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SITE MARKER BEACON SYSTEM

Final Report

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By
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Communications and Electronics Branch

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U. S. ARMY LAND WARFARE LABORATORY
Aberdeen Proving Ground, Maryland 21005

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ABSTRACT

This report covers the development and test of a VHF radio beacon system designed for use as a marker of friendly locations from under the dense jungle canopy. In order to minimize the amount of development required, the design factors of the beacon system were made compatible with the ARC-54 aircraft radio equipment and its associated homing equipment.

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1. INTRODUCTION

Range limitations of tactical radio equipment have been considered a very serious problem throughout the jungle warfare campaign conducted in Vietnam. This condition is primarily caused by the high degree of signal attenuation resulting from the jungle foliage. The terrain masking problem also contributes considerably to the loss of radio signals and a degradation in communications. As early as 1963 the USALWL developed and sent to RVN a Captive Balloon-Borne Communication System for the purpose of improving VHF communications. In this case a radio antenna system was elevated to a height of 500 feet above the jungle canopy by means of a 400 cubic foot balloon system. Although the system produced a substantial improvement in communications, the operational and maintenance problems associated with the inflatable portion outweighed the communication improvements, and therefore on this basis, the system was considered unacceptable for operational field use.

As an alternate approach, USALWL developed a F_1-F_2 type radio-relay system composed of standard AN/PRC-25 radio sets operated in the retransmission mode and designed for deployment on top of jungle canopy by means of helicopter. The system was CONUS tested and sent to RVN for test and evaluation. Difficulties in deployment and maintainability appeared to be the major objections. The system did, however, minimize the effects of the terrain masking problem which resulted in an overall improvement in radio communications.

There also has been a continuing effort to improve antenna systems associated with the AN/PRC-25 and AN/PRC-77 tactical radio sets and their companion base station equipment. Only limited results have thus far been achieved from this effort.

2. DEVELOPMENT

Deployment of an electronic package atop the jungle canopy by means of the M79 grenade launcher was conceived by the U. S. Army Land Warfare Laboratory. It was felt that this approach would tend to minimize the attenuation problem and therefore enhance radio communications. A program was initiated to determine the feasibility of the deployment approach and the ability of the electronic package to withstand the high "G" acceleration forces associated with the gun firing. Based upon simplicity, a VHF beacon system was selected as the electronic module. In order to provide a convenient method of testing, the ARC-44 radio set and its homing equipment were selected as the netting receiver system. Due to the phasing out of the ARC-44, the radio set was changed to an ARC-54. As the program progressed and items materialized, considerations were given to use the system as a marking device of friendly locations from under the jungle canopy.

Upon completion of the development and test of a feasibility prototype model performed by USALWL, a contract was awarded to Bendix Radio Corporation, Baltimore, Maryland to develop twelve (12) engineering field test models. Test results obtained on a limited number of these systems conducted in Panama during February 1968 were inconclusive due to faulty aircraft radio equipment. A decision was then made to check out and calibrate the aircraft support radio equipment before continuing future testing. An in-house effort was also started at this time to investigate the battery requirements. It was determined from this study that a much less expensive battery pack was readily available which satisfied the requirements and could be easily implemented into the present configuration with only one design change.

The length of the electronic package increased approximately 0.5 inches over the original design. This restricted its use in all grenade launchers except the M79. Subsequently, a contract was awarded to Miller Research Corporation, Baltimore, Maryland to repackage the eight (8) remaining systems from the Panama test using the new battery pack configuration. Through assistance provided by the 197th Aviation Company located at Fort Benning, the refurbished systems were field tested during July 1969. Details of these tests are covered in Appendix I.

As follow-on action, a second contract was awarded to Miller Research Corporation to fabricate a quantity of sixty (60) operational systems for future evaluation in RVN. Approximately thirty percent of the systems were expended conducting APG tests necessary to correct the technical problems resulting from the development. The first of these problems experienced was set-back forces caused by the gun firings. The next problem encountered was the antenna breakage problem resulting from the antenna wire entangling with the foliage as system deployed and fell through the jungle foliage. Finally, the mechanical switch designed to operate and apply electrical power to the electronic module upon separation failed to function properly approximately 10% of the time.

As each problem appeared the contractor was contacted and every effort was made to make the necessary corrections and follow-up by additional testing. Due to a shortage of systems the testing program conducted at the end of the retrofitting phase was very limited. Following this action a second test was conducted at Fort Benning September 1970. The main objective of this test was to determine the system's operational reliability. The details of test are covered in considerable detail in Appendix II.

3. DESCRIPTION

The Site Marker System is a radio beacon (Figure 1) designed to mark locations from under the dense jungle canopy. Aircraft homing capability is provided through the use of the AN/ARC-54 Radio Set and its associated direction-finding equipment. The system is deployed by an M79 Grenade Launcher. When the Site Marker System is fired from the M79 Grenade Launcher, the ballistically propelled body assembly penetrates the jungle canopy and travels vertically upward. One and one-half seconds after the launch (at an altitude of approximately 300 feet) a delay charge ignites an expelling charge, which ejects the canister and ogive assemblies from the body assembly and simultaneously actuates the mechanical switch which applies electrical power to the radio beacon contained within the canister assembly. As the canister and ogive assemblies descend, the tether line and antenna system tied between them begin to unwind. As the two assemblies fall into the jungle canopy near the operator, the tether line entangles in the foliage. With the ogive and canister assemblies thus suspended in the foliage and the antenna portion of the radio beacon oriented in a vertical plane, an RF signal is radiated. The beacon continues to radiate a usable signal for a period of approximately 0.5 hour.

The Site Marker Beacon is composed of a 40-mm Cartridge Case Assembly (40-mm Standard Cartridge, XM195), a body assembly, a canister assembly, an antenna assembly, and an ogive assembly, Figure 2.

a. 40-mm Cartridge Case Assembly: The primer and the propelling charge are situated in the base of the 40-mm Cartridge Case Assembly. Expanding gases from the propelling charge pass through six holes in the periphery of the propelling charge housing to fire the body assembly from the 40-mm Cartridge Case Assembly. The heat of the propelling charge gases ignites the delay charge from two transfer charges situated in the base of the body assembly.

b. Body Assembly: The body assembly consists of a plastic cylinder with a plastic base bonded in one end. The plastic base contains the delay, transfer, and expelling charges. It is contoured in such a manner to fit within the 40-mm cartridge case. The base of the body assembly is bonded into the cartridge case. The inner surface of the other end of the cylinder is under-cut to receive the ogive, which snaps into place and is sealed by means of RTV. The 1.5 second delay charge permits the body assembly to reach an altitude of approximately 300 feet before igniting the expelling charge. After ignition, the expelling charge ejects the ogive and canister assemblies plus the antenna system from the body assembly and simultaneously turns on the electrical power to the radio beacon.

c. Canister Assembly: The canister assembly telescopes into the body assembly. It consists of an aluminum cylinder (canister) that contains the radio beacon and a self-contained battery pack made up of three Mallory Mercury Cells, Type E-133. It has sufficient capacity to operate the beacon system for approximately .5 hour. The beacon system consists of a VHF radio transmitter and an audio switching unit used to switch the RF carrier on-off at a 50% duty cycle. The transmitter is a single-channel crystal controlled set to operate at 45 MHz with an average power output of 1 watt.

d. Antenna System: The antenna system operates as a quarter-wave antenna at 45 MHz with the canister assembly acting as the ground plane. It consists of a multiple strand .020 diameter wire covered by a protective nylon sleeve. It is physically attached and becomes a part of the tether line.

e. Ogive Assembly: The ogive assembly is composed of a tether line and a plastic ogive that are joined together with an epoxy potting compound. The tether line is braided nylon tape 1/4 inch wide by .013 thick and approximately 2 feet long. The free end of the tether line is knotted to the antenna which is tied to output of transmitter module located inside canister assembly. Also attached to the antenna system is a nylon cord the other end of which is coupled to the mechanical pull switch. As separation occurs, tension is applied to this cord causing the mechanical switch to operate and turn on electrical power to the beacon.

4. PERFORMANCE CHARACTERISTICS:

a. Flight Characteristics:

Ballistic Propulsion	- approximately 300 feet
Delay Period (from firing to separation)	- 1.5 seconds
Launch Angle	- 10° from vertical

b. Electrical Characteristics:

RF Frequency	- 45 MHz
Switching Frequency	- 5 KHz
Power Output	- 1 watt (average)
Operating Time	- 0.5 hr

c. Physical Characteristics:

Weight (total assembly)	- 12 ounces
Length	- 6.25 inches

5. CONCLUSIONS

Although the system tested did not measure up to satisfactory operating standards, it is considered technically feasible to develop a successful one.

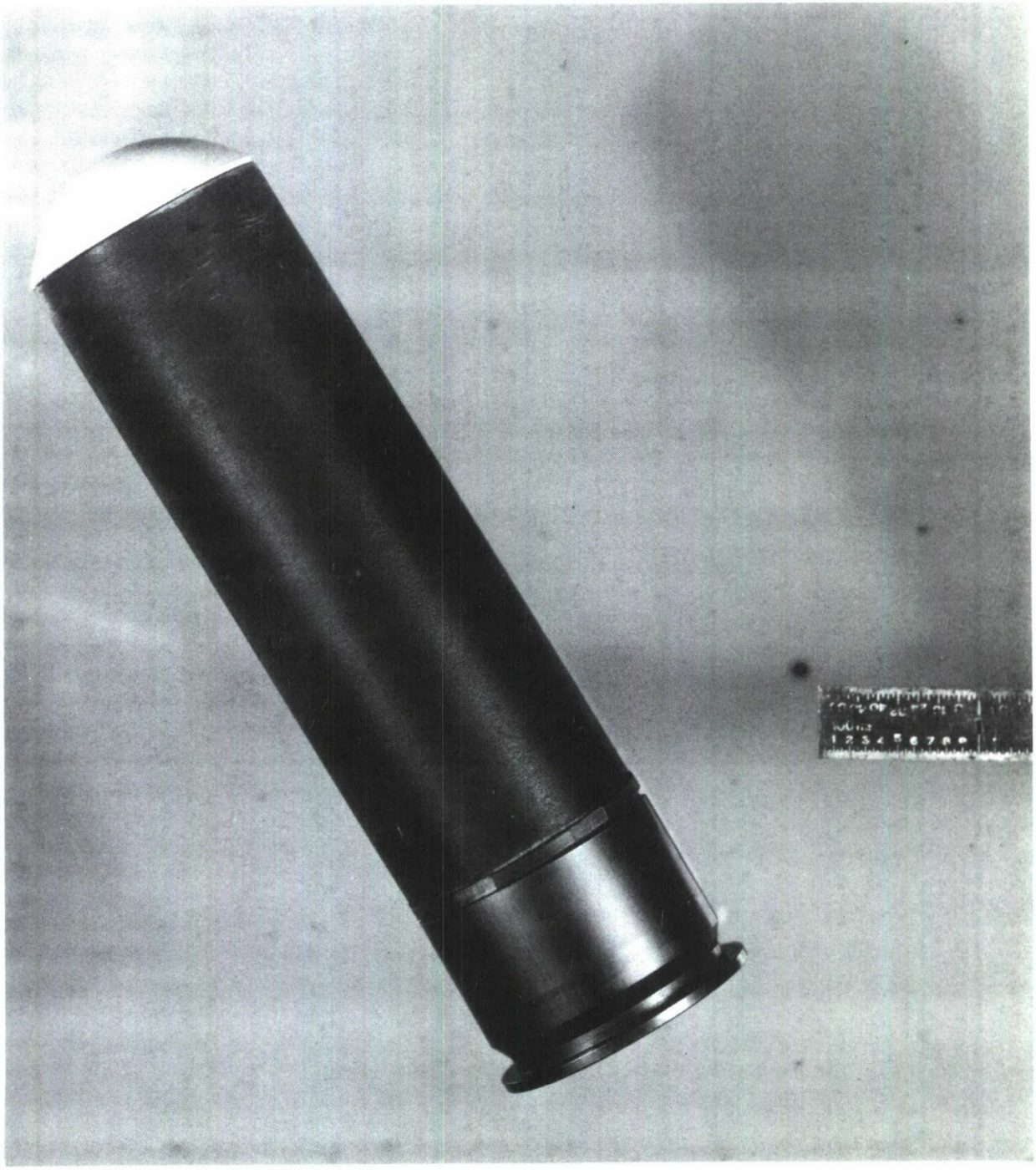

FIGURE 1. 40-mm Site Marker Beacon

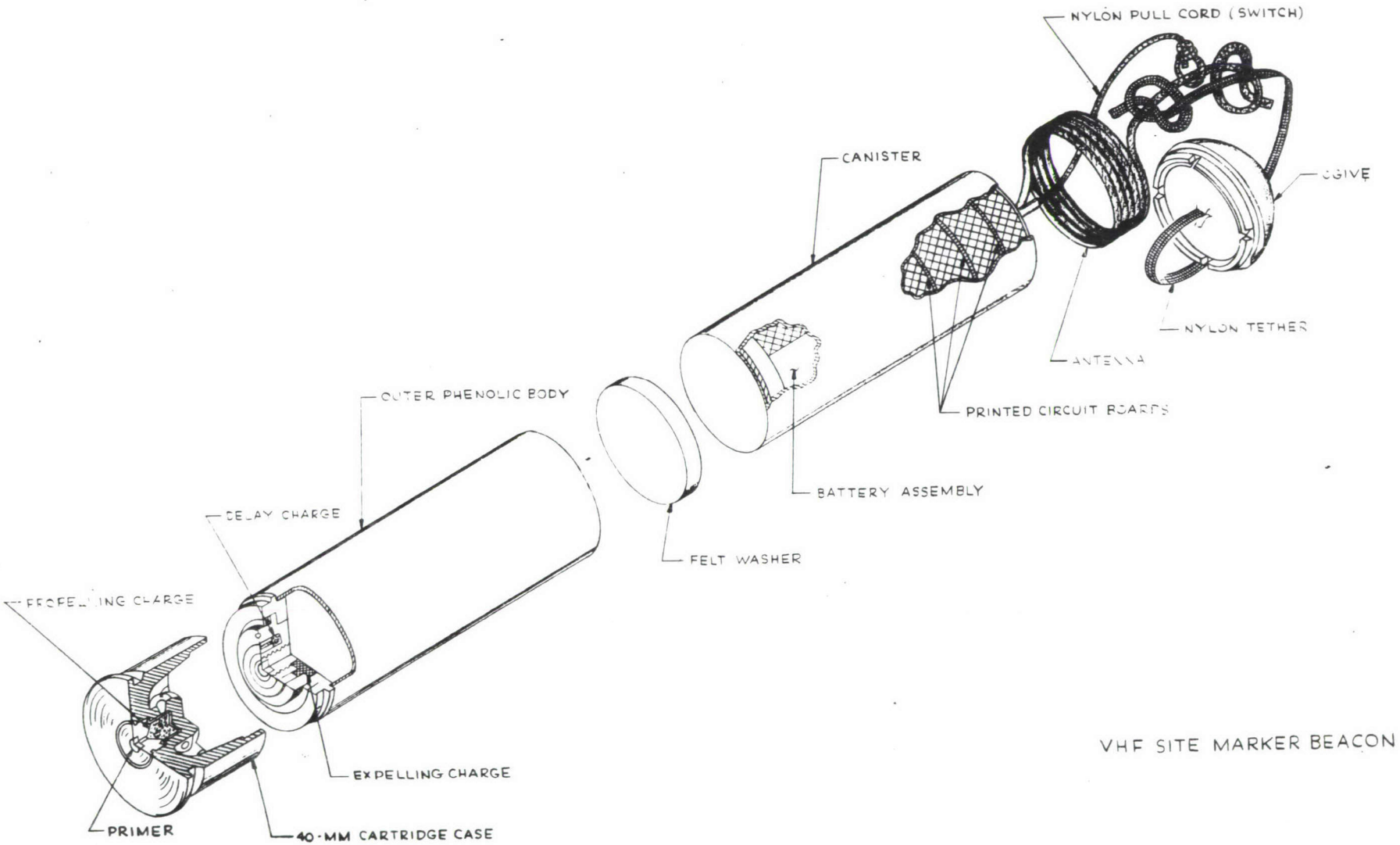

FIGURE 2. 40-mm Site Marker Beacon, Exploded View

APPENDIX I

6 August 1969

TEST REPORT - SITE MARKER BEACON SYSTEM (LWL Task No. 05-E-67)

1. INTRODUCTION: This report covers the operational field tests of the Site Marker Beacon System, conducted at Fort Benning, Georgia, during the period of 29 July thru 1 August 1969. Aviation support was provided by the 197th Aviation Company and the test area was provided by Range Control.

2. OBJECTIVES:

a. To determine effective homing range.

b. To establish accuracy of cross-over.

c. Effectiveness of deployment system.

d. Useful battery life.

e. To determine pilot's reaction to systems operation.

3. METHOD OF TEST: The testing schedule was setup on the basis of having a sufficient time interval of two hours between shots to permit the de-activation of the fired round prior to firing a second round. Two members of the team were assigned to the aircraft, one had the responsibility of coordinating the test with the pilot, while the other maintained the air-to-ground communications. The remaining two members of the team operated from the ground test site. One fired the hand grenade launcher deploying the Site Marker Beacon while the other member of the team acted as an observer to note how well system hung-up in the canopy. AN/PRC-25 Radio Sets were used as ground-to-air communications. The general procedure followed for all rounds was essentially the same. The equipment used for tracking the beacon was the ARC-54 Radio Set equipped with its associated homing device. Upon confirmation of successful launch and turn-on of the Site Marker Beacon the aircraft proceeded on an outbound course at an altitude of 1,500' until the signal was too weak to be useable. At this time the elevation of the aircraft was increased to 2,000' and the test continued until the signal was too weak to be useable. Following this, the action was reversed and the aircraft returned to the site making several passes in various directions to pinpoint the location of the beacon. In all cases, station pass-over was noted by a swing on the vertical needle of the homing indicator. Indications of cross-over was reported to the ground station from the aircraft. Both radio and light signals were used during the night flight to report the cross-over condition.

4. RESULTS:

a. Test No. 1: The round was fired successfully. It was observed to separate satisfactorily, however, it did not turn on.

b. Test No. 2: The round was fired successfully. Hangup was good. Obtained a 20 mile range at an elevation of 1,500'. Station pass-over accuracy approximately 100 meters. Useable signal was still observed to

be present one (1) hour after firing the round.

c. Test No. 3: The purpose of the test was to determine how well the system would perform at night. The round was fired at 2150. It hung-up apparently OK and the batteries seemed to last for about one half hour. Four or five passes from a range of 5 miles were made over the beacon to determine pass-over accuracy. It appeared to be about 100 meters and it was quite consistent.

d. Test No. 4: Round fired successfully, but after 10 minutes of operation it appeared to work erratically, consequently, a second round was then fired.

e. Test No. 5: Ranges obtained are the following: 20 miles at an elevation of 1,500' and 28 miles at an elevation of 2,500'.

f. Test No. 6: Cross-over accuracy noted on this particular round was 100 meters.

g. Test No. 7: System successfully fired into the pine trees. Appeared to hang fairly vertical with the electronic package about 40' off the ground. The homing range was approximately 15 miles. The system works well over a period of about two hours. The station pass-over accuracy still comparable to the previous rounds of 100 meters.

h. Test No. 8: The purpose of this test was to determine what inter action there may be to these beacons closely spaced - within 1/3 to 1/2 mile. The first beacon was fired at approximately 8:15 and a successful homing range of 20 miles was obtained. Cross-over accuracy still comparable to the preceding rounds of 100 meters. The second round was fired approximately two hours later. Station pass-over accuracy deteriorated as a result of the inter action between the two beacons.

5. CONCLUSIONS:

a. All systems deployed successfully.

b. Useful battery life appeared to be approximately one hour.

c. Station pass-over obtained was approximately 100 meters.

d. On the average the homing range of 20 miles was obtained at an altitude of 1,500'.

e. The pilot's comment was that it is a useable system and that he would be able to find the site with this kind of pass-over accuracy.

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f. During the course of the test four (4) different aircraft together with four (4) AN/ARC-54 Radios and installations were used on occasion. No noticeable change in accuracy and/or range was noted in any instance.

6. RECOMMENDATIONS:

a. Forward copy of test report to LO, RVN.

b. Upon the receipt of a valid requirement, recommend that 100 Site Marker Beacon Systems be procured for test and evaluation in RVN.

c. Consider an improved turn-on switch, in view of the fact that the first round fired did not turn-on.

5 Oct 70

TEST REPORT - SITE MARKER BEACON SYSTEM
(LWL TASK NO. 05-E-67)

1. INTRODUCTION: This report covers the operational field tests of the Site Marker Beacon System, conducted at Fort Benning, Georgia, during the period of 28 September thru 5 October 1970. Aviation support was provided by the 197th Aviation Company while the various test areas were provided by Range Control.

2. OBJECTIVES:

a. Effectiveness of the deployment system.

b. To determine effective homing range.

c. To establish accuracy of station cross-over.

d. To determine reliability of overall system performance.

3. METHOD OF TEST:

The testing schedule for the 28 Site Marker Beacon Systems was setup on the basis of having a time interval of two hours between shots to permit the deactivation of the fired round prior to firing a second round. As the testing process got underway, it was immediately apparent that operating beacons continued to emit a useful signal four hours after being fired; consequently, a readjustment in the firing schedule was required. One member of the team was assigned as observer on the aircraft. The other three members of the group maintained and operated the ground test site. The primary test site selected was the same area used to conduct the July 1969 tests. An alternate test site was selected approximately five miles from the prime test site.

Ground-to-air was provided by means of an external AN/PRC-77 Radio Set equipped with the Helicopter Skid Mounted Antenna System. The ground station used a separate AN/PRC-77 Radio Set to monitor the output of the Site Marker Beacon System. The aircraft used the AN/ARC-54 Radio Set and its associated homing equipment to track the beacon system.

Prior to starting the tests, the effective communication range between aircraft and ground station was first established. The aircraft homing equipment was then checked out to insure that the equipment was functioning properly and provided satisfactory operation out to between 15 and 20 nautical miles. Two helicopters were used to conduct the tests. Each time there was a change in aircraft, the homing equipment was checked. There were also periodic checks made on the homing equipment during each day of operation. The general procedure used to test each of the 28 systems was essentially the same. Prior to firing the round the aircraft took up a position approximately 12 nautical miles from the test site at an altitude of 1500 feet. Once the system was fired, confirmation of a signal

was established between the aircraft and the ground test site by means of the ground-to-air communication link. Based upon the receipt of a strong trackable signal the aircraft proceeded on an out-bound course until the signal became too weak for tracking. At this time the aircraft increased its elevation to 2000 feet and proceeded on its way; however, if the signal was marginal at 12 nautical miles, the aircraft proceeded on an in-bound course at an altitude of 2000 feet until the beacon was picked up or the ground station was reached. Upon completion of this test the aircraft proceeded back to the 12 nautical miles waiting zone, established communications with the base station, and prepared for the next round. Station pass-over was noted at least once during each day of testing. A magnetic tape recorder located within the aircraft was used to record the range, altitude, flight pattern, and any other pertinent test information while the ground station recorded such information as missile separation, hang up, and general flight characteristics.

4. RESULTS:

a. Fifteen (15) systems of the 28 fired turned on properly and produced homing ranges between 10 nautical miles and 23 nautical miles at an altitude of 2000 feet depending on the antenna orientation and operating height of beacon above ground.

b. Obtained four (4) nautical miles on three (3) systems which fell through foliage and tracked while on the ground.

c. Approximately 90% of the failures experienced were improper turn-on caused by faulty mechanical power switches.

d. Station pass-over accuracy seemed to be about 100 meters which is comparable to that obtained during tests conducted at APG.

e. Hang-up was not as good as the July 1969 tests but considerably better than at APG. Percentage hang-up on this test was 65%.

f. Complete separation of the electronic package and its plastic canister was obtained on only 57% of the rounds fired.

g. There did not appear to be any correlation between the way in which the system separated and hang-up.

h. In most cases a beacon system which did turn on and hang properly produced a homing range of 10 nautical miles at an altitude of 2000 feet after four hours of operation.

i. The prime site and the alternate site were too close to be useful. Instead of 5 miles apart they should have been more like 10 to 15 miles.

j. A reliable communication range of 20 miles was obtained using the AN/PRC-77 and the Helicopter Skid Mounted Antenna System.

k. Poor workmanship on part of the contractor was mostly responsible for the unreliable performance of the systems experienced during the test.

5. RECOMMENDATIONS:

a. Improve turn-on switch characteristics.

b. Select a new contractor to fabricate a quantity of 100 Site Marker Beacon Systems for a follow-on field evaluation.

c. Conduct additional CONUS testing.

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13. ABSTRACT

This report covers the development and test of a VHF radio beacon system designed for use as a marker of friendly locations from under the dense jungle canopy. In order to minimize the amount of development required, the design factors of the beacon system were made compatible with the ARC-54 aircraft radio equipment and its associated homing equipment.

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