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Implementation issues for the initial deployment of the performance and calibration modules of the MK 92 MOD 2 Fire Control System maintenance advisor expert system.

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THESIS

IMPLEMENTATION ISSUES FOR THE INITIAL DEPLOYMENT OF THE PERFORMANCE AND CALIBRATION MODULES OF THE MK 92 MOD 2 FIRE CONTROL SYSTEM MAINTENANCE ADVISOR EXPERT SYSTEM

by

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December, 1996

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The MK 92 Mod 2 Fire Control System (FCS) is a complex, maintenance intensive shipboard weapon system found primarily aboard the Oliver Hazard Perry class guided missile frigates (FFG-7). This system, based on 1970's technology, frequently requires extensive troubleshooting and supplemental support from shore-based technical experts. A maintenance advisor expert system (MAES) is being developed by the Port Hueneme Division of the Naval Surface Warfare Center (NSWC-PHD) and the Naval Postgraduate School (NPS) to assist the Fire Control technicians aboard ship to better isolate faults in the MK 92 Mod 2 FCS.

This thesis furthers the efforts of the project at NPS by investigating key implementation issues that will affect the deployment of the initial version of MAES to the fleet. Additional deployment issues addressed in the thesis include incorporating lessons learned from deploying other expert systems in the armed forces, gaining support from individual chains of command, training MAES users effectively, involving MAES users in the implementation process, and changing hardware implementation issues. A training plan, implementation plan, and updated MAES user's manual for the initial deployment are included.

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IMPLEMENTATION ISSUES FOR THE INITIAL DEPLOYMENT OF THE PERFORMANCE AND CALIBRATION MODULES OF THE MK 92 MOD 2 FIRE CONTROL SYSTEM MAINTENANCE ADVISOR EXPERT SYSTEM

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ABSTRACT

The MK 92 Mod 2 Fire Control System (FCS) is a complex, maintenance intensive shipboard weapon system found primarily aboard the Oliver Hazard Perry class guided missile frigates (FFG-7). This system, based on 1970's technology, frequently requires extensive troubleshooting and supplemental support from shore-based technical experts. A maintenance advisor expert system (MAES) is being developed by the Port Hueneme Division of the Naval Surface Warfare Center (NSWC-PHD) and the Naval Postgraduate School (NPS) to assist the Fire Control technicians aboard ship to better isolate faults in the MK 92 Mod 2 FCS.

This thesis furthers the efforts of the project at NPS by investigating key implementation issues that will affect the deployment of the initial version of MAES to the fleet. Additional deployment issues addressed in the thesis include incorporating lessons learned from deploying other expert systems in the armed forces, gaining support from individual chains of command, training MAES users effectively, involving MAES users in the implementation process, and changing hardware implementation issues. A training plan, implementation plan, and updated MAES user's manual for the initial deployment are included.

TABLE OF CONTENTS

I. INTRODUCTION

A development project initialized by the Naval Surface Warfare Center, Port Hueneme 4C00 (NSWC-PHD), supported by the Naval Postgraduate School (NPS), and sponsored by the Naval Sea Systems Command (NAVSEA), the Mark 92 (MK 92) Mod 2 Fire Control System (FCS) Maintenance Advisor Expert System (MAES) project was initiated in 1992. It will serve as a tool to aid shipboard Fire Control technicians in diagnosing and troubleshooting faults that occur in the MK 92 FCS. MAES has other benefits that include:

- Reduced mean-time-to-repair (MTTR) which results in improved operational readiness.
- Significant cost savings from a reduction in the number of No Fault Evident (NFE) circuit cards replaced.
- Reduced reliance on outside technical support activities.
- A capability to more effectively train junior fire control technicians in the troubleshooting of difficult system faults in general.
- Proving the value of expert systems which may lead to the development of expert systems for other complex systems such as the MK86 GFCS or the SQQ-28 SONAR processor.

Initial prototype versions of MAES have been developed and tested. Copies of the initial version have been distributed for evaluation to: Fleet Training Center, San Diego (FTC-SD), USS Sides (FFG-14), USS Wadsworth (FFG-19), and Fleet Combat Training Center (FCTC), Norfolk. In July 1995, under the sponsorship of Commander Naval Surface Forces Atlantic (COMNAVSURFLANT), a Navy Scientific Assistance Program (NSAP) grant was approved that would support the implementation and evaluation of the system aboard

COMNAVSURFLANT ships. The next step will be the deployment of the initial production version onboard six East coast based frigates. An effective implementation plan is essential in the transition of the system from a prototype to a deployable system and is the focus of this thesis.

A. OBJECTIVES

This research is directed toward the successful implementation of the initial deployment version of MAES. Proper management of the deployment process is critical to the effective allocation of resources. The thesis has three main objectives. The first is to determine the potential implementation issues that may affect the initial deployment of MAES. The second is to apply the applicable implementation issues to the deployment of MAES. The third objective is the development of an implementation plan, training plan, and a revised MAES user's manual that address the implementation issues.

B. RESEARCH QUESTIONS

This thesis attempts to answer the following research questions:

1. Primary Research Question

- What are the potential implementation issues for the initial fielding of MAES?

2. Subsidiary Research Questions

- How can the identified implementation issues be addressed for the deployment of the initial version of MAES?

- What are the end-user training concepts to be applied to the formulation of a MAES training plan for shipboard technicians?

- What are the hardware implementation issues associated with the initial deployment of MAES?

- What are the lessons learned from the implementation of other expert systems for weapons systems within DOD and to what degree are they applicable to the MAES deployment?

C. SCOPE

The scope of the thesis is limited to examining the initial deployment implementation issues and development of: (1) An implementation plan for the initial deployment of MAES; (2) A training plan for shipboard technicians to be used during the initial deployment; and (3) An updated User's Manual.

D. METHODOLOGY

The research methodology for this thesis includes a thorough literature review of software applications implementation with an emphasis on expert system implementation. In addition, interviews with personnel from other DOD activities that have implemented expert systems were conducted. Addressing the implementation issues for the actual deployment of MAES follows the implementation framework developed by Prerau (1990).

E. THESIS ORGANIZATION

This thesis consists of four chapters and five appendices. The following is a brief description of the contents of each chapter.

Chapter II provides the reader with the issues associated with implementing a software application. The development model developed by Prerau (1990) is presented and is being used to implement MAES. The Lucas-Ginzberg (1990) model for implementation is introduced to determine the implementation factors which need to be considered. Differences in expert system implementation are pointed out.

Chapter III establishes the implementation issues that can be influenced by the deployment team. Different methods of influencing implementation issues are explored.

Chapter IV evaluates the implementation issues determined in Chapter II and applies them to the implementation of the initial version of MAES. Lessons learned from the deployment of other DOD diagnostic expert systems are discussed.

Chapter V provides a thorough review of the duties and responsibilities of the deployment team. Hardware implementation issues are discussed as they apply to the deployment of MAES. The chapter also discusses the contents and purpose of an implementation plan.

In Chapter VI, the research is summarized, and conclusions are drawn. Finally, recommendations are made for the initial deployment and for further research.

Appendix A is an implementation plan for the initial deployment of MAES. Appendix B is a basic training plan and includes a training evaluation form to be used by the deployment team. Appendix C is an updated version of the MAES user's manual and Appendix D is a MAES User Survey Form.

II. IMPLEMENTATION ISSUES RESEARCH FOR TRADITIONAL AND EXPERT SYSTEMS SOFTWARE

This chapter discusses the potential implementation issues involved in fielding software applications and addresses the primary research question, "What are the potential implementation issues for the initial fielding of MAES?" Section A reviews research on implementation issues. Section B explains the foundations of a successful implementation using the Prerau (1990) implementation model. Section C examines implementation from a user and management perspective following the Lucas-Ginzberg (1990) model. Sections D and E discuss how expert systems differ from traditional information systems and how expert systems can be categorized. Sections F and G examine variables that need to be considered when implementing an expert system and the relative importance of implementation factors depending on the category of expert system. Section H provides a summary of the chapter.

A. SUMMARY OF IMPLEMENTATION ISSUES RESEARCH

A great deal of research has been done on the different factors that can contribute towards a successful implementation of an information system. This section summarizes the research on implementation issues that was most applicable to this thesis. Multinovich and Vlahovich (1984) identified thirteen steps which are necessary in a successful implementation strategy. They determined that the steps are interrelated and that some may be done concurrently. Leonard-Barton and Deschamps (1987) concentrated on assessing the effect that upper management can have in the implementation of new technology. Lucas and

Ginzberg (1991) devoted a whole book to the development and testing of a structural model for information systems implementation.

Research has also been conducted in the area of implementing expert systems. Prerau authored a book that provides a step-by-step approach to developing and managing expert systems (Prerau, 1991). Bradley and Hauser (1995) provide a framework for expert system implementation based on categorizing the type of expert system that is being implemented.

B. PRERAU'S METHODOLOGY FOR IMPLEMENTING EXPERT SYSTEM SOFTWARE APPLICATIONS

While the development of any application has unique aspects, Prerau maintains that there are three basic phases in the evolution of a system that can be considered generic: (Prerau, 1990)

- The Initial Phase composed of project start-up, selection of the domain and selection of the development environment.
- The Core Development Phase consisting of the development of a feasibility prototype system and full prototype system.
- The Final Development and Deployment Phase composed of the development of a production system, system deployment, and system operation and maintenance.

According to Prerau, ensuring that an application is developed using the above basic phases as a foundation will better ensure the successful development and deployment of a new system. The reader may wish to review Prerau's discussion of the Initial and Core Development phases. This section will focus on the third phase - the final development and deployment phase of a project.

In the final phases of software development, Prerau states that the final production system is built and the system is deployed. The program then transitions to a maintenance phase , with program and knowledge bugs fixed and possibly new information and features added.

1. Development of a Production System

According to Prerau, the decision to develop a production-quality version of an application from the full prototype system is based on several factors: the results of the field tests of the prototype system; feedback from outside experts, potential users, and management; and estimates of the cost versus benefits of the final system. If the decision is made to proceed, then the development of the production system is initiated. In this phase, the full prototype is made into a program that is robust, reliable, and can be fielded. Then the system is deployed and put into long-term operation. To produce the deployment system, Prerau suggests several issues be explored: (Prerau, 1990)

- Possible representation and re-implementation: There may be benefits in doing a redesign and re-implementation when beginning work on the deployment system. For example, when it is decided that the final production system should be rewritten to allow it to be run on new hardware or with a new software tool, the additional cost of redesigning the representation and implementation might be lower.

- Deployment hardware: The deployment hardware does not necessarily have to be the same as the development hardware, although sometimes the hardware for development was selected with the deployment in mind. Some of the factors involved in hardware selection include: reducing hardware cost, making program operation and maintenance easier, using a hardware vendor that provides better support, and putting the application on hardware that can be used for other purposes.

- Deployment software: The deployment software tool does not have to be the same as the development software tool. If the deployment software is different, the cost of converting from the development software will have to be considered.

- Input/Output formats and mechanisms: The formats and mechanisms for user inputs and to deliver output to users may have to be reconsidered. Comments from the users involved in the field tests and from domain experts may aid in the design of good input/output formats.

- Testing: The production system should be tested and evaluated. Validation tests should determine that the system effectively solves the problem for which it was built, at an acceptable level of expertise. Verification tests should ensure that the expert knowledge acquired has been correctly implemented, that the system is operating accurately to the extent required and is as free as possible of programming errors.

- Documentation: The documentation that will accompany the system must be designed and written. It might consist of printed manuals, on-line help, or both. There may be levels of documentation for system maintainers, system operators, and system users.

2. System Deployment

When the production system is completed and fully tested, the system can be deployed (Prerau, 1990). There are several factors that Prerau (1990) recommends analyzing before deployment:

- Mode of deployment: There are several options. The final system could be delivered to users as a stand-alone system; it could be operated as a separate entity but integrated into the user's environment; or it could be embedded into another system. The users of the system may be responsible for operating it, they may have responsibility for both operating and maintaining it, or they may utilize the system as a service.

- System introduction: If the users have been clearly identified and involved throughout the development, introducing the system into the working environment may not pose many problems. Users to whom the system is new may have to be convinced to change their present mode of operation. Introduction of a new system will change the status quo and may arouse the fears associated with automation. Beyond these standard problems, expert systems have an additional aspect that may cause problems and that is inherent to the technology: expert systems sometimes make mistakes. Often users can accept incorrect results more easily from a human expert than from a computer program. When a system makes mistakes there may be problems getting users to trust the system.

- User training: The methods to be used for training system operators and users must be decided. Training may include formal courses, training manuals, and/or on-line tutorials.

- Documentation: Any documentation for system operators, maintainers, or users not already written should be developed.

Although these areas are directly related to deployment, many of the issues can be examined and choices made while the production system is under development and testing. Many issues may be resolved earlier in the project. A project should have a deployment plan specifying the selected deployment mode, hardware, software, pricing, and so forth. It should specify the sequence and timing of events that will be followed to bring about the initial system deployment. (Prerau, 1990)

3. System Operation and Maintenance

According to Prerau, a long term maintenance group should be formed and trained. Maintenance not only includes fixing problems found during system operation, but also revising internal data and knowledge that changes over time. Since maintenance will require not just changes to the implementation of knowledge but also changes to the knowledge itself, it is mandatory that a domain expert be involved in the maintenance process, even on a consulting basis only. A decision must be made whether to have centralized maintenance, where program patches and revisions come from a single source, or to have a more distributed maintenance plan. The latter approach will result in non-standard versions of the system and may not be desirable. However, it does allow the customization of the software to fit the circumstances of each site. It may become necessary, during the lifetime of an expert system, to make major changes to the software to expand its scope or add new features and capabilities. System revision can be done by the system maintenance group, but if the expansion is large enough, it may be necessary to use an independent development group. (Prerau, 1990)

C. IMPLEMENTING A SOFTWARE APPLICATION

Deployment of a new software application entails bringing such a system into operational use by turning it over to the end user (Multinovich and Vlahovich, 1984). Ultimately, it is end users who determine the success of a system through their use of the system. The deployment process can be considered a critical success factor in whether a software application is accepted by the end users. Lucas and Ginzberg (1990) developed an implementation model based on previous research on implementation issues. They conclude that the most consistent relationships with software success or failure have been demonstrated to be three major issues: management support, user involvement, and conduct of the implementation process itself.

1. The Manager Model for Implementation

The Lucas and Ginzberg model consists of two separable submodels, the user model and the manager model. The manager model in Figure 2-1 consists of the following variables: (Lucas and Ginzberg, 1990)

- Manager acceptance: This variable is a measure of the extent to which a manager wants a particular system to be implemented.

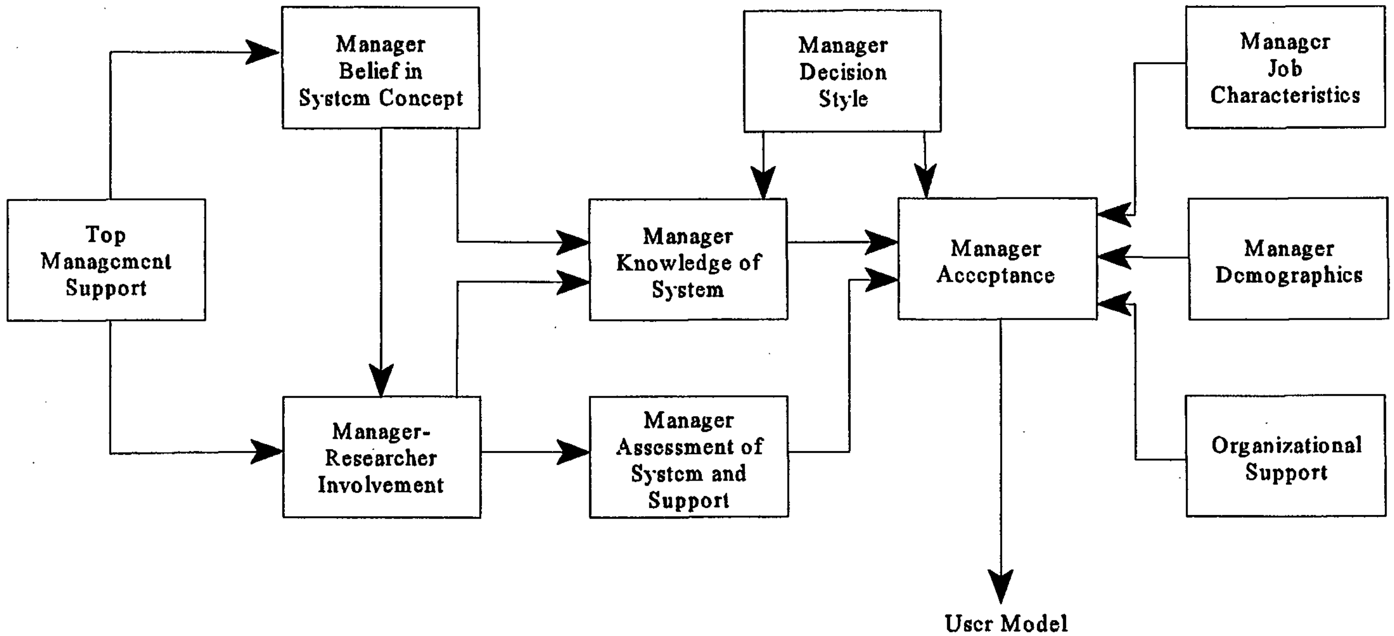


Figure 2-1. The Lucas-Ginzberg manager sub-model.

- Manager knowledge of system: A measure of how well a manager understands the system to be implemented. Better understanding of a system's design and capabilities leads directly to increased acceptance.

- Manager assessment of system and support: Measures the manager's evaluation of the quality of the system and its supporting mechanism. Favorable evaluations should result in increased acceptance.

- Manager belief in system concept: The extent to which a manager believes in the underlying concept or approach behind a system and the ability of that approach to solve the organization's decision problems. Stronger belief in the system concept will result in greater incentive for the manager to become involved in system development and learn about the system.

- Top management support: This variable measures the level of support exhibited by top management in an organization for the use of a particular system. Greater top management support should result in managers being more willing to become involved in system development and having greater belief in the system concept.

According to Lucas and Ginzberg, an implementation process begins with management initiation and acceptance, so the management issues are usually addressed first. A system that is accepted by management still stands a chance of failure if the users do not accept it. But ensuring that the above variables are addressed and optimized increases the probability of a successful deployment. (Lucas and Ginzberg, 1990)

2. The User Model for Implementation

One important objective of a system is to improve the user's job performance. Therefore the Lucas and Ginzberg user model begins with the user's personal stake in the system and ends with satisfaction and performance. The user model in Figure 2-2 consists of the following variables: (Lucas and Ginzberg, 1990)

- User Acceptance: This variable measures the potential user's predisposition to personally use a specific system. It is a measure of behavioral intention that will be reflected in actual use.

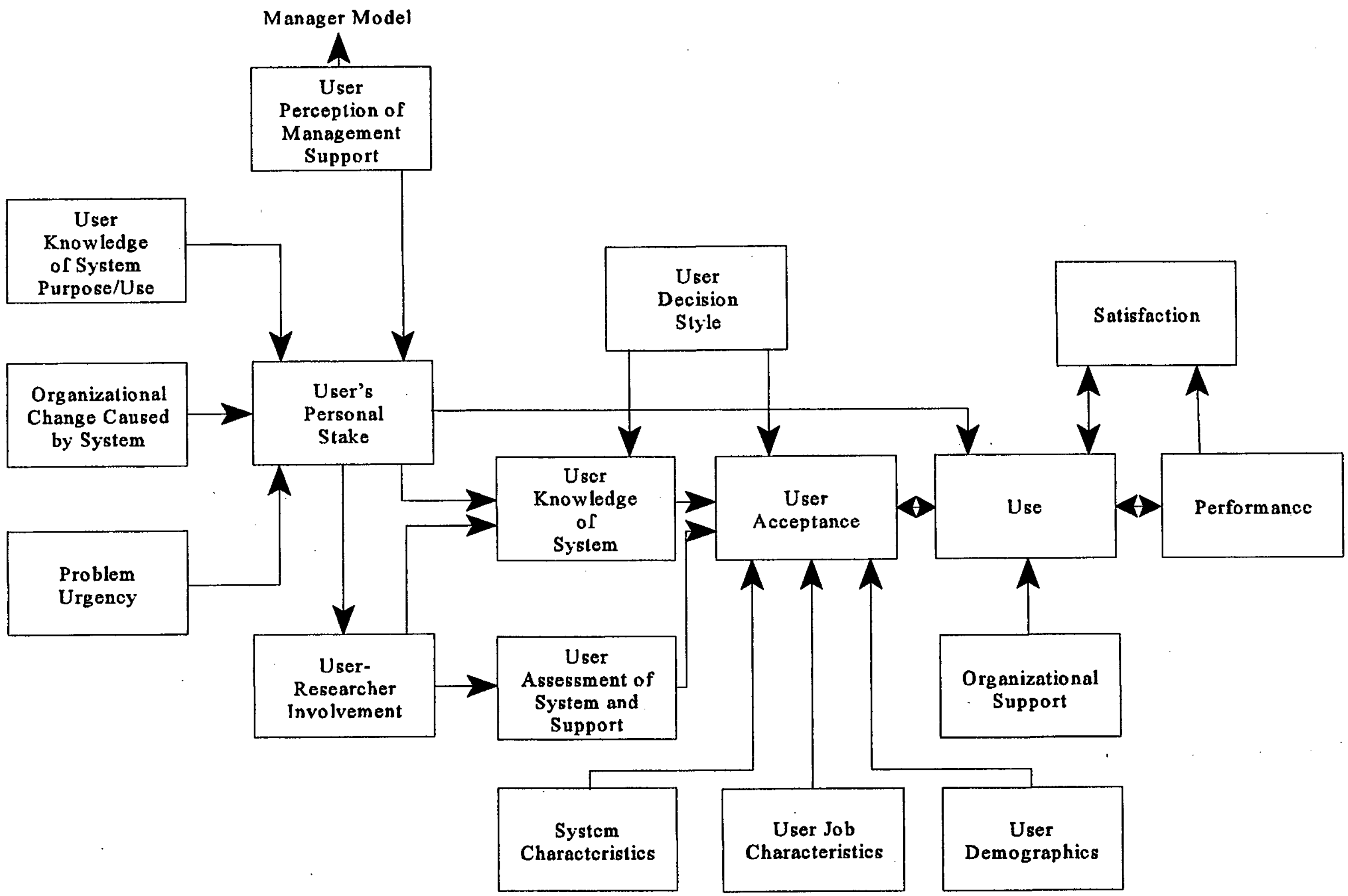


Figure 2-2. The Lucas-Ginzberg user sub-model.

- User knowledge of system: This variable measures how much the user understands the functioning of a system. Better knowledge of a system's design and capabilities leads to increased acceptance.

- User assessment of system and support: Measures the user's evaluation of the system and its supporting mechanisms.

- System characteristics: This variable represents the features and capabilities of the system. Examples of these characteristics may be ease of use or the fit between system capabilities and the demands of the user's job. Easy to use systems which meet the user's needs are more likely to be accepted.

- User-researcher involvement: Indicates the degree of interaction between a user and the system designer. Greater involvement leads to greater user knowledge of the system capabilities.

- User perception of management support: One of the key determinants of the user's acceptance is the manager's acceptance or support of the system. It is the user's perception of management support, not an actual measurement.

- User knowledge of system purpose and use: Without knowledge of system purpose or use, the user will be unable to assess the importance of the system.

- Problem urgency: The greater the user's perception of problem urgency, the more important a system addressing that problem and the greater the user's stake in that problem.

- Organizational support: The degree to which the organization provides the environment and facilities to make access to and use of the system easy.

A system deployment can be viewed as an ongoing process. It continues as long as new users are being introduced to the system. The concept of introducing a system into the existing user operation without major upheavals will require following both Prerau's (1990) implementation methodology, while at the same time paying close attention to the controllable variables in the Lucas-Ginzberg implementation model of introducing a system to the user.

Prerau states that for a successful deployment of an expert system, there must be clearly defined goals for the fielding (Prerau, 1990). From the discussion of the previous sections, these goals can be summarized as follows:

- Obtaining management support. (Prerau, 1990 and Lucas-Ginzberg, 1990)
- Involving the users in the development. (Prerau, 1990 and Lucas-Ginzberg, 1990)
- Involving the users in the evaluation of the prototype. (Prerau, 1990)
- Proper training of the users. (Prerau, 1990 and Lucas-Ginzberg, 1990)
- Establishing effective lines of communication between the users and the maintenance team. (Prerau, 1990)
- Conducting a post-deployment evaluation. (Multinovich and Vlahovich, 1984)

The latter sections in this chapter examine the specifics of meeting the goals for successfully deploying a software application. The following section discusses the differences between an expert system and a traditional information system.

D. DIFFERENCES BETWEEN AN EXPERT SYSTEM AND A TRADITIONAL INFORMATION SYSTEM

Expert systems differ from traditional management information systems in a number of ways. These differences include the type of problem-solving approach, the source and acquisition of system specifications, and the physical design of the system. First, expert systems employ a heuristic approach rather than the algorithmic approach used by traditional information systems. Second, expert systems are designed to provide a solution to a problem based solely on the knowledge of one or more experts. This can limit the degree of user involvement in the design process because the source of the system's knowledge comes from an expert. The reliance on the talent and skill of a knowledge engineer is also a major difference from traditional system requirements. (Bradley and Hauser, 1995)

Another difference in the development process lies in who physically controls the development. Traditional information system development has been handled by the MIS department. Expert system development, however, is different enough that management is often uncertain as to the level of involvement of the MIS department in the development process. Expert systems are often developed to diagnose mechanical problems in complex machinery where technicians, such as industrial engineers, are used in the development process since they understand the problems and are comfortable with computers as tools. This approach can result in a bypass of traditional system development life cycle requirements. Surveys of expert systems found that more than 50% were developed outside the MIS department. (Bradley and Hauser, 1995).

Expert systems possess unique characteristics that distinguish them from traditional management information systems. Expert systems also vary from one another. The following subsections discuss the differences between expert systems and how the previously discussed variables from the Lucas-Ginzberg model and the Prerau development process affect expert system development.

E. CATEGORIES OF EXPERT SYSTEMS

Expert systems possess distinct attributes that differentiate them from one another. If such differences exist between expert systems, then it is possible that a single implementation plan would not be appropriate for all expert systems. Therefore, the first step in expert system implementation planning should include categorizing the system according to its attributes and developing an implementation plan based on those attributes. Expert systems can be broken down into four categories based on the complexity of the knowledge they contain and the level of computing technology used to run them (Meyer and Curley, 1991). Meyer and Curley developed a classification scheme (Figure 2-3) that views expert systems along these two attributes.

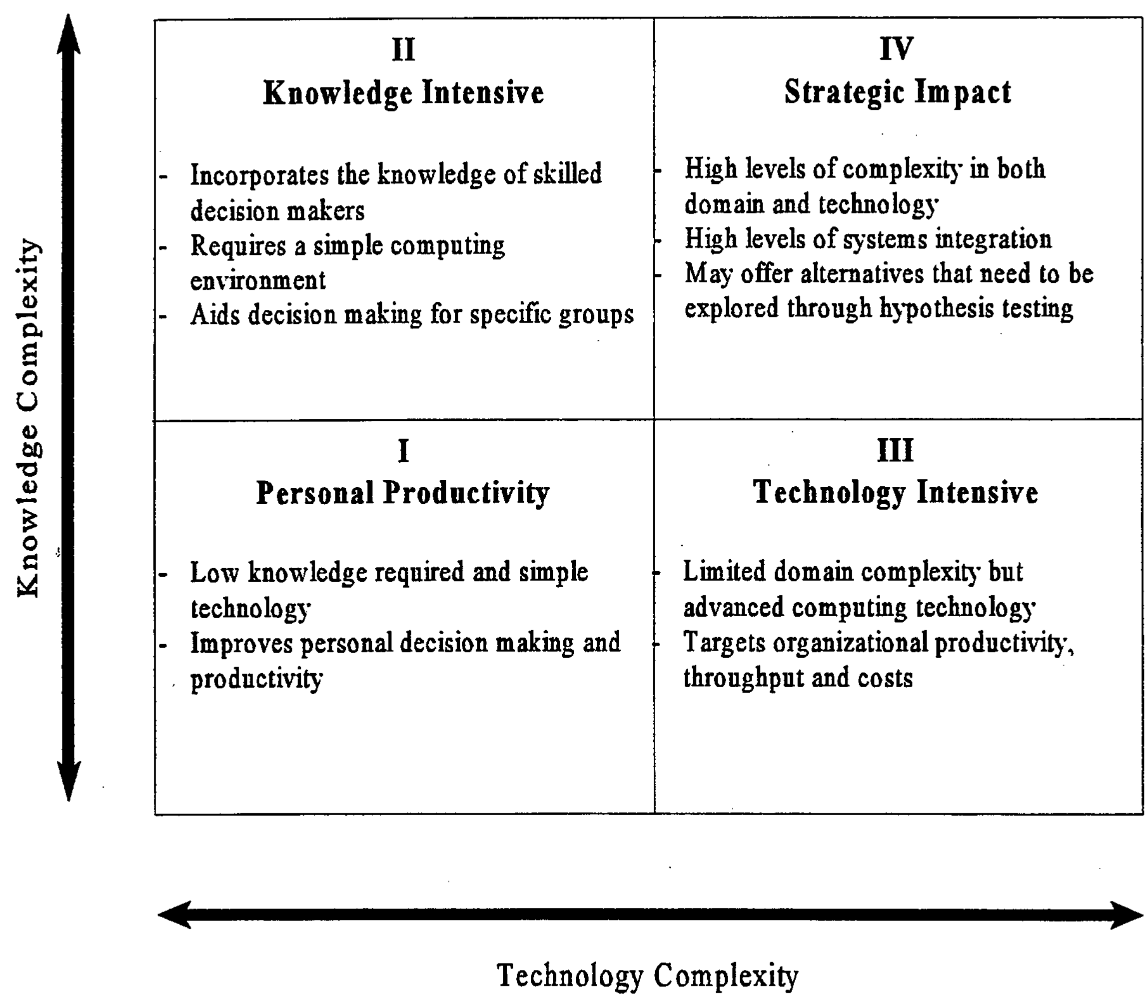


Figure 2-3. Expert System Classification. (Meyer and Curley, 1991)

Within the expert system classification scheme, a system can be classified into one of four groups: (Bradley and Hauser, 1995)

- Category I: Low to mid knowledge complexity; Low to mid technical complexity. These systems are developed in a problem domain that contains highly structured knowledge that can be expressed in IF-THEN rules. They enhance the productivity of a very small group of users who focus on a narrow problem, or a large group of users who make simple, repetitive decisions. These systems are often developed as a PC based applications using a relatively inexpensive expert system shell.

- Category II: Mid to high knowledge complexity; Low to mid technological complexity. This type of expert system is also typically implemented using an expert system shell. These systems address problems in more complex problem domains and require elaborate reasoning in specialized fields. The knowledge required for these systems is much more complex and usually involves true expertise instead of commonly used procedures.

- Category III: Low to mid knowledge complexity; Mid to high technical complexity. These expert systems address problems in highly structured, simple domains. The technology required to implement the system involves special user interfaces, complex database interactions, and usually a large programming effort. These expert systems require the technical knowledge and skill of a computer scientist for development.

- Category IV: Mid to high knowledge complexity; Mid to high technical complexity. This type of expert system is a combination of types II and III. The combination of complex knowledge and advanced technologies requires a development team of trained knowledge engineers and computer scientists. The development effort for these systems usually includes complex programming, data base management, and systems integration as well as an extensive knowledge acquisition effort.

Knowing that expert systems differ not only from traditional management information systems but also from each other can prove valuable in planning an implementation.

F. VARIABLES THAT AFFECT EXPERT SYSTEM IMPLEMENTATION

In addition to the implementation factors previously addressed in this chapter, the unique nature of expert systems carry with them additional considerations for implementation.

Expert systems often require employees to cease their current pattern of behavior, learn a new pattern of behavior that incorporates the innovation, and then persist in the new behavior. Implementation of an expert system involves modifying an individual's behavior to include use of the expert system. Bradley and Hauser (1995) identified a number of factors that can influence user acceptance of an expert system. The factors are organized into three main groups: innovation characteristics, organizational influences, and individual differences.

1. Innovation Characteristics

In expert system implementation, user attitudes may be influenced by attitudes towards computers in general. Prior expectations about the expert system have also been shown to be an important factor in successful implementation. Ginzberg (1981), found evidence that when users hold unrealistic prior expectations about a system, they are more resistant to change and the implementation is more likely to fail.

2. Organizational Influences

Leonard-Barton found that organizational influences impact on user acceptance (Leonard-Burton, 1987). Later sections of this chapter discusses a number of studies that have concentrated on the effects of organizational influence on implementation success. Organizational influence factors include, but are not limited to, user participation in development, rewards for using the system, user training, and formal and informal management support. (Bradley and Hauser, 1995)

3. Individual Differences

Individual differences, such as user education and experience, have been shown to have a significant effect on implementation. A key factor in the personal characteristics of the user is their attitude towards change. The extent to which a user perceives a change to their job environment will often effect the amount of resistance they exhibit. The effect of personal characteristics on implementation is dependent upon the perceived change caused by the expert system. (Bradley and Hauser, 1995)

G. RELATIVE IMPORTANCE OF EXPERT SYSTEM IMPLEMENTATION FACTORS

Bradley and Hauser (1995) suggest that any expert system implementation plan should include a careful consideration of factors in the three categories: innovation characteristics, organizational differences, and individual differences. The relative significance of each factor, however, will vary as a result of the type of expert system being implemented. Table 2-1 represents each factor with a High, Medium, or Low value to indicate the degree of emphasis the factor should have in an implementation plan based on the classification of expert system.

Factor	Expert System Classification			
	I	II	III	IV
Innovation Characteristics				
User perception of computing technology	H	H	H	H
User perception of expert systems	L	M	M	H
Organizational influences				
User involvement in expert system design	H	H	H	H
User involvement in expert system implementation	H	H	H	H
Reward structure	L	M	M	H
Training	L	M	M	H
Top management support	L	M	M	H
Supervisor support	H	H	H	H
Advocates	L	M	M	H
Consulting aids	L	M	M	M
Individual Differences				
User perception of change	H	H	H	H

L = low emphasis in the implementation plan
M = medium emphasis in the implementation plan
H = high emphasis in the implementation plan

Table 2-1. Relative Importance of Expert System Implementation Factors. (Bradley and Hauser, 1995)

The above framework suggests that a single implementation methodology may not be appropriate for all expert systems. Expert system developers should categorize the expert system early in the analysis of the system and develop an implementation plan that emphasizes what is most appropriate for that system. In a resource constrained project, this method can also be used to determine where resources should optimally be concentrated to better ensure successful system implementation. (Bradley and Hauser, 1995)

H. SUMMARY

In this chapter the Prerau (1990) methodology for implementing software applications was examined as a proven, practical approach for developing and managing the implementation of expert systems. Additionally, the Lucas-Ginzberg (1990) model for implementation was examined as it provides both the user's and management's perspective towards implementation. Finally, implementation issues that are specific to expert systems were addressed and found to be dependent on the type of expert system being implemented.

III. IMPORTANT IMPLEMENTATION ISSUES

This chapter provides the background information needed to address the primary and subsidiary research questions listed in Chapter I. Sections A, B, and C examine methods of obtaining management support, involving the user in the development, and training the users, respectively. Sections D and E discuss establishing effective communications and conducting a post-implementation evaluation. Section F analyzes hardware concerns and Section G provides a summary of the chapter.

A. MANAGEMENT SUPPORT

This section examines the research conducted on the importance and methods of obtaining management support and also methods of overcoming the resistance of management to adopt a new system.

1. The Importance of Obtaining Management Support

Since managers and users interact on a regular basis, the manager's attitude toward a system is an important factor for deployment success. Management support has been identified by a number of researchers as a key factor of deployment success (e.g. Ginzberg (1981), Multinovich and Vlahovich (1984),Leonard-Barton and Deschamps (1988), Bouldin, (1989), Prerau, (1990), Lucas-Ginzberg (1990)). Their major findings were:

- Management commitment and support are critical and essential for successful implementation of MIS/DSS. (Ginzberg, 1981)
- Capital resources required for system implementation increase significantly, and management must approve these expenditures. (Multinovich and Vlahovich, 1984)

- Subordinates are much more prone to act when their superiors are interested in the outcome. (Multinovich and Vlahovich, 1984)

- Perceptions of managerial behavior supporting or directly urging use of an innovation are positively related to use. (Leonard-Barton and Deschamps, 1988)

- Obtaining upper management approval is the point in the implementation beyond which you cannot proceed without their consent. (Bouldin, 1989)

- Obtaining management approval is one of the key steps in the initial phases of an implementation plan. (Prerau, 1990)

- One of the key determinants of the user's personal stake is his or her manager's acceptance or support of the system. (Lucas-Ginzberg, 1990)

For most software implementations, this will be a critically important step of the deployment process. Management support is important because it: (Multinovich and Vlahovich, 1984)

- Provides adequate resources.

- Provides psychological support.

- Creates a climate that acknowledges a problem exists.

In the Navy, a factor which is very applicable to the deployment process is that subordinates are much more prone to act when their superiors are interested in the outcome (Multinovich and Vlahovich, 1984).

2. Methods of Gaining Support and Overcoming Resistance

Multinovich and Phatak (1981) conducted research to discover methods of obtaining management support. They propose several methods to gain support from upper management:

- "Sell" the system to management. Management must be apprized of the benefits of the system and convinced that it would be to their advantage to support and implement the system. Implementation of any new technology is in essence a marketing task (Leonard-Barton, 1987).

- Create the illusion of support or generate support by sending copies of reviews to top management, particularly action memos. Others not aware of middle management's support may be led to believe top management supports the system and will in turn support it.

- Ensure that top management reads the memos. By reading the memos, they may change their opinion and support the system.

Bouldin also developed some methods for overcoming management resistance: (Bouldin, 1989)

- Conduct a marketing blitz to ensure that management has some basic level of understanding about the software and its usefulness. Some methods to achieve this heightened awareness are: Utilize email, show videotapes of the software in action, give formal and ad hoc demonstrations and presentations, and utilize your informal network.

- Conduct demonstrations to management to show off the capabilities and advantages of the new software.

- Gain the support of technical experts whose opinion is trusted by management and have them available for testimony during presentations.

- Publicize the results of a favorable cost-benefit analysis.

Obtaining the tacit support of management is not enough. Management must indicate through their words and actions that they support the system (Lucas and Ginzberg, 1990). Actions that show support include: (Lucas and Ginzberg, 1990)

- Attending meetings with the users about the system.

- Providing time for the users to train on the system.

- Becoming knowledgeable about the basics of the system.

- Personally using the system.

In order for management to actually participate in the above actions, they must first be convinced of the benefits of the system. Benefits that will likely appeal to management include: (Multinovich and Phatak, 1981)

- Saving money: May require a cost-benefit analysis.
- Improving Quality of Life: An increase in free time may result because of a possible decrease in the workload.
- Using the system as a training tool: An intangible benefit that may be hard to quantify.

Benefits such as those listed above would go a long way in convincing management that it would be to their advantage to support and implement the system. Management support is so necessary that Multinovich and Vlahovich (1984) recommend aborting any further development of a system if management support is lacking. Continuing the development in such cases would be a waste of time and money.

3. Cost-Benefit Analysis as a Method of Obtaining Management Support

The purpose of a cost-benefit analysis is to assess as accurately as possible the benefits and costs associated with implementing a software application. The analysis of benefits must include determining both tangible and intangible benefits. Tangible benefits include things that can be measured such as reduction in staff size, reduced maintenance costs, and increased handling capacity. Intangible benefits include things that are difficult to measure such as improving employee morale and increased training opportunities. (Powell, 1993)

After the analysis has been completed, the results must be analyzed carefully. Although management may not ever see the exact figures, it is important to be conservative. The main reason that an analysis is done is to enable a person to address whether or not a new system will be a substantial improvement. The quantification will bring some objectivity to an otherwise subjective issue. Management will feel more comfortable if the advocate feels confident in promoting a new system. If the estimates indicate a promising area for productivity improvement, the figures can be used as a basis for obtaining the support of management. (Bouldin, 1989)

B. USER INVOLVEMENT IN THE DEVELOPMENT

Research has shown that users should actively be involved in the development of a system through its life cycle (Ginzberg, (1978), King (1979), Madni (1988), and Lucas-Ginzberg (1990)). The key findings from their research include:

- A new system should satisfy a particular user's requirements without adversely affecting the information requirements of other users in the system. (King, 1979)
- Greater involvement of the user in the development should lead to greater user knowledge of the system's capabilities. (Lucas-Ginzberg, 1990)
- Reports should be made available to users if pertinent. This helps them to feel they are a part of the implementation and encourages involvement. (Ginzberg, 1978)
- The single most important human factors issue is understanding the requirements of the intended user. (Madni, 1988)

User participation must not be token nor given lip service. It must be meaningful and genuine. Enlisting the aid of the users in the development of software is prudent since the users often know much more than can be learned through interviews or surveys. Users have often been through solutions that did not work and may have observed solutions that could have worked if the users had had some type of input to the design (Multinovich and Vlahovich, 1984).

The knowledge by a user that his suggestion was implemented in the design of an MIS stimulates his enthusiasm for the system. Users should therefore be made to feel that they are contributing to a system, no matter how small the suggestion. This not only helps the user develop realistic expectations about the system's capabilities, but it can also result in positive feelings of self-worth and ownership that decrease user resistance to change and commit the users to the system. (Bradley and Hauser, 1995)

It must be understood that user participation is not a total solution but only one part of a successful implementation. There are concerns which should be kept in mind. Users are not professional developers, and, without professional assistance, they tend to miss opportunities for improvement and the applications of appropriate new information technologies. Since users do not generally think in terms of the whole process, their redesign ideas may be limited or flawed. Strong proponents for users participating in system design increasingly warn that it can lead to a form of "incrementalism," rather than any appreciable performance improvements. Even when users have good ideas, there still lies the communication barrier that can exist between the users and the developers. Developers often have difficulty understanding why a user desires a certain feature especially if it conflicts with the developer's concept of how the system can or should be designed. Greater participation by users is not a total solution, but that is not saying that their participation has no value. Participation is necessary, but not sufficient for good system design concepts. Developers' unaided perceptions about users' jobs are often wrong. In conclusion, users and developers must design a system together. (Markus and Keil, 1994)

C. USER TRAINING

This section discusses the importance and contributions of user training towards a successful implementation. Determining training needs and examination of effective training methods will be addressed as factors in formulating an effective training plan. Finally, conclusions will be drawn based on available information on user training as it contributes to the success of software implementation.

1. The Importance of Training

Although user interfaces are designed to be easy to use and prompt the user through system functions, training is still required. This is especially so if the user has minimal experience using computers or expert systems. A successful training program will convince any skeptics that the system is both crucial and necessary. A good initial impression of an application can be established by means of effective training. Properly trained users will have a superior comprehension and awareness of the project. Without proper training, the success of an application can be at risk because training gives the end-users the required skills and knowledge to reach anticipated levels of productivity. Training also produces greater confidence. This translates into the end-user referring to the computer as "my computer" instead of "the computer." As a result, trained users will use an application more efficiently and effectively, decreasing their dependence on support. Computers and expert systems are worth little if the people operating them can not use them properly. Therefore, user training should be considered a critical success factor in the successful deployment of software. (Holek, 1994)

Expecting users to be computer literate is not an assumption that can always be made. Some people are computer illiterate, suffer from computer phobia, or are against changes in the workplace. Also, just knowing how to use a computer does not guarantee that a person can operate a spreadsheet package, word processor, or an expert system. Users must be trained to use the systems they will use in their line of work. Not only on a basis of what button to press, but on a higher level, so that users can do some troubleshooting on their own, and are able to at least assess what the problem is and contact the right person for help. User training will take time, effort, and money. (Nelson, 1995)

The questions that need to be addressed are:

- Who should be trained?
- How much training should be done?
- Which methods should be used for training the users?
- Who should do the training?

Devising the training plan to answer the above questions correctly will contribute to a successful deployment.

Lastly, the training for a software application will not merely mean teaching a user how to input data or how to get answers from the computer. Training also means educating the user in the overall purpose of the system: what it is supposed to do, how does it do it, why do we want or need it done, and who must do it. Effective training does not just tell the users how important their contributions are, it lets them see that they are an important, integral part in the entire process and that the success of the implementation depends on how well they learn what is being taught. (Multinovich and Vlahovich, 1984)

2. Training Plan Formulation

A properly devised training plan will ensure a successful deployment. The software should have already been demonstrated to potential users via presentations and demonstrations that have informed them about its capabilities and relevance to them. The actual training should provide sufficient, detailed information and hands on experience to use the new system effectively (Bouldin, 1989). A framework for building an effective training plan includes: (Nelson, 1995)

- Assessment of training needs
- Development of training materials and methods
- Training of trainers
- Preliminary evaluation of training methods and materials
- Formal training and learning
- Evaluation of training

By paying proper attention to filling in the details of the above steps, training will result in users who are able to operate the system effectively and efficiently, who know who to contact in the event of a problem, and who are aware of the capabilities and purpose of the system. The following methodology developed by Nelson (1995) was used to develop the training plan in Appendix B of this thesis.

a. Assessment of Training Needs

In assessing training needs, it must be determined who to train, what kind of skills need to be trained, what kind of methods of training to use, and who is to carry out the training. On the level of the user, the deployment team must decide what kinds of computer skills each person needs to be able to perform his or her tasks efficiently and productively (Prerau, 1990). An assessment of what systems or pieces of software each individual needs to be able to use will be done. A decision on whether the user needs general use-of-computer training or only system specific instruction has to be made. The opinion of each individual should be heard with regards to interests, actual needs and preferences. On the level of tasks to be performed within an organization, an assessment of what are those tasks and who should be trained to perform those tasks needs to be made. A good practice is to ensure that all relevant personnel become qualified to use the new software. As with any computer system, the organization should have its expert users, and each user who needs to use the software should possess adequate skills. (Nelson, 1995)

Within the last three years, personal computers have become increasingly available to business and government organizations. Even with the widespread use of personal computers, training must address the user who may have no to little experience in using personal computers. The training may therefore have to include the basics of installing the software and accessing the program from the operating system. (Leinonen, 1995)

Training needs to be given to everyone associated with the system. This requirement includes the following personnel: (Holek, 1994)

- Upper management: Acquaint upper management with the capabilities and limitations of the system.
- Line management: This training will enable line management to understand how the users input data to the system and how they use the outputs. The training will allow line management to understand what the software does and how it does it.

- Users: This is an opportunity to stress to the users the advantages that the system has to offer them. The goals of this portion of training is to provide the users with the necessary skills to:
    - Input data into the system.
    - Use the output from the system.
    - Utilizing all the embedded help functions.
    - Keep the system performing the way it was meant to.

It should be stressed that training should not only teach personnel how to operate the software but also teach personnel about the purposes of the software.

Based on the different audiences that the deployment team will be training, different methods of training will have to be used. Training can be arranged into four different categories: (Cousins, 1994)

- Seminar style presentation: Provide trainees with a basic understanding of the operation and purposes of the new software.

- Classroom/Hands-on: Provide trainees with an introduction to the capabilities and purpose of the new software. In addition, users will receive instruction on the advanced operations of the software, e.g., data input, following troubleshooting paths, using online help, etc.

- On-The-Job training: The objective of this type of training is to have intermediary trainers provide training to users who missed the initial training or entered their position after the software was introduced. This type of training can also be used in the event of software upgrades or additions.

- Follow-up Sessions: The objective of this phase of the training will be to monitor the user's performance with the new software. The duration should be approximately once every three months and not last longer than one hour.

The users and line management should attend classroom presentations to teach them about the benefits and purpose of a software application. The users remain at the training site to receive the hands-on portion of the training. A seminar presentation can be given to the upper management in conjunction with a follow-up visit to each department in the organization.

These four types of training will ensure that everyone involved with the new software receives training that is tailored to their specific needs and interests. (Cousins, 1994)

b. Development of Training Materials and Methods

The actual training may consist of a combination of the four different categories of training. A training plan should contain the following elements: (Leinonen, 1995)

- The purpose and objectives of the training
- The required training materials
- A timeline of training events
- A detailed outline of what will be covered
- An evaluation form for the trainees to complete on the effectiveness of the training

The objective of the finished training plan is to ensure that the training is completed effectively and accounts for all the requirements of an off-site training location.

c. Training of Trainers

It is a false assumption that just because someone knows how to do something, then they can just as well teach other people how to do it. There are two possible approaches to selecting and training the actual trainers:

- Train personnel with good communication skills to use the software.
- Train a user-expert to train others.

The attitude and approach of the trainer are very important. If the trainer is unable to deliver the material to the trainees, the results of the training will most probably be ineffective. The use of an outside consultant or even the programmers of the software may be cost-prohibitive and may require too much effort in the "train the trainers" area. (Nelson, 1995)

d. Preliminary Evaluation of Training Methods and Materials

Before starting the actual training, an evaluation of the training plan must be performed. The main points to be considered are whether the training is providing the trainee with the desired and needed skills, whether the target group is the right one, and whether the methods are effective. The easiest and most effective way to do this is to forward a copy of the training plan to the deployment team, software development personnel, and users for review. The goal is to let the interested parties have some input into what kind of training they will receive. After the responses are received, necessary changes are made and reviewed by the training team before deployment. (Leinonen, 1995)

e. Formal Training and Learning

The actual training will be conducted according to the training plan, but not too rigorously — if new problem areas emerge during the actual training, they should be dealt with promptly. Proper training of users has already been identified as a critical success factor. If not carried out properly, it can lead to costly delays, problems and dissatisfaction on the part of the users (Le Compagnon and Leydon, 1991). In general, the training should be a balance between knowledge-based training and skills-based training. The training plan should have also been geared to the specific groups that need to learn about the new software. With these considerations in mind while formulating the training plan, it is anticipated that the major training pitfalls of inapplicable training material and ineffective trainers will be avoided. (Nelson, 1995)

f. Evaluation of Training

At the end of the training sessions, an evaluation will be distributed to the trainees. The questions in the survey should assess the following areas: (Cousins, 1994)

- Presentation of the material.
- Skills of the presenter.
- Whether the trainees felt the objectives of the training were met.
- Classroom facilities.

The trainers will assure the trainees that the evaluations will be read carefully with the goal to improve the training for future participants. For training to be effective, it must be seen as an ongoing process which begins with a determination of institutional and individual needs, involves both users and trainers in the planning process, and includes procedures for evaluating the effectiveness of the training and making changes and adjustments as needed. The training evaluation has been proven to be an effective means of fine-tuning individual training programs. It is also a means of determining specific areas for which adequate training is not being provided. However, a survey will not provide much information on some of the questions which the trainers need to consider if training is to be a part of the deployment process. (Le Compagnon and Leydon, 1991) Some of these questions on the survey include:

- Does the training make the user more self-sufficient?
- Does it make the user more efficient at his job?
- Does it provide a more cost-effective means of support to users than other types of support?

With a well thought-out training plan and a survey that queries the users about the training, the training can be conducted efficiently and productively while being improved in the areas that trainees specify if needed. (Le Compagnon and Leydon, 1991)

3. Conclusions About Training

There is no one right approach to effective user training (Le Compagnon and Leydon, 1991). Effective training can take on any number of different forms, not all of which take place in the traditional classroom environment with an instructor. Documentation, online tutorials, and video tapes can provide alternative, adequate, and cost-effective training for most user needs. These alternatives, however, can not replace the responsiveness of an instructor in person. The training must also be seen as a process to strengthen long-term institutional goals and as a cost-effective means of providing user support (Le Compagnon and Leydon, 1991). Often, not enough time is spent up front assessing needs and planning the training effort, nor is enough time spent evaluating the results and making necessary changes. With proper planning and evaluating, training can be one of the most cost-effective means of providing computing support to users.

D. EFFECTIVE COMMUNICATIONS BETWEEN USERS AND DEVELOPERS/ MAINTENANCE TEAM

A successful implementation does not end with the deployment of the software. Once the software is deployed there must be some mechanism for the users to communicate with the developers and/or the maintenance team. Lines of communication should be a two-way street that provide follow-up and feedback. The users must have a point of contact in the event that they have a question or complaint about the software. Information should also be available on project objectives, status, changes, organizational coordination, and user needs (Schultz, Slevin, and Pinto, 1987). Providing a point of contact also provides an organizational "home" for the software. The need for assigning a system manager has been clearly demonstrated (Keen and Morton, 1978). The system manager that is handling the user support should be: (Keen and Morton, 1978)

- Familiar with the job of the users
- Skilled technically, administratively, and interpersonally
- Involved in planning, priority setting, and decision making in the project

An effective system manager also facilitates the institutionalization of the software while at the same time encourages and makes easier user participation (Multinovich and Vlahovich, 1984). A single point of contact also avoids conflict by having one person prioritize requests from the users.

E. POST-IMPLEMENTATION EVALUATION

It is impossible to determine implementation success without a thorough evaluation (Cerullo, 1979). The determination of success should be based on three factors: (Multinovich and Vlahovich, 1984)

- A prior definition of "improvement".
- A means of monitoring progress toward the goals.
- A review process to determine when the system is fully implemented.

In the case of a newly implemented system, performance will be based on the accuracy of the system resulting from the user's use of the system. Measures of effectiveness will include the realization of any of the benefits projected from the cost-benefits analysis. Satisfaction will be based on the user's opinion of the software. A survey, an example of which is included as an appendix to this thesis, should be distributed to measure ease of use, perceived accuracy, and the perceived impact on the performance of the user's duties (Multinovich and Vlahovich, 1984). The survey should be designed to obtain all the information needed to judge user satisfaction while remaining as unobtrusive to the user as possible. But how can user satisfaction be measured? Lucas and Ginzberg (1990) have formulated a model for assessing implementation success as shown in Figure 3-1.

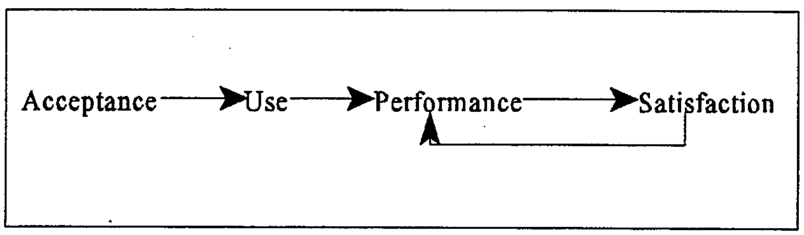


Figure 3-1. Lucas-Ginzberg model of implementation success.

The model shows that in order to ensure that users use the new application, they must be satisfied with it. A survey can gauge user satisfaction and help determine where areas of improvement lie (Lucas and Ginzberg, 1990).

F. HARDWARE IMPLEMENTATION ISSUES

While choosing the right hardware is obviously an important choice in a successful implementation, there is no standard hardware configurations that are defined for the different categories of expert systems due to the unique requirements that every system has. The starting point for determining the hardware that will eventually be deployed should start with an analysis of the minimum hardware required to effectively run the software (McGaha, 1994). Factors that should be considered prior to deployment are:

- Portability: Do the users or the environment require a portable computer?
- Commercial-off-the-shelf vs. Custom design: Is the system able to run on a commercially available computer or does it require unique hardware or an uncommon configuration?
- Operating environment: Is the operating environment of the deployed system harsh enough to require ruggedized computers?
- Cost: Is affordability a concern?
- Expandibility: Does the hardware need to be expandable in anticipation of adding new features or upgrading an application?
- Security: Does the application require a secure operating environment?

Hardware should be chosen after the development of a full prototype version is completed at which time it is easiest to determine the needs of the system (Prerau, 1990).

G. SUMMARY

This chapter examined implementation issues that must be taken into account before deploying a software application. Obtaining management support, involving users in the development of software, training users, establishing effective communications, and conducting a post-implementation survey are important issues to implementation success. Finally, the type of hardware that the software will be deployed on must take into account the six factors listed in Section J. In his thesis, Leonard (1996) lists several factors that are critical to implementation success based on published research: (Leonard, 1996)

- Create realistic expectations about expert system capabilities.
- Involve the users in the development and implementation plan to the degree that they feel they have influence in the process.
- Promote system usage through organizational rewards.
- Provide a system of training that instills confidence in the users and offers the opportunity for additional instruction on request.
- Build enthusiastic support at all levels of management.
- Establish effective lines of communication between the users and the maintenance team by establishing a help desk and points of contact of system advocates.

The implementation issues examined in this chapter will be applied in Chapter V to the implementation of the MK 92 MAES full prototype version.

IV. IMPLEMENTATION ISSUES OF MAES AS A SOFTWARE SYSTEM

The previous chapter addressed general implementation issues involved in deploying a software application. This chapter will apply the implementation issues discussed by Prerau (1990) specifically to the initial deployment of MAES. Section A provides an analysis of the general software implementation issues that affect MAES. It begins with a description of the MAES development history and how it has followed the framework developed by Prerau (1990). Section B presents lessons learned by other DOD activities that implemented expert systems to diagnose weapons systems. Section C examines organizational structures within the Navy and their impact on implementation. Section D applies research on management and user perspectives to the implementation of MAES and Section E is a summary of the chapter.

A. MAES DEVELOPMENT HISTORY

The general software development life cycle model used by the MK 92 MAES development team generally follows a model described by Prerau (1990). He divides the expert system life cycle into three phases: the initial phase, core development phase, and final development and deployment phase (Prerau, 1990). A summary of the MAES development for these phases follows.

1. Initial Phase

The initial Prerau phase consists of project start-up, selection of the domain, and selection of the development environment. In 1991, engineers at NSWC-PHD started the development of an expert system designed to diagnose problems associated with the MK 92

MOD 2 FCS Daily System Operability Test (DSOT). The domain expert for analyzing and documenting the knowledge to be incorporated in the system was a technical representative from UNISYS with over 25 years engineering experience. The knowledge for MAES was acquired from MK 92 technical manuals, the domain expert's analysis of the system, and heuristics of other MK 92 experienced engineers.

The development environment chosen for MAES was an expert system shell from SoftSell called Adept™ v2.2. This tool was selected after extensive evaluation of diagnostic expert system shells and the experience of an Army development team building an expert system for the M1A1 tank's turbine engine. Adept was selected for several reasons. First, Adept uses a graphical, procedural approach to knowledge representation that is suitable for diagnostic systems. Second, it has an integrated graphical user interface (GUI) screen builder. In addition, the tool is easy to use and provides for unlimited run-time versions. Finally, the development version runs on Windows based 80486 platforms and is relatively inexpensive at $695.00 per copy.

2. Core Development Phase

The core development phase consists of the development of a feasibility prototype and a full prototype system. An initial prototype of MAES was built and demonstrated. A full prototype, consisting of the calibration and performance modules, was then developed and fielded to the USS Sides (FFG-14) and the Fleet Training Center in San Diego (FTC-SD)for feedback. The prototype deployment allowed senior technicians both on the ship and at the MK 92 technician school to make helpful suggestions. Examples include:

- The use of photos to assist in following recommended troubleshooting/repair steps and for which pictures are not available in the tech manuals.

- The inclusion of "why" buttons to explain to a technician why a certain step is recommended. This feature also enhances the training capability of MAES.

- The listing of part numbers when a part is recommended for replacement. This will speed the supply administrative process of acquiring a new part.

Bradley and Hauser point out that when technicians observe their suggestions being turned into program features it gives them a sense of accomplishment and involvement in a project (Bradley and Hauser, 1995). All recommendations were incorporated into the system. Involving the instructors at FTC-SD also served the purpose of introducing MAES to student technicians that were about to enter the fleet. This was a method to expose potential users to MAES prior to reaching their ships. Student technicians at the MK 92 "C" school also had the advantage of receiving the introductory MAES training over the course of a week instead of the one day training schedule planned on for the initial deployment.

3. Final Development and Deployment Phase

The MAES project is currently in this phase. During the development and deployment phase, a production system is built and the system is deployed. MAES will then transgress to the maintenance phase, with software and knowledge bugs being fixed and new information and features being added as necessary. To produce the initial deployment version of MAES, several issues were examined.

- Possible representation and reimplementation: Although a prototype of the performance module had been completed, an outside contractor was hired to redesign the software, incorporate new knowledge into the module and ensure that the module was robust and reliable for fielding.

- Deployment Hardware: Factors that were considered for MAES hardware deployment were cost, reliability, portability, and screen characteristics. This topic is discussed in greater detail in Chapter V.

- Deployment software: The deployment software is simply a run-time version of the development software. Users will be able to run MAES without having to install the development software, Softsell's Adept 2.2™, on their computer. Users will not be able to make changes to the distributed software.

- Input/Output formats: Comments from users have reflected that the user interface is extremely easy to learn and use. In recent tests, non-MK 92 technicians were able to diagnose MK 92 faults correctly using MAES, even though they had no prior exposure or experience with the MK 92 FCS (Myer, 1996).

- Testing: The initial version of the calibration module has been tested and evaluated. FTC-SD has been verifying knowledge by allowing student-technicians to use MAES to diagnose faults on a MK 92 mock-up. Knowledge and software validation and verification have been part of the development process.

- Documentation: NSWC PHD will be maintaining MAES after the deployment of the initial version. The following documentation to support maintenance is being assembled for transfer to NSWC PHD: System Level Description, Software Design Document, MAES User's Manual, Version Description Document, and a Program Package. Final versions will be produced as part of the production decision to deploy to all ships.

The implementation plan for the deployment of the initial version provides a guideline for completing the steps required for deployment of MAES and is included as Appendix A to this thesis.

The long term maintenance of MAES will be conducted by NSWC-PHD. Having NSWC-PHD as the only maintenance source allows a centralized approach to maintenance (Prerau, 1990). Work has begun on defining and preparing the deliverables required to support the fielded system.

B. INCORPORATING LESSONS LEARNED THAT MAY IMPACT IMPLEMENTATION

This section addresses the subsidiary research question "What are the lessons learned in the implementation of other expert systems for weapons systems within DOD?" Although personal computers and software applications are widely used throughout DOD, expert system software is a relatively scarce technology that is still not common within the military. However, two large expert systems have recently been deployed by the Army and Navy:

- The Turbine Engine Diagnostic (TED) expert system is used in the Army intermediate maintenance activities to aid gas-turbine technicians in troubleshooting the turbine engines installed in the M1 Abrams main battle tank.
- The Phalanx Integrated Maintenance System (PIMS) used in the Navy to aid fire control technicians on surface ships in maintaining and diagnosing faults in the Phalanx close-in weapon system (CIWS) was deployed over the past two years.

Valuable lessons learned from the deployment of these two systems can be utilized to avoid problems in the MK 92 MAES deployment. The lessons learned from these systems are especially applicable to this deployment because:

- Both expert systems were deployed for military systems.
- Both expert systems have requirements similar to the MK 92 MAES in that they were both designed to aid technicians in the maintenance of complex, technical machinery.
- Both expert systems are used primarily by enlisted technicians.

Video teleconferences (VTC) with the Army Research Laboratory (ARL) at Aberdeen Proving Grounds (which developed and deployed TED) and the Naval Ordnance Station (NAVORDSTA) at Louisville, KY, (which developed and deployed PIMS) were held. Many valuable lessons were learned in these teleconferences. They fall into several categories defined below.

- Training: Lessons learned that improve training methods and materials during initial implementation.

- Maintenance: Lessons learned that improve the post-deployment maintenance of the expert system.

- Post-implementation evaluation: Lessons learned that improve the conduct and effectiveness of the post-implementation survey.

- Hardware issues: Lessons learned that may aid in making choices in which type of hardware to deploy MAES.

The following sections discuss the lessons learned in more detail.

1. Training Lessons Learned

The training lessons learned include:

- Training needs to allow for a wide range of computer experience. Trainers should be prepared to deal with computer illiterate personnel.

- Training teams need to visit each site to conduct the initial training. Besides the obvious benefits to the new user, the developers learned much. Trainers were able to stand beside the technicians as they observed how the user used the expert system and saw how they reacted. As a result they were able to gain first hand knowledge on where the deficiencies were in the user interface.

- Users need to be informed that the issued computer is only to be used for accessing the expert system. Maintenance teams received many calls about software conflicts resulting from the installation of unauthorized software and there is a real threat of the introduction of viruses.

- Training needs to be coordinated with the commands receiving the expert system as far ahead of time as possible. A lack of coordination between activities, will likely result in difficulty getting the right people to attend training sessions.

- Deployment teams should not install multimedia training aids on computers. A training video installed on laptop computers was not found to be worth the time, money, and hard drive resources required.

2. Maintenance Lessons Learned

The maintenance lessons learned include:

- The deployment team should solicit users for suggestions during training sessions. Major revisions to the software were made after deployment based on user feedback.

- Developers should be sensitive to the varying levels of computer expertise that enlisted technicians may have. Expect to add more on-line help for the inexperienced user.

- A single point of contact should be designated for problems with the software. A single point of contact provides consistency to the users that have problems with the software.

- Technical support personnel must be prepared to deal with general computer problems. A large number of requests for assistance were for problems unassociated with the expert system, such as computers that would not boot or problems with the Windows operating system. Plan ahead and prepare for these.

3. Post-Implementation Evaluation Lessons Learned

The post-implementation evaluation lessons learned include:

- The maintenance team should have in place a web page for technical support. Extensive use of the Internet was made to make revisions available for download and to provide a method for technicians to provide feedback and bug reports.

- The maintenance team should include a survey that can be answered by individual users on a web page. It was found that technicians were not answering surveys that were mailed out. Once world wide web access was available, the problem of collecting data diminished.

4. Hardware Lessons Learned

The hardware lessons learned include:

- All technicians should have access to the computer that contains the expert system. Some senior technicians kept the computers locked up for fear of pilferage, limiting access to others.

- Training should emphasize that this system is for troubleshooting purposes only. Some senior technicians used the computers for other purposes, such as administrative tasks.

- Ruggedized laptops are not necessary. Off the shelf laptops have so far fared well in an intermediate maintenance garage type environment.

- The computers that are distributed should have durable pointing devices. Trackball and mouse-type pointing devices tend to become inoperative in a maintenance environment.

- At a minimum, dual scan screen technology should be used for laptop computers. If the laptop will be used in bright sunlight, then an active matrix screen should be specified. Technicians had difficulty discerning details in photos when black and white displays were used.

C. ORGANIZATIONAL STRUCTURES AND THEIR IMPACT ON IMPLEMENTATION

Lucas and Ginzberg (1990) developed an implementation model that addresses management and user concerns in the implementation process Before the factors in the sub-models can be examined, the organizational structure of the ship and the shore-based maintenance and training facilities must be considered. A determination of who fits the roles of management and user must first be resolved.

1. Shipboard Organizational Structure

An organizational chart of the typical chain of command onboard a FFG-7 is shown below in Figure 4-1.

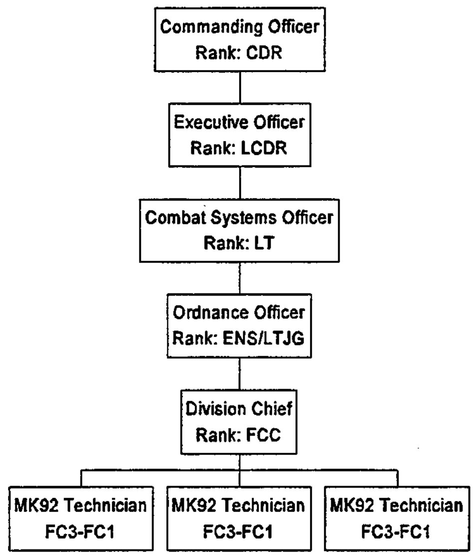


Figure 4-1. FFG-7 Chain of Command.

System operation and maintenance aboard ship are conducted by enlisted technicians who possess the Fire Control (FC) rating with a Navy Enlisted Classification (NEC) of 1102. The technicians receive this NEC once they have completed the 32 week MK 92 "C" school. The manning level for MK 92 FCs on FFG-7 class ships is seven, but may vary from ship to ship. Reserve ships are allotted one less junior technician. Budget cuts and downsizing have contributed to the lack of proper manning levels in the fleet. Reduced manning is a contributing factor for the high number of technical assistance requests. (McGaha, 1994)

Holek (1994) describes three types of personnel that need to be trained: upper management, line management, and users. Applying this framework to a shipboard organization would result in the following classifications:

- Upper management: The commanding officer, executive officer, and combat systems officer.
- Line management: The division officer and division chief.
- Users: All MK 92 technicians; junior and senior.

Classifying shipboard personnel in the above manner will allow the MAES deployment team to tailor their training plan to each category of manager or user.

2. Shore-based Maintenance and Training Organizations

Unlike the shipboard organization, there is no hierarchy associated with the shore-based maintenance and training commands. After enlisted recruits graduate from boot camp and "A" school, they are sent to the "C" school for which they have qualified. In the case of MK 92 technicians, the "C" school is located at FTC-SD and FCTC Dam Neck. Although the schools are not a part of the maintenance organization, they have proved invaluable as a source for testing the knowledge contained within MAES. The school has also served as a way to expose new MK 92 technicians to MAES in a training environment and to gather data on the system.

Technical support is available to shipboard technicians from Fleet Technical Support Centers (FTSCs) and NSWC-PHD. A ship requests technical assistance through the respective type commander's (TYCOM) Readiness Support Group (RSG) via telephone or CASREP. FTSC's are staffed by both senior Navy enlisted technicians and experienced civilian technicians. FTSC technical representatives can be considered line management due to their position as technical experts. However, there are different levels of experience and expertise at the FTSC. Some technicians may, on occasion, use MAES in areas they are less knowledgeable about. They would be considered users in such cases.

D. MANAGEMENT AND USER PERSPECTIVES ON MAES IMPLEMENTATION

The Lucas-Ginzberg (1990) model of implementation consists of two stages: adoption of a system by the managers and adoption of the system by users. This model is applicable to the FFG-7 shipboard organization. The following sections discuss these two areas.

1. Management's Perspective of MAES Implementation

The importance of management support and its contribution to implementation success was discussed in detail in Chapter III. Although the two sub-models from the Lucas-Ginzberg (1990) implementation model include many factors that influence implementation success, only the specific factors that can be influenced by the MAES development and deployment teams are addressed here.

- Manager acceptance: On a US Navy surface combatant, enlisted technicians are influenced in their work habits most strongly by the division chief and somewhat by the division officer. Manager acceptance will in turn be influenced by manager knowledge of MAES and manager assessment of the MAES system and available support.

- Manager knowledge of MAES: The MAES deployment team will instruct division officers and chiefs on the benefits and purpose of MAES and the basics of how the system works. Acceptance of MAES should increase with management education.

- Manager assessment of MAES and support: Showing officers and chiefs the advantages and benefits that MAES equipped technicians will have over technicians not using MAES should gain their support for the system. Providing the division officer and chief with a means of repairing hardware faults and providing technical support for MAES software will gain their confidence of the system.

- Manager belief in the MAES concept: Officers and chiefs who believe in MAES' ability to aid technicians, cut down the NFE problem, and reduce MTTR will want to learn about the system. With this knowledge they will encourage the technicians to use it.

- Top management support: The deployment team should address the commanding officer, executive officer, and the combat systems officer during an informal, half-hour brief on MAES. This would provide an opportunity to inform the ship's upper management of MAES benefits. A short demo should be included. This is an important brief as the ship's upper management, if they believe in the system's importance, can greatly influence how the division officer and chief view MAES.

Obtaining upper management's support can significantly increase the probability of a successful implementation of the system (Lucas-Ginzberg, 1990).

2. User's Perspective of MAES Implementation

Improving the technician's ability to correctly diagnose and solve faults in the MK 92 MOD 2 FCS is one of the primary goals of MAES. A short discussion of each of the applicable user variables in the Lucas-Ginzberg model that can be influenced by the implementation and how they may be applied to MAES follows.

- User acceptance: This is a key variable on whether or not a system will be used. It is influenced by the user variables discussed below. The instruction, demos, and hands-on training should all be oriented at achieving user acceptance.

- User knowledge of MAES: For users to accept a system, they must be knowledgeable of it. The MAES deployment team will train the technicians on how MAES functions, its capabilities, and its limitations.

- User assessment of MAES and support: Training of the users must ensure that they have the necessary means to resolve hardware and software problems. A single point of contact for providing MAES support should be established. NSWC-PHD, as system configuration manager, will be so designated.

- MAES characteristics: This variable represents the features and capabilities of MAES. Easy to use systems such as MAES are more likely to be accepted by the user. The implementation process should cover this variable.

* User-researcher involvement: Although it was not possible for every technician to be involved in the MAES development, users should be made aware of the fact that some of the best features of MAES have resulted from sailor's suggestions during shipboard prototype demonstrations and evaluations at the training centers. This should provide a sense of user ownership of the system.

* User perception of management support: The division officer and chief must foster an environment of support through their encouragement of MAES use when diagnosing applicable MK 92 casualties. Users should also be aware of upper management's support for MAES. Encouraging MAES use as a training tool to study for rating exams and as a tool for conducting training sessions will aid user perception of management support.

* User knowledge of system purpose and use: Training in this area will be concurrent with the variable "user knowledge of MAES". The difference is the focus on the purpose of MAES. Technicians need to be made aware of the high cost of NFEs, the high MTTR, and the increasing reduction in tech assist support.

* Problem urgency: This variable reflects the criticalness and urgency of the problems (NFE's, high MTTR, reduction in tech support) to which MAES addresses. Educating the technicians on the benefits of saving them time and saving their ship money increases their stake in MAES' success.

* Organizational support: This is a measure of the degree to which the deployment team can convince management to allow technicians the time to train on MAES.

Most of the above variables can be positively influenced by how effectively the MAES deployment team conducts the training during their deployment visits to the FFGs. A well thought-out and organized training plan that takes these variables into consideration will be a crucial factor in the implementation's success.

E. SUMMARY

Although MAES is an expert system, general software implementation issues should not be ignored. Adhering to an established and tested development methodology, such as Prerau's, provides a foundation for a successful implementation. Also, the experience that other organizations have in implementing a similar system can be invaluable. If problem areas were encountered in prior expert system implementations, they can be avoided by determining what lessons have been learned.

To properly address each level of an organization that may use MAES, the organizational structure and how it impacts an implementation must be understood. Then, an implementation may be developed that addresses the concerns of both the managers and the users. The next chapter addresses implementation factors that are specific to the MAES deployment.

V. IMPLEMENTATION ISSUES FOR THE INITIAL DEPLOYMENT OF MAES AS AN EXPERT SYSTEM

This chapter applies the implementation methodology and issues discussed in the first four chapters of this thesis to the implementation of the initial version of the MK 92 MAES. Section A classifies MAES in accordance with the Meyer and Curley (1991) scheme and applies expert system implementation factors specifically to MAES. Sections B and C discuss obtaining chain of command support for MAES and involving MK 92 technicians in the implementation, respectively. Sections D and E recommend approaches to training and supporting MAES users. Section F explains how to conduct and evaluate a post-implementation survey while Section G addresses hardware implementation issues. Section H is a summary of the chapter.

A. EXPERT SYSTEM IMPLEMENTATION FACTORS

As previously discussed, expert systems possess unique characteristics that distinguish them from traditional management information systems. The fact that expert systems also vary from one another also needs to be taken into consideration. The following sections discuss how MAES is classified as an expert system and additional considerations that need to be made for implementing MAES.

1. Classifying MAES

Meyer and Curley (1991) developed a classification scheme that views expert systems along two attributes: knowledge complexity and technology complexity. MAES best fits into the category "Knowledge Intensive", since it incorporates the knowledge of skilled decision makers, requires a simple computing environment, and aids the decision making for a specific group. MAES has the following characteristics:

- MAES incorporates the knowledge of skilled and experienced engineers.
- MAES requires a simple computing environment. MAES is a point-and-click system that runs efficiently on a 486-DX4 75 MHz laptop with 8 Mb of RAM.
- MAES aids decision making for a specific group. This group includes enlisted technicians and technical representatives responsible for maintaining the MK 92 MOD 2 FCS.
- MAES was developed using an expert system shell.
- MAES contains complex knowledge and represents true expertise, instead of commonly used procedures.

These characteristics therefore most closely are associated with the "Knowledge Intensive" category. Knowing which category of expert system that MAES falls under aids in implementation planning since each type of expert system is affected differently by implementation factors (Bradley and Hauser, 1995).

2. Expert System Factors That Affect MAES Implementation

The fact that MAES is an expert system carries with it additional considerations for implementation. These were addressed in general in Chapter III. Figure 5-1 is a summary of how Bradley and Hauser (1995) rate the relative importance of implementation factors for different expert systems. MAES's category is encircled. Knowing which factors will be most influential in the implementation and applying them increases the probability of a successful implementation (Bradley and Hauser, 1995). Also, since MAES is a resource constrained project (both in funding and personnel), every factor may not be able to be fully addressed.

Determining where efforts should be concentrated during the implementation process will reduce the risk of failure.

Factor	Expert System Classification I	II	III	IV
Innovation Characteristics				
User perception of computing technology	H	H	H	H
User perception of expert systems	L	M	M	H
Organizational influences				
User involvement in expert system design	H	H	H	H
User involvement in expert system implementation	H	H	H	H
Reward structure	L	M	M	H
Training	L	M	M	H
Top management support	L	M	M	H
Supervisor support	H	H	H	H
Advocates	L	M	M	H
Consulting aids	L	M	M	M
Individual Differences				
User perception of change	H	H	H	H

L = low emphasis in the implementation plan
M = medium emphasis in the implementation plan
H = high emphasis in the implementation plan

Figure 5-1. Relative Importance of Expert System Implementation Factors with MAES Category Highlighted. (Bradley and Hauser, 1995)

From Figure 5-1, the factors that are most likely to have a major influence in the implementation of MAES are as follows:

- User perception of computing technology: Greatly dependent on the complexity of the expert system. The uncomplicated graphical interface that MAES uses eases the risk of technicians becoming overwhelmed by MAES. A thorough tutorial on how to use MAES will be an integral part of the training session and user's manual. All users should receive the training as there is always the possibility of a technician being computer adverse because of a lack of familiarity and training.

- User involvement in MAES design and implementation: Discussed in the previous section, users have provided valuable input on the features of MAES. This fact needs to be emphasized during implementation.

- Supervisor support: Analogous to management support, discussed previously. All levels of management need to participate in the implementation.

- User perception of change: This factor is associated with the technicians perception of how MAES will impact their work routine. Emphasizing that MAES is just another piece of test equipment (albeit a much more effective one) should minimize technician perception of change.

During the MAES implementation, emphasis should be placed on the technician's perception of the technology, how easy it is to use, involvement of the users in the implementation, and gaining management support.

B. OBTAINING CHAIN OF COMMAND SUPPORT FOR MAES

As discussed in Chapter III, management support will be a requirement for the successful deployment of MAES. Applying methods of gaining the support of the chain of command and overcoming resistance to MAES are discussed in this section.

Gaining the support of the chain of command on the ship and of senior technical representatives ashore should be the key objective for the MAES deployment team. The introduction of a new technology that introduces change into the way maintenance is performed will meet with some degree of resistance. As developers, one of our key concerns is that MAES be used when appropriate. If it is not used, a fair evaluation of MAES can never be made. There are several things that may be done.

1. Selling MAES to the Chain of Command

Gaining support of the chain of command is the primary reason that the deployment team will be visiting each ship the day after training the MK 92 technicians. A short brief to the commanding officer, executive officer, and combat systems officer will inform them of the benefits MAES will provide. The benefits that are most likely to appeal to them, and should be stressed during the brief, are MAES' ability to save the ship money (through the reduction of NFEs), increased operational readiness, and improvement in the sailor's quality of life through a reduction in the long hours spent troubleshooting faults. The senior chain of command must be made aware and convinced that their support will be instrumental in convincing the technicians to use MAES. Their position, in the form of a directive which is either oral or written, that MAES shall be used for all applicable faults can have a tremendous influence. Occasional verbal inquiries on the system, demonstrating their continued interest, can also serve as a strong motivator.

2. Getting Line Management Involved

The division officer and chief, the next two players in the MK 92 chain of command, are also instrumental to a successful implementation. They have daily contact that is a direct influence over the MK 92 technicians. The division officer and chief may show support by:

- Attending meetings with the technicians about MAES.
- Ensuring MAES training is part of the technician's training plan and providing time for them to train on MAES. General Military Training (GMT) is usually conducted at least three times a week onboard a ship. Providing time for technicians to train on MAES, as little as once a month, will show them that the chain of command is serious about the importance of MAES.
- Becoming knowledgeable about the basic workings of MAES. It is a practice of good leadership for officers to know the basics of the equipment for which they are responsible. Being familiar with MAES will also allow the division officer to better complete the deployment evaluation that is critical to fleet wide deployment.
- Personally using MAES. If the division officer or chief use MAES, even if just once or twice, they will become more familiar with its capabilities and limitations. This understanding of the system should provide them knowledge to support their insistence that MAES be used.

Although the demands on an officer or chief's time are many, it should only take about 15 minutes to learn how to use MAES (Myer, 1996). If the chain of command is able to devote just a fraction of their time to demonstrate their support for MAES, they play a key role in seeing that MAES is utilized.

3. Generating Support Through Demonstration

Conducting a brief demonstration of the system to the chain of command would be an effective way to present the capabilities and advantages of MAES (Bouldin, 1989). The demonstration must be simple enough to be brief and comprehensible. It should focus on the key features of the system and MAES' ease of use. Illustrating one example of a MAES troubleshooting path and demonstrating its overall capabilities should be sufficient. The MAES demonstration team should keep it simple, brief, and familiar (Bouldin, 1989).

4. Gaining Support Through Respected Advocates

Gaining the support of MK 92 technical representatives that are respected in their field and trusted by the chain of command, will aid in gaining support for MAES (Bouldin, 1989). One strategy would be to have a respected MAES advocate available at the MAES demonstration onboard the FFGs. The key activities that could provide the respected advocates include the Fleet Technical Support Centers, or the ISEA at NSWC-PHD. The training centers may also be a source. An advocate with a lot of experience and that is known to technicians onboard the ship can provide tremendous support for MAES that will be passed on.

5. Distributing a MAES Newsletter

Distributing a MAES newsletter to each ship involved in the implementation would keep management and technicians involved in the project's progress and provide a forum for discussion. The newsletter would also provide a medium to publicize the contributions that fleet technicians have about MAES and provide suggestions on how to use MAES effectively. A newsletter could be published as infrequently as twice a year and be small enough to fill only a few pages and still serve as a tool for developing and retaining an ongoing support by the chain of command. The challenge will be finding the resources, both funding and personnel, to produce such a newsletter.

6. Presenting Information from the MAES Cost-Benefit Analysis

Multinovich and Phatak (1981) state that one of the best ways to obtain management support for a new technology implementation is by presenting them the results of a favorable cost-benefit analysis. Cost-benefit analysis results may provide a means that is easier for the senior chain of command to understand. Fortunately, a cost-benefit analysis for MAES was completed in September 1993 by LCDR Steven Powell, a graduate student at NPS. Key results that should be presented at the shipboard briefing are: (Powell, 1993)

- Approximately 22% of MK 92 parts turned in for repair were No Fault Evident (NFE) parts and CASREPs from ships requesting technical assistance required an average of 251 hours until repair.

- The NFE problem is costing the fleet $900,000 in OPTAR funding per year for 28 Mod 2 ships. Note: the original cost benefit analysis was based on 51 FFG-7s. These figures represent current CNO plans of 28 MK 92 MOD 2 deployed systems.

- With the Calibration and Performance modules, MAES can improve operational readiness 8% and the mean time to repair should improve by 15%.

- The two modules in version 1.0 of MAES can cover approximately 40% of system faults.

Since the figures from the cost-benefit analysis are extremely positive, they should be used to garner management support. In addition, the results of recent system tests at FTC-SD strongly support the cost-benefit analysis findings.

C. INVOLVING MK 92 TECHNICIANS IN THE IMPLEMENTATION

In Chapter III, research had shown that users should actively be involved in the implementation of an expert system throughout its life cycle. Enlisting the aid of technicians in the development of MAES has been prudent since technicians often provide a different perspective of a system. More can be learned through their participation than through interviews or surveys alone. Multinovich and Vlahovich point out that users have often seen solutions that did not work and may have observed solutions that did (Multinovich and Vlahovich, 1984). Without their involvement, valuable lessons may be lost. The MAES development team has actively sought out the participation of MK 92 technicians. It also needs to do so during the implementation.

1. Past Participation of MK 92 Technicians

Throughout the development of MAES, prototypes have been given to technicians for evaluation and suggestions. The MAES program was provided to the USS Sides (FFG-14) for two years and the USS Wadsworth (FFG-9) for six months. They have provided valuable ideas and suggestions for the system.

Instructors at FTC-SD and students have also been included in the development of MAES. They have played an extremely valuable role. Their suggestions have resulted in the addition of more robust on-line help features; the inclusion of photos in the help sections; "Why" buttons that provide insight into the process the domain expert is using to troubleshooting a fault; and the inclusion of supply information that speeds up the ordering process. Knowledge by users that their suggestions are implemented in the design of an MIS stimulates their enthusiasm for the system (Bradley and Hauser, 1995). It has been previously documented that making such users feel they are important to the design and evaluation process by eliciting their feedback can contribute to a successful implementation (Lucas-Ginzberg, 1990).

2. Involving MK 92 Technicians in the Deployment and Evaluation of MAES

The close relationship between MAES developers and the technicians in the fleet and the instructors at the training schools is one reason why MAES has so far been well received. It is important to continue this cooperation during the maintenance of the system. Approaches to maintaining some form of communication between the developers and the users will be discussed in more detail later in this chapter. Alternatives to obtain input from the users include the following:

- Require the technicians that have MAES to periodically submit a Digital Systems Feedback Report (DSFR). This easy to fill out form provides a convenient way for technicians to provide suggestions to MAES developers. The form can be either faxed or mailed. A copy is included in the MAES User's manual (included as Appendix C).
- Solicit user input with periodic surveys. A sample MAES user survey is included as Appendix D. It is discussed in more detail later in this chapter.
- Solicit responses from each ship via standard navy radio message. While intrusive, this method would ensure compliance due to its high visibility.
- Conduct phone surveys of ships that are using MAES. The disadvantage of this method is that it would be man-power intensive and would depend on the availability of technicians and whether or not ships are inport.

The most useful and cost-effective method would be to distribute a survey to MAES equipped ships periodically. A survey would also provide some initial empirical data that could be further analyzed. The aspects that may be assessed would only be limited by the questions included in the survey. Continued user involvement is important to the successful evaluation of the system.

D. TRAINING MAES USERS

The focus in this section is training for the initial implementation of MAES. The generic questions that were raised in the previous chapter about training are addressed for MAES below:

- Who should be trained? All MK92 fire control technicians and FTSC technical representatives. This includes those temporarily assigned other duties (such as mess duty).

- How much training should be done? One day of classroom training with hands-on familiarization would be sufficient. From feedback received from FTC-SD, if they were familiar with basic electronic test procedures and equipment, junior technicians were able to use MAES within one hour (Myers, 1996).

- What training methodologies should be used? Both classroom lecture and hands-on training. These two methods provide the users of MAES with the background and experience to effectively use MAES.

- Who should present the training? A combination of instructors is recommended. For the deployment of the initial implementation, NSWC-PHD should coordinate the training. NPS faculty, familiar with the history and software development should participate. The benefit of having a senior sailor, perhaps from one of the training centers or FTSCs, would provide a tremendous sense of credibility for the system. In addition, FTSCLANT personnel should participate.

The answers to the above questions provide the framework for developing the training plan that will be used by the MAES deployment team.

The actual training provided MK 92 technicians will need to cover sufficient, detailed information and hands on experience in the use of MAES (Bouldin, 1989). Following the steps discussed in the previous chapter on formulating a training plan provides an excellent outline for proceeding. The following six sections discuss each step as applied to MAES training.

1. Assessing Training Needs

To assess training needs one must determine who needs to be trained and to what level each group should be trained. Earlier in this chapter the shipboard organizational structure on a FFG-7 class ship was defined. Tailored training needs to be provided for the various organizational levels. FTSC technical representatives, as well as training center instructors, also have to be trained. A recommended level of training for the different levels in the organization would include:

- Upper management: The commanding officer, executive officer, and combat systems officer should receive a presentation on the capabilities and benefits of MAES, as well as a short demonstration of the system. Approximately one hour should be allotted.

- Line management: The division officer and chief should attend the morning half of the technician training. They should receive information on the background, benefits, and the basics of operating MAES.

- Users: The MK 92 technicians and FTSC technical representatives should receive the training specified for line management. In addition, a hands on training session that covers all aspects of MAES operation should be taught. For the training in the Norfolk area, the FCTC facilities should be considered, as actual faults could be induced as part of the training.

The goal of this training is to ensure that each organizational level understands the purpose, benefits, and limitations of MAES and that the users are comfortable in its operation. The users and line management should receive their training in a classroom away from the ship. Upper management will receive their training aboard their ship. These different levels of training ensure that everyone receives training tailored to their specific needs.

2. Development of Training Material

The NPS has taken the lead on developing the preliminary materials. The main components of the MAES user training program are a training plan and the MAES User's Manual. A preliminary training plan is included as Appendix B and the updated user's manual is included as Appendix C. These documents will be received by NSWC-PHD and will be evaluated after the initial implementation on COMNAVSURFLANT ships. The training plan includes information about:

- The purposes and objectives of the training.
- The required training materials that the deployment team will need to provide to carry out their training.
- A chronological outline of what topics will be covered.
- A training evaluation form to pass out to all trainees to determine if the goals of the training are being accomplished.

The user's manual provides information to users who missed the training or need to refresh their knowledge of how to use MAES. The MAES user's manual should contain the following information: (Lester, 1996)

- An explanation of the purpose of MAES and what information the user's manual provides.
- Step by step instructions on how to install MAES and what the hardware and software requirements are.
- How to initialize, operate, and exit from MAES.

Completing the above documentation is the first step in the training process. The next steps must be complete before the deployment team can progress.

3. Training Team Composition

The training team composition should minimally consist of two persons. One trainer should be from NSWC-PHD, the project manager for MAES and eventual system configuration manager. The second member should be an experienced Navy technician for the MK 92 MOD 2 FCS. Possible sources are a FCC from FCTC Dam Neck or an FCC from FTSCLANT. An FCC should be able to relate well with his fellow sailors. The knowledge and job of the FCC will also provide credibility to the training team. Because this initial deployment is for the evaluation of MAES, a faculty member from NPS should also be part of the team. Data will need to be gathered on MAES and NPS will coordinate this effort. The focus for the NPS representatives will first be to provide information on the problems facing the MK 92 MOD 2 technicians and the benefits MAES offers based on the NPS cost-benefit analysis. The second purpose will be to implement the evaluation process.

4. Preliminary Training Review

While this research has produced the initial training components, review by others knowledgeable of the MK92 is warranted. Therefore, copies of the training plan and user's manual should be forwarded to FTC San Diego, FCTC Dam Neck, FTSCLANT, and MAES developers at NSWC-PHD for review. Feedback should be received and acted upon prior to conducting the actual training.

5. Evaluation of Training

At the end of the training sessions, an evaluation should be distributed to the attendees for their view of training. An example evaluation is included at the end of the training plan in Appendix B. Completed evaluations should be reviewed carefully by the trainer at the conclusion of each training session. Needed changes should be made. A consensus of the training team members should decide on needed changes.

6. Alternatives to On-Site Training

Providing MAES users with on-site training is the preferred method of training. It has the benefit of addressing questions on the spot, providing dedicated attention to a technician having trouble comprehending some aspects of MAES, and a chance to provide a personal brief to the chain of command. Should availability of ships or funding constraints pose a problem with providing on-site training to all ship's crew there are less expensive options that could be considered. Options include:

- Training ship personnel via video-teleconferencing. This method would save the MAES deployment team travel costs. However, it would require considerable coordination and may be subject to time restrictions that are associated with using military video-teleconferencing equipment.

- A videotape could be produced by the MAES deployment team and sent to each ship along with the MAES software and hardware. This option has the advantage of providing MAES users with a well choreographed and structured training session. It would not allow the deployment team to address specific questions nor address the chain of command personally.

- Sending each ship printed training materials along with the MAES software and hardware. This is the least preferred method, but provides an alternative if funding becomes a problem.

- Provide training to personnel at one central training facility on the East Coast. While this poses the least costly alternative for the training team (in terms of both time and money), it puts a heavy burden on the fleet sailors. Not all MK 92 MOD 2 technicians would likely be able to attend because of the costs (in both time and money). The system's goal is supposed to ease the load on the sailor. This shifts the burden from the implementation team to the fleet and is considered the least desirable alternative.

Actual training alternatives may be a combination of the above methods. But the preferred method would be the on-site training of MAES users in their homeports by a professional deployment team.

E. SUPPORTING MAES USERS

This section describes support that should be available to the MAES users after the system has been deployed. The MAES configuration manager will be a project engineer at NSWC-PHD (Code 4W32). The configuration manager will provide MAES users with a single point of contact that is knowledgeable in the technical aspects of the system, both hardware and software.

1. Hardware Support

If a MAES computer suffers a defect that is covered under the manufacturer's warranty, then the ship will get the computer repaired through the applicable company's warranty program. A computer that sustains damage that is not covered by warranty, should have to be processed for replacement. The configuration manager at NSWC-PHD should maintain a list of acceptable models and manufacturers available on GSA schedule or other sources that meet MAES' minimum requirements.

2. MAES Software Support

Software support for the MAES program falls into two categories: pre-bundled commercial-off-the-shelf software and MAES developed software. Pre-bundled software includes all software that comes pre-installed on the computers such as the Windows™ operating system. MAES users will use the provided documentation and commercial support provided by the applicable software company for pre-bundled software. Support for MAES software will be provided by the MAES configuration manager at NSWC-PHD. The user's manual provides MAES users with directions for contacting the MAES configuration manager. It also provides reporting procedures for software problems and suggestions. When upgrades are needed they will be made available by FTP on the NSWC-PHD web page, by transmission via the Streamlined Automated Logistics Transmission System (SALTS), or by distributing upgrades on diskettes via mail to each ship. If resources are available, information on MAES upgrades and user contributions may be available through a MAES newsletter mailed to each ship or by publications listed on the NSWC-PHD web server.

F. CONDUCTING A USER SURVEY

A user survey will be conducted to determine the value of MAES during the evaluation period. It will be used to determine user satisfaction, suggestions that MAES users have, and for documenting recommended improvements that need to be made to either the MAES knowledge or user interface. The MAES user survey should be conducted by mail since this is the most cost effective method. It also ensures that all ships can be contacted whether inport or underway. In a mail survey, the MAES users will have more time to collect facts, talk with each other, or consider replies at length than is possible with a telephone or personal interview. Another alternative would be to use e-mail for responses. A proposed MAES user survey is included as Appendix D.

1. Implementing the User Survey

A primary consideration used in the design of the MAES survey was that the respondent should be able to answer the questionnaire in a short period of time, e.g. ten minutes (Cooper and Emory, 1995). The following procedures should be used to ensure that the survey is returned by as many respondents as possible: (Cooper and Emory, 1995)

- Follow-ups, or reminders, should be conducted after the survey is distributed in order to increase the response rate.
- Advance notification of the survey should be given by the deployment team notifying the MAES users that they will be asked to complete a survey that is important for system improvement and will have a significant impact on the fleet wide deployment of MAES.
- The user survey should be designed to be completed by the user within ten minutes.
- Pre-addressed, stamped envelopes should be provided with the surveys.
- A personalized cover letter should be included with the survey telling the users that their opinions are important to the improvement process and for justification for fielding MAES to all FCS MK 92 MOD 2 ships.
- Users should be informed that their anonymity is assured.

The survey should be conducted at least twice during the implementation of the initial evaluation. This will allow the analysts to gauge any changes in user opinion or use during the initial implementation period. The primary research question for the survey is "What is your level of satisfaction with the MAES software?" A subsidiary research question is "What improvements can be made on MAES?"

2. Analyzing the Results of the Survey

The majority of the questions on the survey are answered by the respondent circling a number. This type of design decreases the time required to complete the survey and makes the analysis of the data easier. The target audience will be all MAES users that have actually used MAES to diagnose faults in the MK 92 FCS.

Methods of analyzing the data should include running a frequency of variables in a statistical analysis program, such as SPSS. A frequency of variables analysis would break out which aspects of MAES users like or dislike the most. A histogram plot should be produced to determine how respondents rate MAES. This analysis should also be useful in determining areas where the software is not meeting the full expectations of the users. Another analysis that could be done is an analysis of variances to determine the correlation between how often MAES is used with satisfaction. The analysis of variance test could also show if there is one aspect of MAES that is poorly designed and deters the user from using MAES. A comment area is included to allow MAES users to elaborate on any of the questions they were asked. The analysts can categorize comments into categories such as ease of use, suggestions, or hardware likes/dislikes to determine if any suggestions are made often enough to warrant attention.

G. HARDWARE IMPLEMENTATION ISSUES

Part of the evaluation of MAES will deal with an assessment of the computer hardware requirements for MAES. During the evaluation, MAES will be deployed on six COMNAVSURFLANT ships using COTS laptop computers. One of the first issues will be to determine if laptop computers are suitable for the effective employment of MAES.

Another element in the evaluation will be the reliability of COTS computers. Other features, such as screen visibility, user input ergonomics, battery life, etc., will also be evaluated. This section discusses the subsidiary research question " What are the hardware implementation issues associated with deploying MAES?" This subject was previously examined by McGaha (1994). The section draws extensively on McGaha's research. It provides updates to his recommendations in areas that have changed.

1. Portability

MAES provides a two-way communication with the technician to diagnose the system. It has been designed with features that will enable the technician to expeditiously diagnose and repair a fault. These include illustrations on how to carry out a called for procedure, pictures, and part number information.

Since the different components of the MK 92 FCS are located in six different compartments of the ship, a laptop computer will provide the portability needed to use MAES effectively and is strongly recommended. McGaha provided additional guidance on the use of dedicated laptop computers that included: (McGaha, 1994)

- The computers should be classified as a piece of test equipment. This will ensure minimal use of the computer for administrative purposes and give first priority for its use to maintenance.
- A laptop computer can be stored more easily and in a secure container.
- A dedicated hardware platform will minimize the potential for viruses and the software conflicts that can occur with other installed software.
- It ensures that a technician has access to MAES at any time, not only to use for troubleshooting, but also for training.

2. Commercial-Off-The-Shelf (COTS) Versus Ruggedized Computers

Although ruggedized computers are designed to withstand an industrial environment, including many elements experienced by a ship at sea, the features come at a high cost. While prices on ruggedized computers have decreased significantly over the past two years, they currently cost three to four times as much as their non-ruggedized counterparts, with prices from $5,000-$10,000. From a personal perspective, based upon five years of sea duty, COTS laptops survive remarkably well onboard a navy ship. The Army has deployed an expert system on both COTS laptops and ruggedized laptops. They found no major advantages for the ruggedized versions (Healfman, 1996). The MAES project has always been an austerely funded project. And while it is desirable to purchase both ruggedized and COTS portables for evaluation, at present, funding for ruggedized computers is not available. Therefore, the implementation plan calls for COTS laptop computers.

3. Cost and Support

Over the last decade the cost for computer hardware has constantly been declining. New generations of laptop computers are appearing approximately every six months. As a result, powerful laptops are frequently discounted 40-50% when a new generation appears. The affordable laptop computers available today for $1500 will provide ample power to run MAES efficiently. The least capable laptop CPU that is available at the time this thesis was written is a 486-DX4 75Mhz chip. Even these types of processors are becoming increasingly hard to find in quantity and by the time a purchase is made for deploying MAES, Pentium-75 MHz chips will most likely be the cheapest CPU available. One of the lessons learned during the course of MAES development is that a low cost computer may not be the cheapest alternative in the long run. Service support for generic brand notebooks has not been as good or as responsive as that of major name brand manufacturers. Reliability has also been a problem with generic brand laptops. With todays more liberated acquisition policy and numerous contracts or alternatives that meet competitive requirements, it is possible to purchase high quality computers with excellent warranty coverage. Indefinite Delivery, Indefinite Quantity (IDIQ) contracts, General Services Administration (GSA) schedules, or mail order companies are all available sources.

H. SUMMARY

In this chapter, the implementation issues discussed in Chapters II and III were applied to the initial implementation of MAES. Obtaining chain of command support for MAES was established as crucial to the success of MAES when deployed. Involving MK 92 technicians in the implementation and properly training all MAES users were also examined. The importance of supporting MAES users and conducting a user survey were addressed. Finally, hardware implementation issues were updated since they were last examined by John McGaha (1994). The next chapter provides a summary of conclusions and recommendations.

VI. CONCLUSIONS AND RECOMMENDATIONS

Deployment issues addressed in this thesis apply to the implementation of the initial production version of MAES on the six Atlantic Fleet test frigates. This chapter summarizes the findings of this research. It also makes recommendations for fielding MAES and follow on research.

A. SUMMARY OF CONCLUSIONS

This thesis research was focused on one primary research question and four subsidiary research questions. The following discussion pertains to these research questions.

1. What Are the Implementation Issues for the Initial Fielding of MAES?

Two different efforts provide a keen insight to implementation issues that confront the MAES deployment. According to Prerau (1990), implementing an expert system is composed of three main phases: The initial phase, the core development phase and the final development and deployment phase. Each phase has certain tasks that must be completed before proceeding to the next phase. Following this implementation strategy ensures that an expert system development team will consider and plan for applicable issues before the actual implementation begins.

The Lucas-Ginzberg (1990) model of implementation examines implementation of a management information system (MIS) from the perspectives of management and the users. Review of this model provides insight to the implementation factors that can influence either management or user acceptance of a new MIS. Knowing which implementation factors will affect management and users the most allows a deployment team to better prepare for the implementation.

Drawing from the previous research efforts, the implementation factors that follow will prove to be critical for a successful implementation of MAES.

- Obtaining management support. The MAES deployment team must include all levels of management in their training. It will be very important to gain their support and keep it.

- Involving users in the development. The MAES project team should continue to involve users and listen to their suggestions and concerns.

- Properly training users. Professional training will be essential for users to use MAES.

- Establishing a support infrastructure and effective lines of communication between the users and the maintenance team. Neglecting this area will turn many players against MAES.

- Choosing the right hardware platform. A key reason for deploying MAES on notebook computers is to support the users need. Deploying the system on a desktop computer could potentially turn users away from using MAES if they experience delays getting access or if needed features are not available where the work is being done.

- Conducting a post-implementation evaluation to determine user satisfaction and where improvements need to be made. This should be an ongoing process even after Fleet fielding. Continual product improvement should be ongoing.

2. How Can Implementation Issues Concepts be Applied to the Initial Deployment of the MAES Initial Version?

Applicable issues were discussed in great detail in Chapter V. The deployment issues that the MAES deployment team faces include:

- Obtaining support from individual chains of command. Communications wil be essential for this issue.

- Involving MK 92 technicians in the implementation and further development of MAES should be ongoing.

- Properly training all MAES users and their respective chains of command is essential. Deployment teams should have at least one senior enlisted sailor.

- Assessing other alternatives to on-site training. The inconsistency of inport availability of FFG-7s may require one of the alternative methods of training.

- Providing support for MAES hardware and software will be essential during the initial evaluation period. Slow or inconsiderate support could turn the community off on MAES.

- Distributing and ensuring that users respond to a post-implementation survey will be essential for justifying deployment fleet wide. Their responses will be the most heavily weighted responses.

- Purchasing hardware that balances value and cost and that proves to be reliable is important. Major hardware failures that are not dealt with promptly, could result in an unfavorable rating for MAES, even though the software performs admirably.

3. How Can End-User Training Concepts be Applied to the Formulation of a MAES training plan for shipboard technicians?

Chapter III examined research that demonstrates the importance of properly training users when implementing expert systems. Users must not only be trained on how to use the system, but also how it works, why it is necessary, and what benefits it will provide. Properly assessing user's basic training needs is the first step in developing a training plan. Other preliminary steps that need to be completed before actual training commences include:

- Training the personnel who will be training the users.

- Developing training material and methods.

- Obtaining a preliminary evaluation of the training plan from involved parties.

The actual training that will be conducted should follow the training plan consolidated by the deployment team. Factors that need to be considered in the development of the training plan are:

- The purpose and objectives of the training as they pertain specifically to MAES. MAES encounters the additional risks of introducing a new technology into the work environment.
- The methods of training that will be used for each level in the chain of command.
- The level of training appropriate for each level in the chain of command. Training should be tailored for each group.
- The development of an evaluation form that will enable trainers to determine areas in which to improve.

An effective training plan will enable the deployment team to provide sufficient, detailed information and hands on training to use MAES effectively and professionally.

4. What are the Hardware Implementation Issues Associated with Deploying MAES?

The hardware issues associated with deploying MAES were addressed at the end of Chapter V. First a determination needs to be made on whether a notebook computer needs to be included as part of MAES. For the initial evaluation, it is recommended that MAES be pre-installed on a laptop and given to each test ship and to the FTSCLANT representatives. A laptop provides the technician with a degree of portability that is needed to effectively utilize all the features of MAES. A dedicated laptop also ensures that MAES will be available whenever the technician needs it to troubleshoot or train. A dedicated laptop also minimizes the conflicts that can arise with other software that may be installed on the computer and minimizes the introduction of viruses if users do not load other software programs.

A ruggedized laptop is not presently affordable for evaluation. When purchasing the laptops, the least expensive new laptops from reputable brand name manufacturers should be purchased. Affordability of a minimally equipped system is not a problem. A laptop that has the minimum MAES hardware specifications is no longer even available in the marketplace unless it has been pre-owned. Therefore, an affordable model from a brand name that comes with an adequate warranty should be sufficient. The method of purchase that provides the best price should be used.

5. What are the Lessons Learned in the Implementation of Other Expert Systems for Weapons Systems Within DOD?

Two expert systems that were designed to diagnose weapons systems have recently been deployed in the DOD. The activities that deployed these expert systems were contacted and the recommendations and lessons learned were discussed in Chapter IV. The key points include:

- Training: a training team that visits each site was found to be valuable. Training must be coordinated with all involved commands.

- Maintenance: useful suggestions are made by technicians after the systems were deployed. Expect to add more on-line help and features.

- Post-implementation evaluation: technicians may not answer mailed surveys. Precautions to prevent unreturned surveys must be taken.

- Hardware: technicians must have access to the system at all times. COTS laptops are durable enough to survive a maintenance environment but should not have a trackball pointing device due to its vulnerability to dirt and grease.

B. RECOMMENDATIONS

The following subsections provide recommendations for deploying the initial version of MAES to the designated test ships and recommendation for future research in the implementation of MAES.

1. Obtaining the Support of Upper Management

Upper management support has been proven to be one of the strongest factors affecting an expert system's successful implementation. Therefore, special attention needs to be paid to the effective presentation of the capabilities and benefits that MAES can provide to each ship. The presentation should highlight key findings in Powell's (1993) cost benefit analysis to underscore the benefits available. A concise brief with a short demonstration should be made to each ship. A MAES advocate from either FTC-SD, FCTC Dam Neck, or FTSC should accompany the deployment team to provide technical backing to the presentation. Management will look for sailor credibility and championing in order to fully support MAES themselves.

2. Involving the MK 92 Technicians in the Implementation of MAES

The opportunity for getting MK 92 technicians involved occurs during deployment training. During the training sessions the deployment team can highlight the contributions other technicians have made and the features in MAES that resulted. If resources are available, it is also recommended that a MAES newsletter be distributed periodically to inform all MK 92 technicians about their contributions.

3. Training MAES Users

The training of MAES users should be conducted by a deployment team that travels to each training site. This method of training ensures that all MAES users on the test ships will receive sufficient quality training. Hands on exercises should be included in the training. The training plan provided as Appendix B may be used as a basis for the actual training. The training evaluation forms should be passed out at the conclusion of each training session and carefully read to determine if changes to the training plan need to be made.

4. Providing Support to MAES Users

A MAES newsletter and telephone support line should be available to aid users. The personnel that will be answering the phone will need to be knowledgeable in both the MK 92 FCS and the MAES software. Additionally, a MAES world wide web page could be constructed in order to provide answers to frequently asked questions and provide downloadable software updates. Open communications and prompt, careful follow-up to each inquiry will be essential for maintaining user confidence in MAES support.

5. Conducting and Analyzing the Results from the User Survey to Determine Fleet Suitability

There will be no way to determine if MAES users are satisfied if a survey is not conducted. The methods discussed in Chapter III to increase user response to the survey should be used. Once the surveys are received, the data should be analyzed to determine user satisfaction and whether improvements are necessary. Continual testing of the system at the training centers can also provide more empirical evidence to compare with projected benefits.

6. Utilizing COTS Hardware

Because it is possible to get computers with three year warranties, and the relatively low cost, it is recommended that the initial issue MAES laptop be classified as a consumable item. If repair is beyond an economic price, the ship will be responsible for replacing it. All of this discussion is based on a premise that the initial evaluation will find it beneficial to deploy MAES on a notebook computer.

Since the least capable laptop that is commercially available as of the writing of this thesis exceeds the MAES minimum hardware requirements, it is recommended that the MAES laptops be bought with cost as the primary consideration. The manufacturer should be a brand name that is reputable and well rated in current computer industry magazines while also providing a competitive warranty. The model that is purchased should also have at least a 10.4" color dual scan technology screen to ensure that help photos are displayed with sufficient resolution.

NPS has evaluated the input pointing devices on notebook computers. The device should be integral to the computer. An attachable mouse/pointing device is not acceptable. Attaching and detaching will pose a reliability issue over time. It also may be lost or could more easily be broken than an integrated device. Trackball pointing devices tend to get dirty and are not appropriate. The touchpad pointing device has become popular on several computers. Its solid state design has proven reliable. However, users who used it did not like the "feel" or the sensitivity. Its effectiveness also may pose a problem if dirt and grease build up on it. The preferred device was the trackpoint stick first used in the IBM Thinkpad computers.

The minimum requirements for a MAES laptop are:

- 486 DX2 66Mhz CPU
- 8 MB RAM
- 10.4" Dual Scan Color Screen
- 340 MB Hard Drive
- Integrated Trackpoint pointing device
- 3.5" 1.44 MB floppy drive

C. FOLLOW ON RESEARCH

Currently, MAES is being evaluated by the MK 92 Mod 2 FCS instructor staff at FTC-SD. MAES is also planned to be evaluated on six Atlantic Fleet ships in November. A survey should be distributed at least twice during the evaluation period. Follow on research could include an analysis of the data received from the survey to determine whether MAES users are satisfied and what improvements need to be made.

APPENDIX A. IMPLEMENTATION PLAN FOR DEPLOYING THE INITIAL VERSION OF MAES

Task	Due Date
Provide inputs to fleet scheduling conference to arrange test ships for deployment.	
Identify personnel for the deployment team.	
Establish a Deployment Team meeting schedule to coordinate preparations and make assignments.	
Establish a checklist to identify the problems, date and specific person to ensure all problems that come up are identified and solved.	
Ensure all documentation applicable to the deployment are available and complete. - Training Plan/Evaluation - Implementation Plan - User's Manual	
Purchase required number of laptop computers.	
Send training plan to evaluating commands for review.	
Ensure that all members of the deployment team who will be conducting training are capable of teaching the required topics.	
Obtain training site from local command in charge.	
Draft radio message informing participating commands of locations and times for training and briefs.	
Arrange lodging and transportation for the deployment team.	
Furnish required security clearances for deployment team access to applicable commands.	
Build Powerpoint slide show for individual command presentations (45 min. duration).	
Deployment team reviews training plan.	
Configure laptops to optimally run MAES (install MAES, video settings, etc.)	

Task	Due Date
Ensure that all required training materials are assembled (See training plan).	
Deploy MAES.	
Document lessons learned.	
Distribute user surveys.	

APPENDIX B. MAES TRAINING PLAN

Training will consist of two days at each site. The first day will consist of classroom training at a local training facility (FTC in Norfolk and base classroom in Mayport). The second day will consist of a brief visit to each ship to brief the chain of command and conduct follow-up training on MAES users.

First Day
Training session to commence at 0800 on the first day.

Required materials: Overhead projector, training slides, student binders that contain copies of training slides and training evaluation forms, canned scenarios for MAES training, MAES H/W and S/W for users (one per ship), associated MAES documentation for users, and MAES laptop for instructor.

Required attendees: Ordnance Officer (first hour), Division Chief, Recommended that ships send all MK92 technicians.

Training Syllabus:

1. Background of MAES:

    A. What is an expert system

    B. The basics of an expert system
        1) Components: Interface, Database, Inference Engine
        2) Expert: Knowledge acquisition, who he is
        3) The Technician: Most important part of the system
        4) MAES Capabilities
            a. What it can and can't do
            b. Discuss results of FTC-SD evaluation

    C. How MAES is different from tech manuals
        1) 70% new knowledge
        2) Knowledge behind MAES is from a UNISYS engineer with 30 years experience

    D. Why the system is important
        1) It Will Save You Time!
        2) It will save money!

2. Intro to MAES

A. Hardware
1) Proper care
2) Basic operation
3) Custody forms
4) Repair procedures
- Who to contact for problems with the S/W or H/W

B. Software
1) Installation
2) User's Manual contents

L U N C H

3. MAES Operation

A. Navigating the program
1) Opening the program
2) Going from screen to screen

B. Canned Scenarios
1) Go through scenarios step-by-step
- One easy and one hard

C. Fill out training evaluation forms

<u>Second Day</u>

Will consist of a ship visit to each ship that MAES will be evaluated on. A space with an overhead to brief the chain of command on each ship will need to be pre-arranged. The dates and times of these briefs will have to be forwarded to the ships as early as possible so they can schedule them.

1. Short (1/2 hr) brief to chain of command (CO,XO,CSO)
OUR CHANCE TO GET MANAGERIAL SUPPORT FOR MAES

A. What MAES does

B. How it will save the sailor time, make his job easier and save the ship money

C. Display Cost/Benefit analysis findings

D. Convince the command of the importance of using the system

- As part of the evaluation they are extremely important as they will be putting the system through its paces

2. Brief follow on visit with the technicians to see if they have any last minute questions.

TRAINING EVALUATION FORM

This evaluation form is provided for you to fill out in order that we can provide you with high quality training. We ask for your cooperation in filling out this short questionnaire. It should take no more than five minutes of your time. Providing us with your name is optional only. Please turn the completed questionnaire in to a member of the MAES deployment team when you are done. Thank you very much for your assistance.

Instructions: Please circle the appropriate response and provide comments, if any, in the space provided at the end of the questionnaire.

1. Was your training room comfortable?

   Yes No

2. Did the instructor tell you what the training objectives were?

   Yes No

3. Do you feel you have an understanding of what MAES can and cannot do?

   Yes No

4. Do you understand how to install MAES from the floppy disks?

   Yes No

5. Do you know who to contact in the event you have a problem or question about MAES?

   Yes No

6. Do you understand how to troubleshoot with MAES?

   Yes No

Comments:

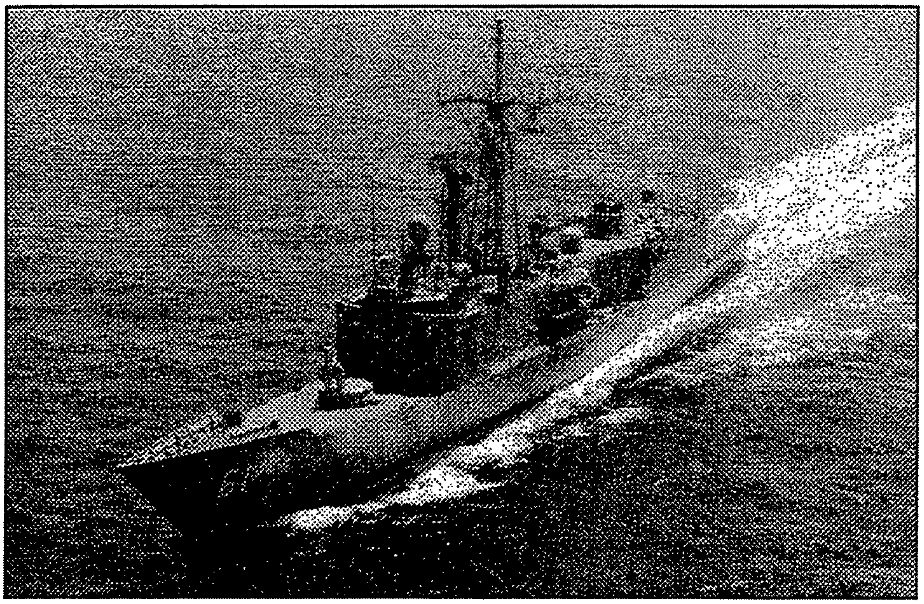
____

____

____

APPENDIX C. MAES USER'S MANUAL

MK 92 MOD 2 FCS MAINTENANCE ADVISOR EXPERT SYSTEM (MAES)



USER'S MANUAL
VERSION 1.0

Chapter 1

Welcome to MAES

Introducing MAES

The MK 92 Mod 2 Maintenance Advisor Expert System (MAES) was developed to assist fire control technicians in the fleet to correctly diagnose casualties in the MK 92 Mod 2 Fire Control System. MAES will increase your operational readiness by giving you "expert" knowledge when and where you need it most. MAES will assist in locating faults discovered in radar system Performance or Calibration during the Daily Systems Operability Test (DSOT). The capability to diagnose RF Power Checks will be included in a later version.

MAES was designed with the following goals in mind:

- Improving your workload by decreasing the amount of time you spend diagnosing faults in the system.
- When required, the ability to communicate with shore based maintenance organizations (such as FTSC) more effectively concerning problems encountered.
- Provide you with a training tool for brushing up your troubleshooting skills.
- Increasing ship's state of operational readiness by decreasing the amount of time required to repair the MK 92 FCS.
- Eliminating circuit cards that are turned in that have No Fault Evident (NFE).
- Saving ships money through reduced ordering of repair parts.

The knowledge that is behind the power of MAES comes from senior engineers with many years experience in diagnosing the MK 92 Mod 2 FCS.

Note: This manual assumes you are familiar with your computer's basic operations. If you are unfamiliar with terms like "dialog" or "double-click", or basic file handling and printing procedures, please read the owner's manual for your computer and your *Microsoft Windows/Windows 95 User's Guide* before using MAES.

Chapter 2

Installation

Reviewing Your Package Contents

Before installing MAES, please take a moment to verify that your package contains the appropriate items and that your computer meets the system requirements for MAES. Your MAES package should contain the following items:

Two MAES Installation disks, 3.5" 1.44 MB
FCS MK92 Maintenance Advisor Expert System User's Manual

If this is your initial receipt of MAES you should also be in receipt of a laptop computer. Please refer to the documentation that came with the computer for it's care and maintenance.

If any items are missing, please contact MAES HelpLine immediately at (805) 982-0141 or DSN 551-0141.

Checking System Requirements

MAES disks are *not* bootable; they do not contain MS-Windows software. To operate MAES, you need the following hardware and software.

MAES is operational under Windows 3.xx or Windows 95. The system requirements for MAES follow:

- IBM PC or 100% compatible
- Intel 80386 DX or higher (486 or higher recommended)
- Microsoft Windows 3.1x or Windows 95
- A hard disk drive with at least 30 MB of free storage space
- Minimum 4 MB RAM (8 MB RAM recommended)
- A 3.5 inch 1.44 MB floppy drive
- A standard VGA monitor that supports 640 x 480 resolution and 256 colors

Note: Less capable monitors may be used, but resolution quality may be compromised. If you have a monitor that is 17" or larger, or a graphics card with more than 2 MB of video RAM, you may achieve better results with a resolution of 800x600.

- Mouse or built-in pointing device

Installing MAES

Installation takes about fifteen minutes.

Before you install MAES, please:

- **Close other applications**
  Closing applications (such as a word processor or spreadsheet program) will free memory and prevent possible conflicts during installation.
- **Turn off virus protection programs**
  Some virus protection programs can interfere with the installation process. Please refer to the user's manual for your virus protection software for information on how to turn off your virus protection program. We also recommend turning off any installed memory-resident programs (such as a screen saver or a pop-up program that appears when you type certain key combinations).
- **Make a backup of your MAES program disks**
  See *Making a Backup of your MAES Disks* at the end of this chapter for more information.

Once you have closed all other Windows applications, disabled virus protection, and made a backup of your MAES program disks, you are ready to install MAES. Follow these simple steps to install MAES.

Note: The following instructions assume your hard disk is drive C and your floppy disk is drive A. If named differently, please use your drive designators.

1. Insert the installation disk 1 of 2 in a 3.5" drive.

For Windows 3.1x users:

2. Choose **Run** from the Program Manager File menu.
3. Type the command A:INSTALIT.EXE and click **OK**. Go to step 8.

For Windows 95 users:

2. From your desktop, double-click the **My Computer** icon.
3. Double-click the **Control Panel** icon.
4. Double-click the **Add/Remove Programs** icon.
5. In the Add/Remove Programs Properties window, choose the **Install/Uninstall** tab. Click **Install**.
6. Click **Next**.
7. The Command line in the installation window should read **A:\INSTALIT.EXE**. Click **Finish**. Go to step 8.

Installing MAES (cont.)

8. The install program will display a panel telling you that it is copying the install program to a temporary area on your hard drive.
9. The install program will display a panel telling you about itself.
10. The install program will begin displaying windows prompting you for responses.
11. When you are prompted to **Select Option**, select **Install MAES 1.0** and click on **OK**.
12. When you are prompted to **Select Installation Drive** select a drive from those listed that has at least 30 MB free space.
13. You will be prompted to specify an installation path. The recommended installation directory is named MAES10. The recommended installation drive is where Windows is installed. For example, if you have Windows installed on drive C, C:\MAES10 is the suggested installation directory. Enter a different path if you desire and then press **OK**.

Warning: Do not specify the \Windows or \Windows\System directories as the MAES directory. However, C:\Windows\MAES10 is acceptable.

14. At this point the install program will begin copying files to your hard drive. A progress meter will show you the status of the installation throughout this process and will prompt you for a disk change.
15. When prompted to **Install Icon**, select the second option **Install Icon in a New Group** and press **OK** unless you prefer to place the icon in an existing group.
16. The **Install MAES 1.0** menu will reappear. Select **Exit Installation** and click **OK**.
17. Windows 3.1x users should find the new icon **MAES 1.0** in the **MAES 1.0** program group and can run it by double-clicking on it. Windows 95 users can run MAES by clicking on **Start - Programs - MAES 1.0 - MAES 1.0**.
18. Remember, at this time only the **Calibration** and **Performance** options are available for use.

MAES is now ready to use!

Making a Backup of Your MAES Disks

To make a backup of your MAES program disks, simply follow these steps:

Note: The source and destination disks must be of the same size (3.5") and capacity (1.44 MB)

Windows 3.1x users:

1. Insert the source disk (MAES program disk).
2. Open the file manager and click on **Disk**.
3. From the drop down menu, select **Copy Disk**.
4. When prompted, insert a blank disk to copy onto.
5. Repeat steps 1-4 for subsequent MAES disks.

Windows 95 users:

1. Open **My Computer**.
2. Click the icon for the disk you want to copy (A: or B:)
3. Select **File | Copy Disk** from the My Computer menu bar. The copy Disk dialog will be displayed.
4. Select the Copy from (source) drive and the Copy to (destination) drive. These drives can be the same. For example, both can identify the A: drive.
5. Choose the **Start** button. Follow the on-screen instructions.

MAES Basics

MAES is extremely flexible and powerful. The interface was designed to be as simple as possible so you can access the knowledge quickly and effectively. This chapter introduces the basic principles and procedures you need to understand to work effectively and efficiently.

Screen Layout

The standard MAES screen is divided into three primary sections. These sections, as shown in Figure 3-1, are the title bar, procedure area, and action area.

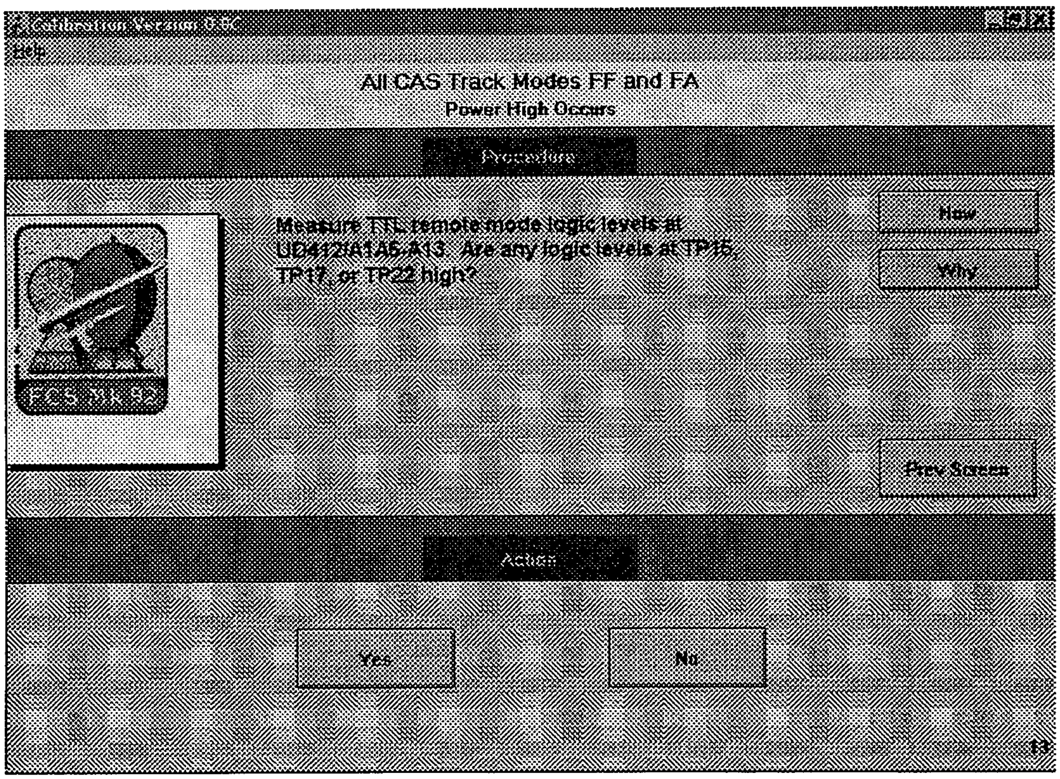


Figure 3-1. MAES Standard Screen Layout

Title Bar

The MAES title bar is always positioned horizontally across the top of the screen. The title bar displays information about where you are in the MAES program. For example, the title bar in Figure 3-1 says “All CAS Track Modes FF and FA” and below it “Power High Occurs”. This indicates that you are troubleshooting a problem with the CAS Track Modes FF and FA and are currently determining whether a Power High condition exists. The title bar will change as you move from one area of the program to another.

Procedure Area

The Procedure Area is the central portion of the MAES display. In Figure 3-1 it is the horizontal bar labeled "Procedure". MAES uses this area to display instructions, procedures, and questions.

Action Area

This area is located in the bottom area of the screen. In Figure 3-1 it is the horizontal bar labeled "Action". This is the area that allows you to interact with MAES by clicking on buttons. In Figure 3-1, the buttons that are available are "Yes" and "No".

Screen Identification Number (SIN)

At the lower, right-hand corner of every MAES screen there will be a small number. For example, in Figure 3-1 it is "13". Refer to this number and the Title Bar if you have questions about MAES or are submitting a Software Feedback Form.

Input Methods

The MAES display screens provide a variety of methods to interact with the program. The most common methods are buttons, list boxes, and check boxes. These objects are used to tell MAES what you want it to do in the way of displaying results, instructions, or help.

Buttons

Inputs to MAES are performed by clicking on buttons. For example, when the button labeled "Prev Screen" in Figure 3-1 is pressed, MAES will display the previous screen. Buttons appear on almost all of the MAES screens. You can only select one button at a time.

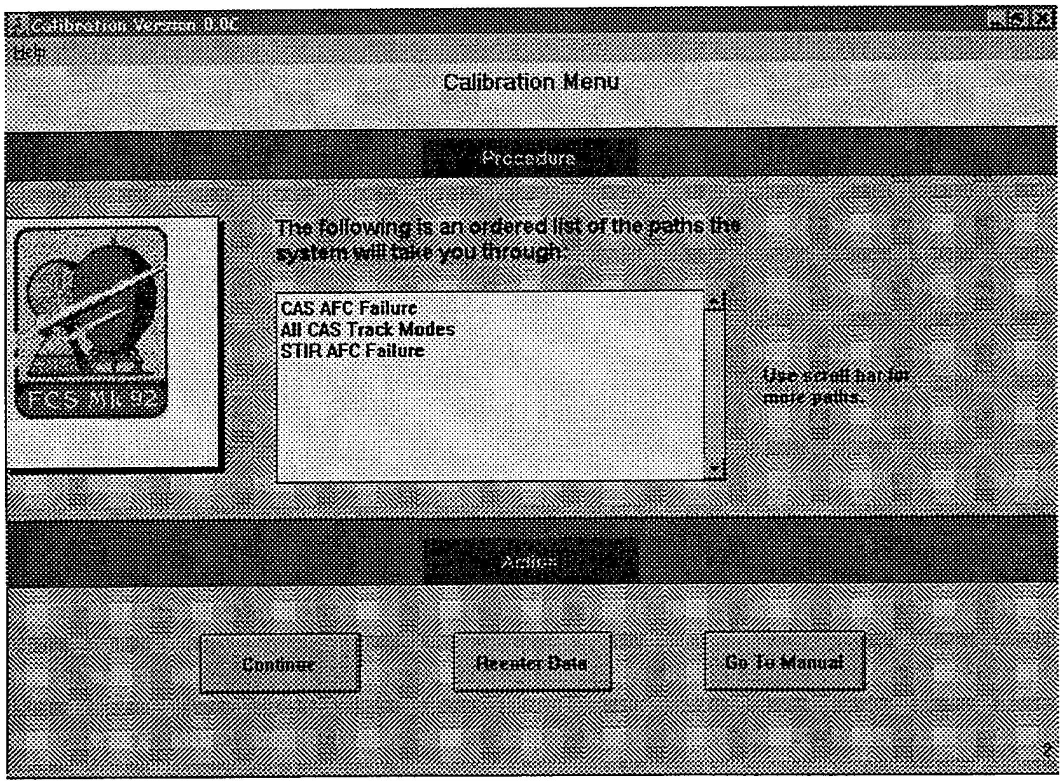


Figure 3-2. MAES Screen Using List Box.

List Boxes

List Boxes are another way to interact with MAES. List Boxes display a list of choices that you may select one option from. If the list box has more choices than can be displayed in the box, then you can use the scroll bars to view all of the contents. Only one item in a list box can be selected at a time. Figure 3-2 is an example of a MAES list box.

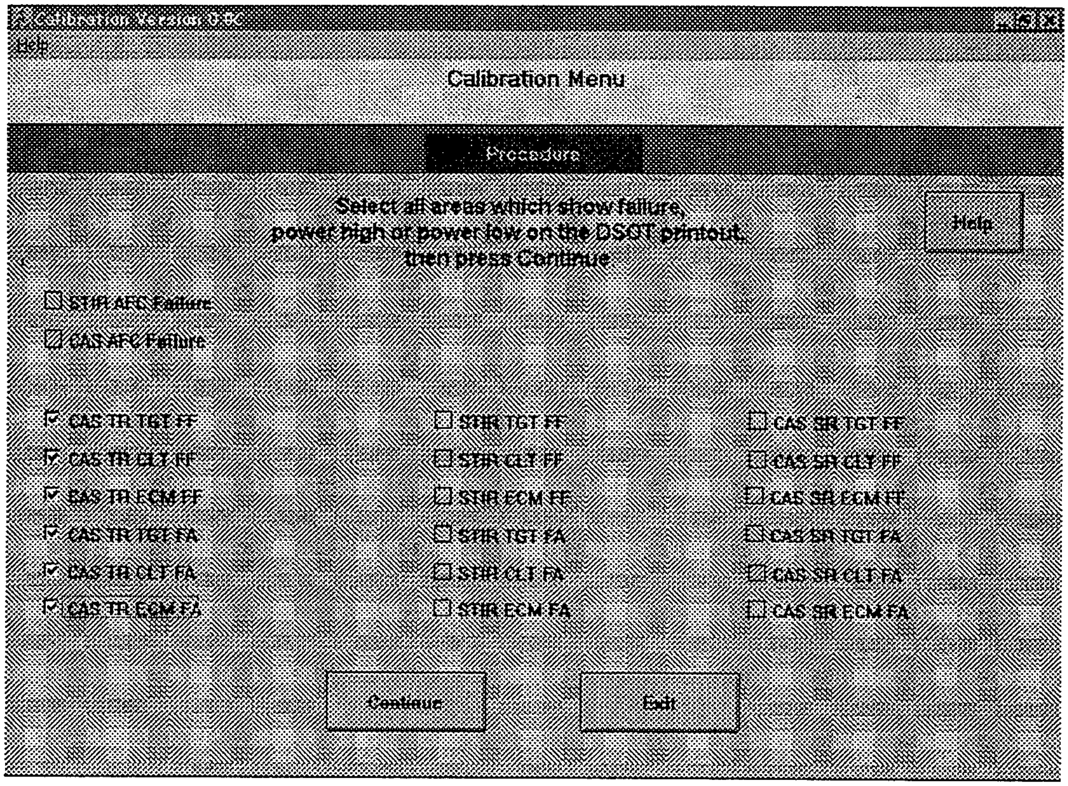


Figure 3-3. MAES Screen Using Check Boxes

Check Boxes

A check box allows you to select or clear an option. You can select as many options as are available by checking their corresponding check boxes. A "✓" is placed in a check box when it has been selected. An example of check boxes in MAES is shown in Figure 3-3. Notice that six check boxes in the left column have been selected.

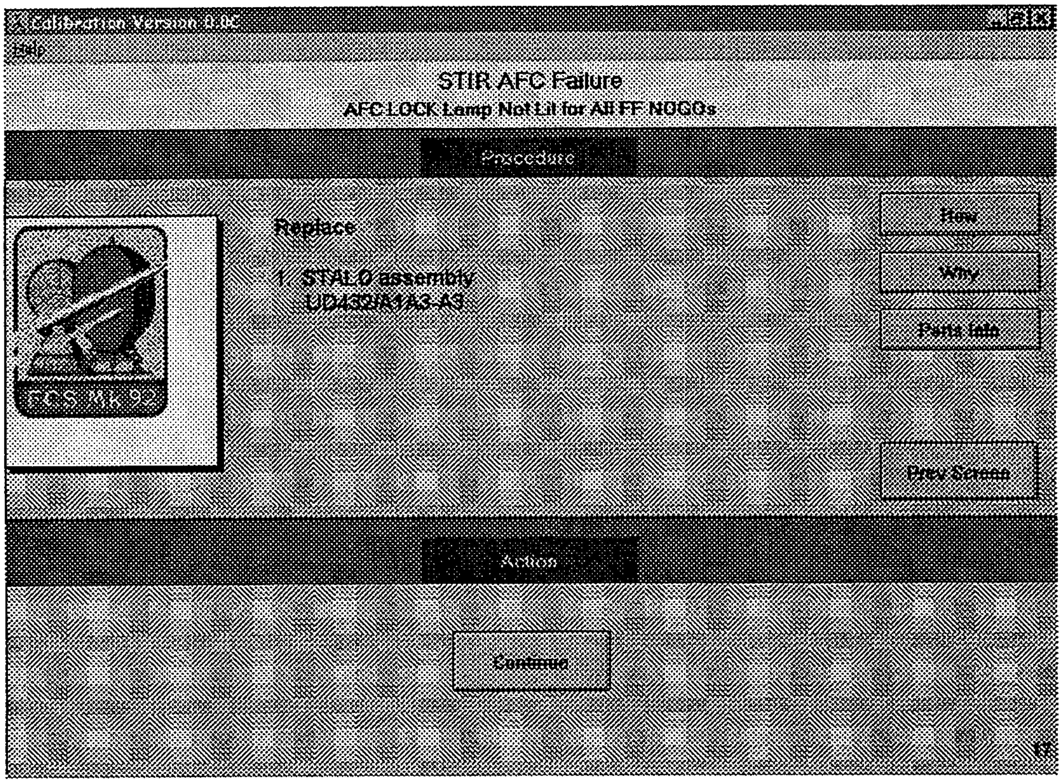


Figure 3-4. MAES Screen with Help Buttons

Help Information

There are three types of help information available to you in MAES. These types include "How", "Why", and "Parts Info". Please refer to Figure 3-4 during the discussion on the help features.

How

Clicking on a "How" button gives you a detailed description of how to perform a required procedure. Once you press a button labeled "How" in the procedure area, a new screen appears with the information you requested. If there is more information than can be displayed in one screen, it will appear in a scrollable window.

Photo

At the bottom of some "How" screens, this button may be available. Clicking on the "Photo" button gives you a photo or series of photos that step you through a procedure that you may need more information on. These photos will appear best if your monitor is set for 640x480 resolution with 256 colors. You may always click on the "Return" button to go back to the Procedure screen where you left off.

Why

Clicking on a "Why" button provides you with an explanation of why MAES is directing you to perform a certain task. This "Why" information gives you insight into how the MK 92 expert we used to design MAES attacks a problem. Once you finish reading the explanation, press "Return" and MAES will take you back to the previous screen.

Parts Info

By clicking on a "Parts Info" button MAES will give you parts information with regards to the part that MAES is recommending you replace. The parts information will provide you with a part number, reference diagram number, if and where the part is used elsewhere in the system, part designation, and the power requirement of that part.

Help Buttons

Clicking on "Help" buttons within MAES will provide you with specific help about the screen you are currently viewing.

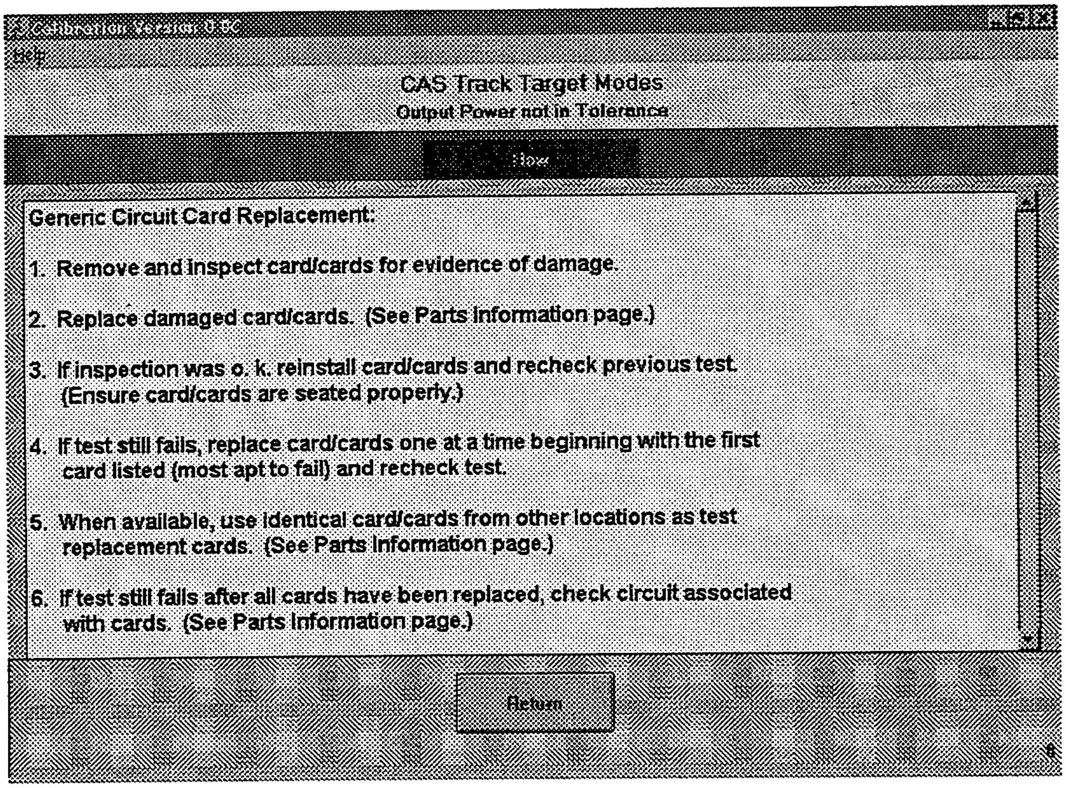


Figure 3-5. Circuit Card Replacement Screen.

Circuit Card Replacement

CAUTION: It is very important to perform the generic part replacement methodology when replacing parts.

Most circuit cards in the MK 92 Mod 2 FCS can be replaced using a generic card replacement procedure. Certain rules, which are intuitive to Fire Control Technicians, must be followed when replacing a circuit card. Procedures for generic card replacement procedure and rules to follow after card replacement are available in MAES as depicted in Figure 3-5.

Rules for Exiting MAES After Part Replacement

The rules that should be followed after a part is replaced are as follows:

1. If an adjustment is performed in the path where the part is to be replaced, exit and perform the adjustment again.

a. If the adjustment can be performed within specifications, rerun DSOT.
b. If the adjustment still can not be performed within specifications, return to the display screen for part replacement and replace the next part listed. Perform the adjustment again.
c. If all parts have been replaced and adjustment is still out of specifications, return to the part replacement screen. Obtain the figure reference for the signal flow diagram associated with parts and continue with troubleshooting.

2. If an adjustment is not performed in the path where the part is replaced, exit to the submenu display screen and check to see if the problem is corrected.

a. If the problem is corrected, rerun DSOT.
b. If the problem is not corrected, return to the part replacement screen and replace the next part listed. Check and see if the problem is corrected.
c. If all parts have been replaced and the problem still exists, return to the part replacement screen. Obtain the figure reference for the signal flow diagram associated with the part and continue troubleshooting.

Note: When returning to the adjustment screen or submenu display screens, make certain that the initial setup is completed before performing an adjustment or when checking to see if the problem is corrected.

Sample Session Using MAES

The following sample session is an example of how to use MAES for troubleshooting a fault. The example assumes a failure in the Calibration module which has failure in all CAS Track modes.

Begin MAES

Start MAES by following the steps previously discussed at the end of the Installing MAES section. To begin MAES, click on the button labeled "Begin Program" on the opening screen with the picture of a FFG-7 class ship.

Select A Module

The next screen that appears will be the MAES Main Menu and is shown below in Figure 4-1. Since this example is assuming a Calibration CAS Track failure, press the Calibration button on the left side of the Action area.

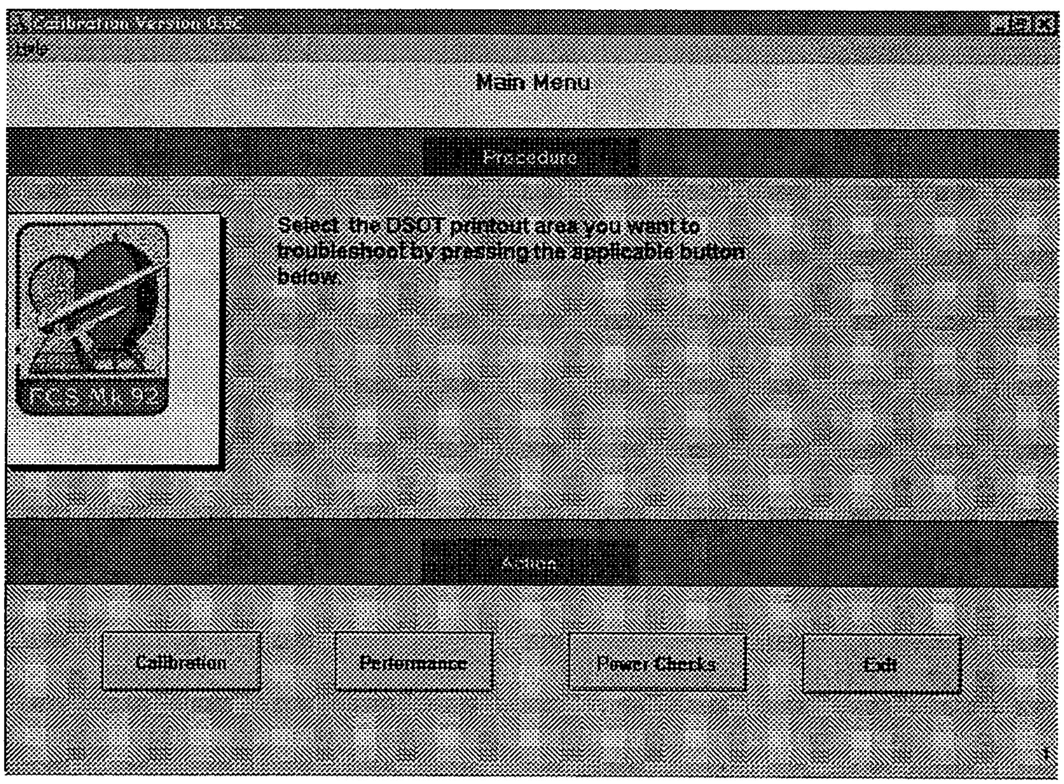


Figure 4-1. MAES Main Menu

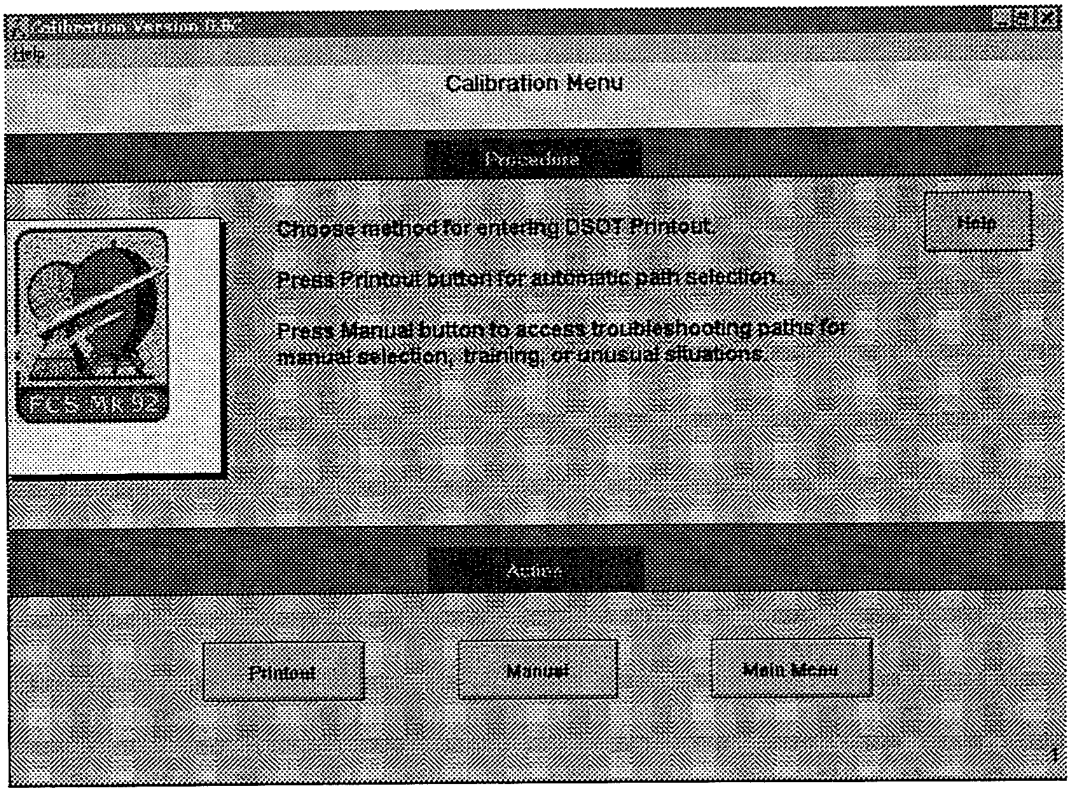


Figure 4-2. Calibration Menu

Once the Calibration button is pressed, the Calibration Menu that is depicted in Figure 4-2 will be displayed.

Select DSOT Entry Method

Two options are available for entering DSOT data on the Calibration Menu: Printout and Manual. The Printout option allows you to select problem areas on a display screen, shown in Figure 4-3, that mimic a DSOT printout. Click on the button labeled "Printout"

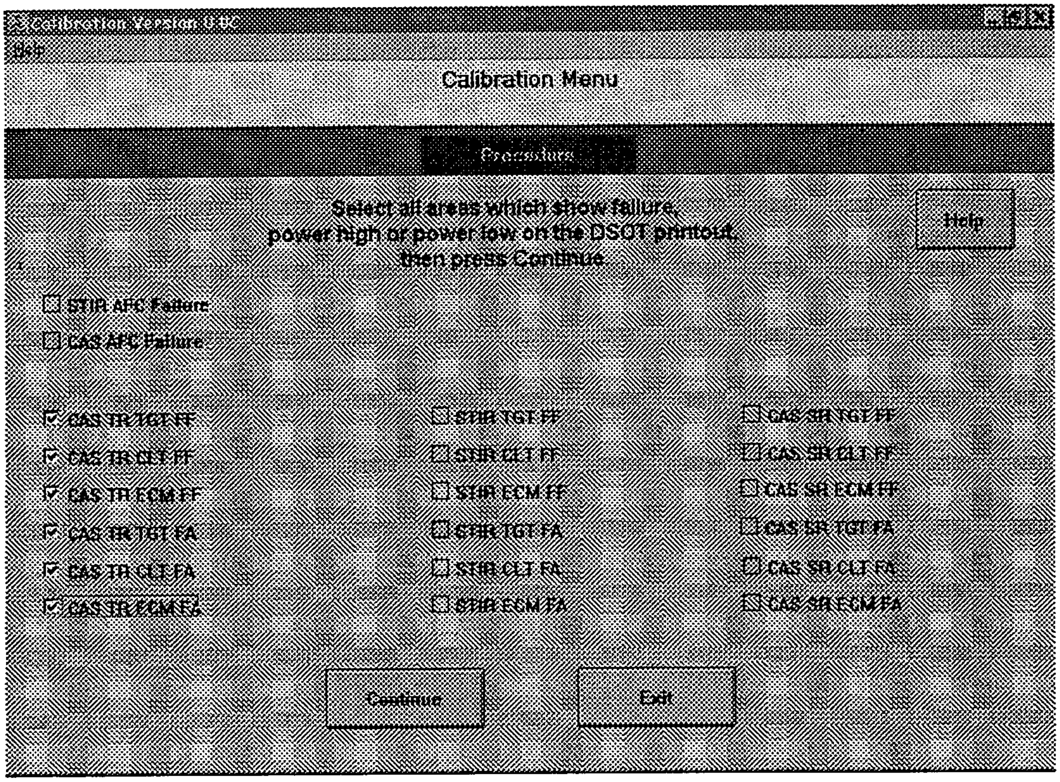


Figure 4-3. Calibration DSOT Printout Menu

Select Failed Areas

The next step is to select the failed areas by using check boxes in the Printout Menu. Check the six boxes shown in Figure 4-3 that are labeled CAS TR TGT FF, CAS TR CLT FF, CAS TR ECM FF, CAS TR TGT FA, CAS TR CLT FA, and CAS TR ECM FA. Make certain that a "✓" appears in each box. Checking these boxes informs MAES that multiple CAS Track failures exist. Once the check boxes have been selected, press the "Continue" button on the Calibration DSOT Printout Menu.

An ordered list of paths, in this case only one that says "All CAS Track Modes", that MAES will take you through will be displayed. Click on the "Continue" button to start performing troubleshooting tasks.

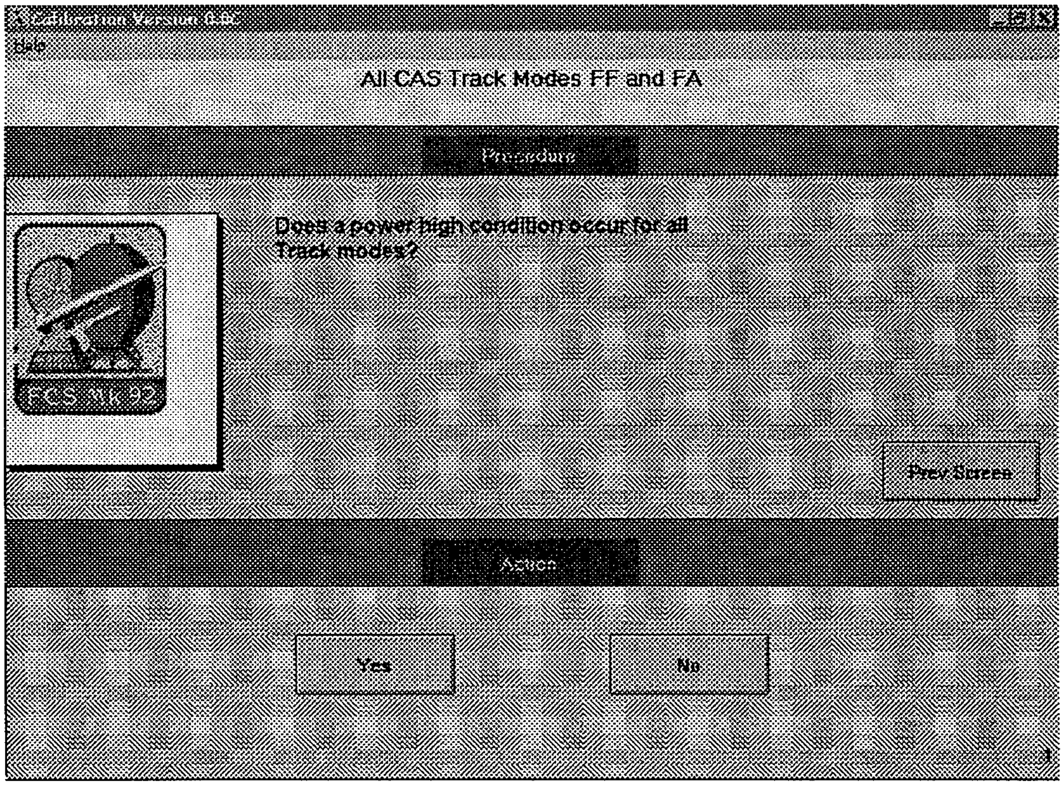


Figure 4-4. Power Hi Task Screen

Perform Tasks

The next screen is shown in Figure 4-4. MAES asks if a power HI condition exists for all track modes, so click on the "Yes" button in the action area. This action causes MAES to display another task screen as shown in Figure 4-5.

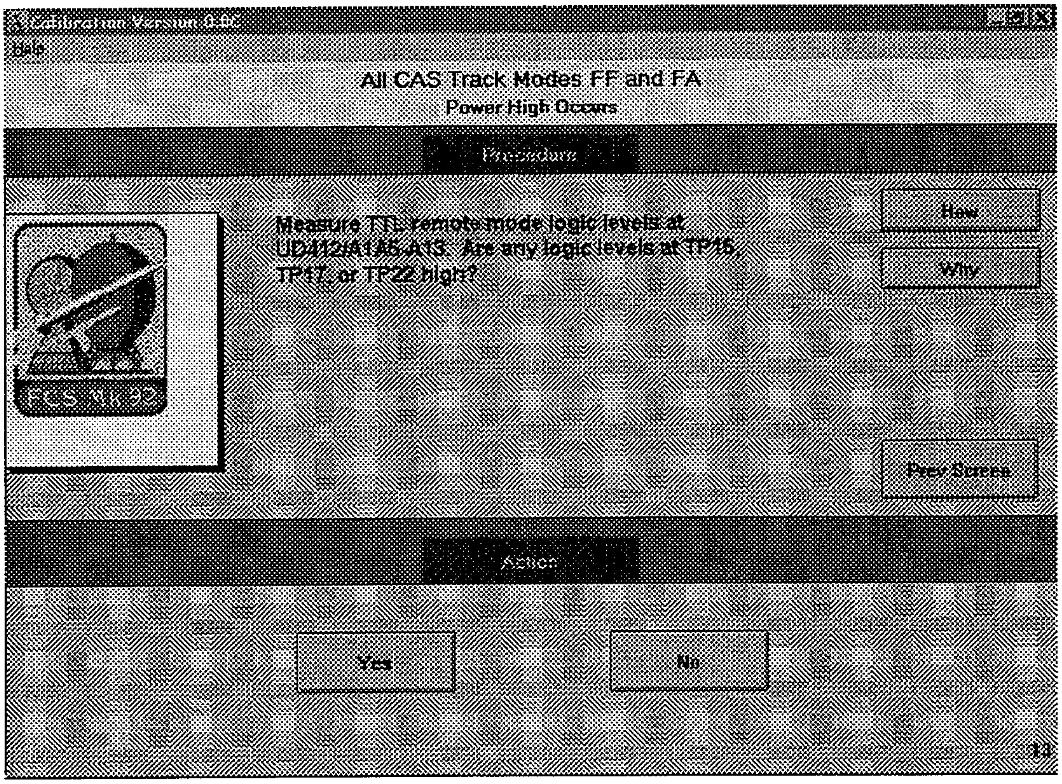


Figure 4-5. Measure TTL Levels

Completing a Task

The screen shown in Figure 4-5 instructs you to measure TTL Remote Mode Logic Levels at UD412/A1A5-A13. If you require help on how (or why) to perform this procedure, you can request on-line help as explained in the next section.

Getting Help

Press the button labeled "How" as shown in Figure 4-5. MAES will give you detailed instructions on how to measure TTL Remote Mode Logic Levels at UD412/A1A5-A13. A view of this information is shown in Figure 4-6. Use the scroll bars to read the entire set of instructions.

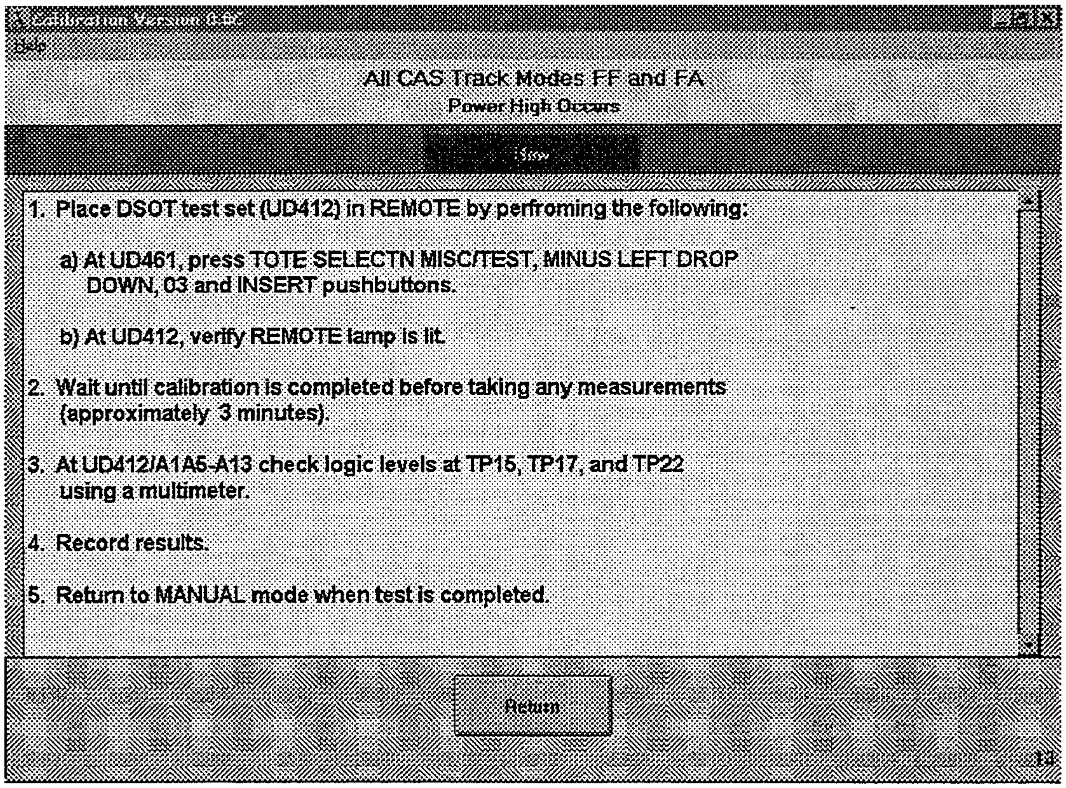
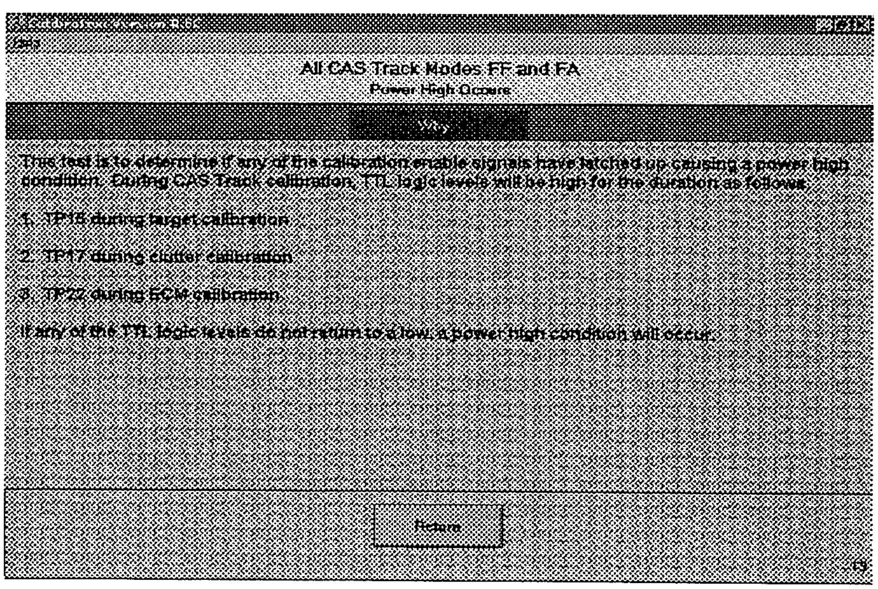


Figure 4-6. HelpScreen (How to Measure TTL Remote Mode Logic Levels)

Once you have finished reading the help information, click on the button labeled "Return". MAES will return you to the previous screen (Figure 4-5). Now click on the button labeled "Why". MAES gives you a concise reason why you are instructed to perform this measurement. The Why screen is depicted in Figure 4-7. After reading the steps in the Why



display, exit back to the Measure TTL Levels by clicking on the "Return" button.
Since an all CAS Track Failure in the example indicates that a logic level at TP15, TP17, or TP22 is high, press the button labeled "Yes" in Figure 4-5. This action will cause MAES to

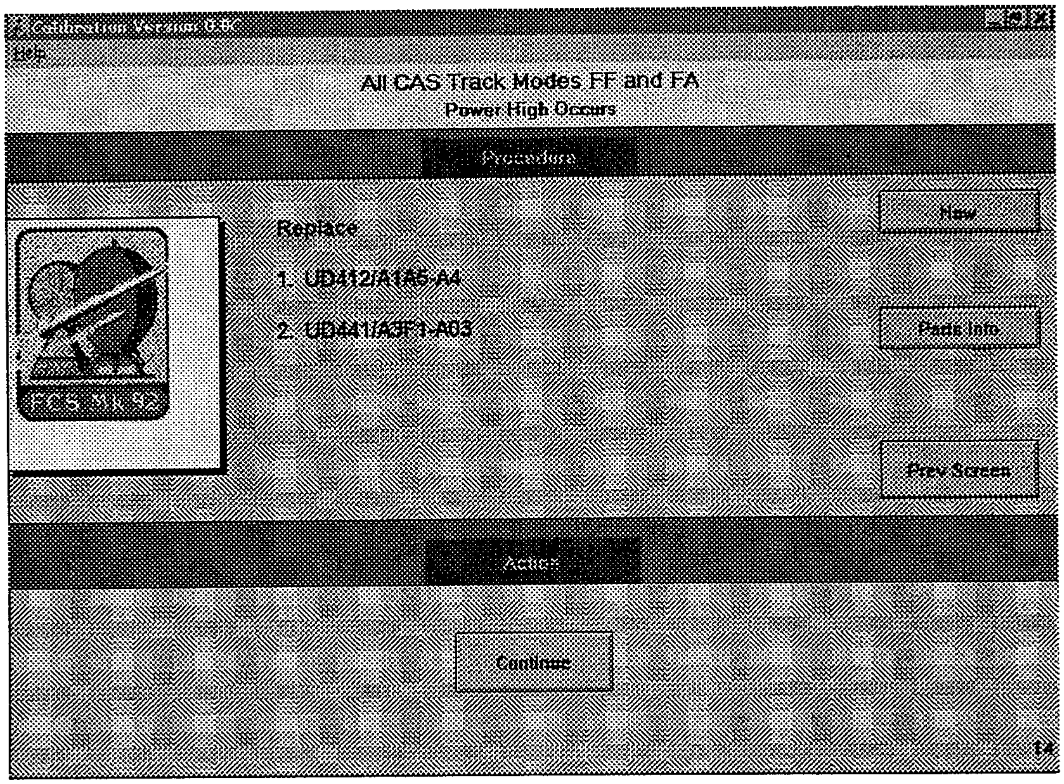


Figure 4-7. Replace Parts Screen

display the Replace Parts Screen as shown in Figure 4-7.

Replace Failed Part

When replacing parts you may access part information that would otherwise take you hours to access via normal supply channels and technical manuals. To use this information, click on the button labeled "Parts Info". The type of information that is available is displayed in Figure 4-8.

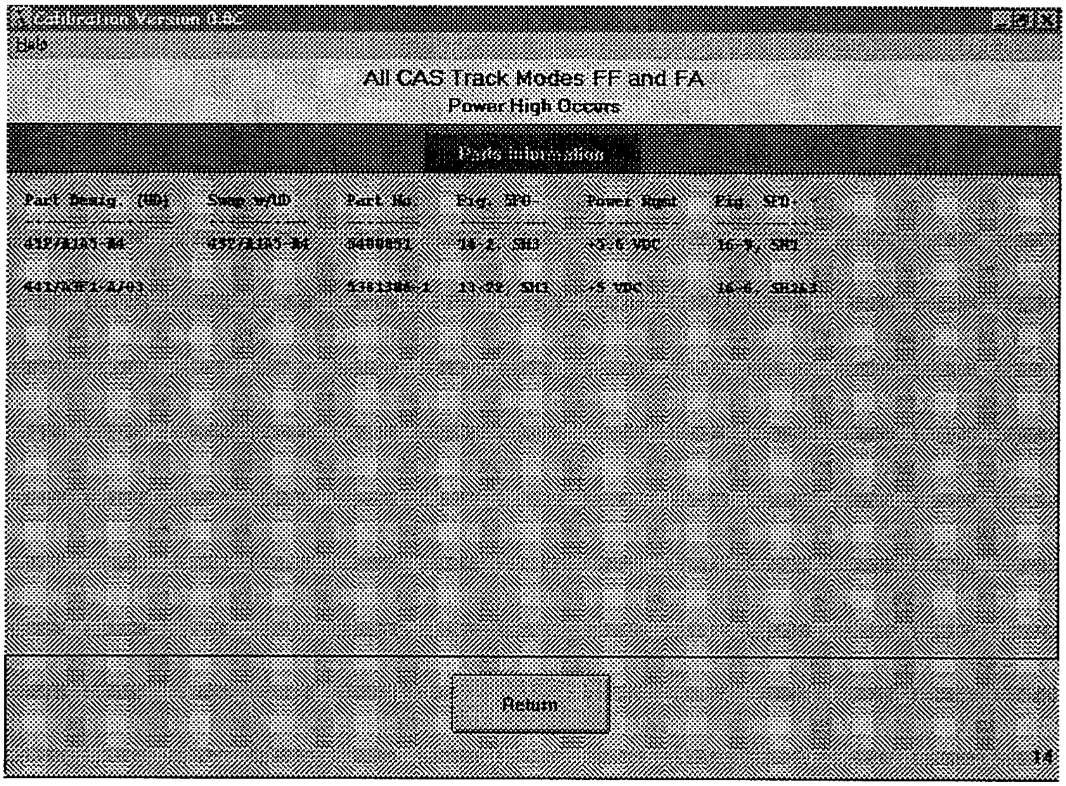


Figure 4-8. Parts Information Screen

Exiting MAES

After you have obtained the part information you need to replace a part, click on the "Return" button. You are now back on the Replace Parts Screen. Clicking on the button labeled "Continue" will return you to the Calibration Main Menu. You may now exit MAES. This concludes the sample session.

Documentation and Technical Support

Technical support regarding MAES may be received from representatives at NAVSEA by mail, telephone, or by GENADMIN message.

NAVSEA Assistance

Hardware and software technical support may be obtained from the NAVSEA technical representatives at the Naval Surface Warfare Center, Port Hueneme Division. The NAVSEA point of contact is Mr. Henry Seto, and he can be reached at:

Mr. Henry Seto (Code 4C46)
Port Hueneme Division, Naval Surface Warfare Center
4363 Missile Way
Bldg. 1211
Port Hueneme, CA 93043-4307

(805) 982-0141 commercial or
551-0141 DSN, e-mail: SETO_HENRY@OM.NSWSES.NAVY.MIL

Message Address: RUWFPBC/NAVSURFWARCENDIV PORT HUENEME CA//4C00//

Documenting Problems and Suggestions

We believe that one of the reasons MAES is so effective at solving faults in the MK 92 FCS is that you, the fleet technician, have been a key component in the development of this software. It was people like you who suggested that we include photos and parts information which have become key features of MAES. If you have a suggestion that you feel would make MAES a more effective tool, please fill out the Digital Systems Feedback Report included as the last page of this manual. You may also use the same form to report a recurrent problem that may be occurring with your software or computer.

DIGITAL SYSTEMS FEEDBACK REPORT (DSFR)

WEAPONS SYSTEM MK: MOD:	SHIP NAME	HULL NUMBER
SHIPBOARD POINT OF CONTACT		DATE
PHONE NUMBER OR CONTACT METHOD	DELIVERY TAPE SERIAL NUMBER	

QUESTION OR PROBLEM: PLEASE PROVIDE ALL AVAILABLE INFORMATION, ESPECIALLY WHAT PROGRAM WAS RUNNING, WHICH MODE (NORMAL, CASUALTY, LOCAL), ENGAGE STATUS, LAMP INDICATIONS, AND WHAT HAPPENED

SEND COMPLETED FORM TO:	OR FAX TO:
COMMANDER PORT HUENEME DIVISION NAVAL SURFACE WARFARE CENTER 4363 MISSILE WAY PORT HUENEME, CA 93043-4307 ATTENTION CODE 4C40 (CM)	PHD, NSWC, SURFACE COMBATANT DEPT ATTENTION 4C40 (CM) FAX NO. (805) 982- 8548

APPENDIX D. MAES USER SURVEY

1. What is your current rank?

□ E1 □ E2 □ E3 □ E4 □ E5 □ E6 □ E7-E9

2. How many years of experience have you had as a MK92 tech?

□ Less than 1 year
□ 1-2 years
□ 3-4 years
□ 5-6 years
□ 7-8 years
□ 9 or more years

3. On what ship are you currently stationed on? ______________________________

4. What is your current billet?

□ Technician
□ Work Center Supervisor
□ Divisional LPO
□ Divisional CPO
□ Other

5. When you had a fault to troubleshoot, what role did MAES play?

□ Did not use MAES to troubleshoot
□ Used MAES in conjunction with the technical manuals □ Used MAES only

6. Have you used MAES for (check all that apply):

□ Troubleshooting
□ Training

7. How often do you use MAES?

□ Never
□ For all maintenance troubleshooting covered by MAES
□ For part of maintenance troubleshooting covered by MAES

8. How has MAES, in comparison to only using technical manuals for troubleshooting, changed the time required for you to repair a fault?

- □ Could not have solved some faults without MAES
- □ Significantly less amount of time to repair faults
- □ Less amount of time to repair faults
- □ More time is required to repair faults
- □ Significantly more time is required to repair faults

Please rate MAES in the following areas:

	Very Dissatisfied				Very Satisfied
7. Ease of use	1	2	3	4	5
8. Ability of MAES to solve faults	1	2	3	4	5
9. MAES User Manual	1	2	3	4	5
10. Viewscreen display (sharpness/brightness)	1	2	3	4	5
11. Supply information	1	2	3	4	5
12. Technical photos	1	2	3	4	5
13. Explanations of troubleshooting steps (Hows)	1	2	3	4	5
14. Explanations of troubleshooting methods (Whys)	1	2	3	4	5
15. Online help	1	2	3	4	5
16. Your confidence in the system	1	2	3	4	5
17. Reliability of:					
Laptop Computer	1	2	3	4	5
MAES Software	1	2	3	4	5
18. Your overall satisfaction with MAES	1	2	3	4	5

Comments:

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