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FINAL REPORT

XM163 VULCAN AIR DEFENSE SYSTEM

ACG-64F

ARMY CONCEPT TEAM IN VIETNAM
APO SAN FRANCISCO 96384

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FINAL REPORT

XM163 VULCAN AIR DEFENSE SYSTEM

ACG-64F

AD 857327

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AVHGC-DST (11 Jun 69) 1st Ind
SUBJECT: XM163 Vulcan Air Defense System

DA, HEADQUARTERS, UNITED STATES ARMY VIETNAM, APO San Francisco 96375

TO: Commander in Chief, United States Army, Pacific, ATTN: GPOP-DT, APO San Francisco 96558

1. The attached final report is forwarded for review and transmittal to Department of the Army. Request one copy of the CINCUSARPAC forwarding indorsement be furnished to Commanding General, US Army, Vietnam, ATTN: AVHGC-DST, APO 96375, and Commanding Officer, Army Concept Team in Vietnam (ACTIV).

2. This headquarters concurs in the ACTIV Final Report and the following comments are offered for your consideration:

a. Any decision made to deploy Vulcan units to RVN should be reviewed in light of current redeployment plans.

b. If the decision is made to deploy Vulcan units to RVN, additional personnel spaces must be made available to USARV by Department of the Army.

FOR THE COMMANDER:

1 Incl
nc

B. A. GOODWIN
CPT, AGC
Assistant Adjutant General

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DEPARTMENT OF THE ARMY
U.S. ARMY CONCEPT TEAM IN VIETNAM
APO San Francisco 96384

FINAL REPORT

XM163 VULCAN AIR DEFENSE SYSTEM

ACTIV Project No. ACG-64F

18 JUN 1969

Approved:

JOHN E. REID
Colonel, Infantry
Commanding

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DEPARTMENT OF THE ARMY
ARMY CONCEPT TEAM IN VIETNAM
APO San Francisco 96384

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18 JUN 1969

SUBJECT: Final Report - XM163 Vulcan Air Defense System (ACG 64F)

Commanding General
United States Army, Vietnam
ATTN: AVHGC-DST
APO 96375

1. Reference: Letter, AVHGC-DH, Headquarters, US Army, Vietnam, 23 February 1967, subject: Letter of Instruction.

2. In accordance with the provisions of the foregoing reference, the attached final report is forwarded for review and transmittal to Department of the Army.

3. Request one copy of the USARV and CINCUSARPAC forwarding indorsement be furnished the Commanding Officer, Army Concept Team In Vietnam (ACTIV).

FOR THE COMMANDER:

JOSEPH W. STRAUB
CPT, AGC
Adjutant

[redacted]

[redacted]

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AUTHORITY

Letter, FOR ACTIV, Headquarters, Department of the Army, Office of the Assistant Chief of Staff for Force Development, 13 May 1968, subject: Army Combat Developments and Materiel Evaluation (CD & ME) Program, Vietnam, Revision of Formal Projects FY 1968-69.

ACKNOWLEDGMENTS

The Army Concept Team in Vietnam is indebted to the following for their cooperation and assistance in the conduct of this study:

II Field Force, Vietnam
1st Infantry Division
9th Infantry Division
25th Infantry Division
5th Battalion (AWSP), 2d Artillery
1st VULCAN Combat Team (Provisional)
US Army Air Defense Center, Fort Bliss, Texas

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ABSTRACT

The Army Concept Team in Vietnam evaluated the XM163 VULCAN Air Defense System to determine its effectiveness in a combat role. The 180 day Department of the Army evaluation began on 26 November 1968. Because of the tactical situation the VULCANs were retained in RVN for an additional 45 days. The evaluation terminated on 20 April 1969. The evaluation was oriented toward a ground role, and the air defense role should targets of opportunity appear. There was no enemy air activity during the evaluation.

The VULCAN is a 20mm Gatling type automatic weapon mounted on a modified M113A1 armored personnel carrier. The gun has a low rate of sustained fire of 1,000 rounds per minute and a controlled rate of 3,000 rounds per minute; the ammunition is electrically primed. For air defense purposes, the system is equipped with a range-only-radar.

A platoon of four VULCANs plus one maintenance float was deployed to RVN and assigned to an automatic weapons artillery battalion. The platoon was further attached to automatic weapons artillery batteries in support of ground elements in the III and IV Corps Tactical Zones.

The VULCANs were tactically employed during a five-month period on missions similar to those assigned to the M42 40mm Duster units and the M55 Quad .50 caliber machinegun units. These missions included convoy security, reconnaissance in force, security for mine sweep operations and engineer quarry operations, security for medical civic action programs, show-of-force runs, perimeter defense, and ambush patrols.

The cyclic rate of high explosive fire was unsurpassed by any other ground combat weapon in RVN, and supported units were highly impressed with the additional firepower provided by the VULCAN. The XM168 cannon proved to be a highly reliable and durable weapon. All shortcomings found in other components of the system are surmountable with no major retrofit requirements.

In view of the limited number of VULCANs committed for the combat evaluation, meaningful experience factors regarding total equipment and resupply requirements were not developed. However, several findings were established regarding TOE changes pertaining to personnel and equipment.

The VULCAN system was highly effective in RVN and it is recommended that TOE VULCAN organizations be deployed to RVN for use in a ground role.

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SECTION I

INTRODUCTION

1. REFERENCE

Letter, FOR ACTIV, Headquarters, Department of the Army, Office of the Assistant Chief of Staff for Force Development, 13 May 1968, subject: Army Combat Development and Materiel Evaluation (CD & ME) Program, Vietnam, Revision of Formal Projects FY 1968-69.

2. PURPOSE

The purpose of this evaluation was to determine the effectiveness of the XM163 VULCAN Air Defense System in a US forces combat role in the Republic of Vietnam (RVN).

3. OBJECTIVES

a. To evaluate ground and, if target of opportunity appear, air role employment of VULCAN as developed by using unit in operation in RVN.

b. To evaluate VULCAN system performance against the various terrain, combat, and other environmental factors affecting system operation.

c. To evaluate VULCAN system organizational requirements to include maintenance support requirements at the direct support level for operation in RVN.

d. To evaluate the maintainability and logistic support requirements for the purpose of developing a logistic support concept for operation in RVN.

4. DESCRIPTION OF THE XM163 VULCAN SYSTEM

a. The primary elements of the XM163 VULCAN system are:

(1) XM741 armored chassis (modified M113A1 armored personnel carrier).

(2) XM168 20mm gun (modified M61A1).

(3) XM157 gun mount.

(4) AN/VPS-2 range-only radar (ROR)

b. The XM741 chassis is intended primarily for operation over all types of terrain at speeds up to 42 mph and ranges to 300 miles. It has an amphibious speed capability to 3.6 mph. Movement of the tracks

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propels and steers the vehicle on both land and water. The water-tight hull is welded aluminum plate. The power train components are located in the forward right section of the vehicle. A General Motors 6-V53 diesel engine supplies power through a transfer case to an Allison three-speed automatic transmission. The vehicle is equipped with a suspension lock-out system that is used when firing from a stationary position. The system is air-transportable and weighs approximately 26,000 pounds when combat-loaded with ammunition and a crew of four.

c. The XM168 gun is a six-barrel Gatling type automatic weapon. It is electrically operated and fired, with power supplied by batteries charged by either the vehicle or an auxiliary power unit. Rate of fire depends upon the speed of barrel cluster rotation, with a high and low rate of 3,000 and 1,000 rounds per minute, respectively. Burst length may be pre-selected by the gunner on the high rate of fire only for controlled bursts of 10, 30, 60, and 100 rounds. The system employs M56A3 20mm high explosive incendiary ammunition and XM220 target practice tracer in a 7:1 mix, respectively. XM246 self-destruct ammunition is also available.

d. The XM157 gun mount is a one-man operated, power driven, servo-controlled turret of new design. The turret has unlimited travel in azimuth at speeds up to 75° per second. The gun has an elevation range of -5° to +80° at speeds up to 45° per second. The armament system may be operated without interfering with the maneuverability of the vehicle. The system carries 2,000 rounds of ammunition; 1,000 rounds are available for firing without reloading. Approximately 200 rounds remain in the feed system during the reloading of the 800-round reserve.

e. The AN/VPS-2 ROR is an integral part of the VULCAN system and is used in the air defense role.

f. Modifications and additional equipment provided for the RVN ground combat evaluation included a night azimuth indicator, quadrant seats for a gunner's quadrant, telescopic sight, 5-mil muzzle clamp, flotation gear, and night vision sight.

5. BACKGROUND

a. The XM163 VULCAN system was produced in CONUS in August 1968. The Department of the Army proposed that the VULCAN be evaluated for suitability for combat employment in RVN.

b. The VULCAN Combat Team (Provisional) was deployed to RVN with personnel arriving on 6 October 1968. The equipment arrived in country on 17 November 1968. It was assigned to the Commanding General, II Field Force, Vietnam (FFV) for a 120-day combat evaluation. The 5th Battalion (AWSP), 2d Artillery was designated the parent unit of the VULCAN Combat Team. The team consisted of four operational VULCAN systems and one float. The operational platoon consisted of one officer and 21 enlisted men.

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6. APPROACH AND SCOPE

a. The VULCANs were employed in a variety of missions similar to those supported by the M42 Duster batteries - usually with cavalry or mechanized infantry units. They were not committed in less than a section (two weapons) size element. The VULCANs operated with the Armored Cavalry Assault Vehicle (ACAV). The ACAV and the VULCAN were highly compatible, having identical chassis, similar signature characteristics, and generally the same mobility and maintenance requirements. Both were used in roles approaching those of an armored reconnaissance vehicle or light tank.

b. The limited number of VULCANs (four) precluded full evaluation in all environmental conditions and operational situations. The evaluation of the VULCAN system did not interfere with the assigned mission of the Duster battalion in which the systems were evaluated, but were used in lieu of the Dusters under combat conditions.

c. The VULCAN Combat Team was scheduled to depart for CONUS on 15 March 1969. Because of the tactical situation, the Department of the Army extended the team for 45 days for combat employment. The actual deployment periods were as follows:

(1)	26 November to 9 December 1968:	Battery A, 5th AW Battalion, 2d Artillery, 1st Infantry Division.
(2)	10 December 1968 to 3 January 1969:	Battery D, 5/2 Artillery, Bear Cat.
(3)	4 to 19 January 1969:	Battery A, 5/2 Artillery, 1st Infantry Division.
(4)	20 January to 10 February 1969:	Battery B, 5/2 Artillery, 25th Infantry Division.
(5)	11 February to 28 March 1969:	II FFV, Long Binh/Bien Hoa.
(6)	29 March to 20 April 1969:	Battery C, 5/2 Artillery, 9th Infantry Division.

7. ENVIRONMENT

All combat employment of VULCAN took place in the II FFV area of responsibility. The terrain varied from inundated rice paddies and

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gently rolling hills to heavily jungled areas and open forests. Other areas of employment included large open expanses of tropical grasses, as well as along the marshes of the major rivers in the Mekong Delta. The climate and weather varied from hot and humid with occasional showers to hot and dry with no rainfall. During the dry periods, movement of personnel and vehicles as well as the occurrence of strong winds created a significant amount of dust. Humidity was high even during the dry periods.

* * * * * * *

The discussion in the following sections is in answer to questions posed in the Combat Evaluation Plan for Gun, Antiaircraft Artillery, Self-Propelled, 20mm XM163 (VULCAN Air Defense System), Headquarters, Department of the Army, August 1968.

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SECTION II

OBJECTIVE 1 - EVALUATE GROUND AND, IF TARGETS OF OPPORTUNITY APPEAR, AIR ROLE EMPLOYMENT OF VULCAN AS DEVELOPED BY USING UNITS IN OPERATION IN RVN.

Air targets of opportunity did not appear during the combat evaluation. Therefore, the discussion of the employment of the VULCAN in an air defense role is limited to the problem of transition from the ground to air role.

1. What problems were involved in moving from a ground support role to an air defense role? How much time was required to change muzzle clamp and ammunition? Were missions compatible?

a. The VULCAN was designed primarily as an air defense weapon. Thus there were some inherent problems in the transition from its ground support configuration to one of air defense. If the VULCAN system were operating with all its air defense equipment on board, then the problem of transition from the ground support role to air defense would be minimal. If the VULCAN were operating without a portion of its air defense equipment, such as the ROR, as was common in RVN, then the transition would be lengthier. The transition time would depend upon the proximity of the VULCANs to the storage location of the ROR, other related equipment, the availability of transportation, and the availability of personnel to perform the retrofit.

b. The 5-mil muzzle clamp was added to the VULCAN inventory before departure from CONUS as a special clamp for the gound support role. Firing was conducted with both the 5-mil and the 17x23-mil air defense muzzle clamp. Observations revealed that the air defense muzzle clamp provided a larger beaten zone. Both crews and supported troops preferred the air defense clamp and the greater target coverage given. Therefore, there was no requirement to change muzzle clamps when reverting from the ground to air role since the air defense clamp was suitable for both roles.

c. The problem of changing to self-destruct ammunition would probably be time-consuming and generally unsatisfactory. The present basic load, of any type ammunition, does not appear to be adequate. Therefore, it would be impossible to carry adequate quantities of two types of ammunition onboard. Storage and availability of transportation affect this change of ammunition.

2. What procedures are required to provide gross early warning to the fire units?

Early warning of enemy air activity would be normally received by the fire units in the same manner as other ADA AW units. The Rapid Alerting Identification Display Data Link would provide adequate intelligence for these units. The Division Warning Broadcast

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Net (AM Voice) would not be available as TOE 44-327T does not provide for AM radios.

3. What targets warrant air defense in areas that require ground support? Who designates air defense targets?

The lack of air targets precluded evaluation in this area. It is envisioned that air defense doctrine and responsible commanders would determine air defense targets.

4. Was the content of FM 44-3 adequate? Were command, control, and coordination procedures adequately described?

a. A review of FM 44-3 revealed that ground support doctrine was not adequate. The doctrine was oriented toward conventional warfare and provided little guidance for the employment of ADA AW in stability operations. The organizational concept in FM 44-3 did not allow for proper tailoring of the VULCAN platoon to meet the tactical situation.

b. Paragraph 2-5 divided the platoon into two sections of four squads each. This organization did not provide adequate flexibility for the ground support missions in RVN. It is preferable that VULCANs operate in four sections of two squads each, as do the M42 Dusters.

c. Paragraph 2-4 provided a battalion motor maintenance section, but no system maintenance section. This arrangement will be adequate only if this echelon of maintenance can be performed at the battery level.

d. Paragraph 2-4 did not provide for a battalion system maintenance officer. An assistant S-4 detailed to systems maintenance or a battalion systems liaison officer is necessary to provide coordination between battery system maintenance and direct support.

e. Paragraph 4-14 did not provide doctrinal guidance for ground support tactics of VULCAN when operating in convoy. Direction should be provided specifically for deployment within convoy, reconnaissance and suppressive fires, and counter-ambush tactics.

f. Paragraph 5-10 instructed gunners to fire low rate when engaging targets in ground mode. This contradicted CONUS direct fire tests which revealed that 10- and 30-round bursts in the high rate were the most effective.

5. Determine the relative effectiveness of VULCAN/Duster/Quad 50 engaging targets above 1,000 feet and below 1,000 feet.

The relative effectiveness of the VULCAN/Duster/Quad 50 in the air defense role could not be determined. This should be accomplished by controlled tests conducted in CONUS.

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6. What type of emplacements were used and what problems were encountered? What problems were noted with camouflage, concealment, and signature characteristics? What types and methods of camouflaging and concealment were used?

Air defense firing emplacements, camouflage, and concealment will not likely vary from that used by the Duster. No specific measures for camouflage and concealment were used. The signature characteristics of the VULCAN will not differ from those of the M113A1 or ACAV, except when it is equipped with the ROR.

7. Was there a requirement for providing indirect fire? If so, how was forward observer function performed?

During the evaluation there was no continuing requirement to provide indirect fire because of the availability of extensive field artillery support. However, on one occasion, a VULCAN fired two indirect missions at intelligence targets. Firing was in conjunction with the AN/MPQ-4A countermortar radar. This particular mission was fired during darkness and, coupled with the tactical situation, precluded the employment of a forward observer. Most indirect fire intelligence missions are fired during darkness and forward observers are seldom, if ever, used. In situations where other means of indirect fire are less readily available, there might be a requirement for VULCAN indirect fire. In such cases, the mortar and artillery forward observers could fill the forward observer function.

8. Was there a requirement for overhead fire?

There was no requirement for overhead fire. The area of operations involved in this evaluation was flat and visibility was frequently restricted by wood lines and jungle. Supported units were reluctant to have the VULCANs fire direct fire overhead because of the point-detonating characteristics of the 20mm HE ammunition and their concern that foliage might cause detonation within proximity of friendly troops. When called upon to provide supporting or suppressive fire the VULCANs were employed forward or on line. In static positions, they were deployed on the berm or main perimeter. In areas of more irregular terrain or in situations of more fluid maneuver, overhead fire could be required.

9. Was there a requirement for preplanned concentrations of fire?

The question of preplanned concentrations of indirect fire was covered in question 7. Preplanned concentrations of direct fire were required. When employed in perimeter defense roles, VULCANs were usually assigned area targets on which they fired interdiction missions at the command of the supported unit commander or in accordance with some type of preplanned schedule.

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10. Was the content of FM 44-3 and FM 44-5 adequate? What portion of FM 44-2 was applicable to the VULCAN ground support role?

The content of FM 44-3 and FM 44-5 was discussed in question 4. The applicability of FM 44-2 to the VULCAN in the ground support role is as follows:

a. Paragraph 132, Basic Concepts. The doctrine was oriented toward the platoon as the basic element. This is true within the AW battery only. In RVN, it must be stressed that the section is the basic element.

b. Paragraph 133, Capabilities and Limitations. The capabilities should be expanded to include types of missions in which the VULCAN participated during the evaluation. The limitations in RVN were the lack of overhead protection and vulnerability to RPGs and mines. The silhouette is equal to that of the ACAV and other track vehicles operating in RVN.

c. Paragraph 134, Mission. Ground support is the basic mission of the VULCAN in RVN. Operations must be oriented toward this capability to provide more flexibility and effectiveness.

d. Paragraph 135, Organization for Combat. The platoon is not the basic element in RVN. Attachment of an AW platoon to an infantry battalion is an unethical tactical employment in RVN. Doctrine must be oriented toward stability operations.

e. Paragraph 137, Communications. An AN/GRR-5 was not included in the VULCAN TOE and therefore the VULCAN squad did not have AM intelligence capability.

f. Paragraph 146, Actions During Attack. This doctrine was appropriate only to conventional warfare. The doctrine must be rewritten to include guidance for employment in stability operations. VULCANs participating in reconnaissance in force operations normally were deployed as a fire support element because of their massive fire power and vulnerability to enemy RPGs.

11. What was the relative effectiveness of VULCAN/Duster/Quad 50 against various targets? What was the relative effectiveness among the three systems for each type target engaged.

Specific data on the relative effectiveness of the VULCAN/Duster/Quad 50 against various targets was not available because of the wide variation in characteristics of these targets and the combat environment. Weapons effects data should be obtained under controlled test conditions in CONUS. There was a general feeling among all personnel involved in the evaluation that the VULCAN was more effective than the Duster or Quad 50 against all types of targets encountered in RVN.

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12. What type targets were engaged (give percentage of each and numbers in range spreads)? Document incidents where use of self-destruct ammunition may have been preferred when engaging ground targets.

Field observations revealed that intelligence and interdiction targets were fired at ranges greater than 1,000 meters. Hard targets and targets of opportunity were engaged within 250 meters and frequently within 25 meters or less. During the evaluation, 110 targets were engaged within the following ranges.

Range (meters)	Targets	Percent of Total Targets
Under 1,000	42	38
1,000 to 1,500	35	32
1,500 to 2,000	19	17
2,000 to 2,500	8	7
Over 2,500	6	6
	110	100

Self-destruct XM246 ammunition, if in plentiful supply, would have been used frequently to preclude firing into friendly villages located down range from potential targets.

13. CONUS indirect fire tests resulted in the recommendation that 10- or 30-round bursts be used for adjustments and 60- and 100-round bursts or the low rate (1,000 rpm) be used in firing for effect. Did the combat evaluation confirm this recommendation?

During the indirect firing, no adjustment was necessary as the firing was in response to information provided by the AN/MPQ-4A radar. However, in fire for effect, 60- and 100-round bursts selections were used as this provided the maximum target coverage in the shortest period of time.

14. What procedures, if any, were developed for using meteorological data in connection with predicted indirect fire?

Meteorological data was not used in connection with the indirect firing.

15. What employment formations were used?

The VULCANs operated in pairs.

16. How and where were the weapons employed?

In supporting cavalry and mechanized operations, they were used as a maneuver element and ready reaction force. The VULCANs performed eight different type missions during the evaluation.

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a. Convoy security. VULCANs were integrated into march columns transporting supplies and ammunition to fire support bases. They provided the heavy firepower element and conducted reconnaissance by fire as well as suppressive fires.

b. Reconnaissance in force. VULCANs were attached to cavalry or mechanized units conducting reconnaissance operations. VULCANs were used with the maneuver element during daylight tactical operations and on perimeter defense during darkness.

c. Security for engineer mine sweep operations. VULCANs provided security for engineer and infantry units clearing enemy road mines. This operation was conducted daily at first light.

d. Security for engineer laterite (soil) operations. VULCANs were positioned to provide local security and to deploy as a ready-reaction force in support of engineer quarry and laterite operations.

e. Security for medical civic action programs (MEDCAP). VULCANs escorted MEDCAP teams to and from villages and provided local security for MEDCAP activities.

f. Show of force. VULCANs were deployed with cavalry and mechanized platoons which traveled roads as a show of force, intending that the presence of tracked vehicles and heavy fire power would deter the enemy from operating in that area. They were also integrated with several other tracked vehicles in logistics convoy. This tactic was often employed when traveling a road that had not been cleared previously.

g. Perimeter defense. VULCANs were either placed on the perimeter as a defensive weapon or within the perimeter as a ready-reaction force.

h. Ambush patrols. During the hours of darkness, two VULCANs were deployed with a platoon of infantry to a selected ambush site. The VULCANs were tactically situated to provide fire in the killing zone should the enemy trigger the ambush.

The following table shows the breakdown of missions by type and operational control.

17. What type of emplacements were used and what problems were encountered?

While in a static posture, VULCANs were emplaced in a firing pit behind a berm and protected by an anti-RPG screen (chain link fence). Normally the vehicle was oriented toward the direction of fire so that the gun fired over the front of the chassis. This posture allowed the squad leader to remain at his position on the vehicle where he could be near the radio and exercise effective command and control of his unit.

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Mission	1st Inf Div	Bear Cat	25th Inf Div	II FFV	9th Inf Div	Total
Convoy Security	16	0	12	0	3	31
Reconnaissance in Force	1	0	9	0	19	29
Security for Engineer Mine Sweeps	28	0	12	0	0	40
Security for Engineer Laterite Operations	11	0	0	0	0	11
Security for MEDCAP	5	0	0	0	0	5
Show of Force	2	0	0	0	0	2
Perimeter Defense	15	23	7	41	26	112
Ambush Patrol	1	0	2	0	10	13

FIGURE II-1. Breakdown of Missions by Type and Operational Control.

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18. What problems were noted concerning camouflage, concealment, and signature characteristics? What types and methods of camouflage and concealment were used?

VULCANs encountered the usual problems characteristic of all tracked vehicles with respect to camouflage, concealment, and signature characteristics. No specific measures for camouflage and concealment were used. Facing the vehicle toward the enemy reduced the silhouette thus decreasing vulnerability to enemy RPGs. The signature characteristics of the VULCAN were not significantly different from other armored personnel carriers, particularly the ACAV. When the ROR was mounted on the VULCAN, its identity was more apparent.

19. What was the relative combat effectiveness of VULCAN/Duster/Quad 50? Include consideration of mobility, maneuverability, maintainability, lethality, availability, crew protection, fire control, range capability, and ammunition resupply.

The combat effectiveness of the VULCAN was superior to the Duster and the Quad 50. It exceeded both these vehicles in all categories except ammunition resupply. The VULCAN was more compatible with the cavalry and mechanized vehicles with which it usually operated than were the Duster or Quad 50. Its high cyclic rate of fire ensured a high degree of lethality. The relatively small basic load of the VULCAN, together with its high cyclic rate of fire, posed a constant ammunition resupply problem. Field observations of the mobility, maneuverability, crew protection, and lethality of these systems are discussed below. Maintainability, availability, fire control, range capability and ammunition resupply are discussed is Sections III, IV, and V.

a. Mobility. The mobility of the VULCAN was superior to the Duster and Quad 50. The modified M113A1 chassis enabled it to traverse light woods, heavy brush, rubber plantations, and wet, marshy rice paddies.

b. Maneuverability. The VULCAN was employed with and able to support cavalry and mechanized units equipped with the ACAV. Because of the VULCAN's compatibility with the ACAV, it was more suitable for this role than the Duster or Quad 50. On one occasion, however, the extra vehicle width caused by the flotation kit restricted the mobility of the VULCAN. While operating in a rubber plantation in the Mekong Terrace, a VULCAN was unable to pass between rows of rubber trees which could be traversed by the support cavalry vehicles. During all other operations, the VULCAN was able to maneuver with the supported units. A favorable comment was made by the Operations Officer, 3d Brigade, 25th Infantry Division: "The VULCAN was able to support our operations better than the Dusters because it could traverse the French-type Eiffel bridges and move through restricting rows of trees in rubber

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plantations." The Duster was a heavier vehicle and became mired more frequently in wet paddies. Because of its width, the Duster could not cross many Eiffel bridges or traverse through many rubber plantations. The Quad 50, mounted on a wheeled vehicle was essentially road-bound.

c. Crew Protection. The VULCAN system provided little protection for its crew. A protective shield should be devised to protect the driver from small arms fire. Although a personnel seat was provided within the vehicle, personnel habitually rode on top of the VULCAN because of the danger of mine detonations. Troops do not ride inside any armored personnel carriers in RVN. Experience has revealed that personnel inside an armored personnel carrier during a mine explosion usually become serious casualties. A means of seating the crew on the deck of the VULCAN to provide comfort while traveling is required.

d. Lethality. The cyclic rate of high explosive fire of the VULCAN was unsurpassed by any ground combat weapon in RVN. Field comments indicated a belief that the VULCAN could destroy any target within its range. Firing was usually executed in 10- and 30-round bursts. Field observations revealed this method was the most effective, providing the best target coverage with the least dispersion. This method aided conservation of ammunition because the gunner knew exactly how many rounds were being expended. Although the VULCAN's firepower appeared to be unsurpassed by any ground weapon in RVN, there is a requirement for a supplemental weapon. An M60 7.62mm machinegun mounted on the right rear of the deck would provide additional firepower during an engagement, as well as a backup weapon should the XM168 cannon malfunction.

20. What were the opinions of supported troops concerning VULCAN?

Supported troops were highly complimentary of the VULCAN system. They were particularly impressed by its increased mobility, flat trajectory of its projectile, and firepower. They would welcome the immediate deployment of additional VULCANs in support of their operations in RVN.

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SECTION III

OBJECTIVE 2 - EVALUATE VULCAN SYSTEM PERFORMANCE AGAINST THE VARIOUS TERRAIN, COMBAT AND OTHER ENVIRONMENTAL FACTORS AFFECTING SYSTEM OPERATION.

1. When evaluated in air defense role: Did any modifications for ground role degrade system effectiveness in air defense role?

   The VULCANs were not evaluated in the air defense role.

2. CONUS ground role direct firing tests indicated that 10- or 30-round bursts at the 3,000-rpm rate were the most accurate. Did the combat evaluation confirm this result?

   While in the ground support role, fire was excuted in 10- and 30-round bursts because more accuracy was achieved in short bursts. The selections were used not only because they provided effective firepower but were also a means of conserving ammunition. Less vibration was evident in the 1,000-round rate of sustained fire, but this mode resulted in the greatest expenditures of ammunition.

3. CONUS ground role direct firing tests at stationary targets indicated that inaccuracies resulting from effects of vibration and recoil were reduced to a minimum by positioning the Static Fire switch in the center position. Did the combat evaluation confirm this result?

   Yes, the Static Fire switch was normally used in the center position when engaging targets. No excessive vibration was evident while firing in this position.

4. How effective were the following?

   a. The XM61 auto gyro sight proved very effective. It functioned properly throughout the evaluation. One sight was deadlined on one occasion. At that time, an enemy mortar round severed the W-3 cable leading to the XM61 sight, causing the reticle to be inoperative. Replacement of the cable was accomplished in two hours. An outstanding feature of the XM61 was its stability. One sight retained its boresight for three weeks, while the weapon was in a static posture. When the VULCANs were participating in mobile operations, the XM61 sight was boresighted daily. No new boresight procedures were developed during the evaluation. The procedures outlined in the operator's manual, TM 9-2350-300-10 (Draft), were used and provided acceptable results.

   b. The M120 telescopic sight proved very durable. On two occasions a broken seal allowed moisture to seep into the telescope causing it to be inoperative. Repairs were performed at direct support level, and the sight was returned to the system within two days.

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c. The AN/TVS-2 night vision sight was added to the inventory of the VULCAN system immediately before its departure to RVN. A modification to the XM157 mount provided seats for attachment of the night vision sight. The sight proved useful and reliable. For the first two months of the evaluation, the AN/TVS-2 was stowed daily in its stowage box and taken out only for use during the hours of darkness. Subsequently, the night vision sight remained mounted throughout the evaluation period. Only one minor problem was experienced while the scope was mounted on the system. Dust entered the sight through the peep holes on the side of the sight. Tape was placed over these holes to correct this problem.

d. The azimuth indicator was an off-the-shelf item designed for the M42 Duster. It was retrofitted for the VULCAN system. During the evaluation, brass gears in the indicator experienced excessive wear causing slippage. Reorientation of the azimuth indicator was required before each use.

e. The M82 gunner's quadrant was used to set elevation for the VULCAN system. No problems were experienced with this piece of equipment or the associated quadrant seats. There was no need for an elevation indicator similar to the azimuth indicator because elevations for indirect fire were readily attained using the gunner's quadrant.

f. Additional fire direction equipment was required for effective indirect fire. The M2 compass was available for initial determination of direction. A range deflection protractor was necessary to enable the VULCAN crew to determine quadrant elevations and changes in azimuth in response to observer corrections.

g. The control panel bulb was inadequate and will require a larger watt bulb.

5. CONUS direct ground fire tests indicated that, whenever possible, firing should be done from the halt, with the lock-out suspension engaged. When firing while moving, firing over the sides of the vehicle was recommended. Did the combat evaluation confirm this result?

Firing at the halt was not always done with the lock out suspension engaged. More firing was executed while the gun was positioned over the front of the vehicle than in any other position.

6. What boresight procedures were developed? Did the sights stay boresighted?

No boresight procedures were developed; the procedures in FM 44-5 were used. The sights remained boresighted with no intermittent difficulties.

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7. Was crew protection adequate?

The VULCAN sytem provided little protection for its crew. A protective shield must be delivered for the driver. Although a personnel seat was provided within the vehicle, all personnel rode on top of the vehicle to ensure more protection from mine detonations. The assistant gunner and squad leader were literally "sitting ducks".

8. In the indirect fire role, how long did it take to emplace the fire unit and set in the firing data?

No assessment of emplacement time was available as the indirect firing was controlled by the battalion operations officer to preclude unsafe firing and, because of this, time was not a factor.

9. Did the system have any peculiar identifying characteristics that compromised its employment?

The only peculiar identifying characteristic of the VULCAN, other than the noise of the firing, was the ROR. Since half of the systems operated without the ROR, it will be recommended that the ROR be dismantled from the VULCAN to prevent ready identification of the system.

10. Were any difficulties encountered when engaging a stationary target in the direct fire role?

No.

11. Were any difficulties encountered when engaging a moving target in the direct fire role?

No moving targets were engaged.

12. Were any difficulties encountered when engaging targets in the indirect fire role?

No.

13. What problems were encountered when traversing terrain in the area of operations?

An exceptionally hard ride was evident and was attributed to the extra heavy combat weight of the vehicle.

14. What problems were encountered because of adverse weather conditions?

There were no adverse weather conditions during the evaluation.

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15. Was radio frequency interference (RFI) experienced during system operation?

No.

16. Did the system cause RFI with adjacent systems or other equipment?

There was no evidence that adjacent systems were affected with RFI; however, complete determination could not be made because of the limited use of the ROR.

17. Was tracer required? If not, is it desirable?

Tracer ammunition was required as an aid in observation. It also provided a ball projectile which was desirable when attacking fortified positions.

18. Was the ratio of seven M56A3 to one XM220 satisfactory? If not, what ratio is recommended? Why?

The 7:1 ratio was satisfactory. When the AP round is produced, it is suggested that a mixture be provided of 7:1:1 (HE, tracer, AP).

19. In the ground role, was use of XM246 ammunition satisfactory? Did self-destruct cause appreciable limitations? Explain.

XM246 ammunition was not used.

20. If you conclude that, in RVN-type employment there is a requirement for XM246 as well as M563/XM220 ammunition, what percentage of each should be provided? Why? How should the various types of ammunition be distributed within a battalion?

Unless there is an imminent air threat, there does not appear to be a continuing requirement for XM246, as the M563/XM220 appears to be satisfactory. However, occasions occurred in certain areas where self-destruct ammunition would have been used. Had this self destruct ammunition been more readily available it could have been used when operating in populated areas. This would prevent richochets and high bursts falling on friendly villages down-range from enemy targets.

21. Should other types of ammunition be obtained/developed for VULCAN? If so, why and in what percentage?

A mix of HE, tracer, AP (7:1:1). See question 17.

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22. When firing during periods of rainfall, were premature bursts observed? If so, report in detail.

Inclement weather was seldom evident during the evaluation. It never rained while the VULCAN was fired.

23. Were controls conveniently located? Was turret tracking rate satisfactory? If not, what changes would you recommend?

Controls appeared to be conveniently located. Turret tracking rate was more than satisfactory. The XM157 mount was designed to permit ease of maintenance and firing checks. However, the configuration of the gunner's seat was unsuitable. Even with the seat in its highest position, it was awkward for the gunner to look through the XM61 sight during firing. As a field expedient, wooden boards and cushions were placed on the seat to raise the gunner to the sight. Because the seat could not be collapsed, access through the gunner's compartment was difficult. Excessive time would be required to extract an injured gunner from his position in the present seat. The gun shield was positioned so that it accidentally came into contact with the declutching pin on the feeder. A ball peen hammer was used to indent the gun shield (approximately ½-inch diameter) to allow free movement of the gun.

24. What is your recommendation for operating crew manning?

The present operating manning satisfactory. In its present confiruration, VULCAN could not accommodate any additional crew members. any fewer ?

25. What is your recommendation for maintenance crew manning?

Maintenance crew manning was difficult to determine and will require a perusal of the TOEs in conjunction with an analysis of the maintenance results of the evaluation. Initially, it appears that additional battery mechanics will be required. Also system maintenance must be either be decentralized or a battalion system maintenance manning crew provided.

26. Was night lighting adequate?

Yes.

27. Did the ROR interfere with ground role missions?

The two ROR sets mounted for the evaluation did not affect the ground role mission. The ROR did not serve any useful purpose while the VULCAN was employed in the ground role. The removal of the ROR from the VULCAN would reduce the combat weight. This would allow the VULCAN to bear the additional weight of the proposed increase in ammunition without any noticeable differences in system performance.

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The ROR and related equipment could be locally stored at the battalion maintenance section. When an air threat is imminent, the VULCANs would either return to the organization for retrofit or a contact team could perform the retrofit at the tactical location of the VULCANs.

28. Did the ROR sustain damage as a result of contact with tree limbs, vines, etc.?

No damage was evidenced by the ROR. The VULCAN did not operate in jungle, wooded, or heavy brush environment. On one search and destroy mission through light jungle, a spider arm on the ROR was broken by tree branches. However, the breakage of spider arms was a continuous problem throughout the evaluation. There were six instances of breakage at the weld between spider arm and ROR dish. Observations indicated these breaks were probably caused by faulty welds. The arms were then riveted in place; however, there were three additional incidents in which the rivets failed.

29. Was the store position for the ROR adequate to protect the ROR during cross-country travel?

The store position was an acceptable and necessary attitude for the ROR during all travel. When the ROR was placed in the store position no adverse effects were experienced during travel.

30. Is a protective cover (for example, of molded fiberglass) needed for the ROR? If so, provide a sketch.

The addition of a protective cover, now being considered, does not appear feasible for the ROR. The ROR is not completely weatherproof. On two occasions, the ROR became inoperative because of water in the Unit 5 Power Supply. One of these occurred while the vehicle was being washed. In another incident, water from an unknown source caused the Unit 5 Power Supply to become inoperative, causing the ROR to be inoperative. On 31 March 1969, during flotation tests, one VULCAN sank when it entered the water too rapidly. After the vehicle was recovered, dried, and lubricated, all systems, including the radios, functioned normally except the radar.

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SECTION IV

OBJECTIVE 3 - EVALUATE VULCAN SYSTEM ORGANIZATIONAL REQUIREMENTS TO INCLUDE MAINTENANCE SUPPORT REQUIREMENTS AT THE DIRECT SUPPORT LEVEL FOR OPERATION IN RVN.

1. What are your recommendations concerning the adequacy of TOE 44-327T and 44-727T (and 44-326T and 44-726T as concerns VULCAN)?

   a. Paragraph 07 of TOE 44-326T does not provide for a battalion systems maintenance section or a systems maintenance liaison officer. An assistant S-4 detailed to systems maintenance, or a battalion systems liaison officer, is necessary to provide coordination between battery systems maintenance and direct support.

   b. Paragraph 06 of TOE 44-327T does not provide for section organization within the VULCAN platoon. Platoon organization of four sections of two squads each is necessary for the VULCAN platoon to fill a ground support role similar to the Dusters and to meet various tactical situations.

   c. Organization of the VULCAN platoon into four sections of two squads each will require the addition to the TOE of eight enlisted section leaders, eight armored personnel carriers, eight drivers, and eight machinegunners. Five-ton vehicles assigned to the battery ammunition and systems maintenance section do not have the mobility to supply ammunition to VULCANs in a forward operations area. The armored personnel carriers provided to the section leaders would perform this function.

2. Should night vision devices be added to TOE? Which device?

   The AN/TVS-2 night vision device should be added to the TOE.

3. Was fire direction equipment required? At which level? Was equipment provided in TOE adequate?

   Fire direction equipment was required at the platoon level Equipment in the TOE was not adequate.

4. Was crew size and organization adequate?

   Other than noted above, the present authorization for crew sizes and organization of the VULCAN system appeared adequate to perform missions in both the air defense and ground support roles.

5. Was communication equipment adequate (consider as divisional unit and non-divisional unit)?

   Communication equipment on the VULCAN appeared to be adequate. This equipment enabled the VULCANs to net with the supporting and

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supported units as well as providing intra-unit communications.

6. Were sufficient maintenance personnel and equipment provided in TOE 44-327T and 44-727T?

The present authorization of maintenance personnel at unit level (TOE 44-327T) appeared adequate if they are authorized to perform maintenance as cited in Section V.

7. Were there items of equipment in the TOE that were not required? (TOE 44-327T, 44-727T, 44-326T, 44-726T)

In view of the limited number of VULCANs committed for the evaluation, meaningful experience factors regarding total equipment requirements were not developed. Except as noted above, quantities of allocated equipment were considered adequate.

8. Were there personnel spaces provided in the TOE that were not essential to effective and continuous operation? (TOE 44-327T, 44-727T, 44-326T, 44-726T)

No.

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SECTION V

OBJECTIVE 4 - EVALUATE THE MAINTAINABILITY AND LOGISTIC SUPPORT REQUIREMENTS FOR THE PURPOSE OF DEVELOPING A LOGISTIC SUPPORT CONCEPT FOR OPERATION IN RVN.

1. What fuel consumption factors were developed?

The following fuel consumption factors were developed during the evaluation.

SYSTEM	MILES	FUEL (GALLONS)
12FS83	3058	1132
12FS81	2662	1040
12FS79	2223	796
12FS82	3001	1152
12FS80	1343	402

2. What ammunition consumption factors were developed?

The following ammunition consumption factors were developed.

OPCON TO	ROUNDS FIRED
1st Infantry Division	80,378
Bear Cat	15,022
25th Infantry Division	14,510
IT FFV	18,090
9th Infantry Division	38,720

3. What barrel consumption factors were developed?

No barrel consumption factors were developed during the evaluation. No premature barrel wear was experienced. Barrels were only replaced during the scheduled 36,000-round maintenance stand down.

4. What other repair parts consumption factors were developed?

There was no trend in excessive parts consumption during the evaluation (see Annex B). In several instances, specific repairs (e.g., chute and conveyor assembly and drum assembly) sometimes required an unusual amount of parts. Each time a last round switch malfunctioned, the following parts were damaged and required replacement: 20 conveyor elements, 8 section assemblies, 1 end assembly, and 1 last round assembly. Failure of the drum assembly sometimes required replacement of 15 partition assemblies and 1 helix assembly.

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5. From maintenance logs, what was unscheduled downtimes and cause?

Considerable maintenance was performed on the VULCAN system during the evaluation (see Annex C). However, this maintenance was not deemed excessive because of the sophistication of the VULCAN system and the established maintenance requirements of the M113A1 armored personnel carrier. Annex C lists each malfunction, probable cause of malfunction, corrective action, and the time required to make repair.

6. Was layout of equipment conducive to ease of maintenance?

Yes.

7. Did manuals and check lists provide adequate and understandable information?

Manuals and check lists in the pertinent VULCAN TMs provided adequate and understandable information and guidance for VULCAN mechanics.

8. Was the maintenance package adequate, more than adequate, or less than adequate? What additional repair parts would you recommend for maintenance package?

The maintenance package was adequate for the evaluation with the exception of the drum assembly. No extra drum assemblies accompanied the VULCAN system for the combat evaluation because Army Materiel Command personnel assumed this item to be durable and reliable. The evaluation proved otherwise, and six drum assemblies were air-shipped during the evaluation.

9. Did the organizational test equipment and tools, provided for in the evaluation, prove satisfactory?

The usefulness of the organizational test equipment and tool sets provided was not entirely ascertained. The mechanics did not use the test equipment to detect system failures as often as they exercised expedient trouble-shooting techniques. The test equipment was a desirable item for it was used to detect the failures when trouble shooting failed to detect the fault. During the evaluation one test set failed; upon opening the second test set, it was found to be damaged. The second test set was cannibalized, providing one operational set for the evaluation. On one occasion, while performing an electrical test with the electrical test set MWM-2, the gun fired. The cause could not be determined. It was suspected that the W-3 cable inadvertently remained connected to the J-3 connector. During this incident, live rounds were fired but no personnel were injured.

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10. Was the basic load of ammunition adequate? Was the on-board portion of the basic load adequate? Was the space and method of storage for the basic load adequate?

a. The present on-board basic load of ammunition was inadequate to support the VULCAN in ground operations. The average duration of a tactical engagement was several hours. The VULCAN must have a larger on-board load to sustain it until resupply can be effected. There was one engagement in which only one VULCAN participated as the other VULCAN was deadlined because of a maintenance problem. The maintenance float was also deadlined. During this engagement its ammunition was nearly exhausted within 25 minutes after enemy contact. Close proximity of the platoon headquarters enabled rapid resupply of ammunition. Had resupply distance been significantly greater, the crew would have been forced to resort to their individual weapons.

b. The space for the on-board basic load of ammunition provided for this evaluation was adequate; however, additional space will be required to accomodate the recommended increase of the basic load. The method of storage caused damage to the ammunition if it remained in this location for several days. During vehicle movement, the swaying of the hanging belt of ammunition caused the rounds to strike bare metal where the hull was welded. This point was not covered with a rubber padding. This caused the extractor lips of the projectile to be damaged. When the ammunition was fed into the drum, the bent extractor lips caused excessive wear on the partition assembly.

11. Based on Maintenance Allocation Charts, list all malfunctions correctable at organization, direct support, and general support levels.

A noticeable increase in sluggish firing occurred while VULCANs were deployed in the Mekong Delta. It was observed that maintenance of the drum assembly, including repair and replacement, was performed at direct support level. However, this maintenance could be performed at organizational level. This would preclude the system's being deadlined while awaiting repairs at higher maintenance activities. In contrast, repair of the sight current generator and distribution box should not be done at organizational level as prescribed in TM 9-2350-300-20 because of parts and tools requirements.

12. What was the time to repair for each malfunction? Indicate personnel who took corrective action (crew, direct support, WFCOM, MICOM, or contractor).

a. Complete information on malfunctions is included in Annex C. During the evaluation, the maintenance team performed all echelons of maintenance. Some of the more significant malfunctions are discussed here.

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b. There were continual problems throughout the evaluation relating to the distribution box. Although the circuitry within the distribution box was reliable (only one card failed), there were six incidents in which the gun failed to fire because of faults attributed to the distribution box. Forty-four screws secure the covers of the distribution box. These screws became loosened during traveling. This, in turn, caused the covers to become loose, allowing the cards in the distribution box to become unseated. The screws which secure the rear cover can be tightened only by removing the distribution box from the mount. A pressure-actuated locking screw was designed to secure the cards in the distribution box. Vibration caused the screw to become loosened, thus allowing the cards to become loose. The access plate on the front cover was not large enough to allow free movement when exchanging and repositioning cards in the distribution box.

c. During the evaluation, maintenance was performed on the drum assembly on seven occasions. Four were during the scheduled 36,000-round maintenace, one was during the 72,000-round maintenance, while two were during unscheduled maintenance. On one occasion, during unscheduled maintenance, excessive wear was discovered within the partition assemblies. The wear was caused by excessive dirt and vehicle vibration.

d. Early in the evaluation, there were three instances in which the last round switch failed to function. This malfunction caused major damage to the conveyor mechanism. During the remainder of the evaluation, only one other malfunction of the last round switch occurred. On 8 April 1969, the General Electric Company representative determined that malfunctions of the last round switch were caused by faulty insulation of the trigger switch.

e. During ammunition reloading, expended links fell from the exit unit assembly, accumulating on the floor of the vehicle. The assistant gunner was required to remove the links to avoid a possible malfunction. The links tended to block the exit assembly or become entangled in the linked ammunition during reloading operations.

f. Two faulty servo-amplifiers associated with the traversing mechanism were replaced during the evaluation.

g. In two instances, the sight current generator became loosened from the mount. These malfunctions were caused by a faulty weld between the generator bracket and the mount.

h. Early in the evaluation, it was noted the equilibrator struck the driver's hatch during traverse when the hatch was in the open position. To solve this problem the rubber bumper stop was removed and the hatch latch was built up approximately 3/4 inch by welding.

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This provided additional tension so the hatch cover could be secured closer to the deck.

13. What was the frequency of and time required for scheduled maintenance? This includes the weapon, vehicle, and ancillary equipment.

Scheduled maintenance performed during the evaluation was daily and weekly as well as 12,000-round, 24,000-round, 36,000-round, and 72,000-round stand downs. Daily maintenance did not vary from that of other military equipment. Weekly maintenance was generally performed within one to two hours. The 12,000- and 24,000-round stand downs lasted from 4 to 8 hours. The 36,000- and 72,000-round maintenance required from 1 to 3 days.

14. In maintenance of the ROR, what effect did non-availability of Direct Support/General Support test equipment have?

The non-availability of Direct Support/General Support test equipment had no ill effect upon the maintenance of the ROR because all maintenance on the ROR was performed by the manufacturer representative. In fact, after the representative left at the end of the scheduled evaluation period, ROR problems could not be solved.

15. How long did it take to mount an ROR on a VULCAN? Would it be feasible for a unit commander to dismount the ROR prior to ground-role missions, and remount the ROR upon completion?

No exercise in mounting and dismounting the ROR was conducted. It would appear feasible to dismount the ROR for ground support missions, if only for the purpose of decreasing the signature characteristics of the VULCAN.

16. Were there indications that malfunction experience for VULCAN in the air defense role will differ significantly from malfunction experience in ground role? If so, list the expected higher-frequency failures and higher-mortality parts.

Malfunction experience in the air defense role will differ somewhat from malfunction experience in the ground role because more equipment will be involved when the system is employed in the air defense role. Since the system was not employed in the air defense role, failures and parts usage could not be determined

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SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

a. The VULCAN system can be effectively employed in a ground support role and still retain the capability of providing air defense protection provided adequate warning is received.

b. FM 44-3 does not provide adequate doctrinal guidance for the employment of the VULCAN system in a ground support role in stability operations.

c. The mobility of the VULCAN is superior to the Quad 50 and Duster because of the inherent advantages of its M113A1 vehicular mount.

d. The VULCAN's cyclic rate of high explosive firepower is unsurpassed by any ground combat weapon in RVN.

e. The XM168 cannon is a highly reliable and durable weapon and all shortcomings found in the other system components can be corrected without major retrofit.

f. The limited number of VULCANs committed to the combat evaluation in RVN precluded the establishment of meaningful equipment and resupply requirements for battery or battalion sized VULCAN organizations.

g. The VULCAN crew did not ride inside the VULCAN because of their vulnerability to injuries incurred from mine detonations.

h. A requirement for a supplemental weapon such as an M60 7.62mm machinegun existed during the evaluation.

i. The present on-board load of ammunition is not sufficient to sustain the VULCAN in a normal tactical engagement.

j. The auxiliary power unit did not serve a useful purpose for the VULCAN in the ground role.

k. The radios were not situated to provide ready accessibility for the squad leader.

l. The range-only radar did not serve a useful purpose for the VULCAN in the ground role.

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2. RECOMMENDATIONS

It is recommended that:

a. FM 44-3 be revised to include doctrine useful to the employment of the VULCAN system in a ground support role in stability operations.

b. Shortcomings revealed in the system's orientation equipment, XM157 mount, and XM741 chassis be corrected.

c. Appropriate changes be incorporated into TOE 44-326T and TOE 44-327T regarding section organization and vehicles.

d. When recommended modifications in organization and equipment are accomplished, TOE VULCAN organizations be deployed to RVN in a ground support role.

e. A collapsible seat be mounted on the right and left rear of the deck for VULCAN personnel seating.

f. A weapon, such as the M60 7.62mm machinegun, be provided the VULCAN for supplemental firepower.

g. The on-board basic load of ammunition be increased to 4,000 rounds to enhance the sustainability of the VULCAN in combat operations.

h. The auxiliary power unit be removed from the VULCAN during ground role operations.

i. The radios be relocated on the top right side of the VULCAN when the stowage rack is relocated.

j. The range-only-radar be removed from the VULCAN during ground role operations.

k. The W-3 cable and J-3 connector be color-coded to allow easy identification by mechanics while conducting electrical tests.

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ANNEX A

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ANNEX B

SPARE PARTS USED

Federal Stock Number	Item	Number Used
1005-017-8806	Bolt assembly, breech	19
1005-070-0941	End assembly, chute (return)	1
1005-070-0942	Section assembly, center (return chute)	6
1005-070-0946	Switch assembly, last round	1
1005-266-2664	Cable, W-6	1
1005-563-7165	End assembly, ammunition	1
1005-564-0968	Section assembly, center	8
1005-605-0554	Guide, bar	2
1005-699-9882	Track, removable (rear)	19
1005-699-9885	Cover, bolt assembly	1
1005-699-9922	Track, rotor center	20
1005-699-9923	Track, front	20
1005-754-5266	Pin, cover mounting	1
1005-754-5267	Contact assembly, firing	2
1005-754-5290	Bolt, clamp	1
1005-785-2605	Timing pin, gun	2
1005-785-2609	Cam, locking	2
1005-787-9802	Barrel	12
1005-812-9979	Feeder assembly, declutching	2
1005-813-0168	Gear assembly, feeder	2
1005-824-4475	Bolt, repair kit	7

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1005-824-4478	Case, chute	1
1005-891-4487	Partition, switch assembly	1
1005-891-4490	Partition, assembly	12
1005-891-4491	Partition & switch, assembly	1
1005-895-3279	Screw, amplifer	2
1005-895-3745	Potentiometer, elevation control	1
1005-895-8726	Cannon	1
1005-901-1743	Travel ring (declutching feeder)	6
1005-907-0400	Element assembly, conveyor	391
1005-907-1849	Sprocket, gear	1
1005-908-3824	Drum, inner gun	2
1005-933-1189	Sprocket, front declutching	1
1005-936-5363	Generator, sight current	1
1005-936-5370	Partition, retainer	84
1005-936-5371	Recoil, adapter assembly	6
1005-936-5376	Front pin, assembly	12
1005-997-4924	Chute, assembly	1
1270-052-0273	Computer, radar	1
1285-034-4472	Power Supply, Unit 5	3
1285-034-4735	Power Supply, 2A2	1
1285-074-9639	Receiver, radar	1
1285-269-4963	Cable, breeze	1
1285-996-9829	Antenna, reflector feed	4
2530-679-8001	Shroud, track	2

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2530-715-3864	Gasket	1
2530-715-6155	Cover, plate access	2
2530-930-2011	Shoe, track	16
2920-818-8635	Alternator	1
2920-900-7893	Regulator, voltage	2
5305-832-6042	Screw, self locking	8
5305-833-6842	Screw, on package kit (TM)	74
5305-855-8281	Screw, generator, sight current	1
5305-989-7437	Screw, control panel	1
5306-849-9347	Bolt, machine	12
5306-889-2933	Bolt, machine	6
5306-974-0864	Bolt, special	40
5315-937-9263	Pin, straight, headless	12
5340-826-7000	Pin, recoil release	2
5340-949-3766	Pin, radar cradle	1
6110-933-1194	Distribution box	2
6240-299-6958	Lamp, head, assembly	5

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ANNEX C

MALFUNCTIONS

DATE	SYSTEM NUMBER	MALFUNCTION	PROBLEM CAUSE	ACTION	LEVEL OF MAINTENANCE	DOWN TIME (in hours)
20 Nov	2	Last round switch inoperative	Microswitch stuck in closed position	Replaced last round switch	0	24
20 Nov	5	Last round switch inoperative	Microswitch stuck in closed position	Replaced last round switch	0	5
20 Nov	1	Radar spider arm broke	Vibration	Replaced spider arm	0	1
21 Nov	1	Elevation and depression erratic	Defective potentiometer in control panel	Replaced potentiometer	0/4	12
22 Nov	1	Radar spider arm broke	Vibration	Replaced spider arm	0/4	1
22 Nov	1	Intermittent loss of IF	Defective IF amplifier (possibly water shorted system)	Replaced radar receiver	0	1
23 Nov	all	Equilibrator hitting driver hatch when traversing in full depressed position	Hatch latch would not hold driver hatch cover low enough	Modified hatch latch (built up hatch latch approximately 3/4 inch by welding)	F	2
24 Nov	5	Feeder pins broke and feeder declutching jumped timing	Gun jammed	Replaced feeder mounting pins and timed the feeder	0	
24 Nov	2	Intermittent mid-range calibration	Breeze cable shorted	Replaced Breeze cable	0	2
27 Nov	5	Feeder, declutching pins broke	Crew broke pin while removing the feeder	Replaced feeder, declutching pins	0	
29 Nov	4	Azimuth indicator knob not releasing	Azimuth indicator knob improperly adjusted	Inspected azimuth indicator and adjusting the knob	0	1
30 Nov	2	Could not reload after firing	Screw missing in exit unit and one damaged link	Replaced screws and defective link	0	

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30 Nov	1	Gun jammed	A projectile was loose in casing and came apart in cannon	Removed damaged projectile	0	¼
4 Dec	2	Lock-out cylinder seal leaking	Inner seal defective	Replaced inner seal	F	4
4 Dec	2	Four tabs stretched at bottom of return chute	Bend in chuting too severe; chute flexes when the weapon starts and stops	Under observation		
4Dec	3	Six tabs stretched at bottom of return chute	Same as above	Under observation		
4 Dec	2	Headlight burned out	Rock broke one and vibration damaged other element	Replaced headlights	0	1
9 Dec	1	Radar spider arm broke	Vibration	Replaced spider after welding	F/H	2
12 Dec	3	Turret moved erratically in azimuth	Defective servo-amplifier	Replaced servo-amplifier		1½
13 Dec	3	Turret would not move in azimuth	Defective diode in servo-amplifier	Replaced diode	O/F	1½
13 Dec	5	Gun jammed	Long round found in cannon	Repaired cannon	0	4
14 Dec	1	Radar spider arm broke	Vibration	Welded spider and replaced	F/H	2
14 Dec	3	Weapon hitting mechanical stops	Cam out of adjustment	Adjusted elevation limit switch cam	0	½
14 Dec	3	Gun jammed	Weak recoil adapters allowing declutching actuating pin to contact gun shield	Replaced recoil adapters and repaired cannon and feeder	0	24
15 Dec	4	Vehicle batteries low	Defective battery cells	Replaced vehicle batteries	0	1
15 Dec	2	Night vision scope inoperative	Unknown	Replaced night vision scope	0	½
17 Dec	4	Vehicle batteries low	Defective regulator	Replaced regulator	0	4
17 Dec	3	Feeder assembly, declutching failed to declutch	Feeder assembly, declutching solenoid inoperative	Replaced solenoid mounting nut and tightened	0*	½

* Required tech Rep Assistance

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18 Dec	5	Weapon had a double feed and jammed the gun	A long round and a defective element	Repaired cannon	0	48
19 Dec	1/4	Vehicle batteries low	Weak cells in batteries	Replaced vehicle batteries	0	1
19 Dec	3	Gun shield rear mounting bracket bent	Weak recoil adapters	Repaired gun shield	0	½
21 Dec	5	Declutching actuating pin contacting gun shield	Not enough clearance or weak recoil adapters	Modified gun shield	H*	1
24 Dec	2	Radar would not indicate ready	Defective 2A2 power supply and Unit 5 power supply	Replaced defective components	0	22
24 Dec	4	Charging system inoperative	Defective regulator	Replaced regulator and adjusted to 28.5 volts	0	4
31 Dec	1	One screw missing in control panel and one missing in the sight current generator	Vibration	Replaced screws	0	¼
1 Jan	4	Charging system inoperative	Loose and worn drive belts	Replaced belts and adjusted belt tension	0	2
2 Jan	2	Bolt access cover broke	One pin vibrated loose and recoil action broke one pin and access cover	Replaced pins and cover	0	½
4 Jan	4	Two defective track shoes	Bonding defective	Replaced defective shoes	0	3
4 Jan	3	No azimuth or elevation	Card loose in distribution box	Tightened the loose card	0	3
5 Jan	3	Weapon would not fire in high rate and fired slow in low rate	Loose cable to K-S relay and burned contact points	Replaced distribution box	0	1
7 Jan	3	Weapon fired all ammunition in system and damaged cannon feeder and seven elements	Undetermined. Possible defective last round switch	Replaced cannon, feeder, and seven elements	0	24
10 Jan	4	Gun timing pin worn excessively	Normal wear	Replaced gun timing pin	0	½

* Field expedient fix level undetermined

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13 Jan	3	Weapon did not fire in low rate	Excessive dust and dirt in system	Crew cleaned weapon and drum assembly (gun still sluggish)	O/F	4
14 Jan	3	Weapon did not fire in low rate	Unknown	After firing a few rounds in high rate, it would fire in low rate		
17 Jan	3	Vehicle charging system inoperative	Defective voltage regulator	Replaced regulator and adjusted the voltage	O	9
17 Jan	1	Excessive time to reload weapon	Defective ammunition links (very stiff)	Turned ammunition in	O	
17 Jan	3	Weapon firing slow and sparadic in high rate, and would not fire in low rate	Partitions worn and inner drum (helix) bent, causing binding of ammunition	Deadlined vehicle. Requires new partitions and inner drum assembly	F	
17 Jan	5	Vehicle charging system inoperative	Defective voltage regulator	Replaced the regulator and adjusted the voltage	O	1
17 Jan	2	Terminal burned on gun drive motor	Electrical connection loose causing arcing at the connector	Replaced drive motor and cable W-3	O	14
19 Jan	1	Handle came loose on unit five power supply	Vibration	Replaced the mounting screw and tightened	O	½
19 Jan	1/2	Rivets loose in lower leg of radar spider arm.	Vibration	Replaced the rivets	F	½
20 Jan	5	Vehicle did not charge	Defective generator and loose connection at diode between the two battery systems	Replaced the alternator and tightened the connection	O	2
20 Jan	1	Intermittent communication problem	Loose connection caused by vibration	Tightened connection at slip ring	O	1
20 Jan	2	Chunk torn from right rear roadwheel	Rock in track assembly	Replaced roadwheel	O	1
22 Jan	1	Did not fire in low rate	Unknown. Probably dust and dirt in system	Fired weapon in high rate then it would fire in low rate		

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23 Jan	3	Equilibrator has hole in both inner and outer housing	Fragments from an enemy mortar round	Straightened the equilibrator housings	0	1
23 Jan	3	Two roadwheel covers broken	Fragments from enemy mortar	Replaced covers and gaskets	0	1
24 Jan	4	Weapon firing slow	During the 36,000-round maintenance the partitions were found to be worn excessively and the helix bent	Replaced the helix and rearranged the partitions where they would wear in different places	F	3
24 Jan	2	Left pivot steer inoperative	Hydraulic connection vibrated loose	Tightened connection and filled the hydraulic system	0	1
24 Jan	4	Headlight burned out	Vibration	Replaced the headlight	0	½
25 Jan	2	Radar did not elevate or depress	A limb from a rubber tree hit the radar reflector	Replaced reflector and feed assembly	0	5
28 Jan	1	Radar did not traverse	A limb from a rubber tree hit the radar reflector	Replaced reflector and feed assembly	0	1½
28 Jan	2	Moisture in M120 sight	Defective seal	Replaced the sight	0	½
28 Jan	2	Weld on case chute	Vibration	Replaced the case chute	0	1
29 Jan	5	Left steering lateral not functioning properly	Lock ring slipped from groove on lateral shaft from vibration	Replaced the lock ring	0	2
30 Jan	3	Charging system inoperative	Defective voltage regulator	Replaced the voltage regulator	0	2
31 Jan	4	Intermittent turret operation	Test set indicated system batteries were low. Maintenance team didn't think so	Replaced distribution box	0	2
1 Feb	4	Intermittent turret operation (same as above)	System batteries were in a low state of charge	Filled system batteries and charged the system (2 qts)	C	1
2 Feb	4	Recoil adapter pad release pin faulty	Vibration caused pin to fall apart	Replaced the quick release pin	0	½
3 Feb	3	Defective helix and partitions	Vibration from traveling over rough terrain and binding of the projectile	Replaced partitions and took helix from system #4 and installed in system #3	0	5

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3 Feb	1	Radar spider arm broke	Vibration	Replaced reflector and feed assembly	0	2
3 Feb	3	Support assembly chute mounting broke	Vibration	Had unit repaired at DS Maintenance (welded fasteners on)	F	4
4 Feb	1	Night vision scope inoperative	Vibration	Replaced the night vision scope	0	½
6 Feb	3	No azimuth or elevation	Cards vibrated loose in the distribution box	Reinstalled cards and tightened mounting screws	0	1
7 Feb	2	Tore off shroud on left side of vehicle and ripped shroud on the right side	Sideswiped stump and traveling through brush	Replaced both shrouds	0	4
10 Feb	1	Azimuth indicator not functioning properly	Out of adjustment	Adjusted the asimuth indicator	0	1
11 Feb	2	Chunks of rubber missing on 12 roadwheels	Rocks and high speeds	Replaced 12 roadwheels	0	4
11 Feb	3	M31 sight inoperative (reticle would not center)	Fragments from mortar attack cut the electrical cable	Replaced cable W-6	0*	2
11 Feb	2/4	Headlight inoperative	Vibration and gravel	Replaced lamp, headlight	0	1
11 Feb	3	Headlight inoperative	Vibration	Replaced headlight assembly	0	1
12 Feb	4	Charging system inoperative	Defective alternator	Replaced alternator		2
12 Feb	4	Bending on two track shoes broke loose	Age of track and type of roads traveled	Replaced two track shoes	0	2
12 Feb	1	Antenna spider arm broke	Vibration	Replaced antenna and feed assembly	0	2
15 Feb	2	Pin defective in radar component cradle	Pin was bent	Replaced the quick release pin	0	½
16 Feb	1	Two system batteries defective	Vehicle voltage regulator adjusted to high and overheated the system batteries	Replaced the system batteries		1

* Tech Rep provided assistance

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16 Feb	1	Partitions worn excessively	Traveling over rough terrain with drum full of ammunition	Replaced the partitions	F	1½
17 Feb	4	M120 sight inoperative	Moisture (fogged up) defective seal	Turned scope in for repair	F	½
17 Feb	4	Headlight inoperative	Vibration	Replaced right headlight	0	½
17 Feb	4	Cockpit utility light inoperative	Wire was broken	Repaired defective wire	F*	1
18 Feb	2	Bracket broke on sight current generator	Vibration and poor spot weld	Replaced the sight current generator	0	2
18 Feb	5	Klystron power supply shorted	Unknown	Replaced the Klystron power supply	0	2
18 Feb	3	Recoil adapter pad quick release pin defective	Vibration caused the pin to fall apart	Replaced the quick release pin	0	½
21 Feb	1	Electrical system inoperative	Lead going from APU inlet to distribution box shorted under vehicle sub-floor	Repaired electrical lead	0	9
22 Feb	2	Sight current generator mounting bracket broke	Vibration and a poor spot weld	Repaired bracket by bolting bracket to case	0/F**	3
24 Feb	2	Night vision scope eye piece broke	Flapper valve missing, cause unknown	Replaced the eye piece	0	½
25 Feb	4	Defective left track	Bonding defective on 12 shoes, all on inside of the track	Replaced track and reversed the sprockets	0	4
28 Feb	4	Turret traversed uncontrolled for approximately ¼ turn, had to turn off system power to stop	Low system voltage (two batteries had swollen cells)	Replaced one battery and removed one battery from system #5 and installed in system #4	0	1
1 Mar	all	Voltage regulator adjusted to high for system batteries	Adjusted in accordance with vehicle manual	Adjusted regulator in accordance with GE Bulletin #14	0	1½

* 1 replaces wire
2 repairs wire
** weld requires D/S

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4 Mar	3	Vehicle batteries low	Regulator adjusted to low to keep vehicle batteries fully charged	Ran vehicle engine and tried to charge batteries	operator	
4 Mar	3	Recoil adapter pad quick release pin defective	Vibration caused top to jar loose and was lost	Replaced quick release pin	1	½
9 Mar	1	ROR locked in stow position	Unknown	No trained personnel available to perform maintenance on ROR		
11 Mar	3	Vehicle batteries low, engine did not turn over	Defective battery	Replaced battery	1	1
12 Mar	1	Radar didn't track; when ROR activated, gun slew to right	Radar out of alignment and limit switch not properly adjusted	Boresight radar and adjusted the adjusted the limit switch	operator/1	4
16 Mar	4	Night vision sight inoperative	Unknown	Replaced with operative one	1	1
16 Mar	4	Azimuth indicator light burned out	Normal wear	Replaced with new bulb	1	½
30 Mar	4	Azimuth indicator light burned out	Normal wear	Replaced with new bulb	1	½
30 Mar	3	Gun motor drive inoperative	Motor brushes worn out	Replaced gun motor drive	1	8
1 Apr	2	Nickel-cadmium battery burned out	Unknown (believe low on water)	Replaced battery	1	1
5 Apr	1	Loose screws on back of distribution box	Vibration	Tightened screws	1	1
5 Apr	5	System non-operational	Firing relay inoperative	Maintenance in progress	1/2*	
6 Apr	2	Gun did not clear	Chipped roller guide	Replaced gun from System #5	1	4
9 Apr	3	Leaky roadwheel	Faulty seal, normal wear	Replaced roadwheel seal		1

* change boxes is #1
correct inner errors #2

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Army Concept Team in Vietnam
APO San Francisco 96384

2a. REPORT SECURITY CLASSIFICATION

[redacted]

2b. GROUP

3. REPORT TITLE

XM163 VULCAN Air Defense System

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final Report

5. AUTHOR(S) *(First name, middle initial, last name)*

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6. REPORT DATE

June 1969 **18 JUN 1969**

7a. TOTAL NO. OF PAGES

46

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

None

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

ACTIV Project No. ACG-64F

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES

None

12. SPONSORING MILITARY ACTIVITY

US Army Vietnam
APO San Francisco 96375

13. ABSTRACT

The Army Concept Team in Vietnam evaluated the XM163 VULCAN Air Defense System to determine its effectiveness in a combat role. The 180 day Department of the Army evaluation began on 26 November 1968. Because of the tactical situation the VULCANs were retained in RVN for an additional 45 days. The evaluation terminated on 20 April 1969. The evaluation was oriented toward a ground role, and the air defense role should targets of opportunity appear. There was no enemy air activity during the evaluation.

The VULCAN is a 20mm Gatling type automatic weapon mounted on a modified M113A1 armored personnel carrier. The gun has a low rate of sustained fire of 1,000 rounds per minute and a controlled rate of 3,000 rounds per minute; the ammunition is electrically primed. For air defense purposes, the system is equipped with a range-only-radar.

A platoon of four VULCANs plus one maintenance float was deployed to RVN and assigned to an automatic weapons artillery battalion. The platoon was further attached to automatic weapons artillery batteries in support of ground elements in the III and IV Corps Tactical Zones.

The VULCANs were tactically employed during a five-month period of missions similar to those assigned to the M42 40mm Duster units and the M55 Quad .50 caliber machinegun units. These missions included convoy security, reconnaissance in force, security for mine sweep operations and engineer quarry operations, security for medical civic action programs, show-of-force runs, perimeter defense, and ambush patrols. (continued)

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Security Classification

14

KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
VULCA[redacted]						
AIR DEFENSE						
GROUND SUPPORT						
FIREPOWER						

[redacted]

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DD Form 1473 (Continued)
XM163 VULCAN Air Defense System

Item 13 (continued)

The cyclic rate of high explosive fire unsurpassed by any other ground combat weapon in RVN, and supported units were highly impressed with the additional firepower provided by the VULCAN. The XM168 cannon proved to be a highly reliable and durable weapon. All shortcomings found in other components of the system are surmountable with no major retrofit requirements.

In view of the limited number of VULCANs committed for the combat evaluation, meaningful experience factors regarding total equipment and resupply requirements were not developed. However, several findings were established regarding TOE changes pertaining to personnel and equipment.

The VULCAN system was highly effective in RVN and it is recommended that TOE VULCAN organizations be deployed to RVN for use in a ground role.

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