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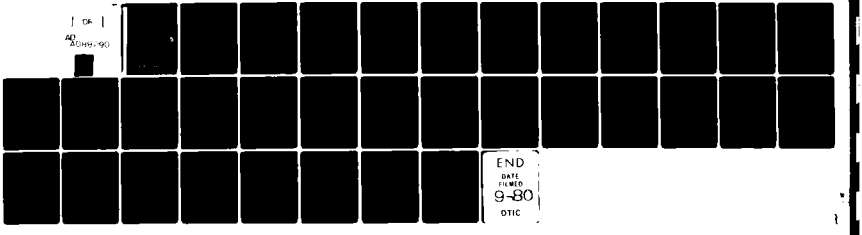

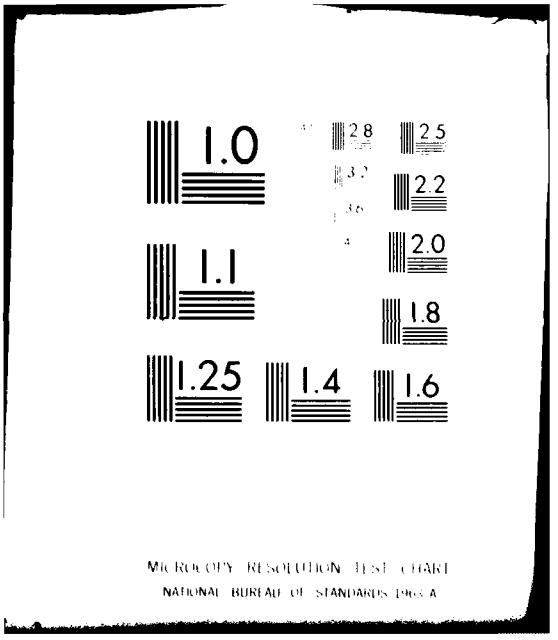
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# RECORD OF SECOND MEETING OF EXPERT WORKING GROUP ON MINEFIELD DETECTION TECHNOLOGY

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RESEARCH INSTITUTE OF MICHIGAN
FORMERLY WILLOW RUN LABORATORIES, THE UNIVERSITY OF MICHIGAN
BOX 8618 • ANN ARBOR • MICHIGAN 48107

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16. Abstract

The second meeting of the Expert Working Group on Minefield Detection Technology was held at MERADCOM, Ft. Belvoir, Virginia on 27-28 February 1979. Presentations were made by MERADCOM, the Environmental Research Institute of Michigan and Braddock, Dunn, and McDonald to the Expert Working Group on the current status and future plans for the project. At the end of the presentations, an Executive session of the Expert Working Group was held. Major conclusions and recommendations of the meeting included the following. The study is to exclude consideration of sensors emplaced in advance of hostilities and scatterable mines. The potential of multispectral scanners, passive IR sensors, wet chemistry photography, SIGINT, and mine neutralization was discussed. Recommendations were made for further review by MERADCOM and by individual members of the EWG of the overall coordination of the program, details of the analytical methodology being developed by BDM, and data on the RF-4C photographic system for use as a technical example in operational analysis.

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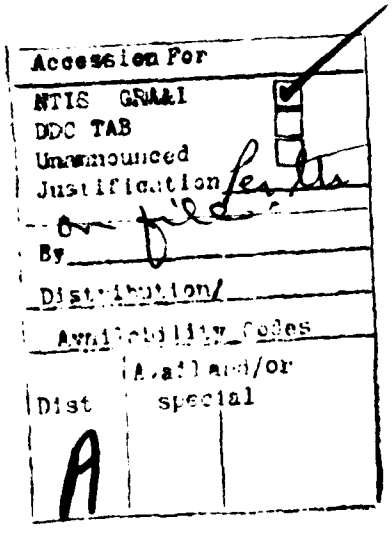

# RECORD OF SECOND MEETING OF EXPERT WORKING GROUP ON MINEFIELD DETECTION TECHNOLOGY

## 1
## INTRODUCTION

The second meeting of the Expert Working Group on Minefield Detection Technology was held at MERADCOM, Ft. Belvoir, Virginia on 27-28 February 1979. Individuals attending the meeting are listed in Table 1. Presentations were made by MERADCOM, ERIM, and BDM to the Expert Working Group, to ERIM, BDM, and MERADCOM professional staff, and to outside observers. Section 2 is a paraphrased record of comments made by individuals in response to the information presented in the briefings. The comments are organized by subject, and where available, the name of the individual is included. Asterisks indicate a change of topic. The comments do not necessarily represent a consensus of the EWG or other attendees. Section 3 presents the conclusions and recommendations of the EWG reached in executive session at the end of the meeting. In Section 4, the proceedings of the meeting are summarized in the form of a series of recommendations, action items, and unresolved issues.

This document has been reviewed for accuracy by MERADCOM and members of the Expert Working Group.

TABLE 1

ATTENDEES OF THE SECOND MEETING OF THE

EXPERT WORKING GROUP ON REMOTE MINEFIELD DETECTION

27-28 February 1979

| NAME | | PHONE |
|---|---|---|
| EXPERT WORKING GROUP | | |
| LTG James F. Hollingsworth, Chairman | | 817-268-1464 |
| Mr. Charles N. Johnson, Jr. | | 703-527-2313 |
| Dr. Seth Bonder | (Vector Research) | 313-973-9210 |
| Prof. William Wolfe | (Univ. of Arizona) | 602-626-3034 |
| Prof. Robert K. Vincent | (Geospectra) | 313-994-3450 |
| Prof. Charles E. Olson, Jr. | (Univ. of Michigan) | 313-764-1413 |
| Prof. Robert O. Harger | (Univ. of Maryland) | 301-454-4171 |
| Dr. Robert C. Heimiller | (ERIM) | 313-994-1200 |
| Mr. Francis B. Paca | (MERADCOM) | 703-664-3330 |
| MERADCOM | | |
| Mr. Richard R. Rogowski | | 703-664-3137 |
| Mr. Peter J. McConnell | | 703-664-5035 |
| Mr. H. J. Peters | | 703-664-5336 |
| Mr. Jerry Dean | | 703-664-4458 |
| CPT John Appel | | 703-664-5484 |
| Mr. Robert A. Falls | | 703-664-4992 |
| Dr. Karl Steinbach | | 703-664-4970 |
| Mr. Robert L. Brooke | | 703-664-5373 |
| Dr. Roland Gonano | | 703-664-4992 |

| NAME | | PHONE |
|---|---|---|
| BRADDOCK, DUNN AND MCDONALD | | |
| Mr. Charles Somers | | 703-821-5048 |
| Mr. William Baum | | 703-821-5046 |
| ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN | | |
| Mr. Yuji Morita | | 313-994-1200 |
| Mr. Irvin J. Sattinger | | 313-994-1200 X361 |
| Dr. Dwight Bornemeier | | 313-994-1200 X453 |
| Dr. Elmer Johansen | | 313-994-1200 X237 |
| Mr. Henry McKenney | | 313-994-1200 X392 |
| Mr. Manuel Lopez | (Washington Office) | 703-528-5250 |
| Mr. H. C. Hatch | (Washington Office) | 703-528-5250 |
| OTHER ATTENDEES | | |
| BG Henry J. Hatch | DCD/USAES | 703-664-3122 |
| LTC Edward Marshall | DCD/USAES | 703-664-3122 |
| CPT T. J. Krupp | DCD/USAES | 703-664-3122 |
| Mr. William Clements | NPIC | 703-351-3308 |

## 2
## INDIVIDUAL COMMENTS

### Coordinated Plan

In response to the recommendation at the first meeting of the EWG, information was presented by MERADCOM, ERIM, and BDM speakers giving a broad outline of the coordinated program of the three organizations, as well as tasks and schedules for each organization's part of the total program.

Mr. McConnell began the meeting with a briefing on the overall program and the functional relationships between the efforts of MERADCOM, BDM, and ERIM. This included a listing of major milestones in the program during FY79, and a schedule of the efforts of the three organizations in conducting their parts of the program. The general interrelation of tasks being conducted by ERIM and BDM was described in terms of task descriptions and schedules, and was elaborated during the later discussion of the technical work being performed on minefield detection technology and on analytical methodology development.

### ERIM Program Objectives and Tasks

McKenney then gave a presentation covering the management objectives of ERIM's technical program, the individual technical program tasks, a description of task inputs and outputs, a schedule of current and planned activity on each task, along with a report of the current status of individual tasks.

### Program Management

McConnell and Brooke pointed out that because of the complexity of interrelation of the individual program tasks, a comprehensive presentation of the task interactions is difficult to present.

However, the required interactions are being accomplished by the individual organizations with coordination of the effort by MERADCOM.

*Bonder questioned whether the material presented on the overall plan was sufficient for the Expert Working Group to evaluate its adequacy with respect to technical content, scheduling, available effort, etc. He emphasized that the Expert Working Group cannot be held responsible for the adequacy of the minefield detection program, if a comprehensive integrated plan is not presented to it for review and comment.

*Brooke: Decisions have been made on how MERADCOM will actively manage and coordinate the efforts of ERIM and BDM in the minefield detection program. MERADCOM is integrating the effort of the two contractors and acting as the interface between the two efforts, assuring that adequate communication of technical results is fed in both directions. The MERADCOM decision has led to the adoption of a method of coordination which avoids formal coupling between the two contractors. Instead, MERADCOM is acting as the interface.

Bonder: Under this mode of management, is MERADCOM acting as an unnecessary filter between the two contractors?

Brooke: This mode of coordination of the two organizations does not preclude direct communication between ERIM and BDM. MERADCOM is closely following the activities of both contractors and is thereby assuring that ERIM screening and analysis effort stays within the guidelines dictated by the operational considerations.

Bonder: What percent of total ERIM project costs is devoted to acquisition of critical data?

McKenney: Roughly 50 percent. This effort is required because we do not have sufficient data on some of the sensors we are considering.

Bonder: Is this critical data acquisition program being adequately coordinated with information supplied by BDM on operational needs for information? Data provided to ERIM from preliminary parametric analyses by BDM of the operational input variables might permit ERIM to better focus its data collection activities and possibly reduce the amount of effort devoted to them.

Brooke: Yes.

*General Hatch: TRADOC will be closely following this study to assure that TRADOC requirements are fully considered.

Brooke: TRADOC will be giving us prompt guidance on any questions raised concerning the direction of our effort.

*Wolfe: Is the Expert Working Group expected to give advice on the management of the program?

McConnell: The Expert Working Group should concentrate its attention on the technical approach and effort being conducted under the program, rather than on the management aspects.

Army Sensor Programs

General Hatch: One of the factors to be taken into account in making system recommendations is the fact that during the next decade, new sensors and sensor platforms will be introduced into the Army without adequate capability for the local commander to survey and digest the large amount of data which will become available to him from these sensors.

Brooke: It is likely that minefield detection systems will not have high priority in future Army inventories. To a considerable extent, minefield detection capability will depend on the availability of sensor systems which have other high priority uses. The minefield detection program is therefore not planning to develop new sensors, but to make use of the large number of sensor systems which

are becoming available to the Army. Where this is done, we may assume in our study that these sensors have already been justified with respect to cost, vulnerability, etc.

Minefield Detection Responsibility and Priority

Brooke: One issue presently being considered is the question of which Army organization unit should be responsible for countermine activity during combat. In the present Army organization, the Corps of Engineers is responsible for handling all countermine systems. However, this is not universally accepted throughout the Army as the best location for this function.

Bonder: An important consideration to be taken account of during the screening process is the matter of availability of each system during combat. This is particularly true of Air Force equipment. How will the Army assure that it has access to these systems when needed?

Heimiller: The question of making Air Force systems available for Army use is presently being considered at a high level in DoD. In our studies, we must follow the decisions developed on this matter.

Rogowski: If a system is sufficiently valuable for minefield detection purposes, the Army must be prepared to make a convincing case of its need for the use of the system.

Bonder: The availability of mine detection missions in competition with other uses of available sensors should be kept in perspective. At present, it appears that mines are likely to have a low priority in comparison with other targets. A decision to use sensors for mine detection will have a cost not only in terms of mission costs, but in terms of the cost of lost opportunities for higher priority missions.

Bonder: The use of inferential methods of detecting minefields or minefield activities will require the commitment of personnel resources to this effort during combat. Is the user willing to commit people to do the field analysis and evaluation involved in this approach to minefield detection?

## Technical Screening Criteria and Candidate Technologies Considered

Morita gave a presentation of major screening criteria considered in the technical analysis of candidate systems and proposed methods of technical analysis leading to the determination of probabilities of detection for use in operational analysis of the systems. Lists of sensors to be considered for screening were presented, including both systems in inventory and under development. A generic listing of systems was also presented, along with a brief general evaluation of each generic type of system.

Harger: Is ERIM's present work on identification and screening of technical opportunities being influenced yet by the analytical methodology being developed by BDM?

McConnell: The analytical methodology hasn't reached the point of being ready for use. Consequently, the operational variables which drive the technical effort are not yet ready for evaluating ERIM's technical approaches. One purpose of EWG2 is to review the methodology presented by Somers. Since the program was already in progress at the time of the recommendations made by EWG1, we have responded to these recommendations by modifying our activities, rather than by beginning all over again. The overall plan will have an increasing impact on the program effort over the next several months.

## Technical Screening Criteria

Bonder: In addition to the technical performance characteristics to be used in screening and evaluation as presented by Morita, the

sensor susceptibility to electronic countermeasures should be included. Platform survivability is also a significant factor to be considered.

*Somers: Quantitative information from ERIM on probabilities of correct detection, false alarms, and missed identifications are an appropriate measure of sensor performance for use in our operational analyses.

Weather

Wolfe: How is the information on weather used?

Brooke: It is used in the technical screening process to evaluate systems on the basis of their ability to operate in various weather conditions. It may also affect military operations.

Bonder: What if BDM doesn't find the weather data supplied by ERIM in satisfactory form for their purposes?

Brooke: We will modify the data content as necessary to meet BDM requirements.

*Paca: A NATO group meeting in Naples in 1970 produced a classified report which is one of the better collections of weather data.

McKenney: ERIM will review this source of data for its applicability to our program.

*Wolfe: Target accessibility has to be defined separately for each sensor. Weather statistics should be available on a monthly basis, since sensor performance will depend significantly on the season of the year.

Somers: For analytical purposes, we plan to take accepted TRADOC positions as to when the war starts or battles occur. We will then use weather conditions appropriate to these assumptions.

Bonder: It would be desirable to use a scenario which evaluates the sensor under some of the poor weather conditions occurring in Western Europe during the winter.

Technical Analysis of Candidates

Heimiller: In discussing methods of analyzing minefield detection effectiveness, we should not lose sight of the fact that the detection task is extremely difficult technically, and that achieving sufficiently high probabilities of detection from individual techniques cannot be assumed in advance.

Harger: The Technical Performance Analysis requires an adequate data base and involves complex analyses. It is doubtful whether we are in a position to produce reliable estimates of probability of detection.

*Wolfe: The Minefield Detection Analysis outlined by Morita is a sizable effort. Is there a detailed plan for performing this analysis?

Morita: For many of the sensors, this type of analysis will have to be limited in detail and complexity and will provide only approximate results. We will start this type of work on sensor systems now in inventory.

Candidate Technologies

Brooke: It is intended that in addition to candidate systems suggested by ERIM or presently in the Army inventory, the EWG should also recommend system concepts for screening and analysis.

*Bonder: As an alternative to classifying generic types of sensors in terms of their technical realization, it might be desirable to classify them in performance-oriented terms, e.g., in terms of speed of response, vulnerability to countermeasures or gunfire, etc.

*Brooke: This study will not include consideration of sensors (e.g., acoustic or seismic) emplaced before the war begins. There are plans for such sensors, but it is not clear that they will be effective for the purpose.

Vincent: Have studies been made to determine signatures for REMBASS sensors?

Answer: A great deal of data are available on such signatures in connection with the REMBASS program. In general, it is necessary to know only the type of vehicle involved.

Morita: For specified types of signature data associated with special operations or equipment, ERIM may recommend tests to collect necessary data.

*Wolfe: Charge-coupled devices used as sensor arrays should be included under the generic type of electro-optical sensors for screening.

*Vincent: In addition to Landsat data, which are freely available, other satellite systems are under development, for example, a French system which is a stereo mapper with 10 m resolution, 4 channels, and one base-to-height ratio. These could be used for detection of minefields through change detection.

Brooke: Because of the extremely short reaction time requirements, change detection systems would not be useful for most of the scenarios being considered in this study. It should also be recognized that in real combat situations, there are a large number of vehicular movements going on, and it would be difficult to distinguish those associated with minelaying operations.

*Vincent: Multispectral methods at high resolution should be considered as a means of distinguishing between vegetation and non-vegetation surfaces. The use of 1.06 micrometer systems combined with another frequency could be a useful system of detecting mines in vegetated area

*Heimiller: Can any decisions be made at the present time concerning the usefulness of SIGINT systems?

Morita: It does not appear that any such system would be useful. COMINT might possibly be used to intercept messages relating to minelaying plans of the enemy, but I would not recommend spending effort on this application at the present time.

Paca: We should obtain advice from Army elements concerned with COMINT about possible utility of this technique.

*Rogowski: With respect to the passive IR type of generic sensor, there is presently a great deal of data on mine detection. We should not spend time on this technique for our studies of the European theater.

Brooke: Passive IR may have some utility for detecting surface mines.

Wolfe: It may be useful under some weather conditions, and for desert scenarios.

*Bonder: Do you plan to identify minefields by using pattern recognition analysis on detections of individual mines?

Morita: Yes.

*Bonder: Is ERIM throwing away any technical opportunities during initial screening? The initial screening does not yet adequately reflect operational considerations which will come from the development of the analytical methodology.

Brooke: Rejections of technical opportunities during the initial screening process will be subject to EWG review, so that considerations falling outside strictly technical performance criteria can be adequately considered.

SCI Data

Lopez: SCI sources of information are being investigated. We expect to have a briefing on our findings at the next EWG meeting for people with appropriate clearance.

Paca: Do you have sufficient SCI billets?

Lopez: Yes, we are allowed 3.

Technical Analysis Example: RF-4C Photoreconnaissance

Lopez presented data relating to the technical performance of an RF-4C photoreconnaissance system for minefield detection which was prepared for use as a pilot example to allow BDM to perform an operational analysis. Because of uncertainties in the technical approach and basic assumptions underlying the example, Lopez was asked to review the work with these uncertainties in mind. It was suggested that Olson and Wolfe review the results of this effort. It was agreed by ERIM that this would be done.

Radar Systems

Johansen discussed alternative methods of detecting minefields by means of radar systems. One method is based on detection of minefields by virtue of a change in average reflectivity of the minefield compared to an area in which mines do not exist. Individual mines are not detected, but there is an increase in average reflectivity of the minefield. A basic question is whether it is possible to clearly distinguish between an increase in return from natural variability and an increase from the presence of mines.

A second method is to use radar with sufficient resolution to detect individual mines. Harger pointed out that decisions must be made pixel by pixel, and that there will necessarily be false alarms. The false alarm rate must be kept sufficiently low to avoid masking the correctly identified mines.

Wolfe: Conclusions regarding radar effectiveness should be based on the ability to detect complete minefields rather than individual mines. This calls for the use of pattern recognition methods.

Johansen: We have not yet had the opportunity to put effort on pattern recognition.

Heimiller: We do not anticipate problems in using pattern recognition methods. In radar, we are data base limited rather than limited by pattern recognition technology.

*Somers: Omission and commission errors in mine detection will occur because of variations in soil properties from point to point.

Johansen: This is true of L-band returns. For X-band returns, surface roughness is the most important terrain characteristic

*Our test plan is to fly the spotlight radar, before deciding whether to fly the X-L band system. Laboratory data on L-band being collected by the University of Michigan should allow us to perform calculations on its utility. The X-band spotlight data can also be subjected to a form of processing which indicates the utility of X-band for individual mine detection.

Brooke: It is not clear that this alternative post-detection analysis of spotlight data will give identical results with flight test data specifically designed to evaluate X-band capabilities.

Heimiller: This point needs to be discussed at length. A separate technical meeting should be held for that purpose.

*Harger: Will you have photo-interpreters look at the radar imagery to evaluate its usefulness?

Johansen: Yes. In addition, we can use our image dissector to obtain accurate statistics on signal and clutter. This consists of analyzing light intensities in the image projected on the output plane of the processor. Targets and clutter appear in this plane

without being degraded by limitations on dynamic range such as would occur if the image were recorded on film. Therefore, radar cross sections can be accurately determined.

*Harger: An alternative to post-processing of spotlight radar data for other purposes would be to conduct tests on a redesigned system, or at least do a conceptual study.

Johansen: These approaches would involve considerable effort, for which we do not presently have sufficient funds.

Electro-Optical and Active IR Systems

Bornemeier discussed ERIM plans for conducting field tests needed to evaluate the effectiveness of an active IR scanner. One feature of the test program is to obtain target and background data at the higher resolution. Equivalent results which would be obtained at lower resolution would be determined by summing high-resolution pixel returns over the area covered by a lower resolution pixel.

*Vincent: The wavelength of 1.06 micrometers is in the camouflage detection range. Why not do measurements at other wavelengths as well?

Bornemeier: We do not have the equipment to cover other wavelengths.

*Question: What are your plans for testing photo systems using camouflage detection film.

Bornemeier: We do not presently have any plans for this technique.

Olson: There are types of paints which have high IR reflectance and are therefore not subject to camouflage detection. The Soviets may plan to use such paints.

McKenney: The spectra of used mines may differ substantially from those of freshly painted mines. Information on this matter is not yet well defined.

*Vincent: There are green and blue dye lasers which might have useful characteristics for mine detection.

Bornemeier: We do not have these systems available to us.

*The magnitude and characteristics of specular reflection from mines was discussed. The quantitative characteristics of specular reflection will have a major influence on signal returns, but are not presently known for the types of mines to be used in the program. Specular reflection will depend significantly on mine shape, including the number and location of facets.

*Brooke: The test program presented by Bornemeier includes the M-19 and M-15 mines. Neither we nor the Soviets have these in inventory, so it is questionable whether they should be tested.

Johansen: The incremental cost of testing these types will be very small. If the information is of any use, we should collect the data.

*Wolfe: If results of these tests are negative, will that end the effort on active scanners?

Bornemeier: It probably will.

Vincent: There may be other experiments worth trying, even if initial results are negative. For example, we could look at the distinction between target and background response in the red and at 1.06 micrometer, as a means of distinguishing between vegetated and non-vegetated surfaces.

*Bornemeier: One platform to be considered for carrying an active IR would be a cruise missile flying at 800 ft altitude and taking images with a swath width of 1600 ft.

Bonder: Cruise missiles may not be available in Europe.

*Question: How about making polarization measurements?

Bornemeier: We are thinking about that.

*Brooke: In considering additions to our experimental program, we should be cautious about expanding our data collection experiments. We are limited as to time and funds available for these programs.

Photographic Systems

Wolfe: The numerical example given by Somers shows very tentative results, but indicates that wet chemistry is not effective because of the excessive time required to provide useful information compared to the combat requirements. If this is so, shouldn't wet chemistry systems be thrown out at this point?

McConnell: We are not yet sure of the actual situation on the basis of these tentative results. A decision point should be reached at EWG3. This decision must also be reviewed by General Hatch.

Gonano: The decision will be strongly dependent on the scenario selected.

Mine Neutralization

Captain Appel briefly discussed mine neutralization methods. The U.S. needs to do much more in this area. His discussion covered a variety of mine neutralization methods:

Track-width rollers,
Track-width plows,
Line charges,
Fuel air explosive helicopter delivered,
Surface launched unit fuel air explosive,
Pyrophoric mine neutralization system,

Vehicle signature duplicator (to detonate magnetic influence mines), and

Hardening wheels and tracks.

Analytical Methodology

Mr. Somers reviewed the current status of BDM efforts toward developing an analytical methodology for minefield detection evaluation. The objectives and technical criteria of the modeling, measures of effectiveness, and basic features of the model were presented. A numerical example was carried out to illustrate the manner in which the model is used. Mr. Somers cautioned against attaching any weight to the actual numerical results obtained, because of the uncertainty of some of the assumptions used in the example.

The model is designed to meet several requirements: It must give correct answers, must concentrate on the issues at hand (i.e., minefield detection technology) and avoid irrelevant issues, preserve maximum flexibility in adapting the methodology to new uses, and use whatever software is currently available.

The model is a two-sided model, with human decisions being inserted at various points in the model. It gives results in terms of expected values. The basic measure of effectiveness is how many more combat vehicles can be maintained in operation against the enemy with mine detection and neutralization measures, than without.

At the present time, the model is not completely automatic. It requires a manual run-through, with automatic contributions from submodels which are already in existence.

Bonder: The time frame for developing the model appears to be very tight, because of the need to assemble the computer model from individual submodels.

*Bonder: In conducting operational analyses in the absence of confirmed information on sensor capabilities, an effective method

would be for BDM to analyze a range of conditions and to feed back to ERIM information on sensitive ranges of each technical parameter.

Brooke: This approach will be taken where it is an appropriate and expeditious way to proceed.

*Vincent: As an alternative to detailed modeling, as presented here, would we be able to get authoritative answers to system effectiveness by presenting our ideas to several experienced tank commanders?

Paca: This is open to question. The responses would necessarily be subjective.

Bonder: Another alternative is to review the large numbers of studies that have been done on combat operations with and without mines. If we know the effectiveness of the combat system vs. percent minefields detected, and the percent of mines detected as a function of seasor type and characteristics, this approach would give us useful answers.

Answer: There is not adequate information on the relationship of percent minefields detected and combat effectiveness. This is the missing link that must be determined by analytical modeling.

*Bonder: A suitable measure of effectiveness would be to compute the loss exchange ratio for the base condition and for the condition in which minefield detection equipment is used. An alternative method of measuring effectiveness of a minefield detection system is to compare effectiveness results with and without the detection system in an equal or constant effectiveness analysis. That is, the analysis will determine the increase in weapon system TOE that would be needed for the unit without the minefield detection capability to achieve effectiveness results equivalent to those achieved if it possessed the minefield detection capability.

The time it takes for the combat unit to reach its objective is also an important measure.

*Heimiller: In evaluating the utility of minefield detection systems, we should keep in mind that they are potentially useful not only for the direct purpose of countering the mines and reducing losses, but also as an indicator of enemy plans. This indirect use should be given some weight in estimating their value.

*Somers: We would like to have inputs from the EWG or other members of the audience concerning possible corrections or additions to parts of the model. Specifically, we would appreciate any inputs on direct and indirect effects of minefield detection, or minefield intelligence utilization methodology.

*Bonder: Methods described in this presentation to illustrate losses due to firepower models are not representative of the real process of attrition.

Somers: For purposes of illustration, some of the models features shown here have been simplified. In the final model, we will use more realistic model features.

*Bonder: What scenarios should be used for minefield detection evaluation? Future scenarios may differ significantly from today's scenarios.

Somers: We are presently using today's models. A good source for future models would be TRADOC.

*Bonder: Please send me documentation for the models being developed so I can review them.

*Olson: In conducting operational analyses of platform survivability, the analyses should take account of the degradation of enemy capability after combat begins. Reduction of enemy capability and partial breakdown of command and control improves the survivability of sensor platforms over values based on initial enemy capability.

*Brooke: Project effort will be distributed in accordance with what are considered the highest priority problems. In order of

decreasing priority, the problems to be addressed include standoff detection of surface mines, standoff detection of buried mines, and close-in detection of surface mines and buried mines. At the present time, there is no defined threat from scatterable mines. Therefore, the consideration of scatterable mines in this current program is ruled out.

It is becoming clear that the primary driving function in making decisions on minefield detection systems is their affordablity.

Bonder: In order to justify these systems, it will therefore be necessary to show trade-offs between alternative approaches to the detection problem, and to demonstrate the cost-effectiveness of systems recommended by MERADCOM.

Paca: Money and personnel spaces in the Army are getting increasingly tight. In order to influence Army decisions in favor of proposed systems, it will be very important to show that the proposed system is a winner.

# 3
# EXECUTIVE SESSION DIALOGUE

*Lt. Gen. Hollingsworth: One of the critical factors in successful conduct of this program is the time factor. ERIM has a large number of technical options to screen before it can reduce them to something meaningful. BDM must put its program together and run the options selected by ERIM. The program should be carried out so that when the next meeting of the EWG is held, the EWG can make timely decisions on the program plan. Otherwise the program will have to be modified and extended.

Since time is a critical factor, I suggest that the next meeting of the EWG should be held in June. This will allow us to review current progress by both ERIM and BDM and determine whether satisfactory ERIM/BDM interaction is occurring. This earlier meeting date will allow more time for program planning decisions.

It has been suggested that a committee of three men be selected to evaluate the military value of the selected systems. If this is done, the selected individuals should be as experienced and capable as we can obtain, Even with this group, it is likely that there will be differences of opinion, and that full agreement on the evaluation of specific systems is remote.

Our attempt to analyze minefield detection effectiveness is hampered by the fact that a clearcut concept does not yet exist for how NATO would conduct and win a battle against the aggressor in Central Europe. If this concept existed, there would be some basis to come up with military requirements to improve readiness, determine needs for transportation, communications, command and control, ammunition, etc., and the corresponding requirements for minefield detection equipment and capabilities.

Paca: General Fiala and General Hatch went to Europe and among other things discussed the BDM scenario we have been considering. They came back with no conviction that anyone understood what they were talking about. There is no meeting of the minds on a satisfactory battle concept.

*Bonder: The technical example for the RF-4C camera system presented earlier should be reviewed to delineate the assumptions made in providing probability of detection curves of minefields as a function of various camera modes and flight parameters. In addition, effort should be placed on developing satisfactory methods of deciding on the existence and extent of minefields from the detection of indicators of the minefield provided by the sensor. If individual mines are detected by the sensor, the existence of the minefield may be deduced by the application of pattern recognition techniques.

To review the RF-4C example, McKenney will have a member of the ERIM staff look at it for the purpose of delineating the assumptions on which it was based. Drs. Olson and Wolfe will then review the restatement of the example.

*Bonder: I have a concern about the ability to succeed in this program, in terms of availability of time and resources as related to the work that has to be done. To resolve this issue, I would like to see a detailed work plan, specifying task inputs and outputs and how each task is to be accomplished.

*Bonder: There is a need to look ahead at this time to the circumstances under which any recommended minefield detection system will be used. Which Army elements will be responsible for each of the operational aspects of system use: sensor operation, sensor data processing, actual use of the information once it is provided. Will necessary personnel and equipment be provided for the minefield detection mission? Will the user be willing to modify established

operational procedures to take advantage of the available information? If the Army is not willing to assign funds or personnel to do this job during actual combat, we may be wasting our time in studying the problem.

Lt. Gen. Hollingsworth: There are presently no firm answers to these questions. The Secretary of Defense, OMB, the Department of the Army, and TRADOC all get involved in the decision on where to put available resources. MERADCOM's job at this point is to provide the best answers we can on the minefield problem. If there is a sufficient military requirement for the resulting systems, MERADCOM must convince the authorities that it should be provided.

Bonder: Still on the question of operational feasibility, who will be responsible for the operational implementation? Is it the target acquisition battalion or the engineers? Effort should presently be placed on talking with TRADOC to clarify what element will be assigned the responsibility and how it will be accomplished.

Olson: The problem is even more complicated than that. We still have not resolved how tactical requirements and responsibilities on surveillance missions are to be divided between the Air Force and the Army.

Bonder: For ground sensors, it is clearly the Army. I am raising the simpler problem: if a ground sensor were to be used, who is going to operate the system and process the data?

Lt. Gen. Hollingsworth: MERADCOM should not get involved in that question.

*Vincent: There is a serious question as to whether an imaging system carried on a ground-based vehicle or airborne platform can provide information within the time constraints called for by the BDM scenarios. These sensor systems will not be fully dedicated to the mine detection mission but must share sensor time with other functions as well. We might do better to recommend systems carried by

the combat vehicles, such as TV, which can provide an immediate response to the mine detection requirement.

Lt. Gen. Hollingsworth: The project should still look at the various approaches to minefield detection, to determine whether there is a capability to do the job within the tight time constraints of the scenarios.

*Johnson: The assumption that 80 percent of minefields can be detected as indicated by the photo example is too optimistic. It depends on the local conditions at the time, the ground cover, vegetation cover, terrain, and climate. This is true for surface minefields as well as buried mines.

Heimiller: The 80 percent figure is for a hypothetical example and was not presented as the "real" value. The problem of determining probability of detection is being addressed. We should reserve judgment till we see some results of detailed experiments and analysis.

*Olson: The section of this study devoted to determining the detection capabilities of various sensors should not be constrained too much at an early stage by full consideration of the operational limits on use of the sensors. Although we do not want to put excessive effort on systems with serious operational limitations, it is still necessary to obtain usable information on minefield detection capabilities as a basis for MERADCOM's further efforts in this field. If this aspect of the study is cut off too quickly, MERADCOM will again be faced with the need to do the work the next time a study of detection systems is called for.

Paca: Since operational constraints necessarily exist, the mine neutralization process of detecting minefields may prove to be an effective method of mine detection fully competitive with remote detection. I would therefore like to see a much better balance between detection schemes and neutralization schemes.

Lt. Gen. Hollingsworth: Detection and neutralization are different processes. A separate study should be devoted to neutralization.

Paca: I am thinking of neutralization schemes as applied for the purpose of detection or in place of detection. If we look at the scenarios with mine neutralization as an option, we may decide to use different neutralization techniques.

Wolfe: Although mine neutralization may be the right approach for some scenarios, our project is charged only with the responsibility for determining what is the role of detection.

*Bonder: An alternative to putting heavy emphasis on analytical methodology is to use already existing results of studies concerning combat operations in the presence of minefields and in the absence of minefields. If the results are known at these two endpoints, the effect of using detection methods can be estimated by a process of interpolation.

Wolfe: A simplfied method of operational analysis could be performed by assuming that sensor systems provide perfect probability of detection, and by assuming variations in the time to accomplish detection. The operational analysis can then proceed to determine the ultimate effectiveness of mine detection methods without any actual sensor data.

Bonder: We suggested that at the first EWG meeting, but the idea was not adopted.

Heimiller: Some time will be required before data are available from ERIM's experimental program. I recommend that BDM start a parametric analysis, based on assumed detection capabilities. The methodology has to provide three things to allow ERIM to sort out the various sensors: (1) ranking of the various sensor systems; (2) the threshold significance below which the system does not provide any benefits, and (3) the maximum allowable time to provide detection information.

Bonder: The results should be presented by lumping the various sensors into capability categories rather than hardware categories.

*Vincent: The multispectral aspect of minefield detection is being seriously underplayed. Only one channel of radar data is being used. Two channels of laser data are being used, but the wavelengths are too far apart. If the 1.06 micrometer laser is used, a 0.62 micrometer laser should also be used, or at least some wavelength between 0.55 and 0.65.

Heimiller: The present plan is that multispectral capability will be estimated based on existing information rather than any new measurement. Are you questioning whether the existing information is adequate to do an evaluation? Multispectral methods are not being ignored. We are just not recommending any more measurements.

Vincent: But if measurements are not made, it may not get adequate consideration later.

*It was agreed that the next meeting of the EWG should take place sometime in June. (Dr. Olson will not be able to meet during the period from June 10 to June 16.) Wolfe recommended that the meeting take place in Ann Arbor.

*Lt. Gen. Hollingsworth: I am impressed with the personnel at MERADCOM and with their interest in getting on with this program. I would like to see continuing harmonious operations between the MERADCOM people and the two contractors. I think the program will produce some worthwhile results, even though time is a critical factor.

Input from everyone involved is going to be a tremendous help. Where an individual has something particular to say that he feels strongly about, I recommend that he correspond either with one of the contractors or with MERADCOM. In any case, a copy of the comments should be sent to MERADCOM. As the overall program manager, MERADCOM can make a determination of what action needs to be taken.

Thank you for turning out, gentlemen.

# 4
# RECOMMENDATIONS, ACTION ITEMS, AND UNRESOLVED ISSUES

This section summarizes the results of the meeting, as derived from the discussions recorded in Sections 2 and 3. Items included in this section include recommendations and action items. In addition, some of the discussions raised issues which were not fully resolved during the meeting. Reference to these issues is included in this section in the form of questions, or as recommendations for further study.

## Project Scope

Should the project concern itself with the question of defining the responsibility for carrying out the minefield detection mission and functions during combat operations, or with how much priority will be given to the minefield detection mission in competition with other combat functions?

To what extent should mine neutralization techniques be studied as a part of the present effort or in parallel with it?

## Detailed Work Plan

The preparation of a detailed work plan, specifying task descriptions, task inputs and outputs was again requested by Dr. Bonder. This information is needed to evaluate the adequacy of the time and resources available to the program in relation to the program objectives.

## Scenarios and Threat

Consideration should be given to using future scenarios in some of our studies. TRADOC would be a good source for definition of these future scenarios.

This study should not include consideration of sensors (e.g., acoustic or seismic) emplaced before the war begins.

Since there is presently no defined threat from scatterable mines, consideration of scatterable mines in the current program is ruled out.

A NATO group meeting in Naples in 1970 produced a classified report which is one of the better collections of weather data. ERIM should obtain this report to determine its applicability to the program.

Identification and Screening

In addition to candidate systems suggested by ERIM or presently in the Army inventory, the EWG should also recommend system concepts for screening and analysis.

As an alternative to classifying generic types of sensors in terms of their technical realization, it might be desirable to classify them in performance-oriented terms, e.g., in terms of speed of response, and vulnerability to countermeasures or gunfire.

The technical performance characteristics to be used in screening and evaluation should include susceptibility to electronic countermeasures.

Is enough emphasis being given to study and experiment on multispectral techniques in the present program? Studies of multispectral methods should consider the use of the 1.0 micrometer band in combination with a band in the 0.55 to 0.65 micrometer region. This combination will be able to distinguish between vegetated and nonvegetated areas. Much greater emphasis should also be given to multispectral radar at wavelengths shorter than, equal to, and greater than the physical dimensions of the item to be detected. Consideration should also be given to VLF.

Charge-coupled devices used as sensor arrays should be reviewed and screened for their value as minefield detection systems.

How much effort should be spent on passive IR sensors?

In view of the short reaction time required by some of the scenarios, how much emphasis should be given to (1) satellite systems for minefield detection, and (2) imaging systems based on wet chemistry?

SIGINT systems should be given a low priority in the minefield detection study.

Critical Data Acquisition

A technical meeting should be held to discuss the validity of doing post-detection analysis of spotlight radar as a substitute for experiments with radar systems optimized for other operational modes.

Should M-19 and M-15 mines be included in the test array? These are not likely to be encountered in combat, but may be used as substitutes for Russian mines or as low-cost indicators of sensitivity.

Effort should be placed on developing satisfactory methods of identifying the existence or extent of minefields, e.g., through pattern recognition processes or statistical analysis.

Technical Example: RF-4C Photographic System

The technical example developed for the RF-4C photographic system should be reviewed to delineate the basic assumptions made in its development. After this has been done by the ERIM staff, Drs. Olson and Wolfe should review the restatement of the example.

Analytical Methodology

The project should consider alternative approaches to operational analysis of minefield detection. Specifically, the study could be conducted by making use of existing data and experience concerning combat operations in the presence of minefields and in the absence

of minefields. Another approach is to conduct simplified studies assuming (1) perfect minefield detection capabilities and (2) no minefield detection capabilities. The results of analysis of these two extreme cases will bracket the actual situation of partial minefield detection capability.

In the analytical modeling, alternative measures of effectiveness should be considered, some of which should include loss exchange ratios. The time it takes for a combat unit to reach its objective and the value of the information as an indicator of enemy plans are also important considerations.

MERADCOM is to furnish Dr. Bonder documentation for the models currently being developed, including documentation of the COMWTH model.

BDM would like to have inputs from the EWG or other sources concerning possible corrections or additions to the model it is developing.

Next Meeting

It was suggested that the third meeting of the EWG be held in June 1979, in order to provide timely inputs to the program planning process. Ann Arbor should be considered as a location for the meeting.