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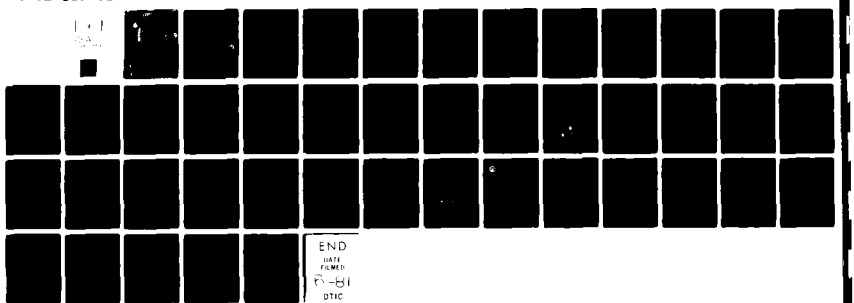

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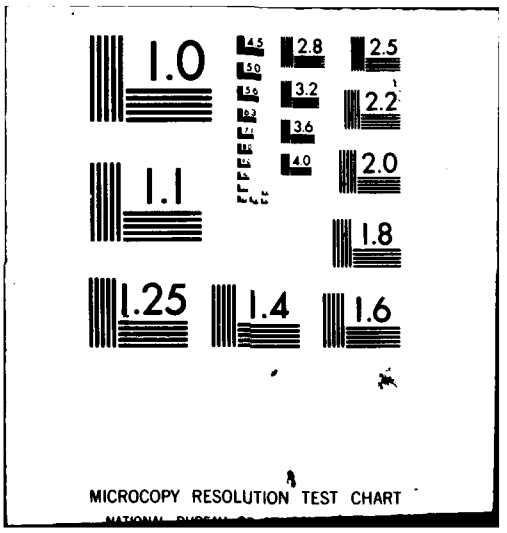
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document examines and reports on Army plans to use modern instrumentation technology to evaluate combined arms unit exercises at the Army National Training Center. The study intent was to focus on the second generation instrumentation support system, addressing technical feasibility and engineering realizability of meeting the schedule of implementation.

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ARMY SCIENCE BOARD
AD HOC SUB-GROUP REPORT ON
THE ARMY NATIONAL TRAINING CENTER

I. INTRODUCTION.

A. Members of the Army Science Board (ASB) National Training Center (NTC) Ad Hoc Sub-Group (AHSG) are very much impressed with the potential of the NTC to significantly improve the readiness of Army troops to fight effectively. The United States is outnumbered by the Soviets in terms of equipment and the fielded Soviet equipment in many categories is superior to the United States. The NTC concept, if properly implemented, gives the United States the opportunity to have a superiorly trained force. It, therefore, can be very critical in determining whether the United States wins or loses a war, if indeed it must fight one. As a recent historical example, the demonstrated superiority of Iranian pilots over Iraqi pilots can be at least partially attributed to their previous participation in Red Flag training. (Red Flag is a U.S. Air Force program similar in concept to the Army NTC concept.)

After witnessing day and night live firings at Fort Irwin California (the site of the NTC) on February 21, 1981, and seeing the large amount of improvement which could be made by NTC training, the AHSG Members have an even greater sense of the importance and need for the United States to have an operating NTC at the earliest possible date. For those unfamiliar with the NTC, a brief description is given in Appendix A.

B. The charge to the AHSG to review the Army's NTC plans, focusing on the second generation instrumentation support system, is given in Appendix C "Terms of Reference (TOR)". The AHSG, consisting of eight ASB Members, as shown in Appendix D, has held six meetings. The agenda for these meetings are included in Appendix E. The AHSG appreciates the time given by the NTC Program Manager (PM) and the NTC U.S. Army Training and Doctrine Command (TRADOC) Systems Manager (TSM) to furnish an understanding of a rather complex program. The NTC PM and TSM are to be highly commended for their grasp of the technical problems and the management of the program. Trips to Nellis Air Force Base, twice to Fort Irwin, to some contractor facilities, and to the Combined Arms Center (CAC) at Fort Leavenworth, Kansas, were all very useful in giving the AHSG an understanding of the status of the program, its relation to the Air Force programs at Nellis Air Force Base, and how the CAC is supporting the NTC.

C. Many reports and documents were furnished to the AHSG, including:

1. The NTC Development Plan, April 1978.

2. The Request for Proposal (RFP) for the Instrumentation Center, 3 July 1980.

3. Environmental Impact Statement, NTC, Fort Irwin Site, January 1979.

4. Survey of Industrial Developers of Training Instrumentation System, System Planning Corporation (SPC), July 1978.

5. An Assessment of Technologies Proposed for Phase II NTC, SPC, October 1979.

D. Very shortly after the System Integration contract was negotiated and signed, a comprehensive presentation of the Phase I system configuration was given to the AHSG by the contractor and his main subcontractors. This presentation gave the AHSG further confidence in the Phase I program and more detailed background for Phase II considerations.

E. Although the total NTC effort will involve about $790M expenditure over the next five years, less than ten percent of this is required for the Phase I instrumentation system, which is, indeed, the key to making the NTC the very effective tool that it is expected to be. First instrumentation is scheduled to arrive in January 1982, an extremely ambitious schedule as shown in Figure 1. The capacity of the NTC will gradually build to handle 42 Battalions for a two week training period each year as shown in Figure 2.

F. Answers to the questions posed in the TOR are given in Section II "Summary Answers to Questions in the Terms of Reference", which follows. That section summarizes much of what is included in more detail in Section III "Findings and Conclusions" and Section IV "Recommendations". However, some items not covered in Section II are covered in Sections III and IV.

FIGURE 1. NTC MILESTONES

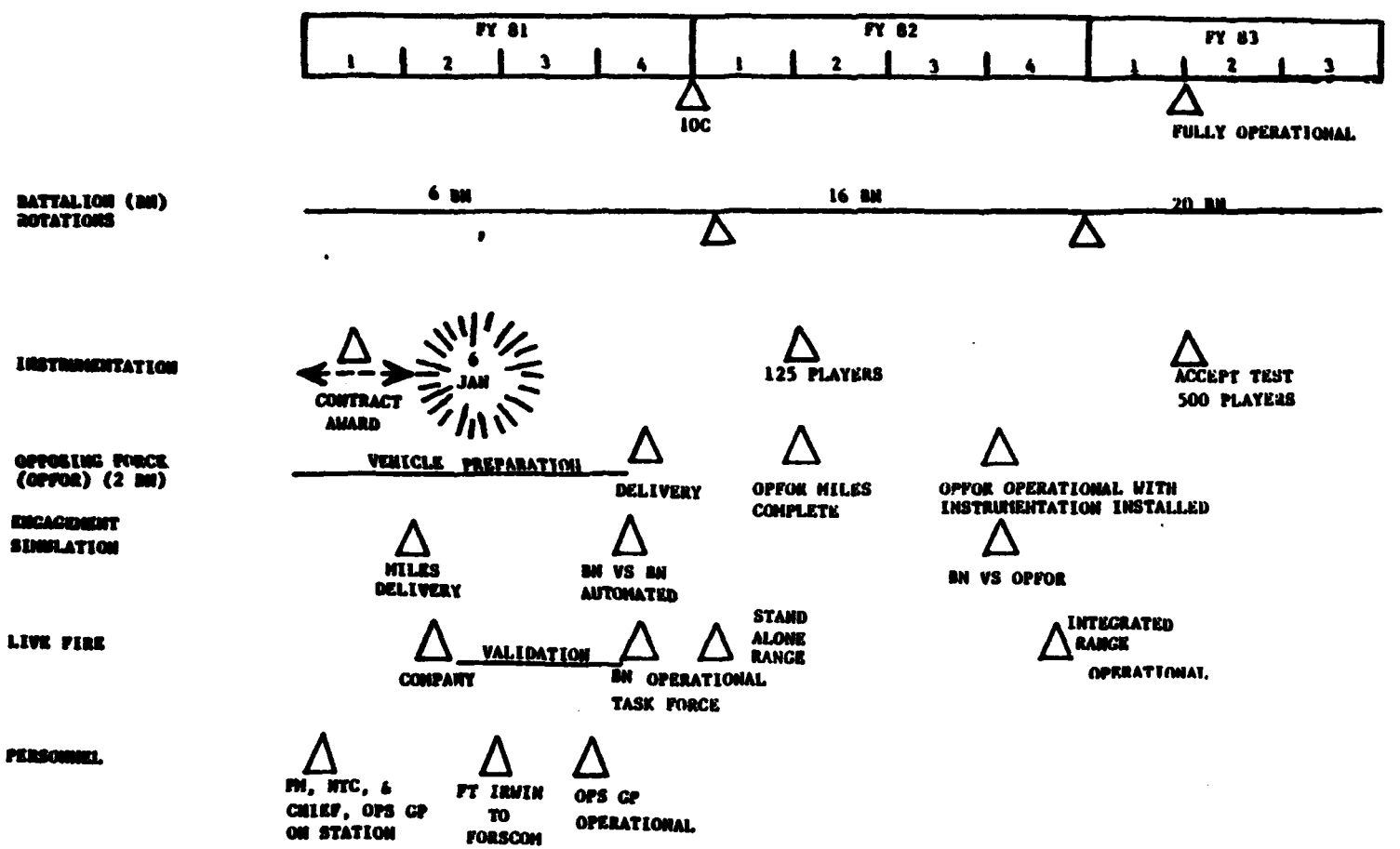
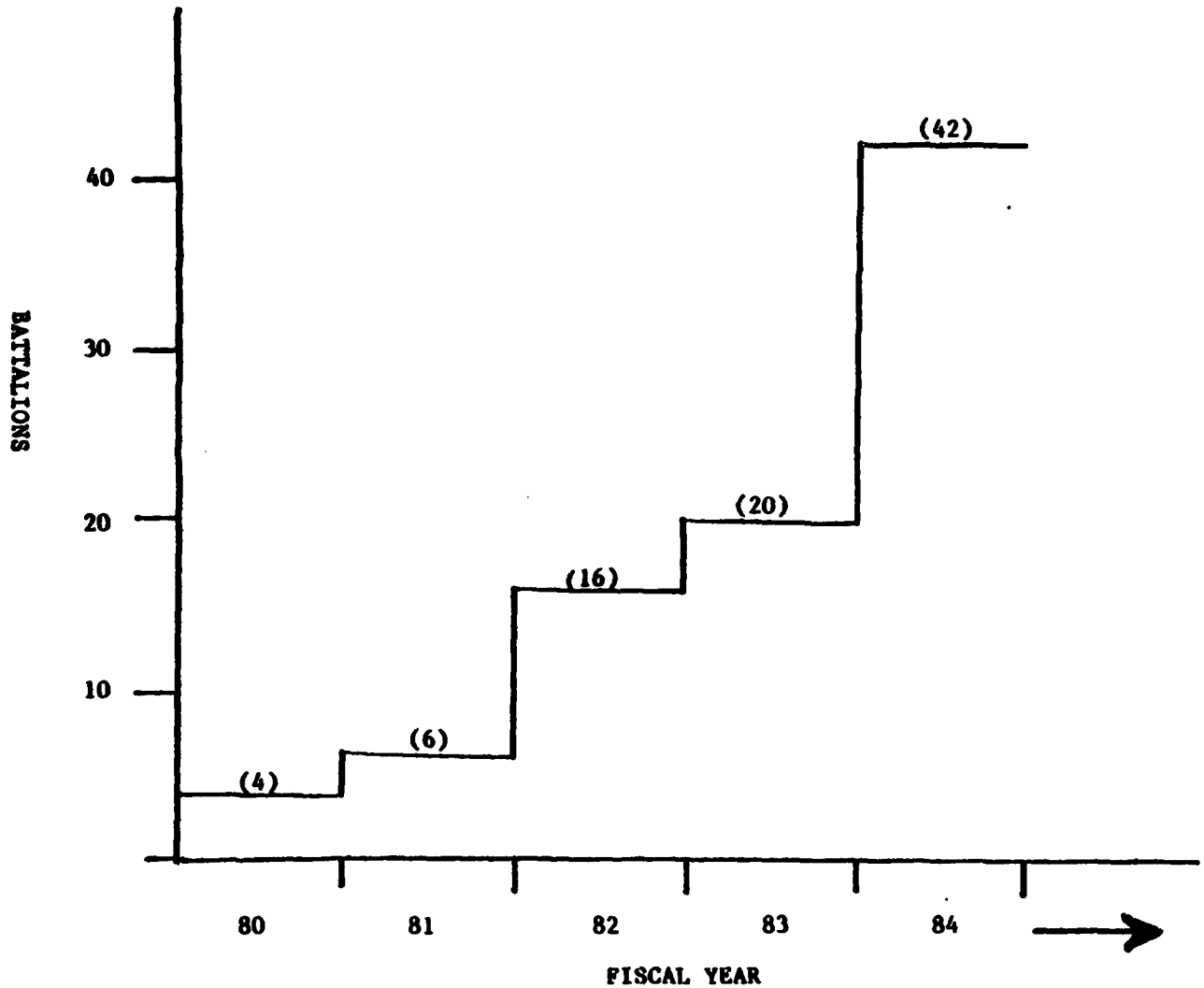


FIGURE 2. NTC CAPACITY



II. SUMMARY ANSWERS TO QUESTIONS IN TERMS OF REFERENCE.

A. Are currently planned Phase II programs and budgets technologically sound, reasonably manageable, and logically structured to achieve milestones? Is the proposed expansion realistically phased and funded?

The phase II program is planned in only a very sketchy fashion. No budget exists for Phase II in 1981 or 1982. The AHSG was told that $5M will be requested for 1983 and $0.5M each year for the next four years beyond 1983. There are no target milestones. Therefore, the answer to the first question has to be "no".

However, this in no way detracts from the importance of the NTC and from the excellent job done by the PM and the TSM in planning for Phase I and getting it underway. Indeed, the above question can be answered "yes" for Phase I. As stated in the introduction, the schedule for the instrumentation system is extremely tight, but the importance of this instrumentation system to the NTC is so great that strong management effort should be applied to adhere to the planned schedule.

It is important to understand that the NTC concept has evolved over several years. One of the most recent and significant milestones was the successful completion of NTC 1A tests in January 1980, with company size forces. These tests plus the U.S. Air Force Red Flag experience have given high confidence that great improvement can be made in training through the use of the planned instrumentation and facilities in full scale, realistic training of Battalion size forces. (See pages 1 and 2 in Appendix A.)

Since Phase II should be evolutionary with respect to Phase I, some of the features of Phase II can better be defined after operational experience with Phase I. However, a number of Phase II related efforts should start now, and it is unfortunate that more planning for Phase II could not have been done and budget provided in Fiscal Year (FY) 1982 to start certain key programs.

B. What other technologies could be applied to second generation NTC instrumentation support systems to efficiently provide quality Phase II instrumentation? Which research and development options with milestones should be integrated into the Phase II plan?

Technologies which could be applied to Phase II include:

1. Microelectronics, including Very Large Scale Integrated (VLSI) systems to permit more distributed computing, thereby making possible greater flexibility, more sophisticated processing of status, and storage of data for periods of time at each player location.

2. Global Positioning System (GPS) to provide 3-dimensional position information and accommodate a larger number of players. This is particularly important to the play of helicopters and aircraft. Also, it may be useful in the intervisibility calculations if the Z position is sufficiently accurate.

3. Novel, but not necessarily sophisticated, approaches to more realistically simulated indirect fire in an affordable manner.

4. Millimeter or submillimeter wave devices for engagement simulation, if the incompatability of the Multiple Integrated Laser Engagement Simulator (MILES) laser frequency with thermal imaging in the dirty battlefield environment proves to be severe and not easily solved by optical techniques. (See paragraph H, Section III "Findings and Conclusions" (page 9) and paragraph D.1, Section IV "Recommendations" (page 15).)

5. Advanced display techniques to enhance training through improved communication with trainees in After Action Reviews (AAR) and to enhance analysis of data.

6. Advanced analytical approaches to provide:

A more systematic definition of training needs and how these needs can best be met by instrumentation.

A more systematic definition of data needs for future studies of tactics and doctrine. A wealth of data will be obtained. It is important to determine what is important to collect and preserve.

Research and development programs which should be integrated into Phase II planning are listed in paragraph D, Section IV "Recommendations" (page 15).

C. <u>What development, engineering, and technical management adjustments should be made to facilitate integration of future technical considerations into the planning, programming, and budgeting system?</u>

It is necessary that someone be given full time responsibility for Phase II planning and implementation. The Sub-Group recommends that such an individual report directly to the TSM. That individual should be responsible for all aspects of Phase II (and excluded from any Phase I responsibilities) to include:

1. Delineating early tests that need to be performed to determine adequacy of presently planned Phase I equipment for Phase II. The most important example is a test to determine the importance of MILES laser frequency incompatibility with weapons system thermal imaging system frequencies.

2. Contracting for and directing developments that need to be performed for Phase II.

3. Performing liaison with other programs such as GPS and Mobile Automated Field Instrumentation System (MAFIS) which can have important spin-offs to NTC Phase II.

4. Performing liaison with programs involving doctrine development, tactics development, testing of equipment, etc., where NTC may provide an important and unique source of relevant information.

III. FINDINGS AND CONCLUSIONS.

A. The NTC will make a significant improvement in the readiness of Army troops to fight effectively and, therefore, should be implemented as rapidly as possible.

B. The Phase I instrumentation system concept is reasonable and will be the key to NTC success - if properly implemented by the contractor. NTC 1A tests lend credence to the soundness of the concept.

C. A review on 8 January 1981 of the Phase I instrumentation program, as negotiated with the contractor, furnished the AHSG a baseline for considering Phase II. The AHSG felt that the system configuration was reasonable and well laid out.

D. The schedule for hardware delivery and integration for Phase I instrumentation is extremely short with first training using the equipment to start in about one year from initiation of the contract.

E. There was no indication of a problem in software development. NTC 1A software apparently operated satisfactorily. However, this was much less complex than Phase I. During the presentation by the contractor there appeared to be an understanding of software problems and an attempt had been made to configure the overall instrumentation to minimize and recognize interface problems.

However, the lack of attention to software problems in many system developments and the problems resulting therefrom leads the Sub-Group to emphasize the importance of ensuring that the software will be properly developed as a part of the total instrumentation system. In particular, proper documentation of the Phase I software is important. Much of this may well be used in Phase II directly or in modified form.

F. Phase II, for the most part, should be evolutionary with respect to Phase I and, as a basic principle, Members of the AHSG believe that those parts of the Phase I instrumentation system which have a high probability of working satisfactorily need not be replaced unless:

1. Better training can be achieved through more accurate (or rapid) measurement and more realistic simulation of battlefield conditions.

2. Greater operational reliability can be achieved.

3. Savings can be achieved without degrading the quality of training or performance.

4. Reductions in size or weight can be made to a degree that enhances training or performance and the instrumentation system becomes more transparent.

The PM expects that the central computer for Phase I will also be used for Phase II. Nothing in this AHSG review of the contracted Phase I instrumentation system would indicate that this is not feasible. It is certainly desirable to retain the Phase I central computer if experience with the Phase I instrumentation operation indicates it performs satisfactorily and reliably.

G. There are several alternative approaches which maybe used in the Phase II subsystem areas. For example, in the position location subsystem a variety of techniques can possibly be used - Position Location Reporting System (PLRS), MAFIS hyperbolic (Long Range Navigation System (LORAN)), GPS, Range Measuring System (RMS), etc. Some, such as GPS, involve very advanced technology. Also, the MAFIS, if developed, should provide much advanced technology which can be used for Phase II instrumentation. It is intended that MAFIS will incorporate such advanced technology as magnetic bubble memory, packet radio techniques, and microprocessors. It uses distributed information processing. It is being developed for the TRADOC Combined Arms Test Activity (TCATA) for testing, but could be adapted to training. It is not clear, however, whether or not it will be affordable for training. It is necessary to have a better definition of the program - what it will do, when, and for how much - than was available when the AHSG reviewed the program. It is understood that such definition is taking place.

GPS offers some real advantages for providing location data and should be given very serious consideration for Phase II. GPS should be available with ten meter accuracy on a 2-dimensional basis in 1985 and on a 3-dimensional basis in 1987. Present estimates of cost for manpack and vehicle equipments seem reasonable.

Fortunately, both MAFIS and GPS developments are planned to be on a time scale compatible with NTC Phase II.

H. Members of the AHSG see as a principal problem the fact that the MILES operates at a little under one micrometer and thus is incompatible with weapons systems using thermal imaging. The MILES contractor is aware of the problem and has some ideas on overcoming it; other scattered conceptual efforts and expertise also exist. However, some real work is required to obtain a better data base on the magnitude of the problem and to develop alternative solutions. It is not expected that this problem will be solved soon. Work needs to be started now in order to be reasonably certain that a solution will be available for Phase II.

The AHSG has done some thinking about the desirability of using millimeter or submillimeter frequencies. A real difficulty is whether one can design an antenna system small enough for anything other than vehicle mounted equipment; there is even concern that a small high resolution antenna could be mounted on vehicles in such a way as to assure reliability under all training conditions. Some small effort should go into studying what might be accomplished using a frequency in the 230 gigahertz range. However, it is most likely that the solution will be in the optical range of frequencies.

I. As a general principle, the engagement simulation system should have a transmissivity through the dirty battlefield environment at least as good as, but preferably better than, the weapons system transmissivity.

J. Currently there appears to be no satisfactory method for simulating indirect fire and handling this in the play except through controllers. The development of a satisfactory solution to the problem of scoring indirect fire in the maneuver area should be a major objective of the Phase II instrumentation system development. (See Appendix B for a report on "Indirect Fire Simulation" by Dr. Donald E. Erwin (AHSG Member).)

As a general principle, an attempt should be made to automate, as much as possible, the functions performed in Phase I by the controller. This applies not only to indirect fire, but also to nuclear, biological, and chemical (NBC) weapons play and to the play of mines.

The AHSG was pleased to learn that the Field Artillery School at Fort Sill, Oklahoma has initiated a contract (with Jet Propulsion Laboratories (JPL), the MAFIS contractor) to make a concerted attack on solving the problems associated with furnishing the necessary equipment and techniques to train in all aspects of indirect fire including the artillery crews and the troops facing artillery fire. It appears that the problem is being approached in a reasonable manner. The AHSG was told that JPL has been asked to carry out an early investigation of the cueing system proposed by Georgia Institute of Technology. The Chairman of this AHSG reviewed reports and discussed the Institute's approach with Mr. Williamson of the Institute and concluded that indeed their approach has merit and should be pursued in some depth.

K. Displays will play a very strong part in analyzing data in preparation for training feedback and in presenting information in such a manner that it can be absorbed so that training takes place. This is particularly true for the Field Training Feedback System where AAR will be presented and studied.

This critical area requires careful monitoring during Phase I. Early tests should be conducted during Phase I instrumentation system operation to determine the adequacy of the displays for both Phase I and Phase II to ensure that the full training value can be extracted from evaluations in AAR.

L. Phase I lacks the capability for having an assessment of intervisibility between individual participants, such as tank-to-tank. It is expected that the intervisibility can be determined for units of participants such as Companies. This may be sufficient, but an analysis is necessary to determine if this is so. If not, provision must be made for assessing intervisibility between individual participants in Phase II.

M. The phrase "train as we will fight" is meaningful only if it is done. The AHSG has been told that this will include fighting at night using night vision equipment; fighting under simulated NBC conditions; fighting under dirty conditions, including the use of smoke; fighting in the presence of and with mines or simulants thereof; fighting in an electronic warfare (EW) environment; the use of close air support, etc. While the AHSG was told that all of these will be included, a detailed plan of how and when each of these will be introduced in Phase I has not been provided. Therefore, it is not yet apparent where the weaknesses may be that should be corrected for Phase II. As new thrusts such as command, control, communications countermeasures are adopted, they should be incorporated as soon as possible into the NTC training program.

At Fort Leavenworth the AHSG was given information on the generation of the many scenarios required. This work appeared to be progressing satisfactorily. However, the Group did not see any detail on how equipment procurement would be provided in a timely fashion consistent with the scenario schedule, except for the instrumentation system itself.

N. In Phase II, it may well be desirable and necessary to provide for more than 500 participants. The sooner this decision can be resolved as to how many participants should be instrumented, the sooner decisions for Phase II can be made.

O. It is important to have close coordination between the Army and the Air Force, not only because of the need to have play with close air support if the two Services are going to "train as they will fight", but also because each Service has developments that can be useful to the other. There seems to be coordination at lower levels, but better high-level coordination is needed to give proper attention to priority of resources.

P. There are no plans to train in simulated built-up areas in the NTC and indeed it would be very expensive and redundant to provide in such a desert terrain. It is the AHSG's understanding that Military Operations in Urbanized Terrain (MOUT) training is being performed elsewhere and at the Company level of training.

Q. The NTC environment is austere and isolated. The quality of the physical environment, the educational services, the recreational facilities and services, etc., at Fort Irwin will be important for the permanent party, and particularly important for the Opposing Force (OPFOR) which will be operating under highly stressed conditions for extended periods of time. Planning and budgeting to meet these needs according to 1980 standards warrants high priority. In particular:

1. Troop housing needs to be substantially upgraded. Current plans appear adequate, but warrant accelerated implementation.

2. Family housing needs rehabilitation. Equally important, contemporary civilian standards of neighborhood planning should be reflected in planning and budgeting, so as to bring existing and future housing areas up to such standards as soon as possible. In particular, this will require that some community facilities be built within family housing areas.

3. Community facilities to support the full permanent party need upgrading. This should be planned, budgeted, and implemented on a timely basis.

R. During the operation of the NTC much data will be collected which can be important in studying the Army as a system - with the objective of improving organization, tactics, materiel, and training. Planning should be initiated early to determine the impact of such considerations on storage and availability of Phase I data and on Phase II system design and data analysis.

S. The essentially empirical Phase I approach to the selection of instrumentation and definition of data requirements appears sound and practical in light of the current circumstances. However, in incrementally improving Phase I and planning for Phase II:

1. Phase I data collection and analysis should be systematically evaluated for relevance, usefulness, and identification of key items of missing data.

2. Such essentially ad hoc, empirical approaches to data requirements definition should be complemented by a more systematic, integrative conceptual framework, perhaps based upon a model of Battalion functioning and effectiveness.

3. An orderly planning and decision making process needs to be defined which identifies data needs, identifies which needs can be instrumented based upon current technology and which may be instrumented by near- and intermediate-term technology improvements, and sets priorities to prepare an implementation plan. The plan should provide for technology development, procurement, hardware development, and necessary use. Where feasible, data collection should be instrumented. Where instrumentation is not feasible, significant data should be captured by alternate methods (e.g., controller notes).

IV. RECOMMENDATIONS.

A. Strong and Continued Emphasis. The TRADOC and Office, Deputy Chief of Staff for Operations and Plans (ODCSOPS) should continue to place strong priority on procuring Phase I instrumentation. The presently planned delivery dates are scheduled so tightly as to border on being unrealistic. However, it is very important to have the systwm operational as soon as possible. Because of the high payoff expected from this program, the NTC should continue to rank among the Army's highest priorities.

B. Budget for Phase II. At the same time, and in spite of the pressures on the NTC TSM's office to implement Phase I, effort must start on Phase II and TRADOC should budget some money in FY 82. Reprogramming may be required to accommodate time constraints. In addition to funds for FY 82, adequate funding for future years must be provided in the budget process. Although the investment in Phase II instrumentation will comprise a small fraction of the overall NTC costs, it can have a high leverage on the effectiveness of the training.

C. Manage Phase II. Someone should be given full time responsibility for Phase II planning and implementation. The Sub-Group recommends that such an individual report directly to the TSM. That individual should be responsible for all aspects of Phase II and excluded from any Phase I responsibilities. These responsibilities should include:

1. Delineating early tests that need to be performed to determine adequacy of presently planned Phase I equipment for Phase II. The most important example is a test to determine the importance of MILES laser frequency incompatibility with weapons system thermal imaging system frequencies.

2. Contracting for and directing developments that need to be performed for Phase II.

3. Performing liaison with other programs such as GPS and Mobile Automated Field Instrumentation System (MAFIS) which can have important spin-offs to NTC Phase II.

4. Performing liaison with programs involving doctrine development, tactics development, testing of equipment, etc., where NTC may provide an important and unique source of relevant information.

D. Programs to be Initiated As Soon As Possible.

1. An analysis should determine the seriousness of the MILES laser frequency being different from that of the thermal imagers and thus degrading the utility of MILES. Also, alternatives to the MILES transmitters and detectors should be developed to eliminate this problem, which at the present time seems to be the most severe problem in the entire system and which affects both Phase I and Phase II.

2. TRADOC should develop one or more approaches to the indirect fire scoring problem.

3. The TSM should program exploratory development in such areas as improved presentation methods, particularly for the AAR. This should include studies of how information can be best presented to improve the learning process for Army units.

4. Studies should determine the advisability of using MAFIS subsystem technology, as well as other advanced technologies (such as GPS) for Phase II training. These studies should address any modifications that might be made to perform the training function more effectively.

5. Develop an integrative, conceptual approach to the Battalion as a system, and use such studies in developing the rationale for the critical variables to be measured by Phase II instrumentation.

E. Coordinate With the Air Force. The Army and Air Force should hold joint coordination meetings to discuss how each may benefit from the other's development programs. At such a meeting or at a separate meeting the two Services should plan on how the Nellis and George Air Force Bases' forces could best assist training at NTC. At both meetings high-level participation by both Services is important to identify and allocate resources.

F. Ensure That the Necessary Data Are Collected and Preserved. ODCSOPS, in coordination with the Office, Deputy Chief of Staff for Personnel (ODCSPER), Office, Deputy Chief of Staff for Research, Development and Acquisition (ODCSRDA), and U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), and other appropriate agencies, should determine what has to be done now and, more importantly, over the long-term to ensure that the data required for studies of the Army as a system are collected and preserved.

1. It appears that a substantial level of effort by ARI or qualified external contractors is necessary over the next few years both to support Phase I and to prepare a sounder foundation of planning for Phase II. To achieve this, additional research, development, test and evaluation (RDT&E) fiscal resources must be provided to support this research to ensure that a well thought out research program can maximize the training value of the NTC.

2. Early, more active, and integrated participation by appropriate organizations with NTC, both in Phase I development and planning for Phase II, is necessary to enhance usability of NTC data to evaluate doctrine and combat development to support Phase II planning and future materiel requirements.

G. Special Attention to Software. Special attention should be given to ensuring that software development supporting NTC hardware is thoroughly documented and can accommodate data base expansion and inquiries as new training or doctrine needs arise.

H. Provide Adequate Quality of Life at NTC. The family housing rehabilitation needs and the community facilities to support the full permanent party should be budgeted and implemented on a timely basis.

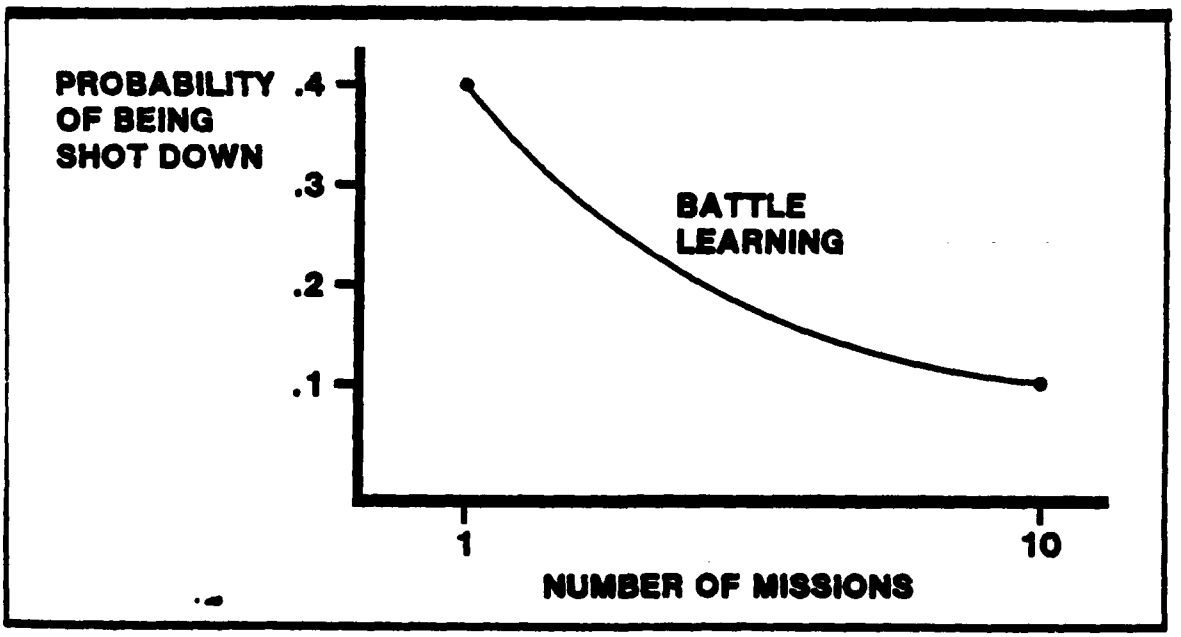
I. Make Provisions for NTC Training in New Weapons Systems. As new weapons systems are developed, provisions should be made for interfaces such as mounting brackets that may be required for mounting instrumentation that will be used during the NTC training. Similar mounting brackets must be fabricated and installed on equipment positioned at the NTC for OPFOR and units to be evaluated.

APPENDIX A
DESCRIPTION OF THE ARMY NATIONAL TRAINING CENTER

1. The NTC concept gives real meaning to the key phrase "the Army must train as it fights" (FM 100-5 Operations).

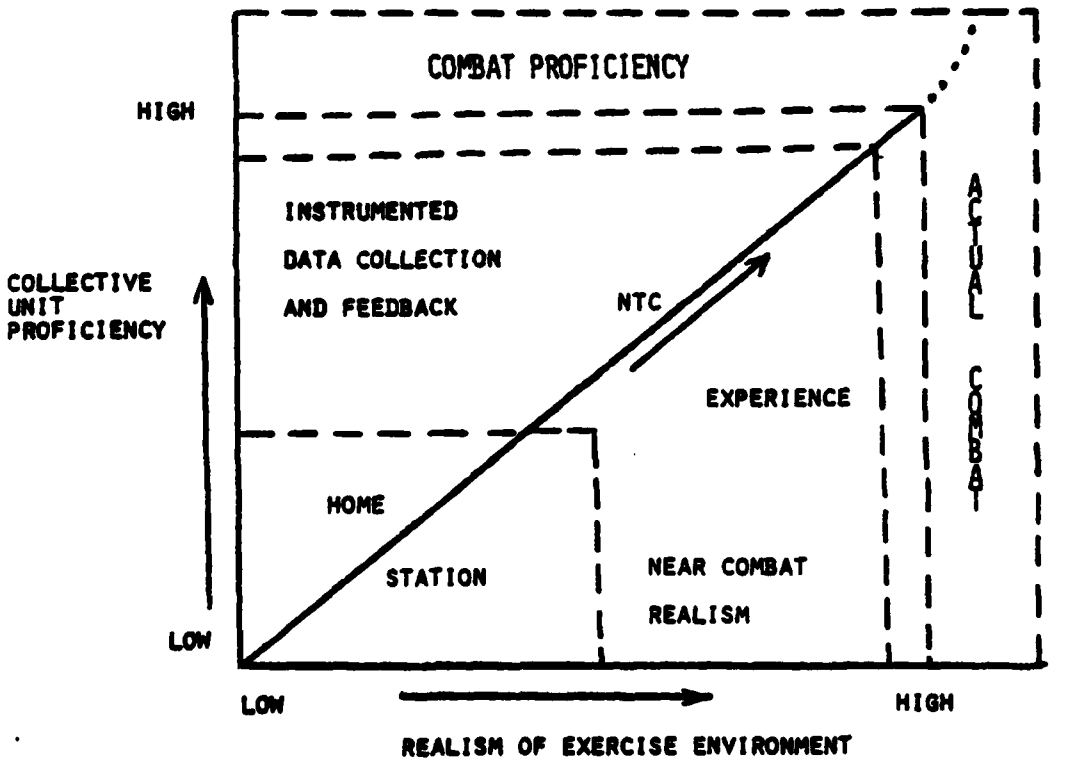
2. Studies of aerial combat experiences since World War II show a dramatic decrease in the probability of being shot down as a function of the number of missions flown (see Figure A-1). The U.S. Air Force Red Flag training is aimed at giving air crews convincing simulation of these first combat missions. It includes using F-5E aircraft with Soviet identification markings simulating aggressor forces and tactics.

Figure A-1. Air-to-Air Combat Survivability



3. Figure A-2 shows schematically what the Army hopes to accomplish. By providing near-combat realism, NTC training should provide experience which will increase combat proficiency - the ordinate. An instrumentation system provides data which is fed back to the units being trained within two hours after an engagement has been completed. Also, packages of data will be sent back with the troops as they return to home station.

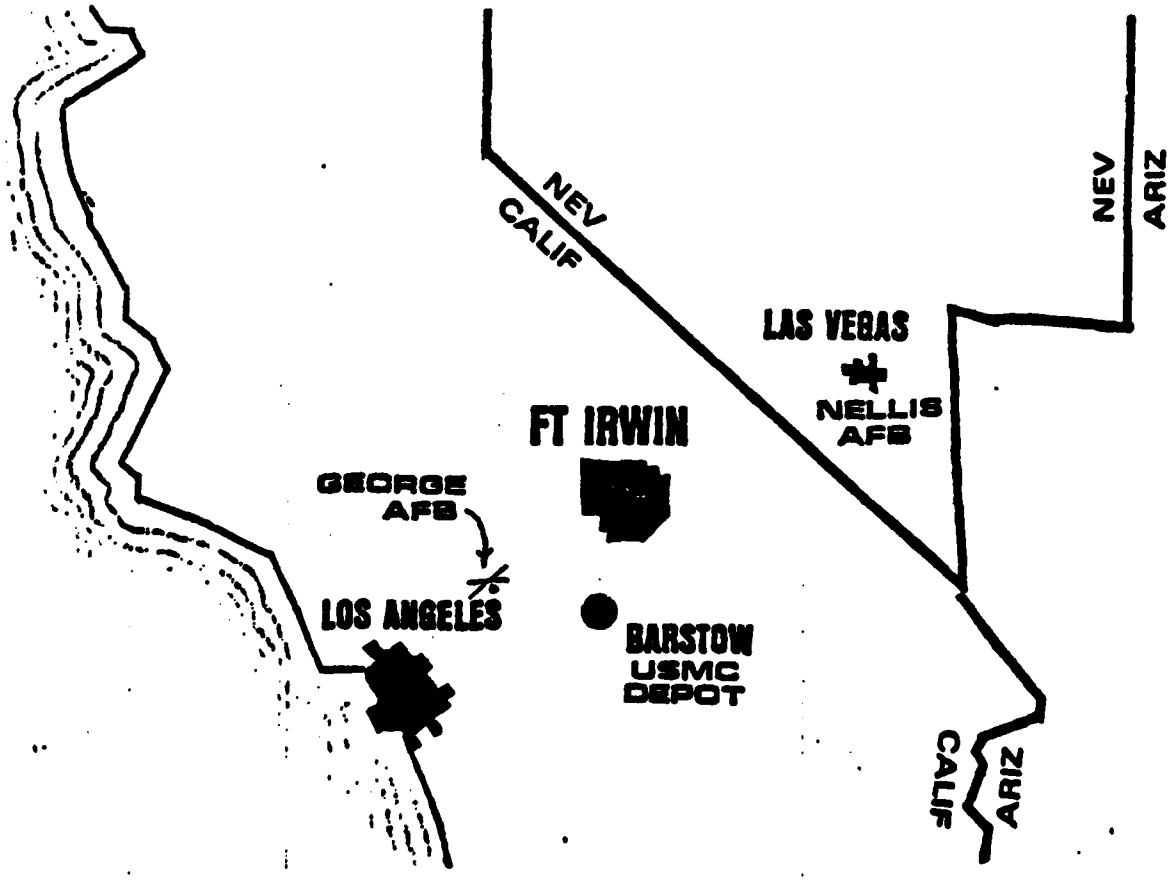
Figure A-2. Training System Relationship of Increase In Unit Proficiency to Exercise Realism With Constraints



4. The purpose of the NTC, therefore, is to establish a place and an environment where Army units can undertake essential combined arms training that cannot be accomplished at the home station and to gather data about battlefield performance and effectiveness of organization and systems under realistic simulated conditions. The primary emphasis is on training, but important data will be collected which can help to improve organization and tactics.

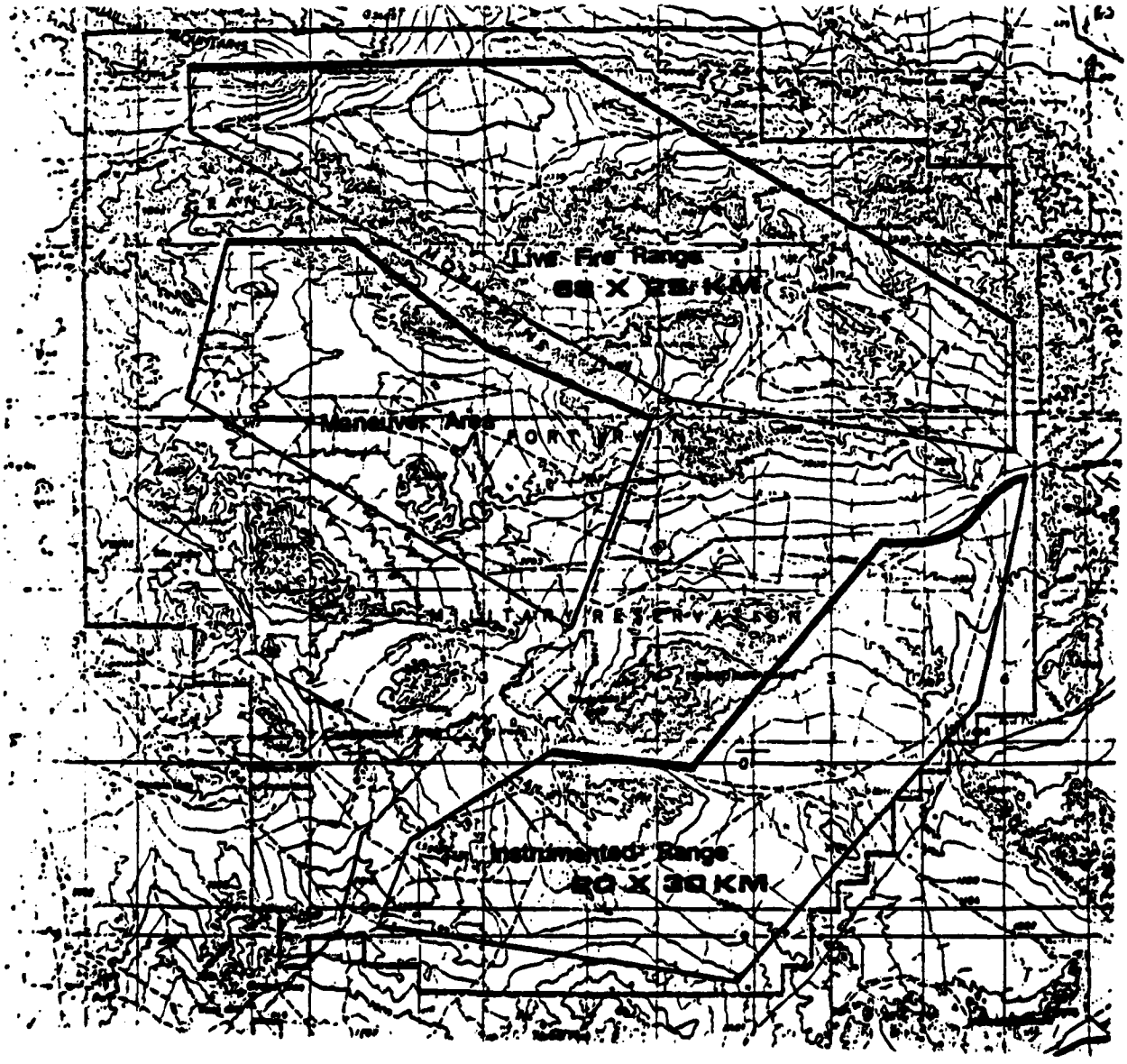
5. To provide realism, one needs a lot of space and that is available at Fort Irwin (see Figure A-3), located near Barstow, California, half way between Las Vegas and Los Angeles - and not far from Nellis Air Force Base and George Air Force Base, both of which can provide support to the training operations. For instance, close air support can be provided from Nellis.

Figure A-3. Area Map



6. Fort Irwin has 642,000 acres (see Figure A-4). Note here that the instrumental range is about 20km x 30km and the live fire range is 68km x 25km.

Figure A-4. Area Map of Fort Irwin.



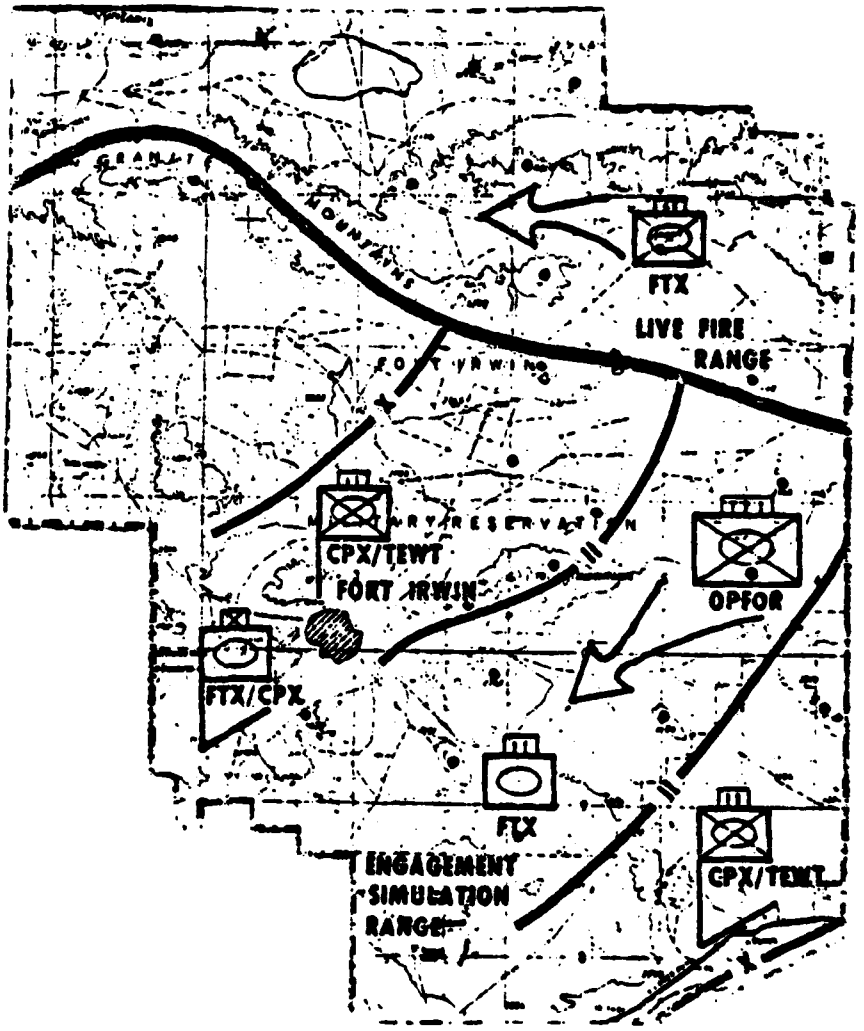
7. Figure A-5 shows how Fort Irwin permits having two full Battalions training on two ranges at one time - each training for two week periods. Three Battalion staffs can operate on one range with two Battalions being simulated on a computer while the third is operating in force and most importantly operating against an "enemy force", i.e., the OPFOR shown in Figure A-5. This OPFOR will use vehicles with Soviet markings and use likely Soviet tactics. There will be additional units on the ranges, i.e., air defense, artillery, and helicopters.

Figure A-5. Tactical Training Ranges.

NTC PLAYERS

- o 2 Full Bns on 2 Ranges
- o 2 Bn Staffs on 1 Range in CPX/TEWT
- o 1 Bde Hqs on 1 Range in FTX/CPX

Misc Additional Units (AD, Arty, Engr, Helicopters, Etc.) on 2 Ranges

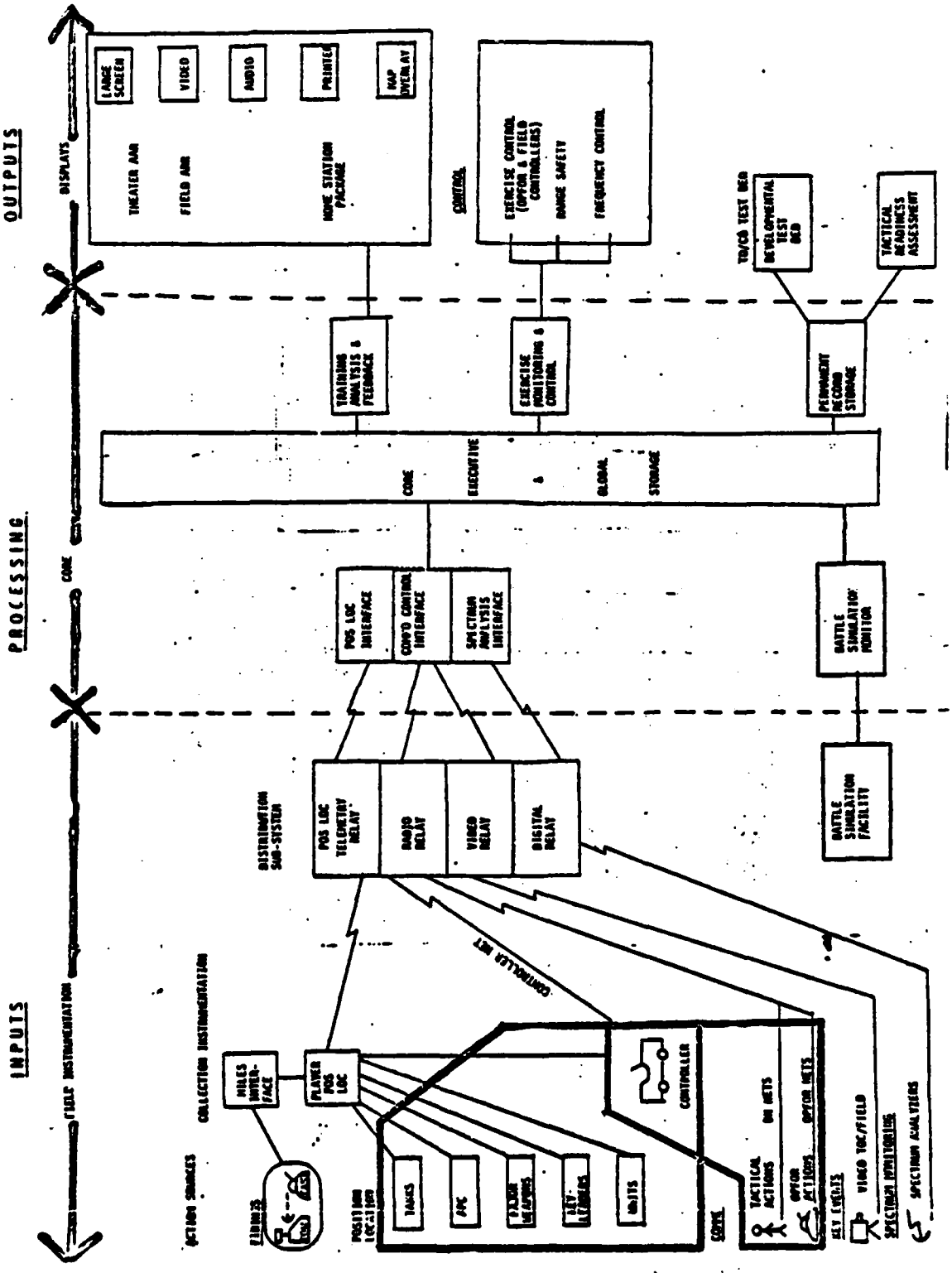


8. The NTC at Fort Irwin offers these unique aspects:

- o Train as a combined arms task force
- o OPFOR provides appropriate force ratios and tactics
- o Smart live fire target array
- o Realistic maneuver distances for engagement simulation and live fire
- o Unconstrained airspace for full close air support play
- o Isolated facility for full power EW play
- o Dirty battlefield conditions
- o Take home package (for use by Commander in determining subsequent training)

9. The heart of the NTC training is the instrumentation system (see Figure A-6). It is expected that the total NTC operation will cost about $790M over the next five years. The cost of the instrumentation system is a rather small amount of this - less than ten percent - but it makes possible some major advances in training.

Figure A-6. Unit Instrumentation Overview.



10. Some points to be made are:

- o There are many inputs to a processing system which then provides several outputs, some for the training function and others for control of these rather complex operations involving Battalion size forces.

- o A position location system keeps track of enemy and friendly players, i.e., tanks, armored personnel carriers, major weapons, and units.

- o Except on the live fire range, laser pulses are used to simulate rounds of ammunition, and detectors on vehicles and personnel detect whether a hit or near miss is achieved. Lights flash and personnel know they or their vehicles have been killed and they can no longer fight. Thus an objective and more realistic scoring of the trainee actions is possible. Controllers alone are very subjective and lack realism. The laser system is MILES.

- o A communication monitoring subsystem keeps track of the friendly actions and enemy actions as reflected by the traffic on the Battalion and OPFOR nets.

- o Key events are recorded by video camera tape units. In order to keep track of the various radio frequency emissions, spectrum analyzers monitor all communications, radar, and intentional jamming emissions. This helps the Army keep its commitments to the National Aeronautics and Space Administration Goldstone Deep Space tracking facility located nearby.

- o All of these data are fed into the CORE, or central data processing system where the data are stored and processed for:

  - oo Training analysis and feedback, including AAR which can be presented to the troops within two hours after an engagement and before another engagement is initiated. The two week sequence of engagements is flexible and emphasis can be changed as a result of the AAR. This report shows how well the trainees achieved the objectives for that engagement, the casualties suffered by both forces, and the decisions and actions that caused casualties and success or failure in meeting objectives.

  - oo Also, as stated before, a home station package is prepared to help improve training at home bases.

  - oo In addition, data is processed for monitoring and controlling, including range safety and frequency control.

11. The NTC is not a substitute for the present training program, but rather is additive and indeed adds a new dimension to training. All units should look forward to their two week opportunity at Fort Irwin to experience near combat conditions and to check out how well they have prepared themselves for such combat.

APPENDIX B
INDIRECT FIRE SIMULATION

In the last meeting (8-9 Jan. 81) of the Ad Hoc Subgroup on Phase II Instrumentation for the National Training Center, the topic of indirect fire simulation was raised several times. Subgroup members expressed concern that there did not appear to be an adequate training simulation for the effects of indirect fire. This concern was reinforced with distribution to subgroup members of a message from the Field Artillery School describing the need to realistically involve Howitzer crews in engagement simulation exercises, such as those to be conducted at the National Training Center. Generally speaking, the adequacy and/or availability of training methods and devices for both artillery crews and soldiers receiving indirect fire in engagement simulation exercises was questioned. The following notes discuss what appear to me to be critical considerations in developing and adopting training procedures for indirect fire in engagement simulation exercises, such as those that will be conducted at the National Training Center, submitted per your request for a report on this topic.

1. Engagement simulations training for maneuver arms should include realistic indirect fire training for both maneuver troops and artillerymen.

   Field artillery has presented increasingly difficult training problems in recent years due to financial and spatial constraints. Range limitations have become more severe as areas around live fire ranges

have become increasingly urbanized. Most artillery field training consists of dry fire exercises in which artillery men set up, go through a drill, move, set up and drill again. Live fire is expensive and requires too much room, consequently it can be done only once or twice a year. In dry fire training, artillery men usually only learn what they have done wrong. Correct, effective behaviors are not identified and "reinforced". Simulation training can provide a learning environment in which artillerymen can execute combat behavior and receive feedback as to right or wrong in terms of both choice and execution. This feedback, and the volume it has, is a critical consideration in providing training behavior that is remembered and incorporated into the trainees' behavioral repertoire. Simulation also can provide the opportunity for both discovery learning [the "'ah-ha, I did it right' -type-of-learning"] that is a very powerful training phenomenon, and for repeated trials, in which "discovered," effective behaviors can be practiced and perfected. Artillerymen do not have the opportunity for these training experiences even in live fire.

For the above reason, it may be more important to identify, develop, and make available effective simulation methods for artillery than for maneuver troops. That is, to a certain extent, maneuver troops have always had indirect fire simulation available in the form of controllers or fire markers placing artillery simulators and assessing casualties on the spot. Although this procedure may not be the most effective simulation method possible (to be discussed later), it <u>is</u> a simulation technique. And soldiers who are not moving behind cover or who are traveling in an exposed vehicle can experience the relationship between the manner in which they are maneuvering and their vulnerability to indirect fire. Furthermore, commanders who order indirect fire in an exercise are able to see its effect and gauge the importance of utilizing it in various missions. One drawback, however, is that the time interval between calling for and receiving indirect fire is not usually realistic, possibly leading to inaccurate expectations regarding the responsiveness of available batteries.

2. Techniques do exist for indirect fire simulation for artillery and for maneuver troops that are compatible with engagement simulation in the NTC. However, only Artillery Engagement Simulation (ARES) developed by the Army Research Institute, appears to have been systematically studied to determine its impact and validity as a training method.

Indirect fire simulation techniques compatible with MILES technology for both maneuver troops and artillery men exist. For maneuver troops, the procedure of having controllers place "rounds" by dropping artillery simulators is compatible with MILES exercises. The extent to which this is an adequate method will be addressed in Note 4: "Training Needs Analyses and Simulation Fidelity." For artillerymen, a simulation procedure has been developed by the Army Research Institute (in conjunction with Human Sciences Research, Inc.). This training procedure resulted from an examination of the important elements in an indirect fire sequence and an effort to exercise all of these elements in a training simulation. The objective of this technique is to involve every personnel component in the artillery firing system: the forward observer, fire direction center and firing battery. The attached figure, taken from the September-October issue of the "Field Artillery Journal," shows the basic components of the system. This training system was field-validated in October of 1979. An ARI report (Artillery Engagement Simulation, Research Report 1245, May 1980) describes results in which a 155 mm howitzer battery significantly improved its speed, accuracy, and consistency of performance. Furthermore, trainees were found to be enthusiastic about the technique, and felt they had learned a great deal. Although the ARES method does not include a flash/bang simulator, it can bring artillery men into engagement simulation exercises using their actual equipment and improving their tactical skills. Furthermore, it appears to be the result of a systematic training development effort in which the method has been subjected to analytic scrutiny in a field validation.

3. There does not appear to have been a systematic training development effort for troops receiving indirect fire as there has been for artillery batteries.

4. "Training Needs and Simulation Fidelity:" Development of simulation methodology should include an analysis of the training need, a determination of what stimuli have to be simulated to elicit behaviors that are the foci for training, and consideration of a method for incorporating behaviors learned in training into soldiers' permanent behavioral repertoires. Design and development of simulation-based training methods should focus on achieving "psychological fidelity" rather than merely attempting to replicate the operational environment through achieving physical similarity.

A designer of a simulation-based training system is faced with the problem of determining how much of the physical aspects of a system have to be faithfully reproduced to achieve effective training.

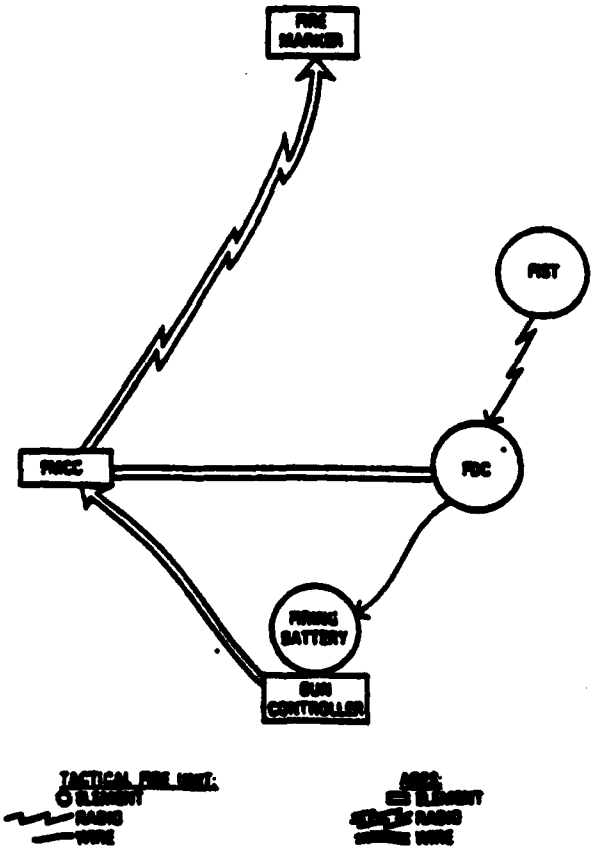
If the assumption is made at the outset that the simulation should be as close to the real thing as possible, the design job is over. What's left over is the often costly and, without doubt, complex implementation job of developing an engineering simulacrum of the operational environment. This appears to be the case, to me at least, for current Army efforts to develop an indirect fire simulation for maneuver troops receiving fires and to a certain extent, the case for recent requirements for training devices for artillerymen. What appears to be lacking are training device/method development requirements that are based on training needs analyses that specify what behaviors are considered to be critical to effective combat performance. These target combat behaviors can then become the bases of an analysis of what cues and stimuli have to be recreated in the simulation to elicit the behaviors critical for training. The last component or step in designing the simulation environment is to build in feedback mechanisms that give the trainee real-time or near real-time feedback as to the success or failure of his or her behaviors in terms of survival and/or job performance.

I have not been able to find an adequate training needs analysis for designing a simulation for indirect fire directed at maneuver troops. I have not seen an emphasis on preparing a training device requirement that focuses on training, rather than physical replication of the operational environment. This distinction is particularly important in light of OMB Circular A-109 which emphasizes the specification of system performance requirements rather than design requirements in system procurement. That is, development of an indirect fire threat simulation for maneuver troops should train effective combat behavior rather than merely replicate, as close as technology will allow, the sound, light, and overpressure effects of a bursting shell.

In summary, development of indirect fire simulation methodology for the National Training Center should be driven by a thorough analysis of training needs and a subsequent analysis of what stimuli and uses are necessary to simulate to achieve "psychological fidelity." This process has been described and executed in a number of contexts before. This approach is capable of providing the best training product in a cost-effective, expeditious manner. Efforts to develop simulators that are not based on such an analysis are misguided.

ATTACHMENT TO APPENDIX B

The goal was to involve everyone in the artillery firing system, including the FIST, fire direction center, and firing battery. The system had to make all elements feel responsible for the final result of putting "steel on target" and had to include a procedure for providing performance feedback. The steps in the system developed for artillery engagement simulation are as follows:



- Maneuver Commander designates the target.
- The FIST calls for a fire mission.
- The fire direction center computes firing data and transmits it to the firing battery sections.
- The firing battery places the data on the guns and "dry fires".
- The gun controller transmits the data on the guns to the FMCC.
- The FMCC computes the probable impact point and sends movement instructions, including distance and direction, to fire markers located at known points in the maneuver area.
- The fire marker paces off or drives the distance and marks the target.
- The FIST team observes the burst and adjusts fire accordingly.
- The FIST team provides feedback to the fire direction center which provides feedback in turn to the firing battery.

APPENDIX C
TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

REPLY TO ATTENTION OF

16 MAY 1980

Dr. J. Ernest Wilkins, Jr.
Associate General Manager
EG&G Idaho, Incorporated
Post Office Box 1625
Idaho Falls, Idaho 83401

Dear Dr. Wilkins,

Request that you empanel an Ad Hoc Sub-Group of approximately eight Army Science Board members to examine Army plans to use modern instrumentation technology to evaluate unit exercises at the Army's National Training Center (NTC). The review should focus on the second generation instrumentation support system, addressing the technical feasibility and engineering realizability of meeting the declared schedule of implementation. Some background literature is attached.

As additional background, please note that:

1. The highest priority Army training initiative is to establish the NTC at Fort Irwin, California. The NTC would provide an area where battalion task forces can be evaluated to gather hard data about battlefield performance and combat effectiveness of organizations and systems under realistic conditions. The battalion task force is the lowest level with a staff to coordinate the complex arms elements of combat power.

2. Since combat conditions are to be duplicated with fidelity at the NTC, battle realism evaluation, and feedback in this environment require comprehensive instrumentation and computer support to provide objective, detailed, and timely assessment of unit performance. Such instrumentation provides the ability to address questions of force readiness and effectiveness of doctrine, organizations, equipment, and training techniques.

3. The NTC instrumentation and control system is designed to collect and report data, enhance overall realism, control the exercise, record and process collected data, and generate displays for review and evaluation. For those actions which are not suitable for direct instrumented collection, controllers will collect data off-line. Instrumentation will include time-space position location, targets, key event recording, voice

and video recording, and appropriate analysis and playback facilities. Initial instrumentation (Phase I) has been demonstrated and is under procurement. It is scheduled to be operational by April 1982. Later Phase II instrumentation would replace or supplement Phase I hardware with advanced technology equipment in FY 85 and beyond.

4. Instrumentation procurement and R&D funds are programmed as follows ($ millions):

	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86
OPA	10.3	4.8	8.8	0.2	0	0	0
RDT&E	0	0.5	0	0.5	0.5	0.5	0.5

NOTE: Phase II procurement would involve significantly increased post-FY 86 funding.

The sub-group should address these Terms of Reference:

1. Are currently planned Phase II programs and budgets technologically sound, reasonably manageable, and logically structured to achieve target milestones? Is the proposed expansion realistically phased and funded?

2. What other technologies could be applied to second generation NTC instrumentation support systems to efficiently provide quality Phase II instrumentation? Which research and development options, with milestones, should be integrated into the Phase II plan?

3. What development, engineering, and technical management adjustments should be made to facilitate integration of future technical considerations into the planning, programming, and budgeting system?

I would appreciate a report on the National Training Center Phase II instrumentation system by the end of September 1980, so that the Army Science Board's advice can be considered as the FY 82 budget is developed.

Sincerely,

Percy A. Pierre
Assistant Secretary of the Army
(Research, Development and Acquisition)

2 Inclosures
1. Pamphlet, NTC, Sep 79
2. NTC Development Plan, HQ TRADOC, 3 Apr 79

APPENDIX D
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APPENDIX E
MEETINGS CONVENED

AGENDA
The Pentagon, Room BF 746

11 June 1980	
0830-0930	Army Training in General
0930-1015	NTC Plans
1015-1130	NTC Instrumentation
1130-1230	Lunch
1230-1330	Live Fire Ranges
1330-1430	Soviet Training
1430-1630	Discussion
12 June 1980	
0830-1030	Harry Diamond Laboratory
1030-1200	Discussion

AGENDA
Nellis AF Base and Ft. Irwin

9 July 1980	
0800-0845	HEMI Briefing
0845-0920	Red Flag Briefing
0920-1130	Range Instrumentation Briefing
1130	Lunch and Travel to Barstow
10 July 1980	
0840-0900	Courtesy Call on Ft. Irwin NG Commander
0900-0945	Tour of Facilities
0945-1200	Helicopter Tour of Ft. Irwin
1200	Lunch and Travel to Pasadena
11 July 1980	
0845-1130	Jet Propulsion Lab, MAFIS & GPS Briefings
1130-1230	Lunch
1230-1300	Travel to Xerox Electro Optics
1300-1600	MILES Briefings

AGENDA
The Pentagon, Room 2E271 and SPC

18 August 1980	
0830-1130	Army Research Institute
1130-1230	Lunch
1230-1630	Executive Session
19 August 1980	
0830-1130	Briefings by System Planning Corporation
1130-1300	Lunch and Travel to Pentagon
1300-1630	Executive Session

AGENDA
Fort Leavenworth, Kansas

13 November 1980	
0830-0840	Welcome Remarks by Cdr, CAC & Ft Leavenworth
0840-1030	Combined Arms Systems Analysis Agency Overview Battlefield Visualization Graphics System Overview
1030-1130	Nuclear Battlefield Simulation
1130-1230	Lunch
1230-1400	CATTS Demonstration
1400-1500	ARTBASS Briefing
1500-1630	Executive Session
14 November 1980	
0830-1030	NTC Contract Status Briefing
1030-1200	Executive Session

AGENDA
The Pentagon, Room 3A486

8 January 1981	
0830-1230	Technical Presentation on NTC Phase I Contract
1230-1330	Lunch
1330-1400	Concept for Air Defense Play at NTC
1400-1500	Phase II R&D Proposal
1500-1630	Executive Session
9 January 1981	
0830-1200	Executive Session

AGENDA
Fort Irwin

21 February 1981	
0850-0910	Courtesy Call on Commander
0910-1000	NTC Command Briefing
1000-1030	Informal Discussions with NTC Staff
1030-1115	Tour of Facilities
1115-1215	Lunch
1215-1530	Live Fire Range Validation - Daytime
1530-1700	Preliminary Range Evaluation and Unit Performance After Action Review
1700-1830	Supper in Field
1830-2000	Live Fire Range Validation - Nighttime
2000-2100	Preliminary Range Evaluation and Unit Performance After Action Review

APPENDIX F
ACRONYM DEFINITIONS

AAR	After Action Review
AHSG	Ad Hoc Sub-Group
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ASB	Army Science Board
CAC	Combined Arms Center
EW	Electronic Warfare
FY	Fiscal Year
GPS	Global Positioning System
JPL	Jet Propulsion Laboratories
LORAN	Long Range Navigation System
MAFIS	Mobile Automated Field Instrumentation System
MILES	Multiple Integrated Laser Engagement Simulator
MOUT	Military Operations in Urbanized Terrain
NBC	Nuclear, Biological, and Chemical
NTC	National Training Center
ODCSOPS	Office, Deputy Chief of Staff for Operations and Plans
ODCSPER	Office, Deputy Chief of Staff for Personnel
ODCSRDA	Office, Deputy Chief of Staff for Research, Development and Acquisition
OPFOR	Opposing Force
PLRS	Position Location Reporting System
PM	Program Manager
RDT&E	Research, Development, Test and Evaluation
RFP	Request for Proposals
RMS	Range Measuring System
SPC	System Planning Corporation
TCATA	TRADOC Combined Arms Test Activity
TOR	Terms of Reference
TRADOC	U.S. Army Training and Doctrine Command
TSM	TRADOC Systems Manager
VLSI	Very Large Scale Integrated

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