then underway, he pointed out that very little, if any, work would be required by Bell to modify the airframe. Therefore, Bell, if given the prime contract, would serve primarily as a mere conduit for funds and direction flowing to Hughes Aircraft, and in doing so would add surcharges for supervision, administrative expenses, and profit, resulting in a direct increase in cost of the TOW/COBRA program. Such an arrangement would also create an unwieldy and ineffective management structure, the line of communication between MICOM and Hughes Aircraft being through AVSCOM and through Bell. As in the TOW/CHEYENNE program, MICOM would be seriously handicapped in its ability to obtain required technical data, to get agreement on test plans, and to bring the expertise of its laboratories to bear on technical problems that might arise. Moreover, the airframe manufacturer (Bell), lacking experience in the many complex factors affecting TOW performance, would be reluctant to guarantee the high performance required. Such a situation had developed in the TOW/CHEYENNE program; i.e., after 3 years of work as prime contractor, the Lockheed Aircraft Corporation was still unwilling to sign a definitive contract guaranteeing to meet demonstrated accuracies of the TOW air delivered system. For these and other compelling reasons, he urged that MICOM be given management responsibility for the TOW/COBRA armament subsystem and that the development contract be awarded directly to Hughes Aircraft.³

(U) MG John Norton, Commanding General of AVSCOM, insisted that the adaptation of the weapon system to an aircraft and the aircraft/weapon system integration was the responsibility of AVSCOM. Rebutting points made in General Eifler's letter, he argued that any "slight" fiscal advantage in having the subsystem contractor as prime would be offset by increased system integration problems; that the effect of the unwieldy management structure would be reduced by a rapport established between the engineering elements of the respective commands; and that the airframe contractor would be even more reluctant to guarantee performance of a Government-furnished subsystem developed with a minimum of airframe contractor participation.⁴

(U) Subsequent letters to AVSCOM and AMC officials failed to

³Ltr, MG Charles W. Eifler, CG, MICOM, to MG John Norton, CG, AVSCOM, 26 Aug 69, n.s. TOW Proj Ofc.

⁴Ltr, MG John Norton, CG, AVSCOM, to MG Charles W. Eifler, CG, MICOM, 23 Sep 69. TOW Proj Ofc.

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resolve the issue to MICOM's satisfaction. Convinced that the proposed management structure would not provide the best possible weapon system at the lowest cost, the Commanding General of MICOM took his case directly to the Commander of AMC.⁵ This effort also ended in failure. The Commander of AMC made the final decision to proceed with the proposed AVSCOM management structure following presentations made in his office on 10 November 1970.⁶

(U) The Army Aviation Systems Command awarded the prime ICAP development contract to the Bell Helicopter Company on 3 March 1972. Under contract DA-AJ01-72-C-0102, in the amount of \$24,732,793, Bell was to design, develop, fabricate, integrate, and test the improved armament and helmet sight subsystem for the AH-1G helicopter. Nine each of the subsystems were to be fabricated and eight of these were to be installed in Government-furnished AH-1G helicopters for use in the test program. The contract also included the design and fabrication of ground support equipment. Material to be furnished by the Government included one chase aircraft, TOW missiles for the test program, certain special tools and test equipment, and spare parts. As the airframe manufacturer, Bell was contractually responsible for meeting the weapon subsystem performance, as well as integrated aircraft requirements.⁷

(S) The ICAP schedule approved in mid-1972 called for the first unit to be equipped in January 1975 and an initial operational capability (IOC) in March 1975.⁸ The AH-1Q COBRA (AH-1G helicopter with XM-65 TOW armament subsystem and the XM-128 helmet sight subsystem) was to replace the M22 (SS-11B/UH-1B) guided missile armament subsystem, which had been adopted as Standard A for interim Army use on 23 July 1964.⁹ As of September 1972, there were 186 M22 subsystems in the inventory—101 serviceable and 85 unserviceable. During the Aviation Closed

⁵Ltr, MG Edwin I. Donley, CG, MICOM, to Gen F. J. Chesarek, CG, AMC, 30 Jul 70, n. s. TOW Proj Ofc.

⁶(1) Intvw, M. T. Cagle w LTC Kenneth P. Worsham, TOW Proj Ofc, 29 Oct 76. (2) Also see Presn to GEN Donley, MICOM Mgt Role for TOW/COBRA, 9 Nov 70. TOW Proj Ofc.

⁷Incl to Ltr, CG, AVSCOM, to ASA(I&L), DA, 10 Jan 73, subj: Req for Apprl of D&F for the Improved Armt Sys for the AH-1G Hel. TOW Proj Ofc.

⁸*Ibid.*

⁹DF, AT/Acft Wpns Cmdty Ofc, MICOM, to Distr, 29 Jul 64, subj: Std A TCLAS of the M22 Armt Subsys. HDF.

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Loop Support Conference held at AVSCOM in late August 1972, it was determined that 54 subsystems would be required (36 Europe, 11 CONARC, 6 Reserve Forces, and 1 AMC) until the TOW/COBRA could be fielded. The remaining 47 serviceable subsystems would be held to meet contingency requirements and the 85 unserviceable subsystems would be cannabilized to support the serviceable units.¹⁰

The AH-1Q R&D Prototype

(U) The XM-65 TOW armament subsystem, designed and built by Hughes Aircraft under subcontract to Bell, was a functional upgrade of the TOW XM-26 armament subsystem* whose capability had been successfully demonstrated in the UH-1B helicopter. However, because of the lack of available XM-26 components and basic differences between the AH-1G COBRA and the UH-1B Huey, the XM-65 used only about 50 identical XM-26 drawings out of a total of 1200. Although the XM-26/UH-1B system exhibited good performance in combat, it required significant maintenance support, it would be expensive to manufacture, and it was overtaken by advances in electronic technology. The use of advances in technology since the XM-26 was built in 1965 resulted in lower cost, much higher reliability, and lower weight for the XM-65 subsystem. Specific examples of performance differences were as follows:

	<u>XM-26</u>	<u>XM-65</u>
Structure	Magnesium	Aluminum
Weight	1,260 lbs. (6 TOW's)	910 lbs. (8 TOW's)
Reliability	112.9 hours	318 hours
Optical Transmission	29 percent	35 percent
Azimuth Look Angle	<u>+90</u> degrees	<u>+110</u> degrees
Maximum Launch Speed		
Demonstrated	100 knots	190 knots

The 1974 negotiated price for the XM-65 and a 1967 Hughes Aircraft quote for the XM-26 indicated that the latter would have a unit recurring cost of about \$100,000 greater than the XM-65. The cost reduction for the XM-65 was attributed to modular construction of the stabilized sight unit and the use of microelectronics laid out

* See above, pp. 76-82.

¹⁰ DF, Land Cbt Sp Items Mgr to CG, MICOM, 1 Sep 72, subj: LCSIMO Weekly Significant Actions, Week Ending 1 Sep 72. HDF.

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on printed circuit boards in such a way that automatic component insertion and wave soldering techniques could be used in manufacturing.¹¹

(U) The XM-65 subsystem consisted of (1) the stabilized telescopic sight unit, located in the nose of the COBRA helicopter; (2) aircrew controls and displays (pilot steering indicator, TOW control panel, and sight unit hand control), located in the cockpit of the aircraft; (3) stabilization control and missile command amplifiers and electronic power supply, all located in the tail boom of the aircraft; and (4) a launching mechanism which allowed standard BGM-71A TOW missiles to be fired from their containers. The basic two-round launcher could be stacked to allow each helicopter a complement of either four or eight TOW missiles. The complete subsystem weighed 566.3 pounds (257.9 kilograms) with four TOW missiles and 894.3 pounds (406.7 kilograms) with eight TOW's. It could fire either the basic 3,000 meter BGM-71A missile or the extended-range TOW having a maximum range of 3,750 meters. The target attack range could be increased to over 4,000 meters by flying the helicopter toward the target after TOW launch.¹²

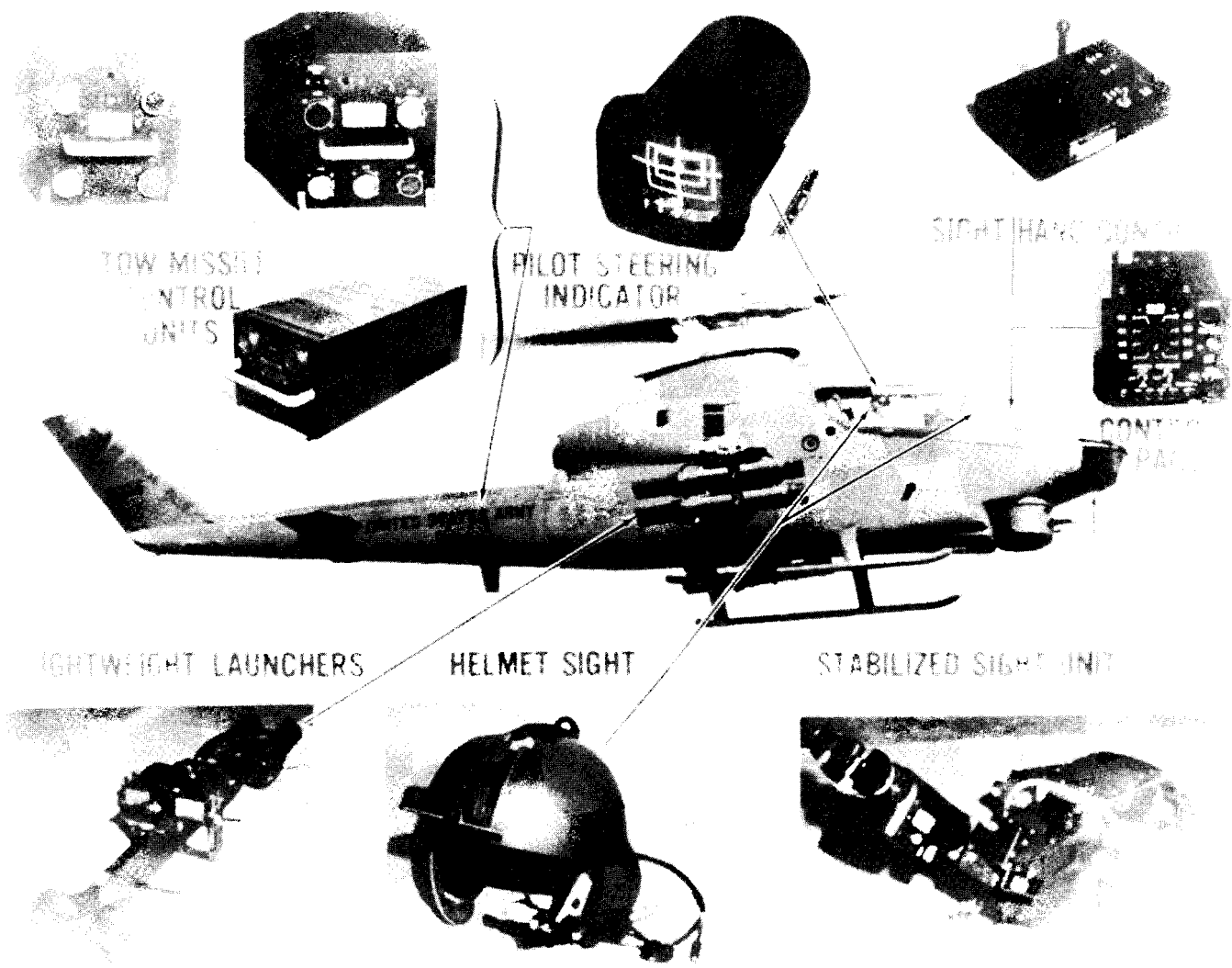
(U) The helmet sight subsystem, designed and built by Sperry Univac under subcontract to Bell, provided the pilot and copilot the capability to acquire, track, and fire upon targets while maintaining area visibility and control of the aircraft. This capability was provided by mounting a sight reticle on the helmet over the eye and causing the weapon system to move automatically in azimuth and elevation as the sight reticle was moved by the helmet. The helmet sight enabled the pilot and copilot to perform earlier target identification and aiming without use of the stabilized sight eyepiece. It would provide target acquisition for both the TOW missile and the flexible weapons, but would not be used for TOW guidance and delivery.¹³

(U) The Bell Helicopter Company began delivery of the eight AH-1Q prototypes early in March 1973. Development, engineering, and service tests of the AH-1Q commenced on 16 March 1973 and continued through January 1974, with a total of 213 TOW firings. All

¹¹ ICAP/AH-1Q Program, 12 Jun 74. TOW Proj Ofc.

¹² (1) *Ibid.* (2) HAC Tract, TOW Missile System, Nov 75. TOW Proj Ofc.

¹³ Incl to Ltr, CG, AVSCOM, to ASA(I&L), DA, 10 Jan 73, subj: Req for Apprl of D&F for the Improved Armt Sys for the AH-1G Hel. TOW Proj Ofc.



TOW Armament Subsystem Components of the AH-1Q COBRA

of these firings were conducted at the Yuma Proving Ground (YPG) except for the 52-round OT II test program at Fort Knox, Kentucky. The targets at YPG were either 2.3 by 2.3 meters (stationary) or 4.6 by 2.3 meters (moving). The targets at Fort Knox were heavily armored tanks driven by U. S. Army personnel at speeds up to 30 mph. The latter tests, conducted in October 1973, were the first attempt to simulate airborne TOW deployment in a tactical situation. Corrections for design deficiencies discovered in these and other firings were proof tested in follow-on evaluation firings at Fort Hood, Texas, and YPG, following limited production classification of the XM-65 subsystem in January 1974. As shown below, 154 of the 213 firings from AH-1Q prototypes scored target hits. Twelve of the 59 target misses stemmed from reliability relevant failures (7 missile malfunctions and 5 XM-65 system malfunctions). Of the remaining 47 misses, 13 were attributed to operator-induced failures, 7 to system design problems (corrected), 15 to firings beyond system capabilities, 3 to aircraft equipment problems, and 9 to other miscellaneous causes.¹⁴

<u>Test Phase</u>	<u>Test Period</u>	<u>Rds Fired</u>	<u>Hits</u>
Launch Effects (Contr)	3/16/73 - 3/26/73	9	3
Gunner Familiarization	4/4/73 - 6/8/73	13	8
Accuracy Test (Contr)	4/5/73 - 5/23/73	16	14
OT I - AASTA	5/31/73 - 6/2/73	5	4
TECOM Prelim Evaluation	7/12/73 - 7/24/73	10	9
Demonstrations	5/14/73 & 7/14/73	2	2
TECOM Service Test	9/11/73 - 9/21/73	18	12
OT II - Fort Knox	10/8/73 - 10/26/73	52	30
AH-1Q Accuracy Test	10/27/73	1	1
TECOM Engineering Test	11/20/73 - 1/21/74	79	67
Launcher Qualification*	1/30/74	8*	4
		213	154

*Helicopter on ground; missiles with live warheads fired and guided from remote location against remotely controlled moving tanks at 3,000 meters range.

Production Release and Follow-On Evaluation

(U) Limited production (LP) type classification for the AH-1Q was approved in January 1974 and was to remain in effect until

¹⁴HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76, pp. 2, 4-16. TOW Proj Ofc.



TOW Missile Firing from One of the AH-1Q R&D Prototypes at Yuma Proving Ground

November 1975. The plan calling for an IOC date of March 1975 had been predicated upon award of the initial production contract in July 1973. The Assistant Secretary of the Army (Installations and Logistics) approved D&F for initial AH-1Q procurement on 26 March 1973; however, PEMA funds for the program were not appropriated until the second quarter of FY 1974, delaying award of the production contract until January 1974 and extending the IOC date to March 1976.¹⁵

(U) The initial production contract, awarded to the Bell Helicopter Company on 31 January 1974, called for the modification of 101 Government-furnished AH-1G helicopters to the AH-1Q configuration, with an option to modify 189 more Government-furnished aircraft in FY 1975. The negotiated contract prices were as follows:

	Basic Quantity <u>(101)</u>	Option Quantity <u>(189)</u>	Total Quantity <u>(290)</u>
Target Cost	\$ 55,802,716	\$ 51,397,284	\$ 107,200,000
Target Profit	<u>3,435,626</u>	<u>3,164,374</u>	<u>6,600,000</u>
	\$ 59,238,342	\$ 54,561,658	\$ 113,800,000
Ceiling Price	\$ 63,656,224	\$ 58,925,027	\$ 122,581,251

Delivery of the FY 1974 buy of 101 units was to begin in June 1975 and be completed in June 1976. Assuming exercise of the option in January 1975, delivery of the 189 units would begin in June 1976 and continue until July 1977.¹⁶ Under the planned conversion program, the first 20 AH-1G's would be modified to the basic AH-1Q configuration and the next 72 would be converted to the AH-1Q with structural provisions for AH-1S (ICAM) modifications. The last 198 units would be completely modified AH-1S's incorporating both ICAP and ICAM components. Follow-on procurement would consist solely of new AH-1S production aircraft.¹⁷

(U) Shortly after award of the initial production contract,

¹⁵(1) Incl to Ltr, Cdr, MICOM, thru AMC, to ASA(I&L), DA, 9 Jun 75, subj: Req for Apprl of an Individual D&F for the TOW/COBRA XM-65 Msl Subsys. HDF. (2) ICAP/AH-1Q Program, 12 Jun 74. TOW Proj Ofc. (3) Ltr, Cdr, AVSCOM, to ASA(I&L), DA, 10 Jan 73, subj: Req for Apprl of D&F for the Improved Armt Sys for the AH-1Q Hel, w incl, & 2d Ind, ASA(I&L), DA, to Cdr, AMC, 26 Mar 73. TOW Proj Ofc.

¹⁶Contr DA-AJ01-74-C-0122(P2B), 31 Jan 74. Tow Proj Ofc.

¹⁷Rept, Army/Bell AH-1S, Bell Helicopter Div of Textron, Inc., undated. TOW Proj Ofc.

follow-on evaluation tests of the AH-1Q R&D prototype were conducted at Fort Hood and Yuma Proving Ground to verify correction of deficiencies. One hundred eighteen TOW missiles were fired at Fort Hood in May and June 1974, followed by 16 TECOM check tests at YPG in August 1974. Targets for the Fort Hood firings, which took the place of OT III tests, were remotely controlled tanks, with additional side armor, moving at speeds up to 30 mph. Results of the follow-on evaluation (FOE) were as follows:¹⁸

<u>Test Phase</u>	<u>Rds Fired</u>	<u>Hits</u>
FOE - Ft Hood	118*	92*
TECOM Check Test - YPG	<u>16</u>	<u>10</u>
	134	102

*Included two extended range TOW's at 3,600 and 3,700 meters, respectively.

(U) Cold weather tests of the AH-1Q were successfully completed at Camp Drum, Watertown, New York, during the period 22-28 January 1975. Of the five TOW rounds fired, three scored hits, one missed the target because of a missile malfunction, and the other missed because the target was out of range.¹⁹

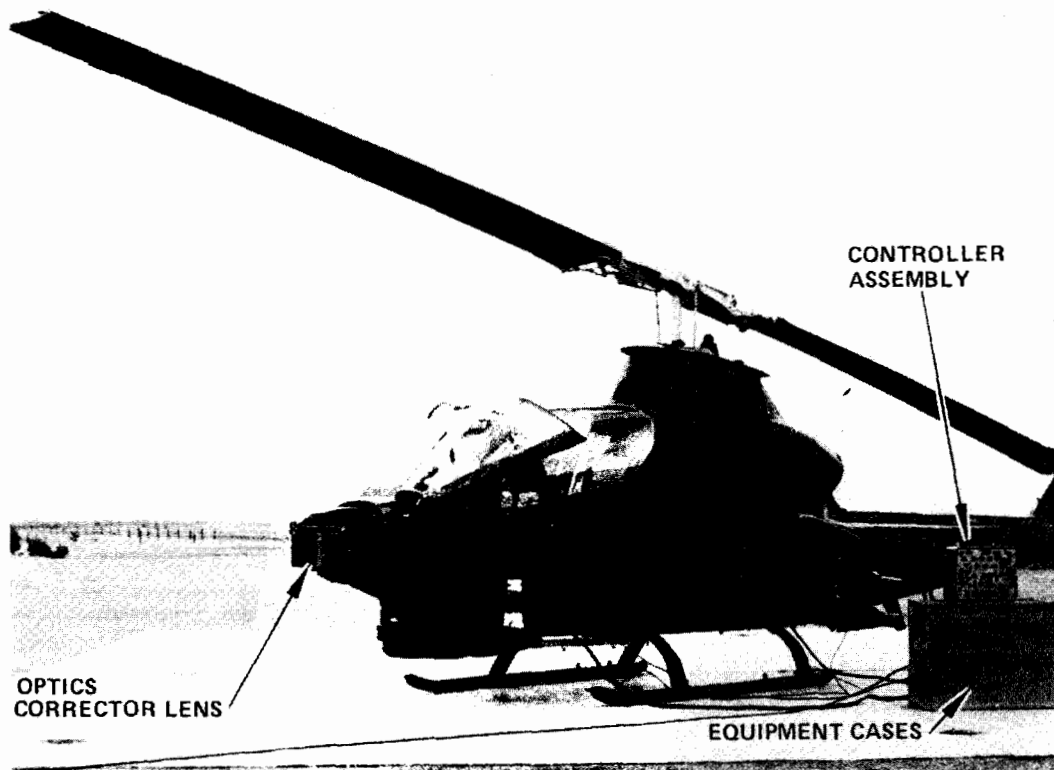
(U) Ground support equipment for the XM-65 armament subsystem consisted of the Test Set, Guided Missile System (TSGMS), initially known as the TOW Airborne System Test Set (TASTS). Developed by the Hughes Aircraft Company under subcontract to the Bell Helicopter Company, the test set enabled two maintenance technicians to perform rapid comprehensive intermediate level maintenance, fault isolation, launcher and telescopic sight unit alignment, and even more thorough verification of normal system operation than provided by built-in test equipment. It was packaged in three field portable cases to enable XM-65 verification at forward bases. Hughes Aircraft built one exploratory development model for \$797,233, and four engineering development models for \$1,442,364. The developmental test sets underwent evaluation at Fort Hood during April and May 1974, and TECOM check tests at YPG in August 1974.²⁰ The Army Missile Command awarded contracts to Hughes Aircraft for production of test sets and repair parts beginning in October 1974. Thirty sets were ordered

¹⁸HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76, pp. 2, 16-24. TOW Proj Ofc.

¹⁹*Ibid.*, p. 25.

²⁰(1) HAC Tract, TOW Msl Sys, Nov 75. (2) Abn TOW Fact Book. Both in TOW Proj Ofc.

with deliveries to begin in October 1975.²¹



TSGMS – GROUND SUPPORT EQUIPMENT FOR XM65

Initial Production Tests

(U) The Hughes Aircraft Company began deliveries of XM-65 production units to the airframe contractor in February 1975, and the U. S. Army accepted the first production model AH-1Q on 10 June 1975. Initial production tests of the AH-1Q began on 19 June 1975 and continued through 19 February 1976, with a total of 91 TOW firings. Of these, 59 were conducted at CONUS test sites and 32 in the Federal Republic of Germany (FRG). Results of the tests were as follows:²²

²¹Hist Rept, TOW PM, FY 75. HDF.

²²HAC Rept, XM 65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76, pp. 28, 30-34. TOW Proj Ofc.

<u>Test Site</u>	<u>Test Period</u>	<u>Rds Fired</u>	<u>Hits</u>
<u>CONUS</u>			
YPG	6/19/75 - 1/28/76	46	39
Ft Rucker	1/28/76	8	7
Ft Hood	2/19/76	5	3
Total CONUS:		<u>59</u>	<u>49</u>
FRG	1/22/76 - 2/5/76	32	22
		<u>91</u>	<u>71</u>

Follow-On Production

(U) In March 1975, after exercising the option for the FY 1975 buy of 189 modified AH-1G helicopters, AVSCOM requested the Army Missile Command to plan for production breakout of the XM-65 subsystem beginning with FY 1976 procurement. The Government assumed configuration control of the XM-65 in the first quarter of FY 1976, following the Physical Configuration Audit (PCA) in May 1975. The D&F for the sole source production contract with Hughes Aircraft authorized a firm quantity of 44 XM-65 subsystems for FY 1976 at an estimated cost of \$10,230,097, with an option for 22 units as a transitional (FY 197T) buy at an estimated cost of \$5,115,049. These XM-65 subsystems would be Government-Furnished Property (GFP) to the AH-1S helicopter contractor (Bell), with deliveries to begin in March 1977. The Army Missile Command consummated the production contract with Hughes Aircraft on 30 November 1975.²³

(U) The LP type classification for the 92 AH-1Q aircraft and for ground support equipment in quantities to support 290 AH-1Q/S aircraft* had been extended from November 1975 to 30 November 1976 by an IPR action in June 1975. At the same time, LP classification was approved for the 198 AH-1S (modified) aircraft and the first 44 AH-1S new production aircraft until November 1976. Subsequent IPR action in June 1976 increased the AH-1S new production LP quantity to cover the 22 units authorized for the transitional (FY 197T) buy.²⁴ To meet recognized U. S. Army requirements for

* See above, p. 184.

²³ (1) Incl to Ltr, Cdr, MICOM, thru AMC, to ASA(I&L), DA, 9 Jun 75, subj: Req for Apprl of an Individual D&F for the TOW/COBRA XM-65 Msl Subsys. HDF. (2) Incl to Ltr, Cdr, MICOM, thru AMC, to Dep for Mat Acq, ASA(I&L), DA, 21 Jul 75, subj: same. (3) Hist Rept, TOW PM, FY 75. HDF. (4) TOW DAPR, 10 Jun 76. TOW Proj Ofc.

²⁴ Incl to Ltr, Richard L. Long, IPR Chmn, to HQ DA, 30 Sep 76, subj: Mins of TCLAS IPR of COBRA/TOW (AH-1S). TOW Proj Ofc.

TOW-equipped helicopters, 439 new production AH-1S aircraft were scheduled for procurement during the FY 1977-80 period. The approved and projected TOW/COBRA procurement by fiscal year was as follows:²⁵

<u>Fiscal Year</u>	<u>Quantity</u>
1974	101 ^a
1975	189 ^b
1976	44 ^c
1977	22
1978	82
1979	94
1980	211
	<u>52</u>
Total	<u>795</u>

^aIncludes 92 AH-1G aircraft modified to AH-1Q configuration and 9 AH-1G's modified to AH-1S configuration (with both ICAP and ICAM components). The 92 AH-1Q aircraft were to be converted to the AH-1S configuration by April 1979.

^bAll AH-1G aircraft converted to AH-1S configuration.

^cProcurement in FY 1976 and succeeding years to consist of new production AH-1S aircraft.

(U) The TOW Project Office completed negotiations for FY 1977 procurement on 19 November 1976. Included in the procurement package were 82 subsystems at a target unit price of \$201,000, 10 telescopic sight unit spares at a unit price of \$32,915, and 8 stabilization control amplifier spares at a unit price of \$87,425, for a total target cost of \$17,619,570 including profit. The fixed-price-incentive-fee contract was to be signed on or about 30 November 1976.²⁶

Improved COBRA Agility and Maneuverability (ICAM)

(U) The purpose of the ICAM program was to equip the AH-1G/Q helicopter with greater power and agility to perform the low, slow,

²⁵ (1) *Ibid.* (2) Rept, Army/Bell AH-1S, by Bell Hel Div of Textron, Inc., undated. (3) Chart, XM-65 Pdn Dlvr, 9 Jun 76. Both in TOW Proj Ofc.

²⁶ Intvw, M. T. Cagle w LTC Kenneth P. Worsham, TOW Proj Ofc, 23 Nov 76.

pop-up, hovering maneuvers required for nap-of-the-earth (NOE) operation. As stated earlier, the first 20 AH-1G helicopters were converted to the AH-1Q (ICAP) configuration and the next 72 were converted to the AH-1Q with structural provisions for AH-1S (ICAM) modifications. The last 198 converted AH-1G's, scheduled for delivery in 1976-77, would be of the AH-1S configuration, incorporating both ICAP and ICAM components. Thereafter, procurement would consist solely of new production AH-1S aircraft.

(U) Among improvements incorporated in the initial AH-1S (modified AH-1G/Q) were a higher thrust tail rotor and drive, an improved main rotor hub, and an upgraded engine. In addition to these dynamic improvements, production models of the AH-1S were to include several new features to make the attack helicopter more suited for NOE operation in the high air threat battlefield. Among these were design improvements to increase protection against visual, radar, and infrared detection and to provide the crew a better chance of survival in combat. The tell-tale sun glint signature of the conventional AH-1G type curved canopy would be virtually eliminated by a new flat plate canopy design. The visual and infrared signature of the aircraft would be substantially reduced by use of an Army-developed infrared reflectance paint which would diffuse sun rays and aid in blending the aircraft with the background. The production model of the AH-1S would also have a new "fly-dry" transmission capable of sustaining a hit and continuing to operate without oil for up to 2 hours and 45 minutes. Other new features included an improved pilot and copilot/gunner instrument panel and cockpit arrangement to accommodate new instruments and avionics in locations appropriate for NOE flight and target engagement.²⁷

(U) Flight tests of the basic AH-1S COBRA began on 24 April 1975 and continued through 30 May 1975, with a total of 48 TOW missile firings. The first six rounds, fired at the Yuma Proving Ground, scored five hits against targets at 3,000 meters, three of them during a hover maneuver and two during forward flight. The other 42 rounds were fired at Fort Hood, Texas, against targets at ranges from 2,000 to 2,930 meters. Thirty-eight of these scored direct hits, one of them during a hover maneuver and the remainder during a pop-up maneuver. One of the TOW missiles misfired because of a bad launcher, two hit an APC in front of the target, and one was fired at night using a flare for illumination.²⁸

²⁷ Rept, Army/Bell AH-1S, by Bell Hel Div of Textron, Inc., undated. TOW Proj Ofc.

²⁸ HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76, pp. 25-28. TOW Proj Ofc.

(U) The basic AH-1S aircraft, its XM-65 and helmet sight subsystems and ground support equipment were reclassified from LP to standard type by an IPR action on 30 September 1976. This IPR action also extended the LP classification for the 92 AH-1Q aircraft from November 1976 to April 1979, by which time they would be converted to the standard AH-1S configuration.²⁹

XM-65/AH-1J Test Program

(U) In addition to its use on the U. S. Army's AH-1Q/S COBRA, the XM-65 TOW armament subsystem was adapted to the U. S. Navy/Iran twin-engine AH-1J COBRA in a development program funded by the Government of Iran. The Iranian Aircraft Program Office at AVSCOM managed the program and the Office of the Chief of Naval Materiel handled the FMS case. Fifty-four TOW missiles were fired in the XM-65/AH-1J test program between 26 March and 29 August 1975, 45 of them scoring target hits. The Iranian Government planned to procure 202 AH-1J aircraft, 65 of which were to be equipped with the TOW. Production deliveries of the AH-1J/TOW U. S. Navy/Iran aircraft began in April 1976.³⁰

XM-65 Airborne TOW Firing Summary

(U) A total of 545 TOW missiles were fired in all phases of the airborne TOW test program during the period 16 March 1973 to 19 February 1976. The results of these tests are summarized in Table 9.

Foreign Military Sales (FMS)

(U) Foreign demand for the XM-65 TOW armament subsystem was expected to equal or surpass the ground-mounted system. At the outset of foreign sales, in mid-FY 1975, the FMS potential for the airborne TOW was estimated at 1,100 XM-65 subsystems, over 100,000

²⁹Incl to Ltr, Richard L. Long, IPR Chmn, to HQ DA, 30 Sep 76, subj: Mins of TCLAS IPR of COBRA/TOW (AH-1S). TOW Proj Ofc.

³⁰(1) Abn TOW Fact Book. (2) HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76, pp. 25-26, 28-30. Both in TOW Proj Ofc. (3) Hist Rept, TOW PM, FY 76/7T, p. 9. HDF.

TABLE 9
(U) XM-65 TOW/COBRA Firing Summary

TOTAL MISSILE FIRINGS		545
Less: Reliability Relevant Failures		
Missile Malfunctions		18
XM-65 System Malfunctions	8	<u>26</u>
		519
Less: Non-Hits		
Operator Induced Failures		27
System Capabilities Exceeded		33
- Poor Visibility		(9)
- Launcher Qualification Firings - Remote		(4)
- Target Out of Range		(8)
- Not Fired at Target		(4)
- Launch Conditions - Constraint Limits		(6)
- Other		(2)
System Design Problems - Corrected		9
Missile Hit Object on Path to Target		10
Aircraft Equipment Problems		12
Aborted Mission - Deliberate Miss		1
Cause Uncertain	<u>12</u>	<u>104</u>
TOTAL HITS:		415

SOURCE: HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Summary,
Mar 76. TOW Proj Ofc.

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extended range TOW missiles, and 120 test sets, a total value in excess of \$1 billion.³¹

(S) The first Army FMS case for the XM-65 was signed in December 1974, when Italy bought two of the subsystems for delivery in FY 1976. The Hughes Aircraft Company modified these systems for application to the A109 aircraft and delivered them to Italy in January 1976 for developmental testing.

(U) During FY 1976/7T, several more FMS cases were processed. Korea bought eight AH-1J/TOW's on a direct sale from the Bell Helicopter Company. In another direct sale, Korea purchased from the Hughes Helicopter Company 125 M500D aircraft, 25 of which were equipped with the XM-65 TOW armament subsystem. The United Kingdom, through the British Aircraft Corporation, awarded a contract to the Hughes Aircraft Company for the design of a roof-sight to be used on the Lynx helicopter for possible XM-65 application.³²

TOW/COBRA Deployment

(S) Deployment of the TOW/COBRA began with the fielding of the new equipment training team and eight AH-1Q aircraft to elements of the Army Training and Doctrine Command (TRADOC) in November 1975. Four of the training base aircraft went to Fort Rucker, one to Fort Eustis, and three to Aberdeen Proving Ground. By 29 February 1976, 25 AH-1Q aircraft and TOW ground support equipment had been delivered to tactical units (8 to the 6th Cavalry Brigade at Fort Hood and 17 to U. S. Army units in Europe), thus meeting the established IOC date of March 1976. Tactical deliveries of the remaining 59 AH-1Q's were completed in July 1976. Deployment of the 198 AH-1S (modified) aircraft began in July 1976 and was scheduled for completion in August 1977. The actual and planned distribution of the 290 AH-1Q/S aircraft was as follows:

	<u>TRADOC</u>	<u>Ft Hood</u>	<u>USAREUR</u>	<u>Total</u>
<u>AH-1Q</u>				
Dpld thru Jul 76	8	21	63	92
<u>AH-1S</u>				
Dpld Jul 76 - Oct 76		16	35	51
Scd: Nov 76 - Aug 77		<u>15</u>	<u>132</u>	<u>147</u>
	<u>8</u>	<u>52</u>	<u>230</u>	<u>290</u>

³¹Hist Rept, TOW PM, FY 75. HDF.

³²(1) *Ibid.* (2) Hist Rept, TOW PM, FY 76/7T, p. 9. HDF.

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(U) Deployment of the AH-1S new production aircraft was scheduled to begin in March 1977 and continue through March 1981. Claimants for the first 106 new production aircraft, in the order of their priority, were: training base and test agencies (10), U. S. Army Forces Command (33), 6th Cavalry Brigade, Fort Hood (40), and U. S. Eighth Army, Korea (23). Distribution of the remaining 399 aircraft was yet to be established.³³

Fielding the TOW/COBRA in Europe

(U) Initial deployment of the TOW/COBRA attack helicopter to Europe was smoothly and efficiently accomplished under Project Hand-Off, a relatively new program designed to improve materiel fielding and the relationship between DARCOM and its Army users. Under this materiel fielding concept, DARCOM or contractor representatives stay with a newly delivered system until all of its problems are solved, the system performs well, and a high degree of operational readiness is attained. It consists of two basic elements: the materiel fielding plan and the materiel fielding operation.

(U) Development of the TOW/COBRA materiel fielding plan was a cooperative effort involving the TOW/COBRA project management office and representatives from the recipient commands and project-related DARCOM elements. Included in the Statement of Quality and Support (SOQAS), which embodied the essence of DARCOM's commitment, were descriptions of the aircraft, the associated test and support equipment, the TOW/COBRA logistics support system, the pertinent technical publications, and the new equipment training program. The TOW/COBRA SOQAS provided for the replacement of defective system components for a period of 60 days, correction of all damage incurred during shipment, and the conduct of flight checks of all aircraft before issuance.

(U) All operating and maintenance personnel received appropriate TOW/COBRA training before materiel release. In the months preceding deployment, the new equipment training team trained 73 pilot/gunners and 419 maintenance personnel. Before issuance of the first aircraft, each recipient unit received 100 percent initial support package fill, including repair parts, technical

³³(1) AH-1 COBRA Master Milestone Scd, atchd as incl to Ltr, COBRA PM, AVSCOM, to Distr, 18 May 76, subj: Coord AH-1 COBRA AH Master Milestone Scd. (2) AH-1Q/S COBRA/TOW Distr Scd, 17 Aug 76. Both in TOW Proj Ofc. (3) Intvw, M. T. Cagle w Leslie J. Alkenburg, TOW Proj Ofc, 16 Nov 76.

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manuals, test equipment, and necessary tools. Members of the materiel fielding team remained with the recipient units until each was fully capable of operating and maintaining the new system.

(U) Among the equipment deficiencies discovered and corrected by the fielding team was a case of defective wiring which had escaped detection in contractor and Government inspections. From a video tape which illuminated the extent and location of the problem, the contractor was able to pinpoint where the problem originated in the production line. The appropriate corrective action was taken within a week, and the contractor later used the tape as a training aid for production personnel.

(U) Field reaction to the continuing TOW/COBRA hand-off indicated that the sophisticated system was being smoothly integrated to attain and maintain a high degree of operational readiness and user satisfaction.³⁴

Field Maintenance and Logistic Support

(U) The operational objective of any weapon system is to deliver optimal performance when needed. The operational availability of the M65 TOW missile subsystem was very high because of its reliability, built-in maintainability, and proven logistic support. The demonstrated system mean time between failure was better than 250 hours. As shown above, only 8 subsystem failures occurred in 545 missile firings, yielding an operational reliability of nearly 99 percent. The total weapon system reliability, including missile, was over 95 percent. Because of the high system reliability, maintenance requirements were low: less than 0.14 maintenance manhours per flight hour for both scheduled and unscheduled system maintenance. Scheduled maintenance was limited to pre- and post-flight inspection and periodic (every 100 flight hours) system verification tests using the Test Set, Guided Missile System (TSGMS). Faults in the equipment could be rapidly detected and isolated to a line replaceable unit (LRU) by means of built-in test. The system could be restored to operational readiness by removing and replacing the faulty LRU with a ready-for-issue unit from supply stock. Depot maintenance included the capability to repair,

³⁴LTG Eugene J. D'Ambrosio, "Project Hand-Off: Fielding Confidence in Equipment," *Defense Management Journal*, Vol. 13, No. 1, Jan 77, pp. 12, 14-15.

overhaul, or rebuild all line replaceable units and the TSGMS.³⁵

(U) The Letterkenny Army Depot was designated as the Airborne TOW repair/rebuild facility in the fall of 1974; however, award of the contract for depot test acceptance equipment was delayed until June 1975 and the facility was not expected to be completely operational until late 1977. Consequently, for at least the first 24 months, depot maintenance support for the TOW missile subsystem would be provided by the contractor. Under this concept, maintenance in the field would be limited to the isolation to, and removal and replacement of, faulty line replaceable units, which would be retrograded through aviation maintenance channels to the Hughes Aircraft maintenance facility. Certain bits and pieces of LRU hardware—e.g., nuts, bolts, screws, lamps, etc.—that could be replaced in the field without extensive use of tools and test equipment would be authorized for stockage and use at the organizational and direct support levels of maintenance.

(U) Realizing that the return of LRU's from support units in Europe to CONUS could not be supported with sufficient pipeline quantities, MICOM established an interim in-country repair facility to provide limited depot level maintenance. It was estimated that 60 percent of the LRU failures could be corrected at this in-country facility, thereby shortening the pipeline and reducing the maintenance turnaround time. The Airborne TOW USAREUR Repair Facility (ATURF), located at Coleman Barracks in Mannheim, Germany, became operational in December 1975. It was headed by a warrant officer and staffed with two Hughes Aircraft engineers, two DA civilian technicians from Letterkenny Army Depot, and a supply sergeant. The actual achievement of the Airborne TOW USAREUR Repair Facility far exceeded the original prediction, some 93.7 percent of the LRU failures as of 1 October 1976 being corrected in-country with an average turnaround time of 5.5 days.³⁶

(U) Depot test acceptance equipment (DTAE) for the airborne TOW subsystem was being developed under a \$5 million contract with Hughes Aircraft Company and a \$3 million contract with Martin Marietta Aerospace, Orlando Division. The Hughes contract, awarded

³⁵ (1) HAC Tract, TOW Msl Sys, Nov 75. (2) HAC Rept, XM-65 Abn TOW Msl Sys - Msl Firing Sum, Mar 76. Both in TOW Proj Ofc.

³⁶ (1) Fact Sheet, Log Spt for the XM-65 TOW Msl Subsys, undated. TOW Proj Ofc. (2) Hist Rept, TOW Proj Ofc, FY 75. HDF. (3) Hist Rept, Drte for Maint, FY 75. HDF. (4) TOW DAPR, 10 Jun 76. TOW Proj Ofc. (5) Intvw, M. T. Cagle w Leslie J. Alkenburg, TOW Proj Ofc, 18 Nov 76.

on 30 June 1975 and due for completion in June 1977, was for long leadtime items of system peculiar fully automated depot equipment. The U. S. Navy paid half of the Hughes contract cost to provide DTAE for the AH-1J aircraft. The commander of MICOM decided in May 1976 that the missile automated test equipment developed by Martin Marietta would be used to the greatest extent possible by all MICOM-managed systems, in order to reduce the proliferation of system peculiar automated test equipment. Accordingly, MICOM awarded Martin Marietta a contract on 10 September 1976 to prepare unit under test (UUT) diagnostic routines, adapters, and interface devices for a portion of the XM-65 subsystem. This contract was amended on 4 November 1976 to include eight of the subsystem LRU's and the related printed circuit boards. Deliveries to the Letterkenny Army Depot were due to begin in March 1977 and be completed in November 1977. In view of the shift in interest from Hughes' to Martin Marietta's DTAE concept, the Army planned to withdraw from the Hughes contract upon its completion in June 1977. Thereafter, negotiations would be handled by the U. S. Navy.

(U) Although the Letterkenny Army Depot was to be fully operational in November 1977, there was a possibility that depot maintenance support for 3 of the 11 LRU's comprising the TOW subsystem would still be provided by Hughes Aircraft. The airborne TOW launcher and stabilization control amplifier were involved in a proprietary rights claim which was yet to be settled.³⁷ Though not considered a proprietary item, the telescopic sight unit interfaced with the stabilization control amplifier and was therefore withheld from release to Martin Marietta pending adjudication of the claim.³⁸

³⁷ (1) Contr DA-AH01-75-C-1264, 30 Jun 75. (2) Contr DA-AH01-76-C-1216, 10 Sep 76. (3) Intvw, M. T. Cagle w Jewell G. House, Depot Maint Div, Drte for Maint, 18 Nov 76. (4) Intvw, M. T. Cagle w Dean Long, D/P&P, 18 Nov 76.

³⁸ Intvw, M. T. Cagle w LTC Kenneth P. Worsham, TOW Proj Ofc, 23 Nov 76.

CHAPTER IX

(S) CONCLUSION (U)

(U) Like most other guided missile programs, the TOW project experienced technical and funding problems, schedule slippages, qualitative and quantitative changes in system requirements, and substantial increases in development and production costs. The widely acclaimed success of the TOW program despite all of the problems and frustrations could be attributed in no small measure to the leadership and dedication of COL Robert W. Huntzinger, who managed the project for 8 years and 5 months, from 25 June 1968 to 30 November 1976. Looking back over his years with the project, Colonel Huntzinger credited the phenomenal success of the program to three factors. First, the Army maintained a firm requirement for the system, even in the face of Congressional disenchantment shortly before and during the early years of production. Secondly, there was always a motivated staff team, both in Government and at the major contractors, who took pride in what they were doing and were dedicated to a quality product, meeting schedules, and reducing costs. Finally, the TOW was the right weapon at the right time and proved superior to the antitank weapons of other nations.¹ The TOW was, in fact, one of the Army's most popular commodities, a total of 22 foreign countries having bought the system for their armed forces through FY 1976.²

(U) From FY 1962 through FY 1976, the U. S. Army and Marine Corps invested \$128.9 million in research, development, test, and evaluation (RDTE) of the TOW weapon system, compared to the March 1963 estimate of \$51,377,000 for the FY 1962-67 period. It was estimated that \$4.4 million more would be required to complete the programmed product improvements during the FY 1977-79 time-frame, for a total projected RDTE cost of \$133.3 million. The time required to complete development and field the system increased from the original estimate of 34 months (January 1963 to December 1965) to 92 months (January 1963 to September 1970), for a total slippage of 58 months.³

¹Ltr, COL Robert W. Huntzinger, TOW PM, thru Cdr, MICOM, to Cdr, DARCOM, 30 Nov 76, subj: TOW PM's End of Tour Rept. TOW Proj Ofc.

²See above, pp. 120, 122.

³See above, pp. 33-34, 110, 156.

(C) The initial Army procurement plan of August 1963 called for production of 174,799 missiles and 2,935 launchers at an estimated cost of \$459.5 million.⁴ The latest plan for Army procurement (April 1976) provided for 134,909 missiles (117,215 tactical and 17,694 practice) and 6,898 launcher systems.⁵ Excluding U. S. Marine Corps and DOD/MAP funds, \$766.7 million was invested in the TOW production program during the FY 1966-76 timeframe, and an additional \$387.7 million was programmed for TOW procurement during the FY 1977-81 period, for a total projected Army investment of \$1,154,400,000 (see Table 10).

(C) About 68 percent of the cost growth and 36 percent (21 months) of the schedule slippage were attributed to qualitative changes in system requirements and the attendant design changes and technical problems. In the course of TOW development, four major program revisions were made in response to changes in system requirements. The first and most expensive change came in 1963, when the Army Materiel Command increased the system range requirement from 2,000 to 3,000 meters, causing a major redesign of the signal transmission system and modifications of the missile motor and guidance subsystems. The change in range requirement and the attendant technical problems contributed to the increase in development cost and added 21 months to the development schedule during the 1964-65 timeframe. The second change was the addition of a night firing capability in 1964. The initial development cost for the gated night sight (about \$10 million) was paid by the Night Vision Laboratory as part of the general night vision program; however, TOW development costs at MICOM were increased to support initial testing. With the change to a thermal sight in 1973, all night sight costs were borne by the TOW project. The 1975 decision to apply electronic counter-countermeasure modifications to all launchers and 48 percent of the missiles increased both development and procurement costs. The fourth and final change in requirements was the increase in range from 3,000 to 3,750 meters. This raised the procurement cost of the missile, but since it only involved the addition of wire to the bobbins development costs were negligible.

(U) The remaining 37 months of the schedule slippage and 26 percent of the cost growth were attributed to technical problems other than those associated with qualitative changes. Reliability and missile safety problems required extensive work, additional testing, and hardware modifications during the 1965-66 period, and

⁴DA Study of Cost Growth in Acq of the TOW Wpn Sys (draft), 27 Jul 76, p. 16. TOW Proj Ofc.

⁵See Table 5, p. 117.

TABLE 10—(U) TOW Funding Program (Actual and Projected)
(in millions of dollars)

Fiscal Year	RDTE			PEMA					TOTAL RDTE + PEMA
	Army	USMC	Total	PBS	Army	USMC	DOD/MAP	Total	
1962	2.2		2.2						2.2
1963	7.9		7.9						7.9
1964	18.5		18.5						18.5
1965	22.3	.2	22.5						22.5
1966	25.6	.4	26.0	4.9 ^a				4.9	30.9
1967	14.1	.9	15.0	7.4 ^a				7.4	22.4
1968	6.0	.7	6.7	.6	15.1			15.7	22.4
1969	2.1	1.1	3.2	.4	81.8			82.2	85.4
1970	2.2		2.2	.1	107.0			107.1	109.3
1971	1.4		1.4	.1	97.3			97.4	98.8
1972	1.1		1.1		55.6			55.6	56.7
1973	.7		.7		44.9		.7	45.6	46.3
1974	5.7		5.7		111.7	22.4	4.2	138.3	144.0
1975	7.4		7.4	.8	98.8	32.4		132.0	139.4
1976	8.4		8.4		140.2	3.8	8.6	152.6	161.0
TOTAL ACTUAL:	125.6	3.3	128.9	14.3	752.4	58.6	13.5^b	838.8	967.7
Projected:									
1977	1.5		1.5		6.6	2.8		9.4	10.9
1978	.9		.9		88.8	35.7		124.5	125.4
1979	1.5		1.5		116.0	16.7		132.7	134.2
1980	.5		.5		75.8			75.8	76.3
1981					67.8			67.8	67.8
1981					32.7			32.7	32.7
TOTAL PROJ'D:	4.4		4.4		387.7	55.2		442.9	447.3
GRAND TOTAL:	130.0	3.3	133.3	14.3	1,140.1	113.8	13.5	1,281.7	1,415.0

^aAdvance Production Engineering. All other Production Base Support funds for facilities.

^bDOD-funded for Jordan and Turkey.

SOURCE: RDTE: (1) TOW TDP, 1 Jan 72. (2) TOW SAR's, 1971-76.

PEMA: (1) TOW SAR, 30 Jun 76. (2) PEMARS Sec D, 31 May 76 (DOD/MAP Funds).

extended the schedule 20 months. During this same timeframe, problems with the missile container caused an additional 2-month extension to the schedule. Engineering tests and service tests during the 1966-69 period revealed technical problems associated with reliability, radio interference, and cross wind effects on the launcher. Problems in obtaining a high production rate for some components also surfaced. In addition to increasing development and hardware production costs, these problems caused a 13-month extension in the development schedule. The last technical problem was closely associated with quality control in the prime manufacturer's production facility. As a result of the missile reliability and quality control problems, the environmental tests and TOW program schedule were extended 2 months.

(U) About 1 percent of the cost growth resulted from a rise in escalation indices, 1 percent from an underestimation of procurement costs, and the remaining 4 percent from management problems. The latter stemmed from poor quality control at the Hughes production facility in Arizona. Aggressive actions by the TOW Project Manager and Hughes Aircraft solved the quality control problem. The program increased production costs, but was a critical element in the correction of TOW reliability problems which threatened to terminate the TOW program in 1967.

(U) The cost growth explained by the foregoing factors take into account the net cost reductions resulting from the quantitative requirement changes (about \$19 million) and the use of competitive procurement and multiyear contracts (about \$13 million).⁶

* * * * *

(U) For more than half a century, from the Somme River to the jungles of Vietnam, tanks have struck terror into the hearts of infantrymen, and field commanders have sought a weapon that could stop the inexorable advance of these rumbling, clanking "Goliaths" with their heavy armor and deadly guns. Today, the "GI Davids" of armies throughout the free world have such a weapon in the TOW antitank/assault weapon system. Like David's sling, the TOW has the accuracy and the power to slay any "Goliath" in the field with a single shot. It is indeed the infantryman's long sought equalizer against his traditional enemy—the tank.

⁶DA Study of Cost Growth in Acq of the TOW Wpn Sys (draft), 27 Jul 76, pp. 24, 26-27. TOW Proj Ofc.

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(U) GEN Michael S. Davison, Commander-in-Chief of the U. S. 7th Army, Europe, whose troops began receiving the TOW in late 1970, declared: "I can't think of any weapon we have received in the last 10 years that our soldiers have accepted more readily and enthusiastically. Even with very little training, the TOW crews have a high probability of destroying enemy armor out to 3,000 meters."⁷ Troops of the 4th Infantry Division, Fort Carson, Colorado, were equally pleased with the TOW, which they started receiving in 1976. SFC Mayceo Hall, the noncommissioned officer in charge of Fort Carson's antitank committee, exclaimed: "It's the most devastating weapon ever issued to the infantry." And LT William Brandenburg, commandant of the antitank committee, said: "The TOW system clearly proved that it can put the infantry soldier on the same footing as any armored threat in existence."⁸

(U) Although designed primarily as an antitank weapon, the battle-proved, highly versatile TOW also provided an effective long range assault capability against fortified bunkers, pillboxes, gun emplacements, and other hardpoint targets. In the ground-based mode, it could be fired on the ground from a tripod or from the M113 armored personnel carrier, the standard M151 jeep, or the M274 light weapons infantry carrier. In the airborne mode, the TOW provided a formidable antitank/assault weapon that combined the accuracy and firepower of the TOW missile with the speed and tactical flexibility of the COBRA attack helicopter. The TOW/COBRA fleet and ground-based TOW units stationed in Europe helped to offset the three-to-one tank superiority that the Warsaw Pact forces had over NATO forces in Western Europe.⁹

(U) Whether on the ground or in the air, the TOW was an invaluable and highly respected addition to the Army's arsenal of operational antitank weapons. The TOW heavy antitank/assault weapon, together with other members of the new generation of anti-tank weapons—the M72 light antitank/assault weapon (LAW), the SHILLELAGH combat vehicle armament system, and the DRAGON medium antitank/assault weapon—provided the Army with the capability to cope with the armor threat through the early 1980's. On the drawing boards were two advanced antitank/assault systems: the VIPER light antitank weapon, which was to begin replacing the M72

⁷ Fact Sheet 57-73 [Extract from *Army in Europe*, Aug 73], AMC Info Ofc, 4 Oct 73. HDF.

⁸ *The Rocket*, 11 Aug 76, p. 10.

⁹ (1) *International Defense Review*, Vol. 4, No. 3, Jun 71.
(2) *The Rocket*, 21 Jul 76, p. 10.

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LAW in 1979, and the HELLFIRE (Helicopter-Launched, Fire and Forget) system being developed as the primary armament for the Army's new Advanced Attack Helicopter (AAH). Scheduled to begin replacing the interim TOW/COBRA system by the mid-1980's, the HELLFIRE/AAH system was a modular missile system that would provide the Army with a family of terminal homing seeker modules and a common airframe to engage a variety of tank and other hardpoint targets.¹⁰

¹⁰Wpn Sys Repts and Chronologies. HDF.

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APPENDIX A

(U) QUALITATIVE MATERIEL REQUIREMENT FOR
HEAVY ANTITANK/ASSAULT WEAPON SYSTEM
(CDOG Para 237b[10])

As approved on 10 November 1964 and revised on 5 April 1965 and 21 December 1965. Reference: AMCTC Item 6455, 7 November 1968. (Original Classification: CONFIDENTIAL - Group 4. Subject to General Declassification Schedule of Executive Order 11652. Declassified on 31 December 1974).

Section I - Statement of Requirement

1. Statement of Requirement

a. Heavy Antitank/Assault Weapon System (HAW).

b. A weapon system which will provide a heavy antitank/assault capability for the infantry, airborne infantry, air assault and mechanized infantry battalions. This system will be capable of being employed from vehicles and from a ground mount. Dismounting the weapon from the vehicle must be a simple and rapid operation. The primary purpose of the HAW system is to defeat the heaviest known enemy armored vehicles at ranges out to at least 2000 meters. It will also be employed against fortifications and other materiel targets. It will provide a 90% probability of a first round hit at ranges out to 1500 meters, and 75% probability for ranges from 1500-2000 meters against stationary targets essential (3000 meters desired). A 75% probability of first round hit against targets traveling up to speeds of 35 KPH essential (50 KPH desirable) out to ranges of 2000 meters is essential (3000 meters desired). It is desirable that a 90% first round hit probability be attained against all targets out to 2000 meters.

Section II - Operational, Organizational and Logistical Concepts

2. Operational Concepts

a. This item will be used habitually in war time and in training exercises in peace time in all climates and geographical areas of the world.

b. The Heavy Antitank/Assault Weapon System will be organic to and will provide long range, lethal, antitank/assault fires for all types of infantry battalions. The HAW system will complement the proposed Medium Antitank/Assault Weapon (MAW). In its primary role - antitank, it will be used to destroy formations of armored vehicles before the fire-power and shock action of enemy armor can be brought to bear effectively on friendly

forces. In its secondary assault weapon role, the system will be employed against vehicles and field fortifications of all types. Maximum effect against grouped personnel, or personnel adjacent to a materiel target, is desired. This system will permit overcoming a potential enemy superiority in density of armored vehicles, particularly tanks, and will facilitate employment of the principle of economy of force.

c. The HAW must be capable of being employed from the M113 or successor vehicles and of being transported in vehicles down to the 1/4 ton truck and the M274 vehicle. A firing capability from the wheeled vehicles is desirable. It must also be capable of being employed from the ground mount. It is desirable that the HAW missiles and appropriate components be capable of employment from Army Helicopters. The launcher with associated equipment, excluding vehicles, must be capable of parachute delivery in phase I of airborne operations. [Underlined portion added by Ltr, CG, CDC, to Distr, 21 Dec 65, subj: DA Apprd QMR for HAW Sys.]

d. The HAW will not change the requirement for tanks to accompany infantry. This system, however, will give the infantry battalion a significantly increased antitank capability and should, therefore, result in reducing the quantitative requirements for tanks to be employed in a purely antitank role. This will release an appreciable number of tanks to be employed for offensive and defensive operations.

e. The system will be capable of being employed during the hours of darkness. The sighting system may be active or passive and should permit identification of vehicular targets at 500 meters required, 1000 meters desired. If necessary, a missile especially adapted to eliminate the infrared (IR) non-compatibility is acceptable. Ancillary night vision equipment may be packaged separately and weights up to 45 pounds including power source, will be acceptable. The night firing capability must be included as an integral portion of the system upon issue to troops.

f. The tactical concept for employment of the HAW will parallel that of the ENTAC system and the 106mm Recoilless Rifle.

3. Organization and Logistical Concepts

a. The Heavy Antitank/Assault Weapon will become organic to units of the infantry, airborne infantry, and mechanized infantry battalions which currently employ the ENTAC and 106mm Recoilless Rifle. It will replace organic 106mm Recoilless Rifle and ENTAC weapons on a one-for-one basis. A crew for each weapon should not exceed four men. [As changed by Ltr, CG, CDC, to Distr, 5 Apr 65, subj: DA Apprd QMR for HAW Sys.]

b. The Heavy Antitank/Assault Weapon is expected to replace the 106mm Recoilless Rifle and ENTAC, with a resultant overall reduction in maintenance and logistical requirements. The anticipated improvement over above mentioned heavy antitank weapons systems in hit capability and kill probability should reduce the number of rounds of ammunition required.

c. First echelon maintenance will consist of preoperational check, care and cleaning, and replacement of batteries, if required, and should be accomplished by no more than two (2) men, essential, one (1) man desirable with a mean down time of no more than thirty (30) minutes, essential, fifteen (15) minutes desirable. Monthly organizational down time should be two (2) hours or less; field maintenance should be less than six (6) hours. If internal circuitry is involved, a simple one step instantaneous go-no-go test procedure will be used. Maintenance echelons above the unit to which the weapon is organic will have maintenance float for immediate issue to replace defective equipment.

Section III - Justification, Feasibility and Priority

4. Reasons for the Requirement.

a. Existing antitank weapons, ENTAC and the 106mm Recoilless Rifle, do not meet current and anticipated infantry requirements for a suitable antitank/assault capability. The reputed maximum effective range of the recoilless rifle, 1100 meters, is insufficient, signature effects are excessive; and ballistic mismatch of the spotting and major caliber rounds results in inaccurate fire at the greater ranges. Present manually guided antitank missiles (1) require carefully selected and highly skilled gunners whose training is long, expensive and continuous, (2) have an excessive minimum range, (3) have poor first round hit probability, (4) are limited in their assault capability.

b. In addition to overcoming the deficiencies listed in paragraph 4a above, there is a continuing need to reduce the number and types of infantry weapons and ammunition to a minimum. This can be accomplished by improving the range spectrum, lethality, first round hit capability and reaction time.

c. The potential enemy armor threat is outlined in detail in the US Army Combat Developments Command, Army Requirements for Direct Fire Weapons Systems (ARDFIRE)(U), dated November 1963. In view of known Soviet advances in armor development, as well as trends in Soviet Army organization and tactics, the infantry antitank capability must be increased significantly in order that the infantryman may survive on a battlefield saturated

with enemy armor. This weapon, therefore, should kill the most formidable enemy armor expected to appear on the battlefield in the 1970-75 time frame.

d. This weapon must be in the hands of troops as soon as possible and should be available during the time frame FY 1967.

e. Applicable reference to CDOG General Objectives and QMDOs.

- (1) 112a.
- (2) 112d.
- (3) 212a.

f. References to pertinent studies and other publications:

(1) Final Report, Fourth Tripartite Infantry Conference, 9-15 October 1960.

(2) Final Report, Fifth Tripartite Infantry Conference, November 1962.

(3) Letter, ATDEV-3 387 (S), Headquarters, US Continental Army Command, 21 September 1961, subject: "Report of Infantry Antitank/Assault Weapons Conference, 25 August 1961."

(4) Technical Note No. 1417, BRL, July 1961, subject: "A Study of HAW (Long Range Time Period)," as revised by BRL Memo Report No. 1365, September 1961.

(5) Report of Experiment, USACDEC, March 1963, subject: "Battalion Antitank Operations."

5. Technical Feasibility.

In July 1962, firings of experimental models showed that the tube-launched, optically tracked, wire guided concept is feasible. Time of flight of the TOW missile out to 2000 meters is nine (9) seconds which indicates feasibility of required reaction time. Recently received information on techniques for employing Laser technology in a simple guidance/homing system for antitank weapons indicates a strong possibility of simplifying current standard guidance systems with simpler, lighter, easier to employ and maintain antitank weapons.

6. Priority I is justified when considering the enemy armor threat and the present day antitank weapons, whose deficiencies are outlined in paragraph 4a above, which are intended to cope with the threat. Paragraph 237b(10) in CDOG has established this as a Priority I item.

Section IV - Characteristics

7. Performance Characteristics.

a. System must be capable of satisfactory continuous performance at all times under the conditions defined in paragraph 7c, Change 1, AR 705-15 essential; under the conditions defined in paragraphs 7a, 7b, 7d, 7e, Change 1, AR 705-15 desired. The materiel must be capable of safe storage (5 years) and transportation under conditions outlined in paragraph 7.1, Change 1, AR 705-15. There should be no requirement for a special storage container for the launcher. A shipping-storage container designed to provide physical protection for the missile and allow stacking is desired.

b. An average trained crew must be able to engage at least three (3) moving targets at varying ranges in a 90 degree arc from the weapon position within 1 1/2 minutes (essential) within 1 minute (desired). A dual requirement of rapid 360 degree traverse and smooth tracking, both in azimuth and elevation is essential. A trained gunner must be able to track and hit a moving target, traveling up to speeds of 35 KPH, essential; 50 KPH desirable out to ranges of 2000 meters. The system must be capable of operation on a terrain slope of at least 10 degrees from a vehicular mount and up to 30 degrees from the ground mount. It is required that operation in the 10 degree slope be without benefit of vehicle leveling. The vehicular mounted system shall be capable of tracking a target through 360 degree traverse from 10 degree below to 20 degree above the deck of the vehicle. The ground mounted system shall be capable of tracking a target through 360 degrees of traverse from 20 degree below to 30 degree above the horizontal.

c. Effective engagement of targets, moving and stationary, must be accomplished at ranges from a minimum safe arming distance. System must have a 90% probability of a first round hit at ranges out to 1500 meters, and 75% probability of ranges from 1500 to 2000 meters against stationary targets essential (3000 meters desired). A 75% probability of first round hit against targets moving at speeds outlined in paragraph 7b above, out to 2000 meters is essential (3000 meters desired). It is desirable that a 90% first round hit probability be attained against all targets out to 2000 meters. The target against which these hit probabilities is to be attained is defined by a vertical target 2.3 meters square.

d. It is required that the HAW system defeat the most formidable tank likely to appear on the battlefield. If penetration of armor is involved, defeat of the Quadripartite Type III heavy tank target will be used as the criteria. Good

performance against specialized skirting devices is essential. When a hit is obtained on a vulnerable area a 90% probability of an M or F kill occurring is essential - 90% probability of a K kill is desired. The system will also be used for attack of fortifications, weapons emplacements and pillboxes. It is visualized that the system may have a bonus effect which may permit the attack of low, slow-flying aircraft.

e. Mission duration time and planned utilization rate is dependent on the number of tanks or other hard point targets on the battlefield, as compared to the number of HAW weapons available. If an integral power supply is required, it must permit at least 24 hours of operation (essential), 72 hours desirable, or for firing a minimum of fifty (50) rounds essential, one-hundred and fifty (150) rounds desirable. It is essential that if power is required, the system not depend on a vehicular power source when the weapon is employed on the ground mount. It is desirable that the power for on-vehicle or on-aircraft operation be provided by the carrier.

f. All components of this system must function properly at least 95% of the time, essential - 99% desired. There must be no degradation of this reliability after limited storage and performance of 1st or 2nd echelon maintenance, or after extended storage and 3rd or 4th echelon maintenance.

g. Reaction time must be minimal. Preoperational check should consist of visual inspection and, if internal circuitry of a missile and/or launcher is involved, a simple instantaneous go-no-go circuit check. Initial loading, preoperational check, and if necessary, a warm-up time should not exceed fifteen (15) seconds, ten (10) seconds desired.

h. Total turn around time of the vehicular mounted HAW should not exceed that of its carrier. In the dismounted role, no more than 30 minutes essential, 15 minutes desirable should be taken to perform routine maintenance.

8. Physical Characteristics.

a. Overall weight of the ground mount, launcher, fire control group and power supply must not exceed one-hundred and sixty (160) pounds essential, one-hundred and twenty (120) pounds desirable. Weight of one (1) round of ammunition, with its container, must not exceed forty-two (42) pounds essential, thirty (30) pounds desirable.

b. The HAW must be capable of parachute delivery in Phase I of airborne for air assault and airborne units, essential. Conventional tie-down equipment will be used for air delivery and

internal and external helicopter loads, essential. This system may be transported on the M274 vehicle, truck, utility, 1/4 ton cargo, 1 1/4 ton, 6x6, XM561, and mounted on the Armored Personnel Carrier, M113 or its successor, essential. A firing capability from the above wheeled vehicles is desirable but should not degrade the ground mount capability from any vehicle or the air drop capability of the M274 vehicle. Mounting on selected Army helicopters is desirable. Wheeled and tracked vehicles should each be capable of carrying the entire system and a minimum of six (6) and ten (10) rounds, respectively essential; ten (10) and fifteen (15) rounds, respectively, desirable. Rapid mounting and dismounting of the system from the vehicle and emplacement on the ground must be accomplished by members of the crew with minimum use of tools. Maximum allowable time is two (2) minutes, essential, one (1) minute, desirable. [Underlined portion added by Ltr, CG, CDC, to Distr, 21 Dec 65, subj: DA Apprd QMR for HAW Sys.]

c. The system, mounted or unmounted, must be rugged enough to withstand transport over extended distances by tactical vehicles, and still perform with the required reliability, hit probability, and lethality. When the HAW is vehicular mounted, it must be capable of remaining loaded and in the firing position while the vehicle is in motion. The system must be capable of being aimed, fired, and tracked from the vehicle while the engine is idling - desired. There will be no requirement for the wearing of special protective clothing or use of special devices in order to fire the weapon.

d. Insofar as possible, the HAW must be immune to enemy electromagnetic countermeasures and solar effects. Signature effects must be reduced significantly below those associated with the 106mm Recoilless Rifle, essential. Weapon systems located fifty (50) meters or more apart must be able to engage two (2) targets simultaneously without mutual interference, essential, twenty five (25) meters desirable. The weapon must not cause interference to, or be affected by, other electronic equipment operating in the vicinity. Following exposure to CBR agents or nuclear fallout, the weapon will be made operable after standard decontamination procedures are used. Use of kits for extreme climatic conditions is acceptable when operating under the conditions outlined in paragraph 7b and c, AR 705-15.

9. Maintenance Characteristics:

The equipment will be designed, if possible, so that organizational maintenance can be performed, without the use of special tools or test equipment. Readily accessible test points will be provided to facilitate maintenance by the use

multi-purpose automatic test equipment.

10. Human Engineering Characteristics.

The configuration of this weapon will allow all functions to be accomplished by the crew while wearing CBR and arctic protective clothing. Noise/sound, before application of ear protection (no greater than 180 decibels required, 170 decibels desired) which occurs when the weapon is fired should have minimum effect on the gunner and crew during the conduct of operations. Noise/sound, with ear protection will not exceed 160 decibels with 150 decibels desired. The firing mechanism shall be placed so as to be functioned during and not cause interruption to tracking the target. Proper placement of handles or knurled components should be considered to facilitate handling by the crew. Size and configuration of each round/container should permit resupply and easy handling and loading in the vehicle. Information needs for operator decisions will be target location and identification. It is desirable, but not essential, that weight be held commensurate with the ability of a 4 man crew to dismount, transport, and emplace the system within the reaction times required under varying conditions of tactics and terrain.

11. Priority of Characteristics.

- a. Performance.
- b. Simplicity of Operation and Training.
- c. Reliability.
- d. Weight and size (transportability).
- e. Signature
- f. Immunity to Interference.
- g. Safety.
- h. Maintainability
- i. Environmental Requirements.

Section V - Personnel and Training Considerations

12. Quantitative and Qualitative Personnel Considerations.

- a. The crew for each weapon should not exceed four (4) men.
- b. Skills required for operating this system should not exceed those required for operating the 106mm Recoilless Rifle, and skills required for maintenance above 2d echelon should not exceed those presently associated with MOS 426, small missile repairman.

13. Training Considerations.

Time required for and complexity of, training must not exceed that required for the 106mm Recoilless Rifle crew. Cross

training of crew members and rapid training of replacement gunners during combat must be possible.

Section VI - Associate Considerations

14. Training Devices.

a. Cutaway mockups of the weapon and ammunition are required. Because most of the training will be done on the weapon itself, a simple, optical, elbow telescope device, capable of being affixed to the sighting unit, should be provided to verify the aim of the gunner during dry firing exercises - required.

b. A missile with an inert warhead is required to permit firing at targets during training.

c. These devices (paragraph 14a and b above) should be developed concurrently with the weapon system so that test, evaluation and issue can be accomplished at the same time.

15. Related Materiel.

In order to achieve the essential and desirable results outlined in paragraph 7d above, it is essential that no more than two (2) types of ammunition be required, INERT and HEAT.

16. Cover and Deception.

Standard camouflage equipment and techniques will be used with this system.

17. It is estimated that the MWDP Armies will be interested in this development. The British and Canadian Armies expressed interest in this system during the Fifth Tripartite Infantry Conference, November 1962 and have been monitoring the development progress.

18. Known existing or development items of other services or countries: British Army - SWINGFIRE.

19. Communication Security. No requirements.

20. Additional Comments:

a. Two (2) important factors that should be considered during the development of this and future antitank assault weapon systems are:

(1) The time that a moving target, out to 2000 meters, remains within the gunner's view, and

(2) The vulnerability of a gunner to enemy reaction immediately after firing the weapon.

b. If, during the development phase, it appears to the developing agency that the characteristics listed herein require the incorporation of unproven features and/or unnecessarily expensive and complicated components or devices, costly manufacturing methods and processes, critical materials or restrictive specifications which do not materially add to the military value of the item and in all instances where it appears that the requirements are too stringent and cannot be met, such matters will be brought to the attention of the Department of the Army and the Commanding General, Combat Developments Command.

c. Explosive Ordnance Disposal (EOD) special tools and safety procedures must be developed concurrently.

21. This materiel requirement is identified as USACDC Action Control Number 1998 and supports the following:

- a. Army Concept Program Army 75
- b. Supports the doctrine in study:
Action Control Number 1557.
Title: Development of an Integrated
Operational Concept to Defeat
Mechanized Forces.
- c. Missions 1: High Intensity Warfare
 2: Mid Intensity Warfare
 3: Low Intensity Warfare Type I
 7: Complementing of Allied Land Power
- d. Phase Materiel
- e. Function Firepower

GLOSSARY

- A -

AAH-----Advanced Attack Helicopter
 AAO-----Authorized Acquisition Objective
 Abn-----Airborne
 Acft-----Aircraft
 ACofS-----Assistant Chief of Staff
 Acq-----Acquisition
 ACSFOR-----Assistant Chief of Staff for Force Development
 Act-----Acting
 Actv-----Activity
 ADC-----Aerophysics Development Corporation
 ADM-----Advanced Development Model
 Adv-----Advance(d)
 AEDG-----Army Equipment Development Guide
 AFF-----Army Field Forces
 AH-----Attack Helicopter
 Amb1-----Airmobile
 AMC-----Army Materiel Command
 AMCTC-----Army Materiel Command Technical Committee
 AMCTCM-----Army Materiel Command Technical Committee
 Meeting
 AMSAA-----Army Materiel Systems Analysis Agency
 Anal-----Analysis
 An1-----Annual
 AO-----As Of
 AOMC-----Army Ordnance Missile Command
 APC-----Armored Personnel Carrier
 APE-----Advance Production Engineering
 APG-----Aberdeen Proving Ground
 App-----Appendix
 Appl(s)-----Applicable; Application(s)
 Appr-----Approve
 Apprd-----Approved
 Apprl-----Approval
 ARGMA-----Army Rocket and Guided Missile Agency
 Armd-----Armored
 Armt-----Armament
 Ars-----Arsenal
 Art-----Article
 ARVN-----Army of the Republic of Vietnam
 ASA(I&L)-----Assistant Secretary of the Army (Installations
 and Logistics)
 ASA(R&D)-----Assistant Secretary of the Army (Research and
 Development)
 Asgmt-----Assignment

Asst-----Assistant
 AT-----Antitank
 ATAC-----Army Tank-Automotive Command
 Atch(d)-----Attach(ed)
 ATGM-----Antitank Guided Missile
 ATURF-----Airborne TOW USAREUR Repair Facility
 Auth-----Authority
 Auto-----Automatic
 AVSCOM-----Army Aviation Systems Command
 Awd-----Award

- B -

Bd-----Board
 Bde-----Brigade
 Bfg-----Briefing
 Bks-----Barracks
 Bn-----Battalion
 Br-----Branch
 BRL-----Ballistic Research Laboratories
 Btry-----Battery
 Bx-----Box

- C -

C&DP-----Comptroller and Director of Programs
 CAP-----Cover, Artillery Protection
 Cav-----Cavalry
 Cbt-----Combat
 CDC-----Combat Developments Command
 CDOG-----Combat Developments Objective Guide
 Cdr-----Commander
 CG-----Commanding General
 Ch-----Change
 Char-----Characteristic
 Chf-----Chief
 Cir-----Circular
 Cmdty-----Commodity
 Cmt-----Comment
 CO-----Commanding Officer
 CofOrd-----Chief of Ordnance
 CofS-----Chief of Staff
 COFT-----Conduct of Fire Trainer
 Com-----Committee
 Comd-----Command
 Con-----Control, Controlled
 CONARC-----Continental Army Command
 Conf-----Conference
 Contr-----Contract, Contractor
 CONUS-----Continental United States

Coord-----Coordinate(d)(ing)(ion)
 CPAF-----Cost-Plus-Award-Fee
 CPIF-----Cost-Plus-Incentive-Fee
 CR-----Command Regulation
 CRD-----Chief of Research and Development
 CSS-----Contact Support Set
 CSTS-----Contact Support Test Set
 CTP-----Coordinated Test Plan
 Curr-----Current
 CVWS-----Combat Vehicle Weapon System

- D -

DA-----Department of the Army
 D&F-----Determination and Finding
 DAPR-----Department of the Army Program Review
 DARCOM-----U. S. Army Materiel Development and Readiness
 Command
 DCG-----Deputy Commanding General
 DCG/GM-----Deputy Commanding General for Guided Missiles
 DCG/LCS-----Deputy Commanding General for Land Combat
 Systems
 DCSLOG-----Deputy Chief of Staff for Logistics
 DCSOPS-----Deputy Chief of Staff for Military Operations
 DDRE-----Director of Defense Research and Engineering
 Decn-----Decision
 Dep-----Deputy
 Dev-----Development
 DEVA-----Development Acceptance
 DF-----Disposition Form
 Dir-----Direct, Director
 Distr-----Distribution
 Div-----Division
 Dmst-----Demonstrate
 Dmstn-----Demonstration
 DOD-----Department of Defense
 DOFL-----Diamond Ordnance Fuze Laboratories
 Dpl(d)-----Deploy(ed)
 Dplmt-----Deployment
 D/P&P-----Directorate for Procurement and Production
 Dr-----Doctor
 D/R&D-----Directorate for Research and Development
 Drte-----Directorate
 DS-----Direct Support
 DTAE-----Depot Test Acceptance Equipment
 DT/OT-----Development Test/Operational Test

- E -

ECCM-----Electronic Counter-Countermeasure

ECM-----Electronic Countermeasure
 ECOM-----Army Electronics Command
 Eff-----Effect, Effective
 Effns-----Effectiveness
 Engr-----Engineer
 Engrg-----Engineering
 EPR-----Equipment Performance Reports
 Equip-----Equipment
 ET/ST-----Engineering Test/Service Test
 Eval-----Evaluation
 Exam-----Examine, Examination
 Exper-----Experiment

- F -

Fac-----Facility(ies)
 Feas-----Feasibility
 FFP-----Firm-Fixed-Price
 fr-----from
 FMS-----Foreign Military Sales
 FOE-----Follow-On Evaluation
 FONECON-----Telephone Conversation
 FORSCOM-----United States Army Forces Command
 FRG-----Federal Republic of Germany
 Ft-----Fort; Foot
 FS-----Feasibility Study

- G -

GFE-----Government-furnished equipment
 GFP-----Government-furnished property
 GLLD-----Ground Laser Locator Designator
 GM-----Guided Missile
 Gnd-----Ground
 GO-----General Order
 Gp-----Group
 Guidn-----Guidance

- H -

HAC-----Hughes Aircraft Company
 HASC-----House Armed Service Committee
 HAT-----High Altitude Test
 HAW-----Heavy Antitank/Assault Weapon
 HDF-----Historical Division File
 HEAT-----High Explosive Antitank
 Hel-----Helicopter
 HELLFIRE-----Helicopter-Launched, Fire and Forget
 Hist-----History; Historical
 Hon-----Honorable
 HQ-----Headquarters

Hv-----Heavy

- I -

ICAM-----Improved COBRA Agility and Maneuverability
ICAP-----Improved COBRA Armament Program
IE&ST-----Integrated Engineering and Service Test
IES-----Industrial Engineering Services
Incl-----Inclosure
Ind-----Indorsement
Inf-----Infantry
Info-----Information
Init-----Initial
Intvw-----Interview
Inves-----Investigate; Investigation
IOC-----Initial Operational Capability
IPR-----In-Process Review
IPR/SSE-----In-Process Review/System Status Evaluation
IPT-----Initial Production Test
IR-----Infrared
ITV-----Improved TOW Vehicle

- J -

JTCG-----Joint Technical Coordinating Group
Just-----Justification

- K -

kph-----kilometers per hour

- L -

Lab(s)-----Laboratory; Laboratories
LAPD-----Los Angeles Procurement District
LAW-----Light Antitank Weapon
LCCO-----Land Combat Commodity Office
Lchr-----Launcher
LCSIMO-----Land Combat Special Items Management Office
LCSS-----Land Combat Support System
Lmt(n)-----Limit(ation)
Log-----Logistics
LP-----Limited Production
LPTC-----Limited Production Type Classification
LP-U-----Limited Production-Urgent
LRIP-----Low Rate Initial Production
LRU-----Line Replaceable Unit
Ltr-----Letter

- M -

m-----meter
Maj-----Major

OrdC-----Ordnance Corps
OSD-----Office, Secretary of Defense
OT-----Operational Test
OTCM-----Ordnance Technical Committee Meeting (Minutes)

- P -

Para-----Paragraph
PBS-----Production Base Support
PCP-----Program Change Proposal
Pdn-----Production
PEMA-----Procurement of Equipment and Missiles, Army
PEMARS-----Procurement of Equipment and Missiles, Army
Management and Accounting Reporting System
Per-----Permission
Perf-----Performance
Pers-----Personnel
PM-----Project Manager
PMP-----Project Master Plan
PM2P-----Project Management Master Plan
PMSO-----Project Manager Staff Officer
POMM-----Preliminary Operating and Maintenance Manual
Pos-----Position
Ppsd-----Proposed
Ppsl-----Proposal
Prelim-----Preliminary
Pres-----President
Pro-----Procedure
Proc-----Procurement
Prog-----Progress
Proj-----Project
PV-----Production Validation

- Q -

QMR-----Qualitative Materiel Requirement

- R -

R&D-----Research and Development
RCLR-----Recoilless Rifle
RDAT-----Research and Development Acceptance Test
RDTE-----Research, Development, Test, and Evaluation
Rec-----Record
RECAP-----Review and Command Assessment of Projects
Reclas-----Reclassification
Regt-----Regiment
Rept-----Report
Req-----Request
Resp(s)-----Responsibility(-ities)
RFI-----Radio Frequency Interference

Rg-----Range
 RHA-----Records Holding Area
 Rkt-----Rocket
 ROC-----Required Operational Capability
 ROTCM-----Reserve Officer's Training Corps Manual
 Rqr (d)-----Require(d)
 RSA-----Redstone Arsenal
 Rsch-----Research
 RSIC-----Redstone Scientific Information Center
 RVN-----Republic of Vietnam

- S -

SAR-----Selected Acquisition Report
 SASC-----Senate Armed Services Committee
 Sbm-----Submission
 Scd-----Schedule
 Sch-----School
 SDR-----Small Development Requirement
 SHIL-----SHILLELAGH
 SOQAS-----Statement of Quality and Support
 Sp-----Special
 Spt-----Support
 SS-----Summary Sheet
 SSE-----System Status Evaluation
 SSMO-----Special Systems Management Office
 ST-----Service Test
 Sta-----Status
 Std-----Standard
 STM-----Service Test Model
 Stmt-----Statement
 Struc-----Structure
 Subcom-----Subcommittee
 Subj-----Subject
 Subsys-----Subsystem
 Sum-----Summary
 Suppl-----Supplement
 Svc (s)-----Service(s)
 Sys-----System

- T -

TACOM-----Army Tank-Automotive Command
 TCLAS-----Type Classification
 TD-----Table of Distribution
 TDA-----Table of Distribution and Allowance
 TDP-----Technical Development Plan
 TDY-----Temporary Duty
 Tech-----Technical
 TECOM-----Army Test and Evaluation Command

TIR-----Technical Information Report
 TN-----Technical Note
 Tn-----Train
 Tng-----Training
 Tnr-----Trainer
 TOE-----Table of Organization and Equipment
 TOW-----Tube-launched, Optically-tracked, Wire-guided
 (heavy antitank/assault weapon)
 TR-----Technical Requirement
 TRADOC-----Army Training and Doctrine Command
 Trf-----Transfer
 Trk-----Truck
 Trp-----Troop
 TSGMS-----Test Set, Guided Missile System
 TT-----Teletype

- U -

UAT-----Under Armor TOW
 UH-----Utility Helicopter
 U.S.-----United States
 USA-----United States Army
 USAAE&SWB-----United States Army Airborne, Electronic, and
 Special Warfare Board
 USAIB-----United States Army Infantry Board
 USAIS-----United States Army Infantry School
 USAMMCS-----United States Army Missile and Munitions Center
 and School
 USAOC&S-----United States Army Ordnance Center and School
 USAMICOM-----United States Army Missile Command
 USAR-----United States Army Reserve
 USAREUR-----United States Army, Europe
 USATC-----United States Army Training Center
 USATECOM-----United States Army Test and Evaluation Command
 USMC-----United States Marine Corps
 UUT-----Unit Under Test

- V -

Veh-----Vehicle
 Vol-----Volume
 VP-----Vice President

- W -

w-----with
 Wkly-----Weekly
 WSMR-----White Sands Missile Range
 WWAP-----Worldwide Asset Position

- Y -

YPG-----Yuma Proving Ground

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