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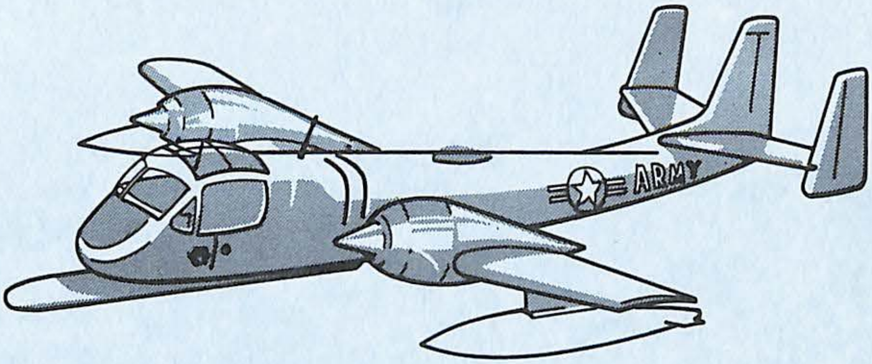
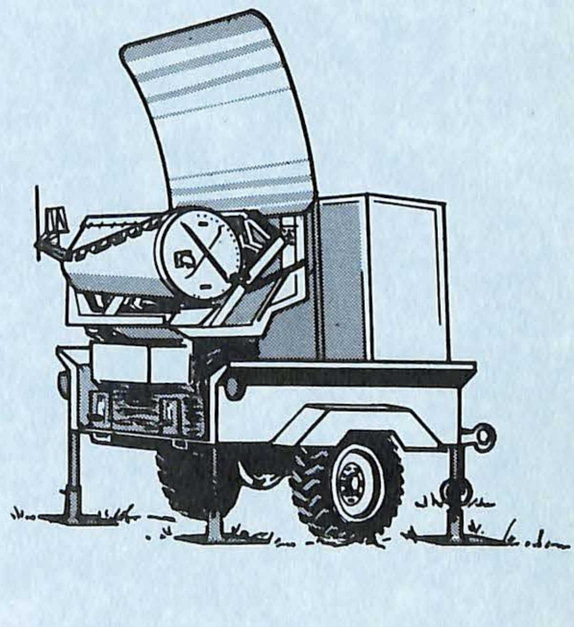


REPORT OF

AD HOC GROUP FOR TARGET ACQUISITION



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DEPARTMENT OF THE ARMY
ARMY SCIENTIFIC ADVISORY PANEL
WASHINGTON, D.C. 20310

27 September 1965

SUBJECT: Ad Hoc Group Final Report

TO: Chief of Research and Development
Assistant Secretary of the Army (R&D)
(In Turn)

1. Transmitted herewith is the final report of the Ad Hoc Group on Target Acquisition.

2. Working with the members of the group and the Military Staff Assistant has been most stimulating and rewarding. All of them have contributed enthusiastically with their time and efforts and share with me a deep interest in any tangible benefits which may result from the recommendations of this report.

Finn J. Larsen

Incl
as

Finn J. Larsen
Chairman
Ad Hoc Group on Target Acquisition

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ASAP AD HOC GROUP

ON

TARGET ACQUISITION

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ARMY SCIENTIFIC ADVISORY PANEL

REPORT OF

AD HOC GROUP FOR TARGET ACQUISITION

1. BACKGROUND (U)

In accordance with a request from the Assistant Secretary of the Army (R&D) and the Chief of Research and Development, the Ad Hoc Group for Target Acquisition of the Army Scientific Advisory Panel was organized to assist the Army in assessing its program for target acquisition.

a. Problem

To assess the Army's capabilities to detect and locate the enemy targets commensurate with the weapons systems within the Field Army.

b. Questions

(1) Is there sufficient effort, both existing and planned for in the future, to provide the Army with the proper target acquisition systems?

(2) What action should be taken in the areas where insufficient target acquisition capability exists?

c. Numerous briefings were held for the Group. A field trip to Fort Sill, Oklahoma was taken. There the Group witnessed demonstrations of the various target acquisition systems presently in the Army inventory. After consideration and discussion within the Group the following conclusions and recommendations are made.

2. SUMMARY (C)

a. The general state of target acquisition has not developed rapidly in recent years. Much information about the disposition of enemy forces is inferred from fragmentary knowledge. While this means of indirect target acquisition is often surprisingly effective, it is not valuable and dependable as direct target acquisition when that is available.

b. Major efforts should be made to improve direct target acquisition capabilities. There should be special emphasis on night-time capability. In addition, some older equipments should be modernized but without an attempt to secure significantly greater capability, since this attempt would lead to undue increases in complexity and cost. This is especially true in the radar field where greater range or greater resolution, in general, are possible only at considerable cost increase.

c. The Group can identify no field of science which would soon dramatically increase target acquisition capability, even though major efforts were to be undertaken. However, significant improvements in some areas can be made on the basis of existing technology. In older equipment such as sound ranging and radar, these are primarily improvements in portability, convenience and effective utilization. In the infrared and night vision field, the possibility of significant operational improvement in clear weather exists.

d. In general, for the available firepower, sufficient capability to acquire targets satisfactorily does not exist and is not likely to be provided by currently planned systems.

e. The U. S. Air Force provides the Army with some target information. Even if transmission time from Air Force sensor to Army user were cut by an order of magnitude, only a fraction of the required Army target information would be provided. The planned systems in various stages of development, however, do offer improvement. Efforts should be applied in each field which can benefit target acquisition. In all future systems, particular emphasis should be placed on design for reliability and maintainability.

3. CONCLUSIONS AND RECOMMENDATIONS (C)

a. General

(1) The regrouping of the surveillance and target acquisition laboratory efforts is an important step in concentrating research and development in the critical Army problem area of accurately locating targets.

(2) It is recommended that the laboratory maintain an effective, close continuing working relationship with the Combat Developments Command.

(3) It should be recognized that target acquisition and firepower are parts of a single system. This concept must lead to a continuing exchange of information between the developers of the components of the system. It is the opinion of the Group that the working relationship has been inadequate in the past.

(4) The U. S. Army should develop and maintain independent target acquisition capabilities over as much of the division area of influence as is technically feasible and practical.

(5) Corps and Army commanders should, in addition, have that target acquisition capability for their weapons which proves economically and technically feasible, when compared with U. S. Air Force target acquisition systems.

(6) The U. S. Army should continue to utilize all available target acquisition and reconnaissance information, including that available from the Air Force.

(7) Standardization of equipment used by all three military departments is desirable in areas such as photo interpretation equipment, film format, and equipment to directly utilize in-flight reconnaissance information.

(8) Rapid transmission and processing of data, and elimination of unnecessary echelons of evaluation, are prerequisites to reduction of time delays in the target acquisition to target engagement cycle. Concurrent target detection and location means should be arranged in the same equipment, whenever practical. However, due regard must be given to minimizing bandwidth to that required for data acquisition rates and to utilize increased bandwidth only for frequency diversion and resilience to jamming.

(9) Recommendations and conclusions which are not readily abbreviated or which are better understood in the context of a technical discussion appear in the body of the report and are, in many cases, omitted from this section.

b. Infrared and Visual

(1) Night vision and detection systems are extremely important and will become even more significant in the future. Army plans which are taking present systems into production and developing more advanced capability should be energetically pursued.

(2) There is a need for night vision and/or infrared anti-intrusion and surveillance devices that can provide azimuth and range to targets.

(3) Considerable emphasis should be placed on research and exploratory development efforts to achieve passive detection capabilities.

Although near-infrared and other active-type devices have applications, the greater potential is in passive-type equipment, such as either far-infrared devices or image-intensifier equipment. Emphasis should be placed on rapid exploitation of these passive devices.

(4) Tactical target detection is severely limited during darkness and inclement weather. Infrared is not and will not become an all weather system. All weather (radar) detection of tactical targets is limited at present primarily to those targets that move.

(5) For acquisition of targets by forward observers, engineering effort should result in lighter weight laser range finders which can be used with good optical equipment for detecting targets.

(6) Introduction of infrared flash detection equipment should substantially increase the operational potential of artillery flash ranging in counter-battery target acquisition applications. In order to maintain simplicity, it is recommended that the 2-dimensional capability be emphasized.

(7) The time displacement and rapid data rate capabilities being integrated into the infrared flash detector AN/GAS(7) require commensurate rapid data transmission and processing techniques.

c. Radar

(1) The U. S. Army target acquisition radars should be redesigned to achieve lighter weight, more reliable, and more readily maintainable equipment. A radar which is more than ten (10) years old is potentially obsolete and the continued use thereof should be carefully examined.

(2) It is believed that a key factor in developing optimum data link bandwidths is an examination of the Army's tactical utilization rate of the data supplied by the sensors. Transmitting moving target imagery only, when it exists, and the delay of fine structure in fixed target data are interesting possibilities that should be considered for bandwidth reduction.

(3) Miniaturization of radar should be accompanied by modularization to improve maintainability.

(4) A man-portable target acquisition surveillance device may be useful in the manuevering battalion. This device should have the range, azimuth and resolution capability of the AN/PPS-6 radar with the capability of detecting stationary as well as moving targets.

If possible, and this is not likely soon, it should have a high degree of invulnerability to detection by countermeasures.

(5) The Artillery Locator, AN/MPQ-32, which is being tested at present should be carefully evaluated on the basis of both cost/effectiveness and the disadvantages of the system with conservative allowance being made for improvements which could be realized in a production model. The tests should include field operations. If a study of signature characteristics reveals the feasibility -- appropriate emphasis should be applied to research and development to detecting counterbattery targets directly before they become active. At present this ability seems to be possible only through indirect target acquisition.

d. Sound Ranging

(1) One or more sets of the Canadian Automatic Sound Ranging System should be obtained soon and tested by the U. S. Army to determine which features of the Canadian equipment are desirable as compared to the U. S. Army GR-8 Sound Ranging System.

(2) It seems likely that features such as data links instead of wire, or automatic processing instead of manual processing, which exist in the Canadian equipment will be found to be advantageous.

(3) Principles already developed by the U. S. Navy in anti-submarine warfare should be reviewed by the U. S. Army for possible application in sound ranging for artillery location.

DETAILED REPORT

4. ASSUMPTIONS (C)

There are certain general assumptions consistent with current trends and probable future events which are necessary for a logical consideration of the target acquisition problem. The most significant of these are indicated below:

a. For the foreseeable future, the Sino-Soviet Bloc will constitute the primary and most sophisticated threat to U. S. forces. This threat includes the possibility of a general war involving indiscriminate use of tactical and strategic nuclear weapons.

b. U. S. forces can become committed at any time to a limited war anywhere along the periphery of the Sino-Soviet land mass. Such limited committal could involve confrontation with regular or irregular forces, partisans, guerrillas, paramilitary forces, or a combination thereof.

c. U. S. Army target acquisition effort will have to develop targets for engagement under all conditions of combat ranging from guerrilla action to general nuclear war.

d. U. S. Army target acquisition operations should be capable of developing targets for all available fire support means. This includes cannon, rocket, and missile artillery, close air support and naval gunfire.

5. DEFINITIONS (C)

a. Target Acquisition. That part of combat intelligence which involves the timely detection, identification, and accurate three-dimensional location of a target in sufficient detail to permit effective attack by weapons.

b. Direct target acquisition. Target acquisition obtained by one intelligence collection means. For example, countermortar radar, forward observer, or photograph.

c. Indirect target acquisition. Target acquisition which is developed from evaluation of intelligence information supplied by two or more means. For example, a comparison of interrogation reports (POW) with reports of vehicular traffic (aerial radar) and reports of radio activity (COMINT).

d. Combat surveillance. Continuous (all weather, day and night) systematic observation of the battle area to provide timely information for tactical operations. The information collected (friendly as well as enemy) is obtained by both technical and non-technical means.

6. ESSENTIAL CONSIDERATIONS (C)

There are certain essential tactical and environmental considerations which are fundamental to the target acquisition problem:

a. Target acquisition is a component of the weapons system. At each major tactical echelon within the field Army, requirements for fire support are satisfied by a weapon or family of weapons with operational characteristics designed to provide the ground commander with appropriate means with which to influence the land battle. Target acquisition is a vital component of each of the weapons system so employed. In order to permit exploitation of the design capabilities of the delivery systems at each echelon, the target acquisition component of the weapons system would ideally be able to accomplish the following to the extent technically feasible:

(1) Acquire targets by the detection, identification and location in three-dimensions of enemy elements.

(2) Acquire targets throughout the spectrum of range capabilities of the delivery system.

(3) Acquire targets throughout the sector of coverage of the delivery system.

(4) Acquire multiple, concurrent targets at a range commensurate with the target engagement capabilities of the delivery system.

(5) Acquire targets within accuracy tolerances which will permit attainment of the design accuracy of the delivery system.

(6) Acquire targets throughout the spectrum of environmental conditions in which the delivery system is required to be operational.

(7) Presentation of acquired target information in a timely manner and usable form.

b. Direct visual observation, within range and visibility limitations, is an important means of target acquisition. An observer with a minimum of training can report targets within seconds and bring fire to bear thereon. Assuming his location was in error, he can readily adjust succeeding fire more accurately on the target. The human observer, however, has severe limitations on the battlefield; he is limited to line of sight capability, his vision degraded by smoke, fog, haze, and his capability becomes severely degraded during hours of darkness. Finally, the unaided eye is limited in range to approximately 5 KM and with optical assistance, has a capability of no more than 10 KM for the detail observation needed.

c. Visual limitations dictate the need for extensive electronic and mechanical devices. MTI radars, infrared, photography, and other techniques are used to permit vision day and night, all weather, and through smoke and haze. In addition, drones, aircraft and other sensor carriers are necessary to extend the range of these viewing devices to the range of the weapons system supported.

d. Certain enemy targets have other characteristics which may be sensed for acquisition purposes. Mortars, guns, howitzers, rockets, and missiles create effects during firing sufficient to provide a potential for acquisition. Projectile trajectories and missile paths may be located by radar and extrapolated back to the point of origin. Sonic shock waves can be detected by sound bases; muzzle flashes may be located by visual or infrared detectors; subterranean shock waves may be sensed by seismic instruments.

e. The vastly increased firepower available to commanders on the future battlefield dictate greatly increased emphasis on dispersion. Tactical concepts on the part of the enemy will rely on massing of forces only long enough to achieve a given mission followed by immediate, speedy dispersal. In addition, we can expect enemy headquarters, reserves, firing units, and other targets to move at much greater frequency than in the past. In this light, target acquisition systems should have the additional attribute of speedy reaction to insure that fire may be brought to bear on the target before or during movement. Since potential enemy delivery systems can generally fire and then evacuate a position in a matter of minutes, our acquisition systems should be capable of location prior to firing, as previously stated, or of immediate location and transmission to firing units after the enemy's firing.

f. Whatever the type of sensor device or technique used, a large per cent of targets will be developed from fragmentary indications.

Normally, no one sensor or technique provides a picture adequate to fully locate and identify all elements of the target, so that a combination of sensors or techniques will be required. In addition, the enemy's natural inclination to avoid detection will mean that a number of acquisition techniques will be necessary, or a number of runs made against a specific area, in order to bring out the existence of a target in that area.

g. The need to detect targets with accuracy over long ranges has created a trend towards highly sophisticated, complex, electronic devices positioned in forward areas and operating in difficult terrain. Urgently needed is a reversal of this trend to give the ground commander rugged, dependable, simple to operate, lightweight equipment with which he can accomplish his target acquisition responsibility.

7. FIELD ARTILLERY GROUND OBSERVATION (C)

a. Artillery observation serves four basic functions: target acquisition, adjustment of fires when necessary, surveillance of fire for effect, and battlefield surveillance. This paper is primarily concerned with the target acquisition of artillery observation. The target acquisition function is concerned with detecting suitable targets, determining their ground location and reporting target data to the Fire Direction Center.

b. Once the artillery ground observer had detected and identified the target, he must locate it by the most accurate means available in order to permit effective engagement. Effective engagement is expressed in terms of target neutralization or destruction in minimum possible time with minimum possible ammunition expenditure. Present techniques dictate that the ground observer employ one of four techniques for determining target location. These are:

(1) Grid coordinates

(2) Reference to a map

(3) Reference to point of known location

(4) Polar coordinates

c. Both the Laser rangefinder and the night observation device are expected to be available during the 1965-1970 time frame. Employment of these instruments in conjunction with artillery ground observation operations can be expected to have the following effects:

(1) When the observer has continuous and accurate position and azimuth orientation, the Laser should provide the capability for accurate initial fire requests.

(2) The night observation device should permit target location of approximately 30% of the daylight capability.

(3) During night operations, the Laser rangefinder and the night observation device currently under development will have to be employed independently. This is undesirable since it does not afford use of the Laser to locate targets within the capability of the night vision device to detect them.

d. Possible adaptations of technology to ground observation requirements are as follows:

(1) Target detection.

(a) Target detection in clear daylight, unobstructed terrain. Target detection during periods of clear daylight where the limits of the field of vision are unobstructed by intermittent screening terrain should be accomplished by means of observer vision aided by a conventional optical device such as the binocular or spotting telescope.

(b) Target detection in clear daylight, obstructed terrain target detection in clear daylight in areas where the observer's field of vision is obstructed by terrain screens can be accomplished by providing the observer with a capability to see over the terrain obstacle while remaining on the ground, or by elevating the observer to a point in the air which would permit him to see over the terrain obstacle. An extended vision device which could be mounted on a vehicle and which could be extended to suitable heights appears feasible. Controlled from within the vehicle, such a device would permit observations of targets obscured by relatively close terrain or other obstacles.

(c) Target detection in adverse weather. Target detection in adverse weather would be facilitated by the employment of a device designed to penetrate adverse atmospheric conditions (rain, fog, haze, etc.).

(d) Target detection during darkness. During hours of darkness, target detection could be accomplished by an image intensification device or by infrared devices.

(e) Detection of concealed and deceptive targets. Detection of concealed targets and/or deceptive or "spoof" targets in daylight or in darkenss would be enhanced by the use of an infrared detection device. An infrared device would provide additional capability for distinguishing between camouflage materials and background terrain. In addition the variation in radiation between actual and deceptive or decoy targets should provide the observer with a capability to identify deceptive targets.

(2) Target location. The provision of an accurate target location capability for artillery ground observation in the post-1970 time frame can probably be best achieved by providing the forward observer and battalion observation post with position and azimuth orientation equipment and additional means for rapidly relating the location of detected targets to observer location position and azimuth data.

(a) Forward observer. Foreseeable state-of-the-art will probably not support development of integrated position and azimuth orientation for the forward observer could involve installation of position determining equipment in the observer's primary vehicle and use of a small, man-portable gyroscopic device for accurate directional orientation. Accurate determination of target location could then be accomplished by using a Laser type device to determine the distance required for accurate polar coordinate data.

(b) Observation post. Observation post requirements for position and azimuth orientation will be similar to those of the forward observer except that position orientation could be satisfied by means other then vehicular mounted position determining equipment. The more static nature of observation post operations should permit use of forward positioning equipments of the long range survey system for position determination. The Laser could also be used at the battalion observation post for target location functions.

(3) Integrated target detection/target location devices. In order to assure that target location can be performed during all periods when target detection is possible, there should be means for practical and efficient integration of both the target detection and target location functions.

(a) The forward observer. Provision of an integrated target acquisition capability for the forward observer can probably best be facilitated by a limited combination of capabilities in one piece of equipment (this might be called the master) and a capability for rapid interchange of other special purpose modules. The master item might be a single piece of equipment with basic optics for a magnified target image, a laser for ranging distance to the target, and a small gyroscopic azimuth-orientor to indicate direction to the target. In the design of the unit, consideration should be given to possible integration of IR and photo-multiplier type devices for target detection under a variety of special circumstances.

(b) The observation post. Integrated target detection/location capability for the observation post could be provided b[illegible] the same general means as that described above for the for[illegible] Here again, some trade-offs in size and [illegible] in favor of increased range capabilities.

8. THE LONG RANGE SURVEY SYSTEM DISCUSSION (C)

a. The long range survey system (LRSS) provides the artillery with two important functions, survey and target acquisition. In the survey role within the corps and in the target acquisition role, it provides a means of accurately fixing targets 275 KM beyond the airborne station.

b. Present capabilities and characteristics are as follows:

(1) The system consists of a master station, an airborne relay, three base (slave) stations and up to 512 forward positioning equipments.

(2) The system locates the positioning equipments by measuring the distances and angles from an airborne relay station to a positioning equipment. The master and base stations measure angles and ranges to the airborne station and the computer located at the master station solves the geometric problem for tri-dimensional coordinates. Up to 50 forward positioning equipments can be located during each sequence of interrogation. The master station employs a coding device to eliminate the confusion, interference and redundancy of all stations operating simultaneously.

(3) The present system is expected to determine the X-Y coordinates of a positioning equipment with an error of 5 meters at 15 KM, 7 meters at 50 KM, and 40 meters of 275 KM. Altitude error is 10 meters at 15 KM, 30 meters at 50 KM, and is widely degraded beyond this range.

c. The present forward positioning equipment breaks down into three man-pack loads weighing 60 pounds. Employment of micro-miniaturization, light weight metals and solid stated electronic circuitry should reduce this weight substantially, reducing the limitations for employment of the forward positioning equipment in enemy held territory.

9. VISUAL AIRBORNE TARGET LOCATOR SYSTEM (VATLS) DISCUSSION (C)

a. The visual airborne target locator system provides an aerial observer with the means to employ predicted fire techniques in the attack of ground targets. The observer must first detect the target by visual means before the airborne optics and related electrical computers can be utilized. Once the target is centered in the telescope, the system automatically computes the tri-dimensional coordinates of the target.

b. Present capabilities and characteristics are as follows:

(1) Range. The present system has slant range capability of 10-15 kilometers from the airborne station. Adverse weather and periods of low light intensity will greatly reduce the range capability of the system.

(2) Each target must be located by the observer from two different locations. Initially, the observer detects, locates, and marks the target location, the aircraft then moves to a new location where the process is repeated. The apex angle between the two aircraft positions must be greater than 30° at the vertex. When altitude of the target areas are known, only one sighting is required.

(3) Capacity. The present system can determine the tri-dimensional coordinates of three targets at a time.

(4) Accuracy. Accuracies of 25 meters CEP have been achieved during systems tests. Experience and operator training can reduce this to 10 meters CEP, more then adequate for the supporting weapons system.

c. Incorporation of a laser rangefinder with the airborne optics will eliminate the need for two sightings on a target. This capability is considered feasible in the present time frame and could increase the efficiency of the present system. Adaptation of a turret type telescope will allow the observer to increase the magnification, extending his visual capability as well as reducing the identification problem. Incorporation of a stablizing device, which will permit the observer to lock on the target while the aircraft is maneuvering, is also being considered.

10. ARTILLERY SOUND RANGING (C)

a. Field artillery sound ranging is a standard technique used for the location of the source of a sound by measurement of the relative times of arrival of a sonic wave front at several accurately located points on the ground. The sounds located are those made when a weapon fires or when a projectile explodes.

b. Present capabilities and characteristics are as follows:

(1) Current sound ranging equipment consists of three essential elements - sound observation posts, a sound base (microphone sensors), and a plotting central.

(a) The sound observation posts are normally located approximately 1000 meters in front of the sound base. The mission of this post is to listen for the sound of hostile weapons firing and, when this firing is detected, to start the recording process of the sound base.

(b) The sound base is made up from four to six microphones on a front of 3000 to 7000 meters.

(c) The sound central contains the device for recording sounds picked up by the microphones, plotting and correction devices, and operating personnel. The assigned personnel read or interpret the recordings, apply weather and plotting corrections, and determines the location of the sound source.

(2) The sound ranging set GR-8 is the one presently used by field artillery sound ranging platoons. This set electrically records time indications of the sounds detected by the microphones on special teledeltos paper. After the tape, on which is recorded indications of the sounds detected by the microphones, is removed from the recording equipment, the arrival times at each microphone are read with a tape reading tool. Time arrivals are determined, current weather and plotting correction are made and the final corrected time intervals are plotted as rays. From the intersection of these rays the location of the sound source is determined.

(3) The GR-8 is capable of detecting sounds at ranges up to 20 KM from the location of the base in an area bounded by perpendiculars extending from the flanks of the base. Sound ranging accuracies are variable with current meteorological conditions and are associated with CEP's of from 50 to 150 meters.

c. Status of research and development effort in sound ranging is as follows:

(1) Canadian Automatic Sound Ranging System.

(a) The concept of the recorder/computer was originated by the Canadian National Research Council and a breadboard model was constructed and exposed to field trials during the period 1962-1963. Canadian Treasury Board approval for a contract for three prototype models of a production recorder/computer was given on 24 Sep 1964. The contract was awarded to Computing Devices of Canada LTD and the company started work on 8 Oct 1964.

(b) The Canadian system concept contains a prescribed number of microphone sensors, a data link, magnetic tape recorders for storage and buffering of received signals, a search and asymptote display for dissemination, relation and analysis, a computer for automatic data processing, and appropriate equipment for hard copy solution read-out. The system is being designed for use at ranges up to 40 KM from the base which will be expandable to 20 KM. Accuracies are expected to be in the order of .1 of 1% range.

11. ARTILLERY FLASH RANGING (C)

a. Flash ranging is the procedure employed to locate enemy counterbattery targets by observation of gun flash and intersection from two or more instrumented observation posts. During World War II and the Korean Conflict flash ranging accounted for approximately 11% of all counterbattery targets acquired.

b. Present system and characteristics are as follows:

(1) The long base flash ranging technique consists of locating a target by graphic intersection. Since targets are located graphically, a minimum of three rays forming an apex angle of intersection of at least 500 mils is required to provide an accurately defined target. A flash long base should be composed of a minimum of three observation post (OP's); however, four are preferred. The base will normally occupy a front of approximately 6000 meters, and provide coverage over a front of approximately 10,000 meters.

(2) Short base flash ranging consists of two OP's and a command post. The base length (the distance between the two OP's of the short base) must be determined by survey. Since the distance between OP's is relatively short, graphic intersection as a means of target location is not satisfactory. In short base flash ranging, the technique of computed intersection is used and targets are polar plotted on a plotting chart.

(3) Current flash ranging equipment is as follows:

(a) Telescope, Battery Command M65 (BC Scope). The BC scope is the instrument presently used at the flash ranging observation post for detecting and measuring the azimuth to hostile gun flash. The instrument is a binocular periscope with 7½ power magnification, a mil-graduated base and an internal mil-graduated reticle.

(b) Plotting board. The flash ranging plotting board consists of a rotating table with a 1:25,000 meter grid engraved on its top surface, a drafting machine with a graduated straightedge, and the necessary supporting base and legs.

(c) Flash Ranging Set AN/GTC-1. The flash ranging set AN/GTC-1 includes all components (except cable and batteries) required to operate the flash ranging system.

(d) Periscope Battery Commander M43. The M43 periscope is an optical (10-20 power) binocular periscopic instrument.

The M43 periscope was service tested and type classified in 1961, but has not been produced in quantities for issue because of the large stock of the obsolescent M65 periscopes in the inventory.

c. Present flash ranging research and development programs are as follows:

(1) Infrared Flash Detector AN/GAS ( ). A flash detector presently under development by the U. S. Army Combat Surveillance and Target Acquisition Laboratory. The infrared flash detector is a low resolution, ambient cooled device designed to utilize infrared techniques for the detection of hostile artillery gun flash.

(a) The field of view of the AN/GAS ( ) will be 400 mils in the horizontal and 60 mils in the vertical. The horizontal field of view will resolve to within 1 mil angular resolution. At present the vertical field of view provides no resolution. Vertical resolution employing the same technical concept upon which horizontal resolution is based would involve the addition of a greater number of photocells than can be sustained by present requirements which limit the weight and configuration of the device to within man-portable standards. A contract has recently been awarded to study the feasibility of employing optical/mechanical means for vertical angle measurement.

(b) The flash detector will be capable of time separation of events displaced 0.002 seconds in time. This provides a much higher rate than is obtainable with present optical equipment. The sychronization of the flash detectors at each observation post will be accomplished by a pulse transmitted over field wire from the flash central.

(c) The stated range requirement for the flash detector is 18,000 meters. In tests of the engineering design model ranges of 21,000 meters have been achieved against 155-mm howitzer firing charge 7.

(d) Time, azimuth and vertical angle will be spark printed on teledeltos paper discharged from a paper feed mechanism in the flash detector.

(e) A lightweight (8 lbs) 12 volt battery with a 15 hour capability is programmed. A 12 volt vehicular battery may be used as a supplementary power source.

(f) The stated weight requirement for the flash detector indicates a 50 lbs limit with no component package more than 25 lbs.

(g) The infrared flash detector is designed to supplement visual flash ranging equipment already in use by the flash platoons of the corps field artillery target acquisition battalion. No change in techniques employed in the solution of the geometry of the flash ranging problem will be associated with the use of this device.

12. RADAR (C)

a. As every technology reaches a state of maturity, the slope of the improvements curve, plotted as a function of time, approaches zero, and from that date on, elaborate and costly research and development programs may be expected to produce minimal improvements in the systems performance. Conventional radar has reached this anticipated point of minimum returns for new development, and the concentration of effort should now look toward the introduction of refinements and the maturing of engineering design to improve reliability, maintainability, and the size, weight and power consumption requirements. The fabrication and configuration changes which can be achieved through the use of solid state devices and integrated circuits can simplify operational procedures, as well as the problems of field maintenance and logistics. Because the new materials and fabrication techniques provide a step-function difference in the physical embodiment of the equipment, the systems now in use are obsolescent.

b. Aside from the obvious need to modernize the physical structure of radar equipment, there is the second obvious need, for those systems where the communications problem is pertinent, to speed up the processing of the information and the delivery of the usable information to the point of utilization by the weapons system.

c. As the complexity of electronic equipment has increased, the problem of field maintenance has become increasingly difficult to solve, and it is now quite impossible to hold men on the job long enough to train them to the needed level of intuitive response to equipment failure patterns. The employment of lifetime career men for the maintenance of complex equipment is impracticable in an Army organization. The only solution to the field maintenance problem lies in the use of equipment design based upon modular construction, with build-in maintenance design which will permit any intelligent man, with a book and a suitable supply of simple meters, to locate and replace defective modules. So long as vacuum tubes are used, modular construction aimed at simplified maintenance cannot be effective both because vacuum tubes are normally of fairly limited life, and because the modules would be too large to carry in the field maintenance spare parts stock. Solid state modules utilizing transistors can be made small in size and light in weight, especially with integrated circuits, which are almost ideal from a modular point of view, and by their use the logistics problem can be greatly simplified. The need for designing equipment utilizing the module plan for field maintenance cannot be over-emphasized. The replacement of the large amount of obsolescent radar equipment in the field can be justified by the improved reliability and maintainability which can be realized, and the reduction of size, weight and power consumption can be accepted as fringe benefits deriving from the change to the new technology.

d. Because of the expectation that fighting may occur frequently under rapidly changing fluid conditions, the desirability of providing identification means for radar equipment should be explored. Also, in view of the need for rapid transportation, it is assumed that all systems will be designed for air transportation.

e. Bascially radar is a line-of-sight sensor. Since it uses relatively long wavelengths and detects reflections from targets in a volume, it is superior to normal vision and infrared in all-weather capability but it is inferior in resolution. In a representative case, a radar might detect a single composite signal from all targets in a range element of $\pm$ 150 feet and azimuth and elevation elements from 0.5 to a few degrees depending on the size of the antenna. Such accuracies are quite unsuitable for artillery fire. Angle and range refinements to the order of .01 to .001 degrees are available for isolated targets such as ships and aircraft, prominent fixed targets and moving targets amongst a complex of fixed targets.

f. The one microwave area that may currently be under-developed is the referenced 30-300 KMC which has recenlty been responsive to laser techniques and is thus shared by IR without the control of polarization and electronic amplification inherent in radar. The shorter wavelengths permit higher resolutions that come at a cost in time for area scan routines until area focusing on arrays of multi-detector techniques are perfected. Such "windows" as the one at 32-40 KMC also have an attractive all-weather passive capability with its inherent loss of direct time ranging. Certainly the Army should foster research and experimental developments both radar-wise and infrared-wise in this area.

g. To emphasize that radar is limited to line-of-sight is simply to say that adequate target acquisition always requires a line of sight or its equivalent if counterfire is to be effective. Thus, in general, adequate target acquisition for any targets but those immediately beyond the FEBA entails getting appropriate sensors into a position for a line of sight on those targets. To be effective against mobile targets this subsequently entails communications in another portion of the limited electromagnetic spectrum. Every means must be employed to keep this to as small a portion of the spectrum as possible. Unfortunately, some of the projected air-ground relays embrace an exorbitant amount of the spectrum, which has the immediate consequence of excluding the simultaneous use of such sensors.

h. The current and projected complement of the Army's radars for target acquisition consists of the TPS-25 ground surveillance radar, MPQ-4 countermortar radar, SLAR Side-Looking Airborne Radar, side looking radar as one option of the MQM-58A drone system, MPQ-32 counterbattery radar, and possibly the TPS-33 and PPS-5 antipersonnel radars.

i. An unfortunate penchant for elaboration is displayed in the extension of the archaic TPS-21 to the TPS-33 with a proliferation of controls and adjustments that can only lead to increased probability for malfunction. Antipersonnel radars can be of inestimable value to the infantryman against patrols and surprise insurgency especially associated with guerrilla warfare. Such a radar must be extremely simple, small, reliable, and essentially expendable. Certainly the PPS-6 developed at Fort Monmouth seems to have most of these qualifications, at least as far as the Marines are concerned. It seems to this Group that the Army has been tardy in exploiting this device.

j. The ground surveillance TPS-25 currently is only used as early warning against moving targets; and it was finalized in the early 1950's. Incorporating a split range gate and azimuth and elevation monopulse in an updated version would reduce the range error to $\pm$ 25 ft and the angles to the 1 or 2 mils that have been achieved for an airborne intruder. These would be quite sufficient for prompt non-visual target acquisition at a cost of a new antenna and 20 lbs or less of data processing. Automatic tracking is a further extension that should be reviewed realistically to determine whether it is worth the extra complexity.

k. The MPQ-4 counter-mortar radar is essentially the first and best of the Army's target acquisition radars. The large FOSTER scanner is essentially the only practical means to cover the area sufficiently rapidly to get two precision fixes on a single missile. It is doubtful that a phased array can do any better for the same size and weight. On the other hand, the transmitter, signal and data processing should be modernized to achieve a reliable light weight unit.

l. The airborne SLAR is also 10 years old. Currently it is defective for prompt target acquisition due to the uncertainty of the position of the plane and the time for processing the photos. The ground picture, taken simultaneously with the MTI, can locate the plane and targets if adequate significant terrain features are in the field of view. The photo processing-relay link is both time-consuming and utilizes excessive bandwidth. The latter is especially so when due consideration is given to actual rate of acquisition of significant data bits.

m. The MQM-58 drone system is a valid attempt to increase the line-of-sight range with sufficient accuracy for an all-weather prompt target acquisition against tactical targets as well as surveillance. Until a better system to increase line-of-sight target acquisition is developed, and proven, basic elements of the MQM-58 system should be completely developed. Careful attention should be given to eliminating all unnecessary sensors and to simplifying the system.

n. The radar, DPD-2, seems excessively expensive, and the relay requires excessive bandwidth. The latter remark should especially be leveled against the KS-64 in-flight film processing and vidicon relay. The actual data rate is very low for six inch or one foot resolution, even with a 300 knot plane. It would seem prudent to acquire and relay directly this information on a vidicon a line at a time and reconstitute it as a strip photo on the ground. This is actually as fast as the data is acquired. Certainly successive frame pictures could also be taken and stored for subsequent development for more detailed scrutiny when the drone returns, if it does.

o. The MPQ-32 counter-battery radar has been under development seven years and advertises a 1972 availability date. An envisaged capability of locating batteries by shell tracking after the manner of the MPQ-4 engendered this equipment. However, the first implementation seems certain this year. There is a question that it will be a prototype for any procurement. Since the MPQ-32 has come this far, it is most urgent to test it thoroughly; not so much to see how it meets specificiations as to ascertain wherein it might be adequate operationally and wherein it and the specifications were definitely inadequate. Only as a consequence of such tests can the Army and Industry determine its over-and-under-design and whether or not technology has a counter-battery capability based on shell fire. Certainly the problem of locating defiladed batteries will persist but any acceptance of the MPQ-32 must be on an operationally acceptable basis.

p. It seems appropriate to revive other means wherein radar effects direct all-weather harassment of the enemy's ground forces. Reference is made to the Navy's A6A Intruder that penetrates across the FEBA, preferably at low altitude and high speed, to locate and optionally lock-on enemy moving targets. This permits prompt, direct, accurate attack on these vehicles and the avenues of support without passing over them. This complements the Army's concern with the enemy's tactical and battlefield movement and supply. It should materially inhibit the enemy's mobility and thus put a premium on friendly airborne photo and IR reconnaissance as significant target acquisition.

13. ARMY RELIANCE ON AIR FORCE TARGET ACQUISITION (C)

a. For its long range weapons such as SARGEANT or PERSHING, the Army has no effective means of direct target acquisition, being almost wholly dependent on either Air Force reconnaissance or map information for the location of fixed targets. While "stay behind" troops can be provided equipment to mark such targets, the technique is certainly not one of high reliability.

b. For these large nuclear weapons, map information or Air Force reconnaissance information will often be adequate. If the potential target is a slowly mobile one, such as a large troop concentration, the improvements in transferring photographic information from the Air Force to the Army which are either contemplated or underway will probably result in significant improvement in the ability to fire on such targets. The present transfer time, which often permits eight hours or more to elapse from the time the Air Force detects a target until an Army battery capable of firing on the target has the information, is far too great.

c. For several reasons, the Army must improve its own capability to detect targets for tube artillery and for missiles when they are used against targets at shorter ranges. The primary mission of the tactical Air Force in a theatre is to destroy enemy air power. Air Force reconnaissance is therefore directed against Air Force targets as a first priority: Army targets are priority 2B to the Air Force. While priorities can officially be changed, organizational loyalties remain.

d. A recent war game, Measuring Stick, was run as a JCS study of ability to locate targets during a hypothetical NATO war in Central Europe. While the Air Force overflew significant numbers of targets, no battalions were recognized as battalions, only 6% of division command posts were identified, and only 10% of trains and depots were recognized. Of 186 SAM sites, 8% of more than 100 enemy sites were identified. Air Force reconnaissance was quite ineffective against targets vitally important to the Army.

e. It is often assumed that target distribution is relatively uniform behind the FEBA. This is not the case; a high density of enemy targets lies in the first ten miles behind the FEBA, with a second high density zone centered about 20 miles behind the FEBA. The third high density zone extends approximately from 60 to 90 miles behind the FEBA. Targets throughout the first two high density zones currently can be detected by SLAR and drone flights, and Army capability to recognize its own targets in this area can be expected to improve.

f. The Army should utilize target information furnished by the Air Force, and to make this as easy as possible, identical or completely compatible photo-interpretation, photo-processing and similar equipment should be used whenever possible in all three military departments. Since target acquisition and firing on the located target are operations which are part of a single systematic process, the system will function more effectively under a single organization. At times when targets go undetected, when aircraft cannot fly, or in order to bring fire on rapidly moving targets, or on targets such as squads or individual enemy vehicles, it is essential that the Army develop a target acquisition capability more nearly comparable with its firepower.

14. TARGET ACQUISITION IN THE IR-OPTICAL REGION (C)

a. There are 3 modes of operation of IR devices for possible target acquisition use. These are passive detection of reflected radiation from natural sources, passive detection of thermally radiating objects, and active detection of illuminated targets. There are many advantages of using infrared sensors in the target acquisition role. On the logarithmic scale, the infrared-optical region represents a large part of the electromagnetic spectrum within reach of detection, far larger, for instance, than the span of frequencies use for radar. Detection systems operating in this region utilize a very large variety of physical effects, methods of functioning, and modes of information acquisition many of which are completely passive or otherwise relatively invulnerable to ECM. Under favorable conditions, the rate of information (bits per second and dynamic range) obtainable via IR-optical instruments can exceed, by any standards of assessment, the capabilities of all other conceivable means of target acquisition, and this is coupled with a high potential for target identification. The demands of weight, volume, and cost of these systems is small compared, for example, with those of radar. The greatest disadvantage of infrared is the fact that the visibility of these devices is reduced by fog and haze and rain. It is also a line of sight device.

b. The outlook for the ultimate capabilities of starlight viewers is favorable. As these devices are based on a photoemissive detection process, their performance in the future may well approach the theoretical limit given by the photon noises of the incident radiation. Then even the lowest night sky illumination would suffice to yield better than TV resolution with full motion portrayal capability. This information is read out by line-scan and can thus be transmitted via data link to a distant receiving station. However, the contrast (which even in clear weather may be as low as 1%-20% as a result of differential reflectivities in the scene) may become too low in medium or even slight haze for distances of .05 - 5 km. Thus the need for IR target acquisition will continue even if the night viewing systems have reached their theoretically feasible limit.

c. Passive infrared, or thermal, imaging methods reproduce observed scenes by virtue of their emitted thermal radiation, or more exactly, by virtue of differences (1) either in temperature of (2) in surface emissivity and reflectivity that the various parts of a scene exhibit. The sensing of a temperature pattern endows thermal imaging with a unique dimension: all activity, particularly that of tactical targets of interest, is accompanied by the dissipation of heat and therefore recognizable by a temperature elevation, if the detecting mechanism is sufficiently sensitive.

d. The thermal imaging approach to target acquisition is judged to be the the most effective and versatile means of reconnaissance, if and when it has reached its full, theoretically limited performance. Ideally, thermal imaging systems can do at night what TV can do by day, in addition to 2 other advantages, viz, far greater range in haze (and light and fog), and recognition of tactically interesting targets by their heat dissipation. However, these advantages are matched by commensurate difficulties, and the devices have gone in their development only part of the way towards their ultimate usefulness. To a large part this is due to the lack of IR-optical lens systems which should be available in the future.

e. Instead of forming a thermal image on a target or retina and subsequently viewing it or scanning it by electric beam for a line read-out, it is possible to dissect an infrared viewing field with a single element detector. By rotating prisms and mirrors it is possible to project various parts of a scene point by point onto a small detector whose signal is then submitted to a data link or is directly reconstructed on a corresponding display device.

f. For targets more than 5 km behind the FEBA, IR-Optical acquisition equipment must be airborne. The criterion of 5 km is used here as an order of magnitude value only, since weather conditions, size and nature of the target, and the background and terrain around it may increase or decrease the range by a sizable factor.

g. The present imaging performance of IR (and also photo-multiplier) in-flight scanning shows detail that may well approach that of daytime photography. However, this is accomplished under conditions of speed and altitude which may be unsuitable under actual combat conditions. Airborne reconnaissance vehicles may be forced into relatively high or relatively low altitudes, high speeds, or evasive flight patterns, each of which may require a drastic revision of present target acquisition equipment.

h. The following are the systems now in operation of development:

(1) Airborne IR Mapping Systems which operate by scanning the field directly under the plane by means of a rotating mirror. More specifically, the mirror throws an image, element by element, of a line scanned over the ground, onto the infrared detector, while the forward motion of the plane provides the progression of the line scan in the vertical direction. Since the system is mechanical, the information rate typically is limited to 10,000 to 100,000 elements per second. For example, a three-sided mirror at 6,000 rpm will produce 300 lines per second, and if each line contains 300 discernable elements, 90,000 pictures elements per second are recorded.

(2) Forward Looking IR views the ground ahead of the plane under an angle of about 20 degrees from the horizontal. Under these conditions the plane motion will provide a sufficient vertical progression of the line scan only at high speeds. At lower speeds, a rectangular scan pattern has to be provided. Because of this situation, this mode of operation is considerably behind the mapping discussed in the previous paragraph, even though it may be advantageous in many respects. Sensitivity and cooling considerations apply as before.

(3) Air-to-ground thermal imaging would provide TV acquisition rates or better: i.e., about 500 lines or more per frame at 30 frames per second. This corresponds to the order of 10^7 elements per second compared to 10^5 for mechanical scanning. However, the difficulties enumerated for ground operation thermal imaging apply to an even higher degree to airborne operation. Distant field viewing has not yet been demonstrated with TV type thermal imaging. Furthermore, some type of vehicle motion compensation is necessary, at least for fast planes or drones (but is not required for LALO type equipment). The fairly advanced state of the art in airborne night viewing permits the anticipation of night-time TV pickup from airborne systems. Image motion compensation will be necessary for most conditions of side-or-down looking. For hovering vehicles, such as LALO, such provisions are unnecessary.

i. The present system of laser scanning consists of projecting a laser beam to the ground via a rotating mirror. A photomultiplier observes the reflected radiation from the instantaneously illuminated element of the scene and in proportion to the received signal, modulates the intensity of a light beam. The latter may be deflected in sychronism with the laser beam by using the same mirror so that it reproduces the original scene on a moving film. Alternatively, a line read-out is possible with some sychronizing signal which can be transmitted to some remote station.

k. The signal received by the photomultiplier includes stray light from all angles. Furthermore, the present system uses a CH gas laser with only 100 kw output power. These facts are responsible for the relatively small range of 1500 feet.

l. At present, further development work on air-to-ground laser scanning is underway. The main objective of these current efforts are the syncronization of a viewing scan with the laser scan so that the viewing angle substantially accepts only that part of the scene that is instantaneously illuminated; and the acquisition of three-dimensional information by viewing the scene from two aspect angles. For this purpose, the laser is pulsed (250 kc/sec, pulse length 20 x 10^{-9} sec, 100 kw inst. power). Furthermore, "gating" of the photodetector can be combined with nanosecond pulsing. This means that if an electronic shutter keeps a detector inactive except for a time occuring $t=2$ L/c after the emission of the pulse, only light (velocity: c) from the target at distance L will be accepted, although intervening haze and dust backscatters the reflection in random fashion.

m. The expected result of the new laser scanning development will be greater range (5 km), operation at high aircraft speeds, and three-dimensional information.

n. In the area of target acquisition equipment, cooling means are necessary in the following category:

(1) Infrared detectors and thermal imaging tubes. For best performance, cooling to at least 77°K, but preferably as low as 30-4.2°K, is absolutely essential.

(2) Lasers. Although present equipment with moderate performance does not need special cooling means, they may be required for highly efficient, high power lasers which will be in use in the future. Certain solid state lasers need only water cooling; others (such as diode lasers) require 77°K and below.

(3) Optical methods and systems, as a result advances, can now be pushed into the millimeter region where the atmosphere is again transmitting and where weather conditions may be less important. Therefore, a reevaluation of the military target acquisition potential in that region appears indicated.

PRESENTATION TO ARMY SCIENTIFIC ADVISORY PANEL

The Ad Hoc Group on Target Acquisition chaired by Dr. Larsen completed its study and published its report on 27 September 1965.

The problem this group addressed was an assessment of the Army's capabilities to detect and locate enemy targets, commensurate with the weapons systems within the Field Army.

Briefly the conclusions and recommendations of the Group were that:

1. The CS&TA Laboratory maintain an effective, close continuing working relationship with the Combat Developments Command.

2. A continuing exchange of information between developers of target acquisition equipment and firepower equipment must be maintained, since together these equipments constitute a single system.

3. The U. S. Army should develop and maintain independent target acquisition capabilities over the division area of influence.

4. Corps and Army commanders should have a target acquisition capability which is economical and technically feasible when compared with Air Force target acquisition systems; and should continue to utilize all available target acquisition information from Army and Air Force elements.

5. Standardization of equipment in all services in areas such as photo interpretation film format, and in flight recordin g and viewing, is desirable.

6. Rapid transmission of processing of data, and unnecessary echelons of evaluation will reduce time delays should be paramount.

7. Concurrent target detection and location should be arranged in the same equipment where practicable.

8. Night vision devices, laser range finders and infrared flash detection equipment should substantially increase the operational potential in counter battery target acquisition.

9. U. S. Army target acquisition radars should be redesigned to achieve lighter weight, more reliability and more maintainability.

10. Sound ranging should include data links instead of wire, and automatic processing instead of manual processing.

On 10 December 1965, the Report of the Ad Hoc Group was forwarded to USAMC and USACDC for comment.

These comments have been received.

USAMC agreed with the conclusions and recommendations insofar as technical and materiel aspects are concerned and are preparing a Program Change Proposal which will include recommendations for work in the field of target acquisition materiel taking into account your recommendations.

USACDC commented that the report does not address all the collection means available to the Army (to wit: Army Security Agency systems, and reconnaissance units which are organic to battalions and division echelons which normally support the Corps.)

The USACDC study called "Tactical Reconnaissance and Surveillance" (TARS-75) will examine the total battlefield surveillance program. Your report will be provided to the TARS-75 Study Group for analysis of its impact on, and contribution to, the over-all surveillance program.

Since military characteristics for infrared flash detectors are some 16 years old, CDC has been preparing a QMR for flash ranging to bring the stated requirement up to date.

CDC especially concurred with your recommendation to study signature characteristics of artillery shells and missiles prior to further development of a counter battery radar, and your emphasis on research and development to detect counter battery targets before they become active.

To keep you up to date on the status of some of your recommendations:

1. Army activity in the field of night vision being energetically pursued. Production of first generation equipment. (Individual Weapon Sight, Crew Served Weapon Sight, and Mid-Range Night Observation Device) is being expedited for test and use in Vietnam. The first shipment arrived in Vietnam about 1 January 1966. Work is continuing on second generation equipment.

2. Effort has been initiated on a new laser range finder (second generation) with better accuracy, reliability and maintainability, weighing no more than 17 pounds including power supply. This is about half the weight of the first generation equipment.

3. The ground surveillance radar AN/PPS-5 has been type classified "Limited Production" and 125 will be purchased primarily for Vietnam use.

4. CDC is presently working on early submission of a QMR for a man-portable ground surveillance radar (Hand Held Radar).

5. AMC has been directed to purchase one Canadian-UK Automatic Sound Ranging System for test in the U.S. This test will take place in mid-1967.

6. With regard to drones the Army is presently reviewing the requirement for drones. This review is being done as part of the TARS-75 Study. In the interim period AMC is gathering a technical Data Base.

7. The AN/MPQ-32 Counter Battery Radar has arrived at Ft Sill and approximately 60 firings have been observed to date, and test data gathered. Tests will be performed against 81 mm mortars, and 105, 155, 175mm and 8 inch guns at various ranges, quadrant elevations, and aspect angles to determine the characteristics

(radar cross-section and signature) of targets (shells). Limited testing against HONEST JOHN's will also be conducted.

8. The U.S. is meeting with the UK in May 1966 to discuss collaborative efforts for a new counter battery radar with less ambitious requirements than presently existing in the U.S. approved QMR. CDC has been requested to prepare a new QMR and relegate the old QMR to the status of a QMDO, an objective need but not sufficiently feasible to be called a requirement.

9. Insofar as counter mortar radar is concerned we have let three competitive contracts on a design plan study for a lightweight (500# or less) airmobile and airborne counter mortar radar; and we are considering the development of a 360° counter mortar radar for use in RVN at airfields and other areas which require perimeter defenses against mortar attack.

10. Improvement of the MOHAWK as the interim STAAS has been approved. In this connection the resolution of the APS-94 SLAR is being improved to 120 ft at 50 kilometers, improved engines will be installed on all versions of the MOHAWK, a doppler navigation capability will be installed and film data annotation will be provided.

In conclusion, I propose to:

a. Brief you on the PCP to be prepared by AMC prior to its submission , and

b. Forward copies of your report to the TARS-75 study group for analysis and incorporation into the TARS study.