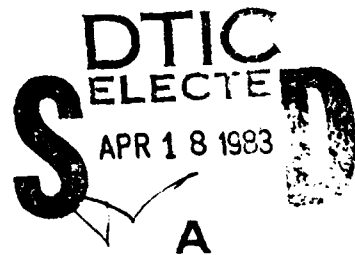


Research Note 82-14

DEVELOP AND EVALUATE NEW TRAINING AND PERFORMANCE
SYSTEMS FOR MAINTENANCE JOBS:
FINAL REPORT

Walter R. Harper, Henry K. Simpson, Richard G. Fuller,
and Douglas H. Harris
ANACAPA SCIENCES, INC.

TRAINING TECHNICAL AREA



U. S. Army

Research Institute for the Behavioral and Social Sciences

April 1981

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Item 20 (Continued)

In work completed prior to the final year, a prototype MPS was developed and operated by the contractor staff. Maintenance managers reported that the MPS provided useful, unique, and valid information to aid maintenance operations. During the 46-week period in which the prototype system was operated at Fort Carson, Colorado, the relationships among maintenance workload, efficiency, and skill were studied. As workload increased, efficiency decreased. However, changes in skill levels, through personnel turbulence and/or training, mediated between workload and efficiency. For example, efficiency might actually increase with increased workload, if skill levels increased as well. This finding supported the underlying premise of the MPS, that effort expended on increasing maintenance skills would pay off in increased maintenance effectiveness.

✓ The final year produced a streamlined and expanded MPS that could be handed over to and operated by Army personnel. The system encompassed 10 technical Military Occupational Specialties (MOS's) and the equipment of a mechanized infantry division. The system was proven during a 10-week implementation period at Fort Carson, Colorado. Also, a study of MPS potential in geographically dispersed operations, such as in USAREUR, concluded that the MPS would operate satisfactorily if data collection from outlying units were coordinated with maintenance control system procedures. ←

A total of 34 reports, manuals, system descriptions, and performance aids were prepared and submitted during the three-year project. These publications provide details on the project and the resulting MPS.

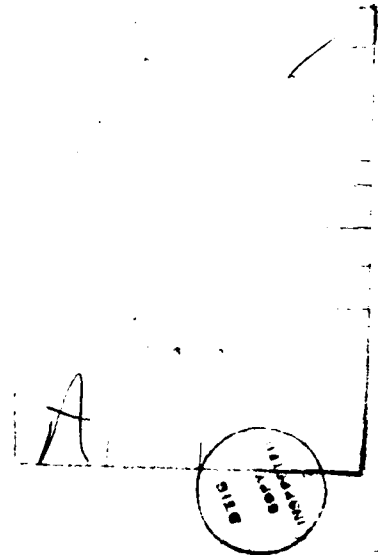
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FINAL REPORT

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FOREWORD

This report describes the final year of a three-year project. The objective was to develop, implement, and evaluate a Maintenance Performance System (MPS) designed to enhance performance on Army maintenance jobs. From the specific maintenance-related measures provided by the system, managers and supervisors can assess maintenance shop productivity and efficiency, and relate them to personnel skill and performance. Deficiencies can be identified and corrected by unit-level training. The completed system, including supporting documentation, was developed and handed over for operation by Army personnel.

A total of 34 formal reports, manuals, guides, and related documents was produced throughout the three-year project; 17 of these were produced in the third year. These documents are cited as source references throughout the text, where appropriate, to lead the reader to more detailed explanation than is feasible here. A project bibliography is also included in this report.

Anacapa Sciences, Inc., completed the work under Contract MDA-903-78-C-2007, with technical direction by the U. S. Army Research Institute for the Behavioral and Social Sciences (ARI). The project was also sponsored by the Army Training Board (ATB) and by the U.S. Army Ordnance Center and School (USAOC&S).

DEVELOP AND EVALUATE NEW TRAINING AND PERFORMANCE SYSTEMS FOR MAINTENANCE JOBS

BRIEF

Requirement:

To develop, implement, and evaluate a Maintenance Performance System (MPS) that will enhance Army maintenance performance through more effective unit-level training; to incorporate within the MPS a means for diagnosing maintenance performance problems and for prescribing appropriate training solutions, including the establishment of training priorities and specification of training resources and methods; and to design the MPS to be operable by Army personnel without contractor assistance.

Approach:

- Evaluated and modified the prototype MPS which had been developed and implemented during the project's first two years.
- Expanded the MPS to include a total of 10 technical Military Occupational Specialties (MOS's) and a complete equipment inventory of a mechanized infantry division.
- Analyzed tasks for each MOS and equipment item for use as a basis for defining maintenance performance and mechanic skills.
- Developed an MPS subsystem to diagnose maintenance problems and to prescribe appropriate unit-level training, including training priorities, resources, and methods.
- Prepared supporting documentation for the MPS: system description, operator's manual, training guide, and user's interpretation guide for performance measures.
- Implemented the MPS in two forward support companies of a direct-support maintenance battalion for operation by Army personnel.
- Studied the potential of the MPS in geographically dispersed operations, such as in USAREUR.

- Evaluated the MPS by analyzing data of various types collected during the final two years of the project.

Findings:

The final year of the project produced a streamlined and expanded MPS that can be handed over to and operated by Army personnel. The MPS, as finally configured, encompassed 10 MOS's and the equipment of a mechanized infantry division. The system was proven during a 10-week implementation period in two forward support companies of a direct-support maintenance battalion at Fort Carson, Colorado.

Analyses completed during the third year of the project showed that the MPS does not duplicate management and training information from existing or planned Army systems, such as the Standard Army Maintenance System (SAMS) or the USAREUR V Corps Maintenance Activity Management System (MAMS). The performance, skills, and training information provided is unique to MPS.

The MPS will operate satisfactorily in geographically dispersed operations, such as those characterized by operations in USAREUR, provided that the required data collection is closely coordinated with maintenance control system procedures.

Detailed analysis of maintenance performance measures and indices generated during a 46-week implementation of the prototype MPS during the second year of the project supported the underlying premise of the MPS: that efforts directed toward increasing the skills of maintenance personnel in the unit will have a positive influence toward improving effectiveness of maintenance.

For each of the MOS's studied, increased skill levels of maintenance personnel related strongly to positive changes in maintenance efficiency. Skill level was defined as the percentage of critical tasks on which repairmen, on the average, had reached proficiency. For example, increased maintenance workload (total direct repairman-hours spent on all maintenance jobs) significantly reduced maintenance efficiency (average repairman-hours per job). However, when the skill levels of repairman increased during the period, the expected effect of workload was mitigated. When skill levels decreased (usually through personnel turbulence), reductions in maintenance efficiency were found to be even more pronounced than when skill level either remained constant or increased.

Results of user surveys indicated that 70 to 90 percent of managers and supervisors rated MPS information as useful, unique, and valid.

Details of the three-year effort were provided in 34 different reports, manuals, and related documents.

Utilization of Findings:

The completed MPS will remain on-site at Fort Carson, Colorado, under sponsorship of ARI, for a six-month period to accumulate a reliable data base for subsequent evaluation. An evaluation plan was submitted, in a separate report, to provide guidance for this effort. Beyond this, tentative plans include installation and evaluation of the MPS in an armored or mechanized infantry division located in CONUS or USAREUR. Implementation in other types of units will require adaptation of the MPS to new MOS's and equipment items.

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INTRODUCTION

Much concern has been directed toward providing adequate training to the volunteer soldiers who maintain today's inventory of Army weapons systems. Both the content and delivery of training have been complicated by the increasing complexity, sophistication, and diversity of the systems to be maintained. To meet the challenge of providing adequate training within budgetary constraints, the Army changed its philosophy of conducting most training in institutions to a philosophy emphasizing training at the unit level. Under the new philosophy, the objective is to provide training in the field where it is needed and when it is needed.

Unit-level maintenance managers and supervisors now have increased responsibility for diagnosing maintenance performance problems, identifying training needs, and preparing appropriate training programs to meet these needs. The preparation of curricula and materials to support unit-level training is still centralized at Army schools that have the propensity for specific MOS training.

The current project was initiated because maintenance managers and supervisors needed a way to diagnose training needs and to prescribe and execute training solutions. Prior studies had noted that managers and supervisors lacked timely information for the identification of maintenance performance problems, and lacked methods for the application of existing training materials to overcome specific skill and procedural deficiencies. Not only did the maintenance manager and supervisor require training information not hitherto available, but they also needed to know how best to implement training decisions that would conform to the pressures and needs of the operational mission. Implementing a training decision that was practical within the limits of available resources required answers to supervisor's questions such as:

- What problems are causing poor maintenance performance?
- If poor performance is the result of inadequate repairmen skills, what skills are lacking? Are these skills generally lacking in repairmen with the same MOS or are they confined to specific individuals?
- Which maintenance problems in shop productivity can be solved by unit-level training? What are the options for conducting training at the unit level?
- What specific training resources are available to the unit? Which resources best suit specific training needs?

The project focused on these issues. In the third year of the project, a system was completed and implemented that could answer these questions for managers, supervisors, and trainers.

OBJECTIVES

The overall objective of the three-year project was to develop and evaluate a system to improve the performance of maintenance jobs. The system was to include methods for diagnosing maintenance performance problems, especially those related to training, whereby prescribed solutions would entail use of training resources available at, and under control of, the unit. The product was to be a Maintenance Performance System (MPS), that would encompass a spectrum of equipment items and MOS's, and would be capable of Army-wide application.

In the first year of this project, a preliminary system was developed in conjunction with the 704th Divisional Maintenance Battalion at Fort Carson, Colorado. The system identified problems in the areas of training, resources, management, and motivation. Although developed as a model, this system showed potential for identifying problems related to lack of technical skills, poor shop management, and poor utilization of resources. The system provided maintenance managers at battalion and company levels with data that reflected training needs in the context of existing resources, management controls, and personnel availability.

The main objective of the second year's work was to refine and expand the MPS, and to evaluate the operation of the system in direct-support maintenance at Fort Carson, Colorado. These specific objectives governed the work done in the second year:

- Expand the "model" MPS to a wider-based system by including additional MOO's, equipment, and maintenance tasks.
- Develop diagnostic-prescriptive methods for incorporation in the MPS so specific and appropriate training solutions could be developed for maintenance problems.
- Implement the enhanced MPS in one direct-support maintenance company and assess its utility.
- Compare direct-support maintenance procedures in CONUS with those of comparable units in USAREUR to identify procedural differences that could affect MPS.

Year-two results led logically to the following objectives for the third and final year of the project:

- Further expand the prototype MPS to include a total range of MOS's and equipment for a direct-support company.

- Develop appropriate comprehensive documentation for the MPS to meet requirements for a self-contained system--operator and user manuals, training guides, and performance interpretation guides.
- Prepare the final system for operation by Army personnel without contractor help.
- Develop a training course and train unit personnel in MPS operation.
- Compare conditions pertaining to direct-support maintenance in dispersed environments such as USAREUR as they relate to operation of the MPS.
- Design the final MPS package so it may be implemented in other Army maintenance battalions in other locations.
- Assess, within available operating periods, the effect of the system on unit maintenance performance.

APPROACH

The MPS was refined, expanded, implemented, and evaluated in the third year. The diagnostic-prescriptive concept that was examined for feasibility in previous stages of the project was developed and incorporated into the system. Supporting documentation and training materials were developed to facilitate use of the system by the Army without contractor assistance. Training documentation was developed so that it could be used in units which do not have the MPS. A detailed Work Plan was developed as a "blueprint" for the tasks to be performed during the third year. This Work Plan was modified to meet new requirements and modifications generated as the system developed.

As a preliminary step, a detailed review was made of the prototype MPS and of the results of its operation during the second year of the project. MPS outputs generated during an extended period of implementation within direct-support maintenance units were analyzed. In addition, comments and recommendations from field users regarding the utility and validity of MPS outputs were studied. These reviews and analyses were described in detail in Volume 1 of the First Interim Report for the third year.¹ The key steps in the third-year approach are illustrated in the flow chart of Figure 1. In addition to identifying the key steps, the flow chart shows the relationships among them.

¹Harper, W. R. Develop and evaluate new training and performance systems for maintenance jobs. Volume 1: MPS expansion, evaluation and related issues. Santa Barbara, California: Anacapa Sciences, Inc., First Interim Report, September 1980.

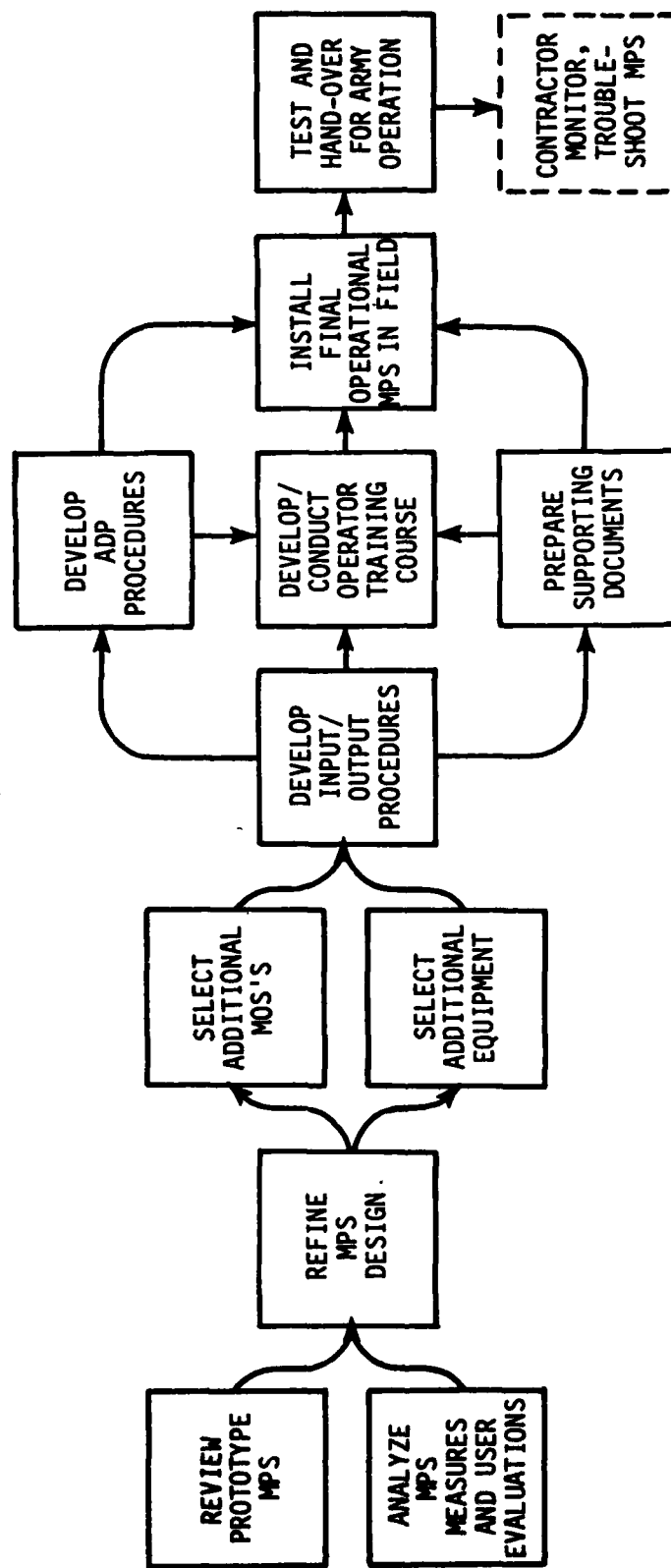


Figure 1. Key steps in third-year approach.

RESULTS

The final year of the project produced a streamlined and expanded MPS that can be operated by Army personnel. As finally configured, the MPS encompassed 10 MOS's and the equipment of a mechanized infantry division. The system was proven during a 10-week implementation period in two forward companies of a direct-support maintenance battalion at Fort Carson, Colorado.

MPS DESCRIPTION

The MPS provides specific maintenance-related performance measures that permit managers and supervisors to assess maintenance effectiveness and relate it to mechanic skills and maintenance training needs. The MPS establishes specific training priorities and specifies the training resources and methods required for overcoming specific performance deficiencies. The components of the MPS are illustrated in Figure 2. This figure also shows the flow of information among MPS components.

The MPS generates two basic types of information: management and training. Management information includes maintenance man-hour availability and use, average direct man-hours per job, average direct man-hours per job by equipment and task, average job completion time, and average days equipment spends in each job status. Training information includes individual skill histories, group skill histories, skill growth indexes, and prescribed training to overcome deficiencies. This information is generated via maintenance data collected on special forms. A brief description of input follows.

Examples of Maintenance Data Input

The forms cited facilitate maintenance data entry into the IBM 5120 system without additional clerical work. Form MPS-1 (Job Order Status) is used to record job progress through the shop. Form MPS-2 (Job/Task Performance) is used to record specific tasks done on faulty equipment, names of the repairmen who did the work, and direct labor hours spent repairing the fault. Form MPS-3 (Daily Man-hour Availability) entries list repairmen's availability in terms of hours available for work and hours on direct labor and overtime. Form MPS-4 (Roster Update) is used to record changes affecting the MPS roster of personnel derived from orderly room records. Form MPS-5 (Training/Performance Demonstration) is used to record technical training received by repairmen or to list a demonstration of task competence by repairmen. Form MPS-6 (Task Experience History) is used to record the experience a repairman has had performing tasks listed in the MPS. Form MPS-7 (Special Priority Flag) provides a manual method of recording training

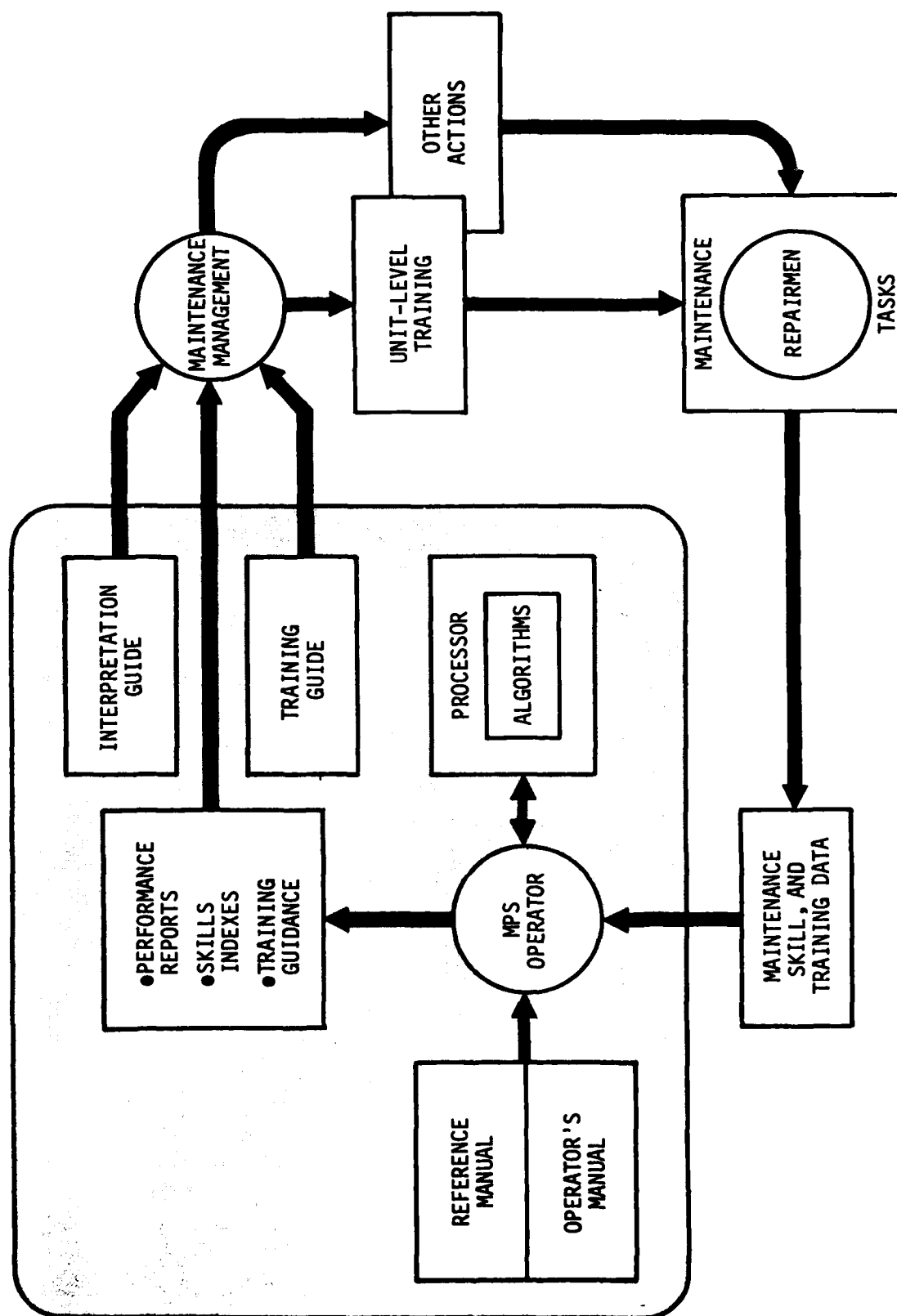


Figure 2. Components of the MPS (Shaded area).

priorities that must be added to, or deleted from, the computer-generated training requirements list. Form MPS-8 (Interpretation Comments) is used to record narrative comments for clarifying unique circumstances that may make report interpretation difficult. Form MPS-9 (Training Requirement Priority Threshold) is used by training managers to decide on the number of training tasks, by level of importance, that should be displayed on MPS Table 9.

MPS reports are provided to commanders, maintenance managers, supervisors, and individual soldiers. Management reports are generated every two weeks; training reports are generated every six weeks. These distribution intervals were based upon the rates of change of the information reported. The operating cycle of the MPS is illustrated in Figure 3. Detailed descriptions of MPS reports, data processing, and information collection procedures were provided in Volume 3 of the First Interim Report of the third year.² To round out the description of the MPS, a brief discussion follows of system reports.

MPS Output Summary

The management reports listed previously include Table 1 (Man-hour Availability and Use). The measures show assigned man-hours, manpower hours available, man-hours spent on direct labor, man-hours overtime and ratios of available man-hours. Table 2 (Average Direct Man-hours Per Job) shows the average amount of time in hours for each job done by a specific MOS. Table 3 (Average Direct Man-hours Per Job by Equipment and Task) specifies for the maintenance manager the average time taken to perform a specific task on a listed equipment item. Table 4 (Average Job Completion Time in Days) represents the total elapsed time from receipt of a job at the DS company to the time of the job being picked up by the customer. Table 5 (Average Days Spent in each Job Status) shows the time spent in selected job statuses, including awaiting parts and awaiting pickup.

The remaining four tables (6-9) are primarily oriented to data on training. Table 6 (Skill and Growth Indexes) shows data numerically and graphically for each repairman and also provides group indexes. Table 7 (Skill Development Summary) shows a current level of skill by MOS together with an index of the constituents of that skill level. Table 8 (Individual Skill History) shows the skill level of each repairman in each MOS listed by specific tasks on equipment items. Table 9 (Training Requirements Summary) indicates to unit training managers and trainers what job exposure is needed, what training needs to be developed, and which personnel require the training.

²Simpson, H. K., Fuller, R. G., & Harper, W. R. **Develop and evaluate new training and performance systems for maintenance jobs. Volume 3: development of output formats, processing, and collection procedures.** Santa Barbara, California: Anacapa Sciences, Inc., First Interim Report, September 1980.

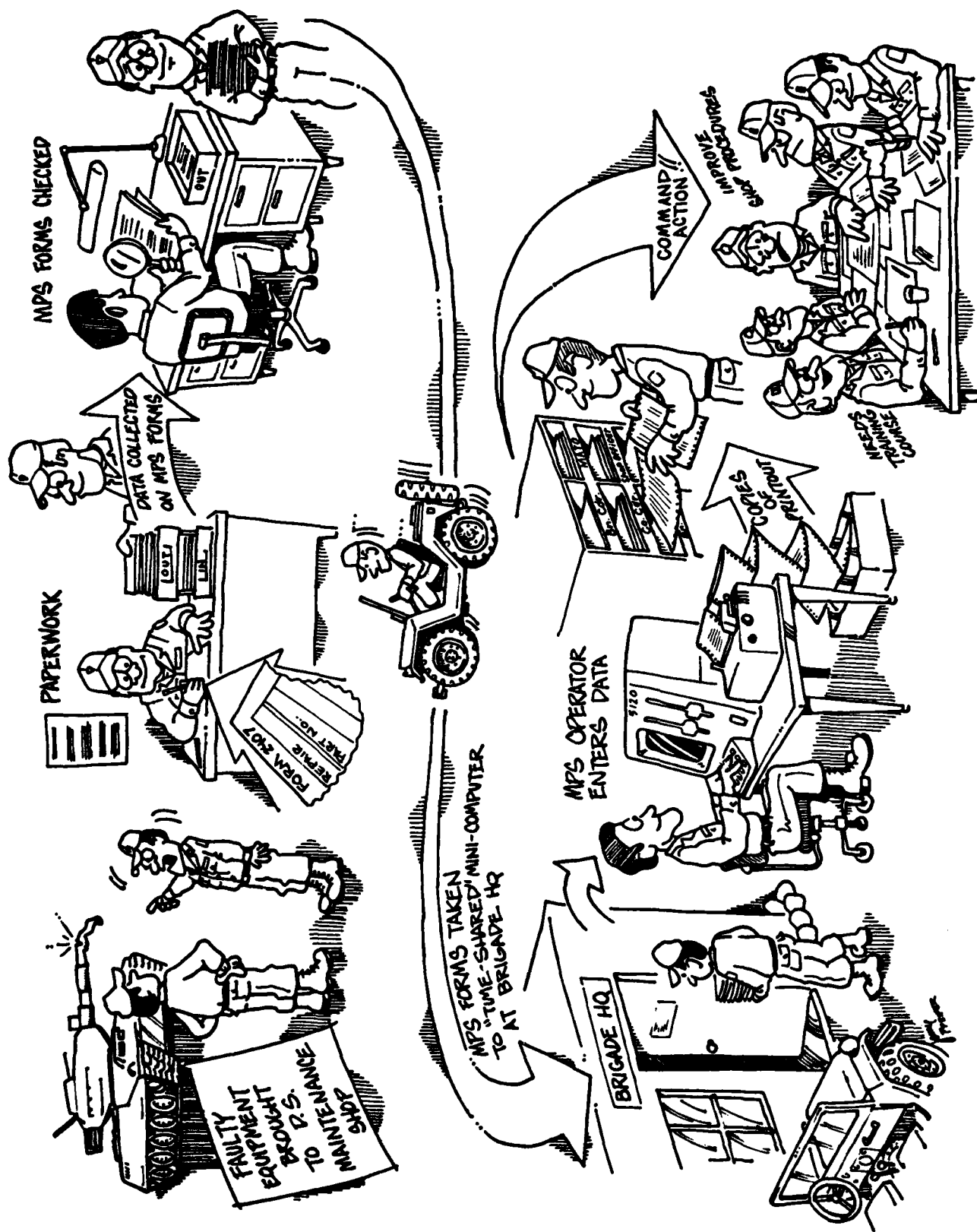


Figure 3. The operating cycle of the Maintenance Performance System.*

*In the style of PS Magazine, the preventive maintenance monthly.

The 10 MOS's covered by the MPS are listed in Table 1. These 10 MOS's are included in those authorized for a mechanized infantry division maintenance battalion and which existed in sufficient numbers to provide useful information.

One of the most important features of the MPS is its ability to help unit leadership identify and satisfy the specific training requirements of subordinates. The MPS permits users down to the company level to identify, diagnose, and prescribe corrective actions for skill deficiencies of repairmen. The MPS specifies training priorities in terms of specific tasks and specific individuals, and specifies the training materials to be used and the training methods to be employed. Furthermore, information is maintained on the status of task proficiency by individual and group. This information is stored and becomes part of the MPS data base.

TABLE 1
TECHNICAL MOS'S INCLUDED IN MPS

MOS	DESCRIPTOR
31E	Radio Repairman
41C	Fire-control Instrument Repairman
44B	Metal Worker
45B	Small Arms Repairman
45K	Tank Turret Repairman
45L	Artillery Repairman
52D	Power Generator Equipment Repairman
63G	Fuel and Electric Equipment Repairman
63H	Tracked Vehicle Repairman
63W	Wheeled Vehicle Repairman (as of CMF 63 change effective 1 October 1980)

SUPPORTING DOCUMENTATION FOR THE MPS

- **Operator's Manual**³ describes methods and procedures that MPS operators need to operate the system, including data collection, data entry, quality control, and report generation procedures.

³Fuller, R. G. *Development of a maintenance performance system for maintenance jobs: MPS operator's manual*. Santa Barbara, California: Anacapa Sciences, Inc., December 1980.

- **Guide for Individual Technical Training in Direct Support Units**^{4,5} presents the prescribed approach for accomplishing individual technical training within direct-support units. The guide is for those responsible for technical training in units, whether or not the MPS is installed. The second volume provides specific training resources applicable to specific MOS's, tasks, and performance deficiencies.
- **User's Reference Manual**^{6,7} provides a ready source of reference information and lists appropriate background data to help the user understand both the development and operation of the MPS. The manual was designed specifically for users who have had no previous experience with the MPS or have newly arrived in the direct-support unit and are required to use the system output. The system operating procedures and output are described in the manual in process/product terms. The second volume provides comprehensive input/output examples of MPS data and procedures.
- **Interpretation Booklet**⁸ summarizes interpretation of information provided in the weekly or six-weekly reports in concise ready-reference form. This booklet is designed for field users and is in an easy-to-use "hip-pocket" format.

⁴Simpson, H. K., & Fuller, R. G. **Guide for individual technical training in direct support units. Volume 1: Training methodology.** Santa Barbara, California: Anacapa Sciences, Inc., December 1980.

⁵Fuller, R. G., & Simpson, H. K. **Guide for individual technical training in direct support units. Volume 2: Training reference information.** Santa Barbara, California: Anacapa Sciences, Inc., December 1980.

⁶Harper, W. R. **Maintenance performance system user's reference manual. Volume 1: System description.** Santa Barbara, California: Anacapa Sciences, Inc., January 1981.

⁷Harper, W. R. **Maintenance performance system user's reference manual. Volume 2: Input/output examples.** Santa Barbara, California: Anacapa Sciences, Inc., January 1981.

⁸Harper, W. R. **Development of a maintenance performance system for maintenance jobs: Interpretation booklet.** Santa Barbara, California: Anacapa Sciences, Inc., March 1981.

RELATIONSHIP TO OTHER MAINTENANCE SYSTEMS

The MPS does not duplicate management and training information available from other Army maintenance and training systems. Continuous checks were made on the status of other developing systems, such as the Standard Army Maintenance System (SAMS), Maintenance Activity Management System (MAMS), and Maintenance Control System (MCS). At this time, no redundancy is foreseen between the MPS and these other systems. However, as other systems evolve, they might expand to incorporate features of the MPS or subsume the MPS within them.

MPS OPERATION IN DISPERSED UNITS

The MPS will operate satisfactorily in geographically dispersed operations such as those characterized by operations in USAREUR. The potential for MPS operation in USAREUR was investigated through visits to 13 direct-support components of the maintenance units stationed in West Germany. A detailed description of the USAREUR visit was published in January 1981.⁹

RELATIONSHIP BETWEEN TECHNICAL SKILLS AND MAINTENANCE EFFECTIVENESS

An underlying assumption of this project and of the MPS is that efforts directed toward increasing the technical skills of mechanics will pay off ultimately in increased effectiveness of maintenance. Even though this relationship appears to be a logical one, there has been little objective evidence to either support or refute it. A major difficulty in studying such a relationship has been that maintenance effectiveness is potentially influenced by many other variables in addition to repairmen skills. Thus, examining simple relationships has been essentially impossible.

Time-series analyses of maintenance performance measures and repairmen skill indices revealed that changes in maintenance skill levels within units related strongly to changes in measures of maintenance effectiveness. Skill level was defined as the percentage of critical tasks on which mechanics, on the average, had reached proficiency. Analyses were performed of measures and indices generated by the prototype MPS during a 46-week implementation in the second year of the project. During this period, technical skill levels did not change much as a consequence of directed training actions (because the complete diagnostic-prescriptive subsystem was not, at that time, part of the MPS) but primarily because of personnel changes that took place. That is, technical proficiency levels increased, decreased, or stayed constant as a result of changes in the mix of assigned personnel.

⁹Harper, W. R. Development and evaluation of new performance systems for maintenance jobs. USAREUR visit report. Santa Barbara, California: Anacapa Sciences, Inc., January 1981.

For each of the MOS's studied in the time series analyses, increased technical skill levels seemed to have a strong positive effect on maintenance efficiency. For example, increased maintenance workload (total repairmen-hours spent on all maintenance jobs) reduced maintenance efficiency (average number of repairmen-hours per job) in a significant number of cases. But, when the skill levels of repairmen also increased during the same period, the negative effect of workload on efficiency was mitigated.

This notion of the strong influence exerted by changes in skill level was reinforced by evidence that when skill levels decreased, reductions in maintenance efficiency were found to be even more pronounced than when skill level either remained constant or increased. In short, our analysis strongly suggests that decreased maintenance efficiency caused by heavy workload could be improved by an improvement in the level of technical skill.

MPS ACCEPTANCE

Results of user surveys indicated that 70-90 percent of commanders, managers, and supervisors rated MPS information as useful, unique, and valid. Acceptance of the training-oriented reports was particularly strong since most users felt that the reports fulfilled their need to decide what training was required, who needed it, and how it should be conducted. In addition, users were pleased with the simplicity and operational ease of the MPS, and with the quality of the supplementary documentation provided.

CONCLUSIONS

1. Efforts devoted to developing technical skills within maintenance units are likely to pay off in increased maintenance effectiveness or in counteracting forces that would otherwise reduce maintenance effectiveness. Therefore, unit-level individual technical training should not be construed by maintenance leadership as an activity that detracts from "getting the maintenance job done." In the long term, unit-level technical training is getting the job done.

2. The MPS is capable of providing useful and valid information for performance-based technical training. The system provides maintenance leaders and trainers with: training priorities in terms of specific tasks and individuals, the appropriate training resources to be applied, and the guidance on selecting the training methods to be employed.

3. The MPS can be operated and used by Army personnel.

4. The MPS does not duplicate management and training information from existing or planned Army systems, such as the Standard Army Maintenance System (SAMS) or the USAREUR V Corps Maintenance Activity Management System (MAMS). Information provided by the MPS on maintenance performance, skill levels, and training is unique to MPS.

5. The MPS will operate satisfactorily in geographically dispersed operations such as those characterized by operations in USAREUR.

6. The MPS can be implemented in maintenance battalions not normally in armor or mechanized infantry divisions. Implementation for each group requires adaptation of the MPS to the maintenance MOS's and tasks of the unit prior to implementation.

**DEVELOP AND EVALUATE NEW TRAINING AND
PERFORMANCE SYSTEMS FOR
MAINTENANCE JOBS**

TECHNICAL SUPPLEMENT

PROJECT GUIDELINES

The prototype MPS developed, implemented, and evaluated during previous stages of the project was refined, expanded, and prepared for Army operation and use during the final year of the project. The MPS provides information and procedures for actions by Army commanders, managers, and trainers responsible for solving maintenance performance problems and overcoming deficiencies in technical skills. The MPS was developed in accordance with guidelines established initially by the contract and subsequently during working meetings with the representatives of the sponsoring agencies. The following guidelines were provided for the third year:

- Data sources and operation of the MPS will continue on a not-to-interfere basis in "C," "D," and "E" companies of the 704th Divisional Maintenance Battalion at Fort Carson, with permission of the commanding officer.
- Data reduction and dissemination of results will also continue to be the responsibility of Anacapa staff for the first months of the final year. Off-site data reduction and batch processing will continue to be used for the prototype system. When the final operational version of the MPS is developed, on-site data reduction and processing will be used.
- Automotive, armament, fire-control, service and recovery, and communications/electronics tasks performed by the holders of appropriate MOS's will be related to the equipment inventory of customers of the 704th.
- The system will be designed to be operated and used by the Army; Army operation will be tested before the end of the project.
- Data collection will remain the responsibility of the Anacapa staff until military personnel are adequately trained to take over this function.
- Appropriate system documentation will be developed oriented to user's needs. This documentation should accompany the operational version of the MPS when handed over for Army operation.
- Anacapa Sciences will be responsible for developing and conducting an appropriate training course for military personnel prior to the handover of the MPS in the field.
- When the MPS is implemented at Fort Carson, Anacapa Sciences staff will assume an advisory and consultant role until unit operators are adequately practiced in system operation.

- No automated data processing system will be used in the course of this research except for storing and processing of experimental project data, or for demonstrating the feasibility of the concept over an extended period. Any procedures or methods developed in connection with storage of experimental data shall, however, remain the property of the Army at the end of this contract.

TECHNICAL APPROACH

The work conducted during the third year was directed toward meeting the following primary objectives:

- Expand the MPS to include all key MOS's and tasks related to the equipment maintained by those MOS's within a mechanized infantry division.
- Develop and implement a diagnostic/prescriptive subsystem for the MPS.
- Prepare the components of the enhanced final MPS for operation by Army personnel.
- Provide MPS user's manuals, operator's manuals, unit-level training guides, and performance interpretation aids to support MPS operation and use.
- Evaluate the final MPS's capability to supply useful and valid training and management information.

Related work done during the MPS final development phase included study of the relationship between technical skills and maintenance effectiveness, assuring that the MPS would not be redundant with existing maintenance systems, and examining the potential for the MPS in dispersed conditions similar to those existing in USAREUR.

The approach to MPS development and conduct of secondary tasks was described at length in the first and second interim reports produced for the third year (see Reference 1, Page 5, and Reference 10, below). A summary is included here of the key steps in the MPS development.

MPS DEVELOPMENT

Selection of Additional MOS's

The model system developed in the first year focused on a single MOS (63H--Automotive Repairman) and two items of equipment. The prototype system developed in the second year added four more MOS's and four items of equipment.

¹⁰ Harper, W. R. Develop and evaluate new training and performance systems for maintenance jobs. Second interim report: Final development maintenance performance system. Santa Barbara, California: Anacapa Sciences, Inc., February 1981.

At the outset of the third year's work, the intent was to provide full coverage of all maintenance MOS's and associated equipment in a mechanized infantry division. The investigation into MOS candidates for inclusion in MPS revealed a possible 20 MOS's that could be included. The criteria used for final selection were that the MOS under consideration must actually be on-site and work on appropriate equipment within his specialty. However, we found that some MOS's were in the TO&E, but their MOS-specific equipment was not available in the division inventory and there was no real requirement for staffing in the related MOS. A notable example was MOS 31J (Teletype Equipment Repairman).

From the 20 candidates for inclusion, therefore, only 10 MOS's met the criteria. These MOS's were:

- 31E--Radio Repairman
- 41C--Fire Control Instrument Repairman
- 44B--Metalworker
- 45B--Small Arms Repairman
- 45K--Tank Turret Repairman
- 45L--Artillery Repairman
- 52D--Power Generator Equipment Repairman
- 63G--Fuel and Electric Equipment Repairman
- 63H--Tracked Vehicle Repairman
- 63W--Wheeled Vehicle Repairman.

Other repairmen with different MOS's worked in these duty MOS's full time on a permanent basis. For example, MOS 26C (Radar Repairman) worked full time in MOS 31E (Radio Repairman). Men in categories such as these were listed for our purpose in their duty MOS rather than their formally assigned MOS. Our objective throughout was to build a practical system that reflected real-life conditions rather than design to "what should be."

Addition of MOS-Related Equipment

The process used to identify and select additional equipment items serviced by the forward support companies of the 704th Divisional Maintenance Battalion was basically one of matching equipment to MOS responsibilities and AIT-taught tasks. The tentative equipment list for field validation was developed from an analysis of the inventory listed for each customer battalion in the Battalion Organizational Property Book held by DMMC. Equipment not serviced at the DS level but by other units of the 704th was not included in the listing.

Although some items were listed by model type in the property book, they had been replaced by different models. Generators, for example, come from many different manufacturers, have different TM's and different structure, but have similar characteristics. These items were included. The tentative list was submitted to subject-matter experts, such as senior warrant officers, to ensure that the equipment listed on paper did indeed represent those items actually serviced by the battalion. The modified list formed the nucleus of task and performance-step statements which were required for recording individual experience and task performance in the MPS.

The tasks for MOS 45K (Tank Turret Repairman) and MOS 45L (Artillery Repairman) were combined on the same list (but shown in separate blocks) as 45K/L. In field conditions, these MOS's interchange on the same tasks without regard to assigned MOS's since their skills are so similar. Those men in both MOS's got credit for all tasks they performed.

A similar decision was made on the tasks for the 63H (Tracked Vehicle Automotive Repairman) and 63W (Wheeled Vehicle Automotive Repairman). The CMF 63 change of 1 October 1980 included MOS's defined by these two specialties. However, the consensus from the field has been that until the new AIT graduates from the school are received at the units, personnel already on-site will continue to perform tasks on both categories of equipment. For reasons similar to those for the MOS 45K/L, MOS 63 is listed on a temporary basis as 63H/W.

The relationship of the MOS's, their tasks, and the equipment on which the tasks are performed, is shown in Table 2.

Completion of Job Analysis and Task Inventory

A list of all job-related tasks was compiled. The intent was to use Soldier's Manuals tasks as a criterion of criticality. This proved only partially successful because the Soldier's Manuals for MOS's in CMF 63 were in the process of revision to conform to the CMF change and were not available; the scope of CMF 63 tasks was not fully documented at that point.

The procedure was generally as follows: a preliminary list of critical tasks was obtained from the school having AIT proponentcy. The critical tasks listed were compared with those cited in the Soldier's Manual or equivalent list. The Soldier's Manual lists tasks in two categories. Those cited in Chapters 2 or 3 are considered most critical by the proponent schools. Each task in these chapters contains details of conditions for task performance, standards for task accomplishment, key steps in performance of the task (performance measures), appropriate references, and study aids. The tasks in Chapter 4 of the Soldier's Manual are considered important but not critical. They are thus listed by number and title only with an appropriate TM reference. The final task lists were reviewed for validity and accuracy of description by subject-matter experts and shop personnel. The tasks and equipment included in the final list reflect the results of this review.

Identification and Validation of Key Performance Steps

Key performance steps were technically not required for MPS operation. However, we found that they are almost mandatory for definition of what is included/measured during performance of a task. During field trial of the prototype MPS, major difficulties were experienced among users in deciding exactly what task statements meant; hence, the detailed key steps.

TABLE 2
BREAKDOWN OF EQUIPMENT LISTED IN MPS BY MODELS AND MOS's

MOS	MPS EQUIP. CODE NO.	EQUIPMENT	MODELS INCLUDED
63H (Tracked Vehicle Repairman) After 1 October 1980	1	M60 family	M60A1 - Tank M60A2 - Tank M9 - Dozer M728 - Combat Engineer Vehicle AVLB Chassis
	2	M113 family	M113A1 - Personnel M106A1 - 81 Mortar M125A1 - 107 Mortar M220 - TOW M548 - Cargo M577A1 - Command Post M901 - ITV
	3	M109/M578	M109A1 - Howitzer M578 - Light Recovery Vehicle
	4	M88	M88 - Medium Recovery Vehicle
	5	Other	All other tracked vehicles
63W (Wheeled Vehicle Repairman) After 1 October 1980	6	M151 family	M151A1 M151A2 M718A1 - Ambulance
	7	Gama Goat	M561 - Cargo M792 - Ambulance
	8	M880 family	M880 - Cargo M881 - Cargo M882 - Cargo M883 - Shelter M884 - Shelter M885 - Shelter M886 - Ambulance
	9	2½/5 ton M series	M35A2 - Cargo M36A2 - Cargo M49C - Fuel M50 - Water M109 - Van M185 - Van M51 - Dump M52 - Tractor M54 - Cargo M813 - Cargo M814 - Cargo M816 - Wrecker M817 - Dump M818 - Tractor

TABLE 2 (Continued)

MOS	MPS EQUIP. CODE NO.	EQUIPMENT	MODELS INCLUDED
63H (Continued)	9	2½/5 ton M series (Continued)	M819 - Wrecker M820 - Van M821 - Stake
	10	Other	All other wheeled vehicles
63G (Fuel and Electric Re- pairman)	11	Brakes	All wheeled vehicles
	12	Carburetors	M151 and M880 series
	13	Distributors	M151 series
	14	Fuel Pumps	All vehicle fuel pumps
	15	Generators/ Alternators	All generators/alternators
	16	Injector Nozzles	All diesel engines
	17	Regulators/Control Boxes	All regulators/control boxes
	18	Starters	All vehicle starters
	19	Other F&E	
52D (Generator Repairman)	20	GED Generator	Gas engine driven generators
	21	DED Generator	Diesel engine driven generator
	22	Other	Material handling equipment and any other equipment
31E (Radio Repairman)	23	RT-246/524 R-442	Receiver/Transmitter, RT-246/VRC Receiver/Transmitter, RT-524/VRC Receiver, R-442
	24	GRA39	Control Group, AN/GRA39
	25	C-2296/7/8	Control, C-2296/VRC Control, C2297/VRC Control, C-2298/VRC
	26	AM-1780	Amplifier, AM-1780/VRC
	27	PRC-77	Radio Set, AN/PRC-77
	28	CVC	Helmet, Comb. Veh. Crewman
	29	TA-312	Telephone Set
	30	Other	All other equipment
41C (Fire Control Equip. Repairman)	31	Aiming Circle	M2
	32	M17 Series Binoculars	M3, M13, M15, M16, M17, M19
	33	M18 Binoculars	
	34	M1 Collimator	
	35	M13 Computer	Ballistic Computer, M13
	36	M1 Quadrant	
	37	M19 Periscope	M19, M24

TABLE 2 (Continued)

MOS	MPS EQUIP. CODE NO.	EQUIPMENT	MODELS INCLUDED
41C (Continued)	38	M32/36 Periscope	
	39	M15 Quadrant	M13, M15
	40	M145 Telescope	M145, M146
		Mount	
	41	M17 Rangefinder	M17, M17A1, M17A2
	42	M53 Sight	
	43	M105 Telescope	
	44	M118 Telescope	
	45	M117 Telescope	
	46	M10 Ballistic Drive	
	47	Infinity Sight	8635466
	48	Compass	M2 and Lensmatic
	49	Other	
45K/45L (Tank Turret Repairman/ Artillery Re- pairman)	50	M60 Tank family	M60A1 - Tank M9 - Dozer M728 - Combat Engineer Vehicle
	51	M109A1 Howitzer	
	52	Other	All other armament work
45B (Small Arms Repairman)	53	M16	Rifle
	54	Cal .45	Pistol, M1911
	55	M203 GL	Grenade Launcher, M203
	56	81mm	Mortar, 81mm
	57	107mm	Mortar, 107mm
	58	M60 MG	Machinegun, 7.62mm, M60
	59	M2 MG	Machinegun, cal .50, M2
	60	M85 MG	Machinegun, cal .50, M85
	61	M240 MG	Machinegun, 7.62mm, M240, M73, M219
	62	Other	All other small arms
44B (Metalworker)		Various	Oxyacetylene Welding Arc Welding Glass Repair Fuel Tank Repair Radiator Repair Body Repair Other

The definition of tasks in precise terms (i.e., by key performance steps) was considered vital in development of the MPS since it made the connection between what soldiers **actually** did to what they were **supposed** to do, according to the Soldier's Manual and other task-oriented documents. The final MPS reflected both field user's and the school/SQT requirements.

Development of MPS Reports

The MPS reports provide information related to the 10 MOS's described previously. The information falls into five technical categories:

TECHNICAL CATEGORY	MOS'S INCLUDED
Automotive	63G, 63H, 63W
Generator	52D
Armament	41C, 45B, 45K, 45L
Communications and Electronic (C&E)	31E
Service and Recovery (S&R)	44B

The MPS reports were designed to reflect the need for brevity, simplicity, and ease of interpretation. The recipients of the reports included:

- Battalion Commander
- MATO
- Company Commander
- Shop Officer
- Maintenance Platoon Leader
- Automotive Maintenance Technician
- Armament Technician
- Communications and Electronics (NCOIC)
- Individual soldier
- Company office

The MPS produced a total of 58 reports. These included a roster, a set of interpretation comments, and nine different types of tables. The roster was used to track individual soldiers and MOS's. The interpretation comments were used to highlight events that could influence the quantity or quality of data in the reports.

Maintenance management information was developed for use in gauging maintenance efficiency, effectiveness, and personnel availability. These reports were generated at bi-weekly intervals and distributed to commanders, maintenance managers, and senior supervisors.

Training information was developed to reflect various aspects of skill, training, and training management. These reports were generated every six weeks and distributed to training personnel and training management.

Most of the reports in the MPS were logical derivatives of those in the prototype MPS. Some tables in the prototype system were not included in the final system because users assessed them as having limited value. A detailed discussion of each output table, with examples of its format, is contained in Volume 2 of the User's Reference Manual (Input/Output Examples). (See Reference 7, Page 12).

Data Processing Program Development

The specification for the MPS program to process experimental data was developed to encompass four general requirements: data input, report generation, data base editing, and data base compression.

Since the anticipated system operators were to be Army enlisted personnel with no specialized background, the specification required that the program contain extensive prompts and otherwise made simple to use; all operator inputs were to be error-checked for range, type, and in some cases compatibility with prior inputs.

Operator Training

Two persons designated by the 704th Divisional Maintenance Battalion Commander were trained prior to installation of the MPS in the field environment at Fort Carson. Only one person was required to operate the system. However, sound logistics planning required that a reserve operator be available so that the system would still function if the primary operator was not available. (The actual operation of the system required about 32 man-hours weekly.) The five-day training course covered key components of the MPS under operator control in the military environment. The curriculum included roster preparation, collection and entry of maintenance data via the various MPS special forms, and "hands-on" use of the data-processing equipment so operators could become skilled in use of the keyboard and printer. A copy of the operator training course curriculum is shown as Figure 4.

The Operator Manual cited previously (see Reference 4 on page 12) was used as a course textbook. In addition, special material was supplied for study by the operators.

Implementation of the MPS

Immediately after the system operators were trained in all aspects of the system, the data processing hardware was installed in the headquarters building of the 704th Divisional Maintenance Battalion, Fort Carson, under control of the

MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY	
0800	RGF/DHH ORIENTATION	RGF	HOW TO USE MPS-1 & 2	RGF	REVIEW USE OF FORMS	HKS	REVIEW DATA ENTRY	HKS	
0900	RGF MPS OVERVIEW START UP AND RUN			HKS	HOW TO ENTER DATA FROM MPS-4 AND GENERATE A ROSTER	HOW TO ENTER DATA FROM MPS-5, 7, 8, & 9		HKS	
1000	RGF ROSTER PREPARATION AND HOW TO USE MPS-4 & 6	HKS	HOW TO USE MPS-5, 7, 8, & 9	HKS	HOW TO ENTER DATA FROM MPS-6	HOW TO GENERATE REPORTS		HOW TO USE SUPPORT PROGRAMS	
1100								CLASS EXERCISE	
1200	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH	
1300	RGF CLASS EXERCISE	HKS	HOW TO USE MPS-5, 7, 8, & 9 CONT.	HKS	HOW TO ENTER DATA FROM MPS-3	CLASS EXERCISE	EXERCISE CONT.	RGF/HKS	
1400	RGF HOW TO USE MPS-3	HKS	REVIEW USE OF IBM 5120 AND INTRODUCTION TO MPS PROGRAMS	RGF	HOW TO ENTER DATA FROM MPS-1 & 2		REVIEW AND HANDS-ON STUDENT DEMONSTRATION OF ALL PROCEDURES		
1500	HKS INTRODUCTION TO IBM 5120 AND OPERATOR EXERCISE	HKS	CLASS EXERCISE	RGF	CLASS EXERCISE	HOW TO DISTRIBUTE REPORTS			
1600									
1700		AT-HOME REVIEW CHAPTER 5				AT-HOME REVIEW CHAPTER 7			

Figure 4. MPS operator training course curriculum.

MATO. All users were briefed on the requirements for data collection and the amount of cooperation that would be required from them (continuing on a not-to-interfere basis). They were shown examples of MPS reports suitable for application in their day-to-day work, and told how to use these reports to take corrective action. The battalion commander and company officers attended these briefings and made it possible to install the system for operation by Army personnel. Army personnel collected data, processed the data, and distributed the reports to users at the appropriate time intervals.

The role of Anacapa staff during this phase of MPS operation was limited to supervision and monitoring the operation of the system. Minor problems in system operation were corrected on-site. Modifications were made to the procedures at that time, as required.

MPS-RELATED RESEARCH TASKS

Relationship of MPS to Other Maintenance Systems

Guidelines for the project specified that any performance-based maintenance system must be compatible, and not redundant, with existing or planned maintenance information systems. Consequently, close liaison was maintained with SAMS development staff since SAMS will eventually become the Army's single overall maintenance system. A major objective of SAMS is to provide a standard system to meet the needs of the field commander and reduce his reporting burden at the national level. However, the retail (i.e., direct-support unit) level of SAMS does not provide a level of feedback to the company commander comparable to that in the MPS.

The Maintenance Activity Management System (MAMS) was investigated on-site in V Corps in USAREUR to assess its possibilities for integration with MPS. MAMS is primarily designed to provide a picture of equipment status and parts supply for the supply command (SUPCOM) at corps level. For example, data are entered directly into a dedicated minicomputer in each participating shop office. Thus, a "living" record is kept on shop work. A major advantage of MAMS is that any person in the shop can interrogate the MAMS memory to check job status.

A special review was made of some of these relationships and reported in November 1980.¹¹

¹¹Jarosz, C. J. **Analysis of data base compatibility of the standard Army maintenance system (SAMS) and the maintenance control system (MCS) with the maintenance performance system (MPS).** Santa Barbara, California: Anacapa Sciences, Inc., November 1980.

MPS Operation in USAREUR

Visits were made to 13 direct-support components of maintenance units in USAREUR to find out whether the MPS would operate in the dispersed environment of most units in USAREUR. The basic tenet governing MPS operation in CONUS is that it will be centrally located and will be capable of operation by one person spending 32 hours per week on data collection, data entry, data processing, and output dissemination. When companies and contact teams are 50 to 60 miles apart, communication and data transfer become more difficult. However, USAREUR has developed highly efficient systems for collecting maintenance data from dispersed units. Courier pickups are made at daily intervals. The data are coordinated and combined in the MATO's office of the divisional maintenance battalion.

Relationship Between Skill Level and Maintenance Effectiveness

Time-series analyses were completed of data collected during the 46-week implementation of the prototype MPS to determine relationships among changes in workload, efficiency, and skill levels. An underlying assumption of this project and of the MPS is that efforts directed toward increasing the technical skills of mechanics will pay off ultimately in increased effectiveness of maintenance. Data were collected over the 46-week period on the maintenance performance and skill levels of four different MOS's in two different direct-support companies. The eight cases provided different combinations of changes among workload, efficiency, and skill levels. Skill-level changes were mainly a function of changes in personnel mix rather than from training.

Analysis of False Removal Data

The project included the investigation of the frequency of the unwarranted removal and replacement of parts which had been incorrectly diagnosed as faulty. The hypothesis was that parts falsely removed could indicate a training need. This was particularly important if repairmen had used parts exchange as a means of avoiding a more precise and time-consuming diagnosis of a repair problem.

A voltage regulator was chosen as a suitable test item since data on its path through fault-to-fix were available in sequence from customer's initial report to return to service of the equipment (or its final disposition). In the 20-week period of the analysis, only 22 percent of the voltage regulators received in the DS shop could be construed as false removals. Table 3 illustrates the five categories of repair from which data were collected. Although the number in the sample ($N = 165$) is not inconclusive, the indications so far are that false removals should not be considered as a reliable indicator of repairman skill level.

TABLE 3
SUMMARY OF VOLTAGE REGULATOR REPAIRS

REPAIR ANALYSIS CATEGORY	TOTALS BY CATEGORY	TOTALS AS PERCENTAGE
1 Tests OK—No service needed	24	15%
2 Screw adjustment (through cover) to within 26-30V	12	7%
3 Screw adjustment (cover removed) to within 26-30V	5	3%
4 Major adjustment (replace capacitor/condenser, etc.)	34	21%
5 Discard—or forward for rebuild	<u>90</u>	<u>54%</u>
TOTALS	165	100%

DISCUSSION OF RESULTS

The third year of the project produced a refined and expanded MPS with supporting documentation capable of being operated and used by Army personnel. Prior to the end of the project, the MPS was operated and used satisfactorily for a 10-week period by the 704th Divisional Maintenance Battalion at Fort Carson, Colorado. Plans are for continuing operation and use of the MPS at Fort Carson under ARI monitorship for a total period of about 24 weeks. Previously, the prototype MPS was operated by the contractor at Fort Carson for a 46-week period during the second year of the project. The results of these efforts are discussed here as well as plans for future implementation and evaluation of the MPS.

ARMY OPERATION AND USE OF MPS

Complete implementation of the MPS, under Army control, operation, and use, required that the system be fully developed. Therefore, installation at Fort Carson was not initiated until all system refinements and programming were completed, the diagnostic-prescriptive subsystem had been developed and tested, supporting documentation (operator and user manuals, training guides, and interpretation aids) had been prepared, and Army MPS operators had been trained. These efforts were completed four months prior to the scheduled completion date for the project. Consequently, the MPS has been operated and used by the Army for a 10-week period prior to the preparation of this report.

The MPS is being operated under control of the MATO at battalion headquarters. The system is operated by two soldiers temporarily assigned from other duties. One serves as the primary operator and the other as a substitute operator inasmuch as only 32 man-hours per week are required for MPS operation.

The relatively short period of time during which the MPS has been operated by the Army is insufficient for an evaluation of the impact of MPS on maintenance effectiveness. However, the time has been sufficient to ascertain that the MPS can be operated satisfactorily by Army personnel and can be used effectively by commanders, maintenance managers, and supervisors. Discussions with system users indicate that they can understand and use the types of information provided. Furthermore, users have been positive in their assessment of the potential value of MPS for maintenance management and training. Greatest enthusiasm has been for the diagnostic-prescriptive methods provided by the **Guide for Individual Technical Training in Direct Support Units**. The information and methods provided for establishing training priorities, selecting training resources, and determining appropriate training methods appear to satisfy fundamental needs of unit-level training.

RELATIONSHIPS AMONG MAINTENANCE WORKLOAD, SKILL LEVEL, AND EFFECTIVENESS

The importance of developing technical skills at the unit level was highlighted by time-series analyses completed of data collected during the experimental implementation of the prototype MPS during the project's second year. Measures of maintenance workload, skill level, and effectiveness were obtained for 23 successive two-week periods. Workload for an MOS was defined as the total number of man-hours spent on technical tasks during a two-week period. Skill level within an MOS was equated with the percentage of direct-support technical tasks on which mechanics were proficient, on the average, within the unit. Maintenance effectiveness was measured by the number of man-hours required per job, on the average, within the unit. Each of the measures was provided by the MPS. During the 46-week period of study, these measures were obtained for four different MOS's within each of two different direct-support maintenance companies.

The results of the time-series analyses are summarized and illustrated here. More detailed discussions of the analyses and results were provided in a separate report.¹²

In all cases but one, the workload trend increased over the 46-week period of study. The condition under which maintenance was being performed was represented by a continually increasing workload punctuated by intermittent peaks and valleys, as illustrated in Figure 5. The analysis showed that increased workload appeared to have a strong and consistently negative impact on maintenance efficiency across all MOS's in both companies. Simply stated, our interpretation is that as workload increased, maintenance efficiency decreased. However, this general relationship was mitigated by changes in repairmen's skill level. That is, any increase in skill level that took place in the same period as an increase in workload, stopped or reduced the expected drop in maintenance efficiency. In several cases, the positive impact of an increase in skill level seemed to counteract the negative impact of increased workload to produce an overall increase in maintenance efficiency. Conversely, those cases where workload increased while skill growth decreased showed drastic reductions in maintenance efficiency.

During the 46-week period of prototype MPS implementation, little or no structured unit-level training was performed. The training diagnostic-prescriptive subsystem was under development and, therefore, was not part of the MPS at that time. Consequently, most of the changes in skill level resulted from personnel changes in the units. For example, replacing less-experienced with more-experienced personnel increased the skill index. On the other hand, replacing more-experienced with less-experienced personnel decreased the skill index.

¹²Harper, W. R., & Gutmann, J. C. **Develop and evaluate new training and performance systems for maintenance jobs. Special report. Evaluation: findings, plans, and examples.** Santa Barbara, California: Anacapa Sciences, Inc., March 1981.

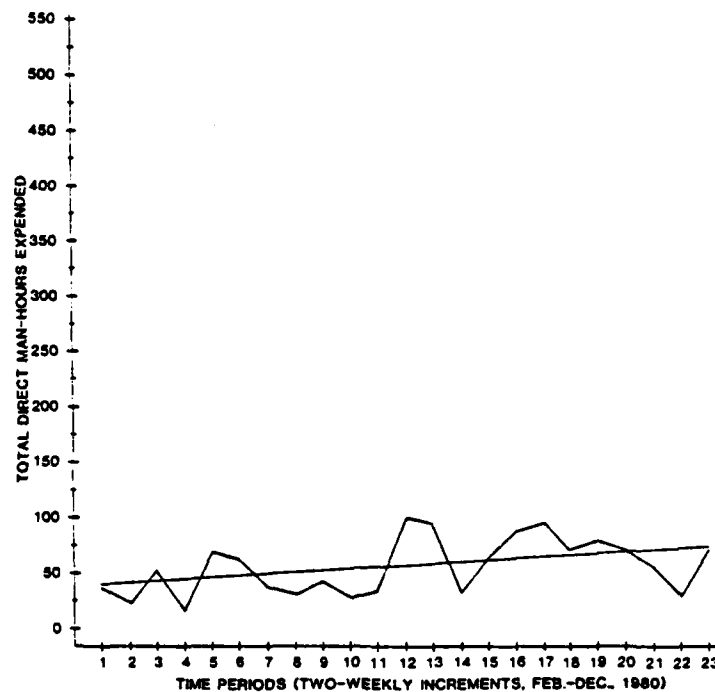


Figure 5. Total direct man-hours (shop workload) for MOS 41C ("E" Company).

The results of the time-series analyses are exemplified in the data from the fire-control section of "E" Company of the 704th Divisional Maintenance Battalion. These results are shown graphically in Figures 5, 6, and 7. Within each figure, actual data points are shown along a least-squares fitted linear trend line. As shown in Figure 5, workload increased over the 46-week period from 38 man-hours to 75 man-hours, an increase of about 100 percent.

The skill level of repairmen is shown in Figure 6. At the start of the period, personnel in this unit holding the 41C MOS (Fire Control Instrument Repairman) could perform 26 percent of the critical tasks of this MOS. By the end of the period, the skill level had increased to 73 percent, an increase of almost 300 percent.

As shown in Figure 7, the average number of man-hours per job for the MOS 41C decreased during the period by about 50 percent from three man-hours to 1.5 man-hours.

Examination of the three graphs in the example cited reinforced the notion described earlier--i.e., that although workload increased, the expected decrease in maintenance efficiency did not materialize because of the strong influence of an increase in skill level--in fact maintenance efficiency was improved.

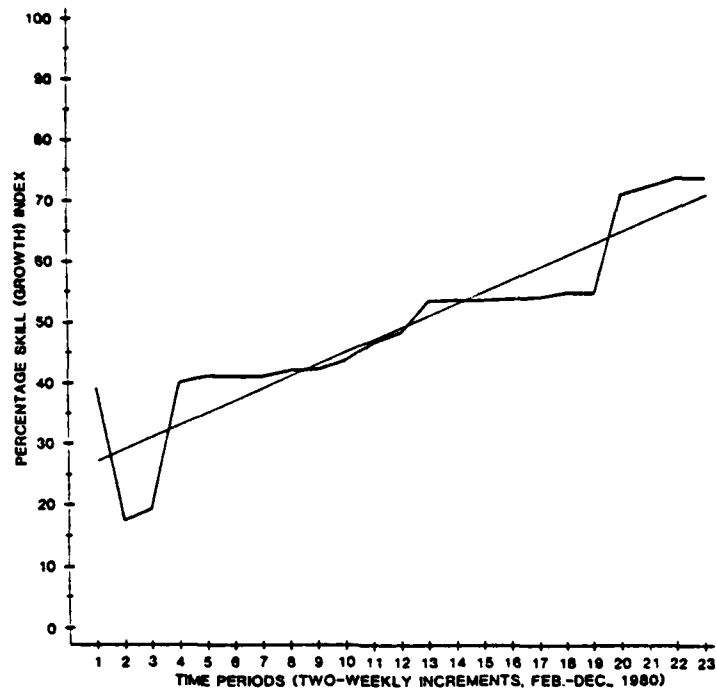


Figure 6. Skill (growth) index shown as percentage growth for MOS 41C ("E" Company).

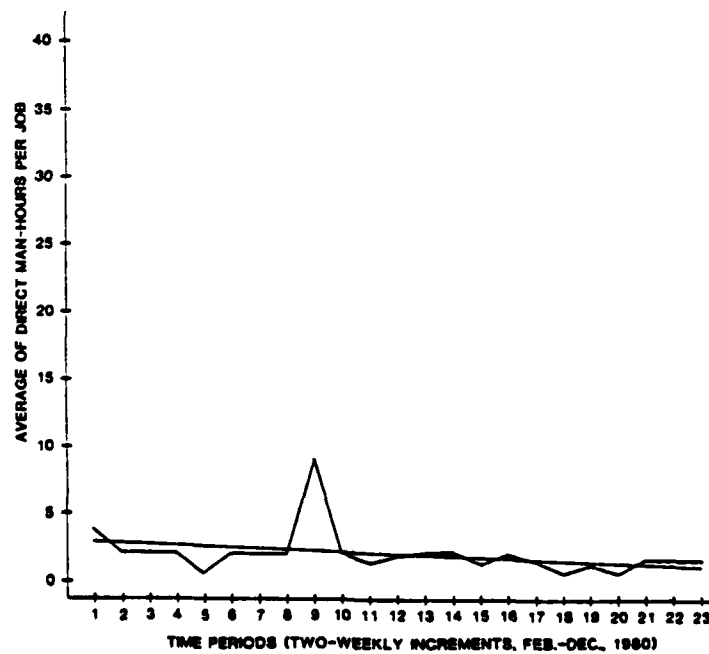


Figure 7. Average direct man-hours per job for MOS 41C ("E" Company).

MPS USER OPINIONS

Results of user surveys concerning MPS operation reflected positive attitudes toward the system and indicated general user acceptance of the concept. The surveys consisted of a series of interviews with commanders, maintenance officers, warrant officers, and non-commissioned officers. The training reports were the most enthusiastically accepted of the MPS outputs because they were considered to fulfill a need in training development which had not been well met within the Army. The automatic recording of individual repairmen's performance, as part of a composite record to identify training needs and priorities for all men within an MOS, was considered to be of great value by the users.

The focused training requirements information (training diagnoses) was considered to be valuable by warrant officers and senior non-commissioned officers charged with conducting the required training. They reported that although they were responsible for conducting skill training, in many cases they were not sure which MOS's or tasks should be given the greatest priority. The training components of MPS outputs provided answers to these questions based on actual shop data. Officers found the summary reports showing skill levels by MOS useful in helping decisions related to planning of SQT training for MOS's. The battalion commander of the 704th indicated that it would be beneficial if the MPS were expanded to encompass all training information for all MOS's to provide an overall training decision base.

EVALUATION PLAN

Under the assumption that the MPS will be installed at other Army facilities in CONUS and USAREUR, additional opportunities will exist for building a foundation of data for MPS evaluation. Consequently, future installations of MPS should be made with a view toward evaluation. In the simplest, most practical terms, evaluation would require the initial establishment of a baseline condition against which to compare the subsequent impact of the MPS.

The baseline could be established by installing the MPS for an initial period without distributing its output. Such a period would be required anyway to assure satisfactory operation and to assess the stability of the performance and training measures provided. During this period, maintenance and training activities in the unit would proceed essentially unaffected by the MPS.

Once sufficient baseline data were collected, users could be indoctrinated with MPS objectives, information, and procedures. Appropriate MPS manuals, guides, and performance aids could then be distributed. Then, MPS outputs would be regularly distributed as specified in the MPS supporting documentation. Commanders, managers, supervisors, and trainers would use the information for analyzing problems and taking appropriate training actions. A detailed step-by-step evaluation plan for new MPS installations was provided in a separate document. (See Reference 12, Page 32).

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