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This study examines the manning implications of fielding new Army equipment focusing on the potential personnel impact of complex systems.

Block #7 (Cont)

GEN Leonard F. Chapman, Jr. (USMC-Ret)
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(12)

DEPARTMENT OF THE ARMY
ASSISTANT SECRETARY OF THE ARMY
RESEARCH, DEVELOPMENT, AND ACQUISITION
WASHINGTON, D. C. 20310

ARMY SCIENCE BOARD

AD HOC SUBGROUP REPORT

MANNING ARMY SYSTEMS

SEPTEMBER 1982

REPORT OF ARMY SCIENCE BOARD
PANEL ON
MANNING ARMY SYSTEMS

SEPTEMBER 1982

I. INTRODUCTION

The impetus for this study was the growing concern that the Army might not be able to operate and maintain new technologically advanced equipment with available personnel. While the Army has been developing personnel and training requirements for the many new systems that are being introduced, there was a worry that the full scope of the problem was not yet understood and that some sort of disaster might be impending. The letter requesting the formation of an ASB panel and the Terms of Reference for the panel are at Appendix A. The membership of the panel is shown at Appendix B. The panel met for a total of 10 days between 31 August 1981 and 7 May 1982.

As a first step, in order to form our own assessment of the situation, we selected a number of major new systems for study. These systems represent major Army investments and encompass a range of new technologies and operational characteristics (see Figure 1). Since these weapon systems are either only now being introduced, or are still in development, considerable subjectivity is necessarily involved in evaluating potential operational and maintenance problems. In the case of maintenance problems, our first thought was to base an assessment on detailed comparisons of maintenance ratios and MTBF and MTTR for the new systems compared to the systems that were being replaced, but that proved to be an overly ambitious objective. Except where the Sample Data Collection system has been in operation, systematic maintenance data on fielded systems are not available, and where it was in operation, interpretation of the data was not always straightforward.

We finally decided that it was more important to examine the goals that had been set for maintenance ratios and MTBF and MTTR for the new systems, what rationale and considerations were used to fix those goals, and what success the programs were having in reaching the goals. Because of time limitations, we confined this examination to four of the new programs listed in Figure 1 (marked with an asterisk).

a) Crew Operations.

As a first step, a "quick look" was taken at the concepts for crew operations for each of the new programs in Figure 1. Although system complexity and sophistication is increasing, the required crew tasks do not appear to be more compled. However, system reliability could alter this observation. Failures in the more complex systems increase the degraded operational modes that must be anticipated in combat and are bound to add to the training and proficiency problem. The soldier training programs for the new systems were reviewed by the recent TRADOC Soldier-Machine Interface Requirements (Complexity) Study. Some increases in operator training time appear necessary, but these increases are expected to be modest rather than major. In many cases, (such as firing the M1 gun, operating PATRIOT) if the equipment works as intended, crew operations are simpler for the new systems as compared to the old.

Having noted that, there is still a fundamental question that perhaps cannot be answered until these systems are deployed in substantial numbers. Many new technology features are "intelligence amplifiers". The pace of battlefield decisions is increasing. The full exploitation of the potential provided by the new technology depends on the soldiers' capabilities and level of proficiency. On the basis of the very limited exploration of this area that was feasible for the Panel, we are not entirely comfortable with the prospects for ultimate system effectiveness. We will return to this issue in our recommendations.

b) Maintenance.

A somewhat different picture emerged from our examination of the maintenance area. A key maintenance issue for these more complex systems is fault diagnosis/fault isolation particularly for complex electronics. Even if the MTBF for the new system is comparable to the MTBF for the old, the more complex equipment can fail more ways, and fault diagnosis translates into both a hardware & software problem. It has been long recognized that built in test equipment (BITE) and automatic diagnostic equipment is needed although it has been only belatedly recognized that design for maintainability, using built-in test equipment and self diagnostic software, must begin during the conceptual design of the system. The development of diagnostic hardware and software should be executed concurrently with the design of the operational system. Thus, while significant problems have been encountered in the M-1 and PATRIOT diagnostic systems, in large part because this concurrent development was not followed, these problems are not a good indication of how well automated diagnostic and maintenance strategies could work. However, even if concurrent development is followed, fault detection may continue to be a problem.

Diagnostic systems are designed by dividing possible system failures into two sub-groups: (1) those faults which are most likely to occur and which will be anticipated and planned for in the diagnostic system design and (2) all of the other faults which are less probable and, consequently, assumed safe to ignore in the diagnostic system design.

Typical examples of the first type are an "open" or a "short" in some single system component; typical of the second type is the simultaneous occurrence of two or more "opens" or "shorts". While trade-offs can be made on the relative size of the two groups, there is always a group which must be ignored and, as a matter of practice, it is much larger than the first group. On the average, the more reliable the system is, the better is it's diagnostic system's performance. Conversely, if the system's failure rate is relatively high, faults of the type ignored by the diagnostic system can be expected to occur often enough to make the diagnostic system, on the average, appear to be unsuccessful.

These characteristics of automatic diagnostic systems lead us to make the following two observations. First, every effort should be made to insure the highest system reliability to minimize the likelihood that the diagnostic system's capacity will be exceeded. Clearly, automatic diagnostic systems should not be viewed as a means for compensating for low reliability. Second, if the system is very complex, it is unlikely that an automatic diagnostic system can ever be made to work well enough to eliminate the need for a high level of maintenance skill. On the contrary, when the diagnostic system of a complex system fails to properly identify the fault, it is likely that some kind of multiple failure has occurred that will challenge the most highly skilled and experienced maintenance person to successfully correct.

Each of the programs we visited had a highly visible reliability and maintainability program. Each of the programs was optimistic about the prospects for meeting the established program reliability goals. But we did not have enough time to explore the technical problems in depth to form our own engineering judgments about whether "get well" programs were going to be successful. However, assuming that the reliability and maintainability goals are met, personnel skill requirements for maintenance and repair can be expected to increase because of the considerable increase in the complexity of the diagnostic equipment.

In the course of the discussions with the engineering and management people for these four programs, we made a point of probing the depth of analysis and supporting data that might show whether or not the MTBF goals for the different subsystems actually represented a technological limit. For example, if you look at the <u>distribution</u> of the maintenance ratio for the new M-1 tank compared to the M60A3 (Figure 2), it is apparent that the reliability of many of the new subsystems is markedly different (sometimes better, sometimes worse) than the old subsystems while the <u>overall</u> maintenance ratio is essentially the same. It would be remarkable if technology limits on subsystem reliability led to that result. Project response to our probing was spotty and not very convincing. The projects were working assiduously to fix bad actors (such as the transmission for the M-1 tank) to meet the MTBF goals for those subsystems, but where the goals were being met, the project was clearly satisfied. There was no evidence that the engineers were being pressed to improve MTBF beyond the original allocations, and there was no technical evidence to indicate that the original allocations represented a realistic limit on MTBF. If, in fact, reliability can be improved, that raises the question of the potential overall manning benefits of a systematic effort to improve reliability.

II. CAN RELIABILITY BE INCREASED

The general assusmption has been, (with Russian practice offered as one model), that improved system reliability would be purchased at the expense of system performance. However, results achieved on a number of recent mililtary programs have shown that the MTBF of complex advanced technology systems can be dramatically improved (sometimes by more than a factor of ten) without any significant loss of performance. Key lessons have been learned about the fundamentals of increasing reliability such as the importance of defining realistic mission profiles, the reduction of stress factors by selectively derating design criteria, and the need for a disciplined failure modes and effects analysis. Systems for which major improvements have been obtained range from an INS system for the F-18, the A6E TRAM Detecting and Ranging Set, the F-404 jet engine with four times the reliability of its predecessor in the same thrust class, the J79, but with ½ the weight, and the highly sophisticated F15 with better reliability than the F-4E.

There is always the possibility that such dramatic improvements in reliability are primarily a reflection of the poor initial condition of these systems. On the basis of the information available to us, we cannot exclude that possibility, but the more important point is that the systems cited as examples have been developed by experienced segments of U.S. industry to military requirements. As such, they are representative of the current state-of-the-art in the application of new technology. The marked improvements did not take place as a matter of course, but were the result of systematic high level focussed efforts. These examples do not prove that reliability can always be improved without performance penalties, but they do show that it should not be assumed that there must be performance penalties.

But even if some sacrifice in system performance is necessary to increase reliability, that may be a preferable choice considering an overall assessment of Army manpower and logistics, costs, and operational effectiveness. What are established as "required" system performance characteristics are often treated with a rigidity that can not be supported in terms of overall military effectiveness. Some modest relaxation of that rigidity may be readily justified militarily, if the benefit is an increase in system operational availability and operational effectiveness and a markedly reduced maintenance & logistics load.

While knowledge about how to improve system reliability is steadily increasing, that knowledge has not reached the point where precise predictions of what can be accomplished can be made for new systems. An important part of improved reliability comes from a better understanding of design details and design "stresses", and the introduction of new advanced technology systems invariably implies new designs and new hardware with new questions. Consequently, the prediction of reliability for a new system is uncertain and cannot be based on the probabilities of "random" failures, since the problems to be fixed are not generally "random" failures, i.e., they emanate from incomplete knowledge and foresight, not from known probability distributions. This fact of life must be taken into account in setting reliability goals and in structuring the development effort to improve reliability.

III. IMPACT OF INCREASED RELIABILITY

Some potential major benefits of increasing MTBF are

A. Operational availability in war would increase

B. Soldier confidence in the equipment would grow. This increases the liklihood that the performance characteristics supposedly designed into the equipment will actually be realized in war.

C. Operational training would be simplified and more effective, if the need to be concerned about equipment failures was reduced.

D. As MTBF increases, the maintenance strategy gets simpler. It becomes feasible to base the maintenance strategy on larger line replaceable units (LRU) assemblies since the need for replacement is reduced. That greatly reduces the need for fault isolation at a lower component level which can lead to very expensive and only partially effective diagnostic systems.

E. The maintenance strategy for peacetime would tend to converge with the maintenance strategy for wartime. The diagnostic system is not normally designed to deal with battle damage, i.e., more than a single component failure. If the maintenance strategy is based on fault isolation no further than larger LRU assemblies then system functional fault detection and replacement would become similar in peacetime and war. There would be no need for fault isolation at a lower component level.

F. The need for highly skilled technicians at the organizational level would decrease since they are primarily needed for diagnosis, not for replacement. If the failure rate of larger LRU assemblies is greatly reduced, the use of civilian maintenance support becomes more practical. There may be little need for in-country subsystems repair.

G. The size of the maintenance organization can be reduced. The manpower level can be set by requirements for battle damage operations not reliability maintenance and repair.

H. The Maintenance & Repair training program could be reduced saving skilled manpower and money. The training cost in money and time for new recruits is high considering to their average enlistment period as soldiers.

I. The demands on the logistics system would be reduced and fewer spares would be needed, improving military effectiveness and reducing cost.

The actual total of the benefits to be derived from increasing system reliability of course would vary from weapon system to weapon system. Intuitively, we believe that there would be a major impact on the Army's problem in maintaining technologically advanced equipment with available personnel. Some price would have to be paid in the R&D programs to increase reliability due to

a) Increased engineering costs for more sophisticated design and test analyses

b) Increased manufacturing costs for more demanding parts selection and fabrication control

The most important need now is for studies to evaluate (quantitatively where feasible) the overall benefits of the above factors (as well as others we may have overlooked) to provide the needed perspective for establishing system goals. These studies should be available before TRADOC and DARCOM negotiate new system performance specifications and agree on a program. We are most definitely not advocating the development of elaborate system computer simulations for this purpose. Rough cost estimates are all that are needed to help set the goals for system development. Precision at this stage would only be illusory.

The basic problem at present is that the incentive to set demanding reliability goals for the original specifications is lacking. There have beem some notable program exceptions, such as the UTTAS, where a reduction in maintenance and support requirement was the major technical goal. However, in most cases, TRADOC generates a system requirement to respond to the need for enhanced operational capability to meet changes in the threat. Along with specifying desired performance characteristics, TRADOC also specifies what it considers to be the minimum acceptable RAM requirements. On several of the new major systems, not surprisingly, the minmum requirement was to achieve maintenance ratios comparable to those for the systems' predecessors. DARCOM, on the other hand, seeks to adjust the requested performance requirements to what they think they can successfully develop and at the same time meet the minimum maintenance requirement set by TRADOC.

What is missing is a comprehensive strategy for setting development goals. In our opinion, the minimum acceptable maintenance ratio requirements should be thought of as a floor. We believe that the studies of the overall benefits of increased reliability will provide a strong incentive to set much higher goals for new systems. The dramatic improvements in system reliability that have been achieved in selected programs gives every reason to believe that intensive work in this area will be fruitful.

IV. CONCLUSIONS

The development of an overall program for successfully manning new army systems involves practically all of the functional areas of the Army. (This is reflected in the range of briefings for the Panel shown in Appendix C.) Up to now, to a considerable extent, manning army systems has been dealt with as an "open loop" process. Operational and maintenance features have received extensive attention in system specification but with few exceptions, such factors as the quality and number of required personnel, training costs, and logistics costs, have not been treated as major costs and problems that must be traded off against other new system objectives. New system specifications are established and then Personnel is given the task of developing a plan to support the operation and maintenance of the new equipment. As a rule, the characteristics of a new weapon systems are driven by anticipated or observed changes in the threat or the opportunities offered by improved technology. In our view the issue is not whether to use advanced technology in enhancing system capability, but rather how to use the new technology to produce the best overall effectiveness <u>including</u> manpower costs and capabilities. We have become convinced that there is a real potential for improved Army effectiveness and at the same time for a significant easing of the manning problem, with reduced overall cost. There is a strong and obvious motivation for seeking the edge in weapon system performance. But military objectives are not satisfied if soldiers cannot effectively operate the equipment, if equipment is not available when needed or if undue resources must be diverted to support functions rather than to combat capability.

In fact, major increases in system reliability may be essential if the Army is going to implement its new battlefield concepts for the future, i.e., highly mobile, sustainable, autonomous forces, as in Air-Land Battle 2000.

V. RECOMMENDATIONS

The questions in the original Terms of Reference were focussed on ways and means of assuring the Army's ability to operate and to maintain the new advanced systems being introduced. There was an implicit assumption that the expected levels of system failure were a more or less inevitable attribute of advanced technology systems. We believe that a different question should be asked. In setting system specifications, including reliability goals, how much weight should be given to the objective of reducing the Armys overall manpower costs required for the operation and maintenance of new systems? The answer to this question has led to our recommendation that the Army adopt a new strategy to reduce future manning problems. However, before discussing this principal recommendation, we will briefly summarize several recommendations on issues raised by the original Terms of Reference.

1. What personnel qualification needs, e.g., trainability, education, result from technical characteristics of new army equipment?

The specification of personnal qualifications needs takes place late in the process of development. We recommend that soldier/machine, manpower, and training impacts be examined early in the material acquisition process to insure that proper weight is given to these factors in the system specifications.

An increase in educational level would certainly be desirable, but does not seem crucial except for limited numbers of highly skilled individuals needed in the maintenance area.

2. Do technologically advanced weapons systems present more intensive soldier training requirements than previous generation equipment?

Yes, we believe that the new systems do require a higher level of training, but one that probably can be managed.

The enhancement of readiness and effectiveness by part task simulators deployable with TOE units would seem to be an idea whose time has come. The technology is available to exploit low cost, readily exportable and individually oriented devices that can both develop and evaluate soldier skills. Army efforts in this area should be strongly supported because of the potential of this new technology.

We believe that the maintenance training methodology and maintenance techniques should be re-examined. The question is what level of functional understanding is desirable for trouble shooting as opposed to the current approach which is a rote application of procedures.

While the utilization of man-machine technology early in system development can be improved, although we are not persuaded that the proposals to develop elaborate methodology for this purpose is a useful approach. We are faced with rapid changes in the form and nature of the man-machine interface which seems to us to require innovative application of the fundamentals of man-machine technology rather than the attempt to build up quantitative models of the past.

The full exploitation of the "intelligence multiplication" inherent in the new electronics depends on the development of suitably adapted operational software. Good software reliability depends on the careful definition of tasks that the operator is expected to perform, where the degree of operational flexibility incorporated in the software must be carefully tailored to the expected operator capabilities. The lack of such detailed operator interface specifications can be expected to lead to software failures. We recommend evaluation of these factors by simulation early in the development process. The need for such simulation, in defining the operational software for say airborne fire & control systems (such as TADS/PNVS) is well recognized, but the need will become equally acute for other systems as the introduction of electronic intelligence grows.

3. To what extent could advancing technology provide hardware, e.g., built-in test equipment, to assist operations and maintenance personnel?

Built in test equipment and automatic test equipment are essential, but they are not a cure-all and if not made part of the initial design, may not perform adequately. We recommend a strategy to use advancing technology to limit the required scope and complexity of the BITE & test equipment.

4. Can such assisting technology be added without imposing operational or other burdens on the weapons systems?

If we develop a complex piece of equipment with only moderate reliability, the complexity of the diagnostic system is not only likely to be a hardware and software burden, but could also be a severe operational and training burden.

5. Although the principal focus should cover a few major systems, what common conclusions emerge to suggest systematic changes pertinent to the overall research, development, and acquisition process?

We recommend a new strategy for reducing the future manning problem. In our opinion, a new reliability thrust is needed to change the scope and nature of the manning problem. While advanced systems are more complex, advanced technological techniques can also be applied to make them more reliable. Much more demanding reliability goals should be set for new systems than at present (together with the necessary front-end funding) with the objectives of markedly reducing manpower costs for training, maintenance, and logistics as well as improving system operational availability in wartime. High system reliability would appear to be an essential factor in the implementation of new battlefield concepts, such as Air-Land Battle 2000, which assume autonomous, functioning units.

The following specific steps are recommended to implement this strategy

a) Task TRADOC to carry out studies to determine how overall Army manpower costs would vary with improvements in the reliability of proposed complex weapon and weapon support systems. Much better reliability should allow a decrease in the size of the maintenance and associated logistics organizations and should decrease the soldier training costs for operations as well as maintenance. The results of these studies would provide an essential motivation for determining reliability goal requirements for any new systems.

b) Establish reliability goals for new systems at the appropriate level in the Office of the Secretary of the Army. This is recommended in order to assure, at project initiation, that the weight given to overall manning problems and manning costs is based on a broad Army perspective. At issue is the tradeoff between future manning problems and costs, system performance, and program funding level and funding profile. We also recommend that the Office of the Secretary of the Army form a multi-agency ad hoc group of experts from successful high reliability programs to advise on reliability goals and on the program structure required to achieve these goals. It will take an awfully long time to effect real changes if the key "lessons" and "techniques" have to be relearned over again for each program.

c) Establish strong incentives in the award of contracts for achieving reliability goals. If possible, avoid complicating the situation by associating reliability goals with scoring criteria used to assess the impact of failures on mission success. Scoring criteria often change with the evolution of operational concepts. In the past, a great deal of management and industry attention and argument has been focussed on scoring criteria, rather than on the technical issues.

d) Establish systematic programs to improve reliability as product improvement programs for systems already developed, or well along in development. Establish these programs at the same management level as for (b) to assure the required perspective, funding support, and attention.

SYSTEMS SELECTED FOR STUDY

- MAJOR ARMY INVESTMENTS
- ONE-FOR-ONE REPLACEMENTS (SIMILAR FUNCTIONS)
- NEW TYPES OF SYSTEMS AND FUNCTIONS

OLD	NEW
M-60	* M-1
COBRA	* AH64
HAWK	* PATRIOT
VRC-12 SERIES RADIOS	SINCGARS
M113	* IFV
CONVENTIONAL 155 MM ARTILLERY SYSTEM	COPPERHEAD SYSTEM

* VISITED PROGRAM MANAGEMENT OFFICE

FIGURE 1

MAINTENANCE RATIO
(% TOTAL)

	M60A3	M1 PREDICTION	M1 STATUS
MOBILITY ELECTRICAL	3.8	3.2	6.5
SUSPENSION	26.0	3.2	18.0
TRACK	26.9	8.1	15.0
ENGINE	5.5	5.2	17.0
TRANSMISSION	1.0	1.4	10.0
FINAL DRIVE	9.0	.4	1.6
MOBILITY OTHER	6.7	8.2	9.2
FIRE CONTROL	5.8	6.2	5.4
GUN TURRET DRIVE & STAB	10.5	11.4	7.3
GUN MOUNT/RECOIL	--	5.0	--
GFE	.5	10.7	2.0
NON MOB ELECTRICAL	1.0	3.5	2.1
NON MOB OTHER	3.6	4.7	5.9
M/R	1.49	1.0	1.34

FIGURE 2

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

17 April 1981

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

Dear Dr. Wilkins,

It is requested that you empanel approximately seven Army Science Board members to examine Manning Army Systems.

Technologically advanced equipment being introduced in the next few years may impose higher technical and educational requirements for Army personnel, particularly supervisors and those engaged in maintenance activities. As the number and, perhaps, the quality of eligible volunteers may decline in the next few years, techniques to offset projected people shortfalls need to be examined. It appears that Army plans for personnel acquisition, training, and retention need to be better coordinated to redress potential deficiencies.

Accordingly, the panel should examine the potential personnel impacts of fielding complex systems such as PATRIOT, the XM-1 tank, the Advanced Attack Helicopter (AH-64), the new utility helicopter (UH-60), and the M-2 Infantry Fighting Vehicle. The panel should address the following Terms of Reference:

1. What personnel qualification needs, e.g., trainability, education, result from technical characteristics of new Army equipment?

2. Do technologically advanced weapons systems present more intensive soldier training requirements than previous generation equipment?

3. To what extent could advancing technology provide hardware, e.g., built-in test equipment, to assist operations and maintenance personnel?

4. Can such assisting technology be added without imposing operational or other burdens on the weapons systems?

5. Although the principal focus should cover a few major systems, what common conclusions emerge to suggest systematic changes pertinent to the overall research, development, and acquisition process?

The panel should review recent studies, such as ARI's paper on Manned System Integration, the GAO report on Ownership Considerations, and the AMSAA discussion paper concerning Man/Machine Interface. Additionally, appropriate briefings can be provided from a variety of Army agencies. The panel should provide an analytical overview (rather than reporting on the host of on-going activities in this area) by restricting their primary scope of work to short, weapon system specific summaries.

It would be appreciated if a final report could be submitted five months from the initiation of work. Dr. Norwood will provide assistance.

Sincerely,

Arthur Daoulas

Arthur Daoulas
Acting Assistant Secretary of the Army
(Research, Development and Acquisition)

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BRIEFINGS

31 August 1981 - The Pentagon

Maintenance/Logistics System	DCSLOG
Personnel Implications of Current Sys	Soldier Spt Ctr
Reliability Study	Mr. Willoughby, Navy
OSD, DSB Views	Mr. Meth, OSD

1 September, 1981 - The Pentagon

Complexity Study Update	Col. Mickelson
Operational Concepts of New Systems	DCSOPS

15 October, 1981 - The Pentagon

Operational Concepts of New Systems: PATRIOT, TACFIRE	ODCSOPS LtCol Helmuth
Russian Design Procedures	Dr. Alexander
Army Fixed Forward Concept	LtCol Bower, US Army Ordinance School

16 October, 1981 - The Pentagon

Panel Review of System Evaluation	Mr. Bradshaw(APL) Mr. Bennett(AMSAA) Dr. Risser(ARI)
Operational Concepts of New Systems: SINCGARS	LtCol Abney
Meeting with DCSPER	LtGen Thurman

10 December, 1981 - The Pentagon

ASVAB Update	Dr. Eaton(ARI)
Maintenance Data	Dr. Risser(ARI)
PM Trade	Dr. Hofer
BOIP/QQPRI/Div 86	Col. Bettinger(SSC)

11 December, 1981 - Warren, MI

M2 FVS	Maj. Kern
M1 Abrams Tank	LTC Raffiani

BRIEFINGS (Continued)

6 January, 1982 - St. Louis

Introduction to the AAH System	Brabson
AAM-RAM	Lauber
AAH-Design	Vark
TADS/PNVS	Donald
Diagnostic Problems and Status	Jackson
Trouble Shooting Procedures	Jackson
Simulators & Trainers	Jackson

7 January, 1982 - Huntsville

Introductory Remarks	Mr. Compton
Patriot Film	
RAM Demonstration	Mr. Chance
Diagnostics Program	Mr. Welch
Support & Training	LTC Byrne
	CW3 Jorgensen

7 May, 1982 - The Pentagon

TRADOC RAM Overview	Mr. Demers
RAM Reg. & Analysis	Capt. O'Brien
RAM Overview	Lurber
Achieving User Requirements	Mr. Hollman

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