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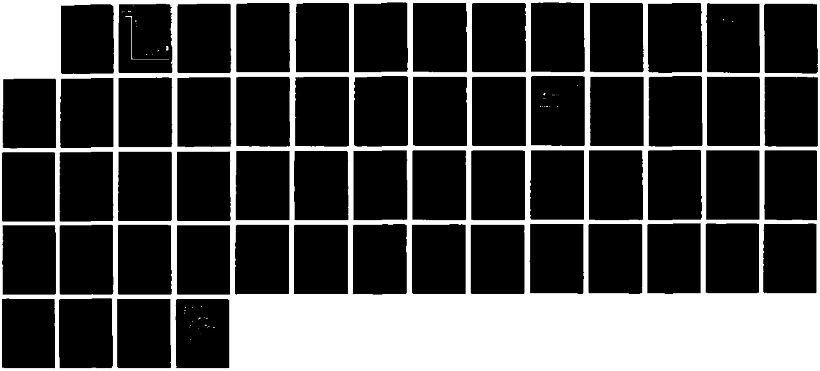

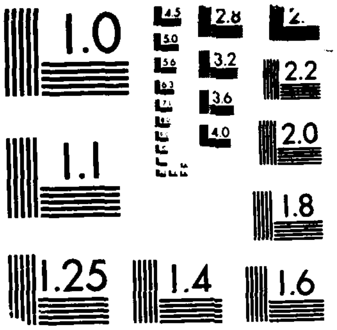

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INTEGRATED MAINTENANCE INFORMATION SYSTEM (IMIS):
A MAINTENANCE INFORMATION DELIVERY CONCEPT

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This technical paper describes the concept for the Integrated Maintenance Information System (IMIS) under development by the Air Force Human Resources Laboratory (AFHRL). It summarizes the major research and development projects that have been completed or are in progress in support of developing the system. With the IMIS concept as a baseline, work at AFHRL has centered on feasibility studies and field tests for automated technical information delivery; presenting the information on a hand-held, rugged computer in the shop and on the flightline; development of diagnostic models to improve fault isolation and rectification; automated Aircraft Battle Damage Assessment; and studies of the impact of IMIS on maintenance training. The final output of the IMIS program will be a prototype system and functional specifications for developing an IMIS for operational use.

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Summary

The Air Force Human Resources Laboratory (AFHRL) is developing an Integrated Maintenance Information System (IMIS). IMIS will demonstrate the capability to access and integrate maintenance information from multiple sources and present the information to technicians through a rugged, hand-held computer. Results of the program will form the basis of requirement specifications for such a system.

AFHRL is performing preliminary research in many areas key to the success of the IMIS concept. These areas include digital authoring and presentation of maintenance instructions, integrated diagnostics aiding, human-computer interaction, and advanced portable computer hardware technologies.

The research and development (R&D) based on the IMIS concept is being conducted to support intra-Service initiatives to automate technical instructions and provide more effective diagnostic capabilities. USAF major commands are involved in the concept refinement and evaluation.

IMIS will be the culmination of a complex and thorough R&D effort. Specifications developed by the project will be proven effective through vigorous field evaluations by Air Force maintenance technicians. As a result, IMIS will improve the capabilities of maintenance organizations to efficiently use available manpower and resources and effectively meet combat sortie-generation requirements.

Preface

The Integrated Maintenance Information System (IMIS) is funded by a program element within the Computer-Aided Logistics Support (CALS) initiative of the Air Force System Command. The Air Force CALS initiative is sponsored by the Department of Defense as a comprehensive defense modernization program for computer-aided logistics information systems. The IMIS work is consistent with the Air Force Human Resources Laboratory, Logistics and Human Factors Division, mission to improve the combat maintenance capability and readiness of the Air Force.

This technical summary is an extension of an earlier unpublished paper, with the same title, by Capt Joseph C. Von Holle, IMIS Project Manager (Combat Logistics Branch, AFHRL). The authors wish to thank the following individuals for their gracious assistance on this paper: Dr. Donald Thomas, Senior Scientist (Combat Logistics Branch, AFHRL); Mr. Terry Miller, Operations Research Analyst (Combat Logistics Branch, AFHRL); Maj Paul Condit, Assistant Branch Chief (Acquisition Logistics Branch, AFHRL); and Mr. David R. Gunning, IMIS Technologies Director (Combat Logistics Branch, AFHRL). Their help is greatly appreciated.

The present IMIS concept is the result of early scenario development by Robert C. Johnson, Branch Chief (Combat Logistics Branch, AFHRL). The concept was further developed in later work by David R. Gunning.

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I. INTRODUCTION

The Logistics and Human Factors Division of the Air Force Human Resources Laboratory (AFHRL/LR) is dedicated to improving the supportability of Air Force systems and the productivity of maintenance personnel. The Combat Logistics Branch of AFHRL/LR is developing the Integrated Maintenance Information System (IMIS). The objective of IMIS is to improve the capabilities of base-level aircraft maintenance organizations by providing technicians with a single integrated information system for intermediate and organizational maintenance.

II. THE IMIS CONCEPT

The modern maintenance environment is becoming increasingly inundated with additional computer-based information systems. Examples include the Comprehensive Engine Management System (CEMS), the Core Automated Maintenance System (CAMS), and the Automated Technical Order System (ATOS). Each new maintenance aid forces technicians to learn yet another system. AFHRL is developing the IMIS to facilitate the use of the valuable information these new systems offer, while eliminating the specialization required for each. The IMIS will use a very small, portable computer/display to interface with on-aircraft systems and ground-based computer systems to provide a single, integrated source of the information needed to perform maintenance on the line and in the shop. The IMIS will consist of a workstation for use in the shop, a portable computer for flightline use, and an aircraft interface panel for interacting with aircraft systems (Figure 1). The IMIS will access, integrate, and display maintenance information for use by the technician. It will provide the technician direct access to several maintenance information systems and data bases including historical data collection and analysis, supply, technical orders, and automated training systems. The IMIS will display graphic technical instructions, provide intelligent diagnostic and rectification advice, provide aircraft battle damage assessment aids, analyze in-flight performance and failure data, analyze aircraft historical data, and interrogate on-aircraft built-in-test capabilities. It will also provide the technician with easy, efficient methods to receive work orders, report maintenance actions, order parts from supply, and complete computer-aided training lessons. The portable computer will function independently to display all of the information the technician needs for on-equipment maintenance. Even if the base-level computer systems are unavailable or the aircraft systems are malfunctioning, the IMIS will be able to display technical order information and diagnostic aids to the technician. The portable computer will make it possible to present quality information by taking advantage of the computer's ability to interact with, and tailor information to, technicians of varying levels of expertise.

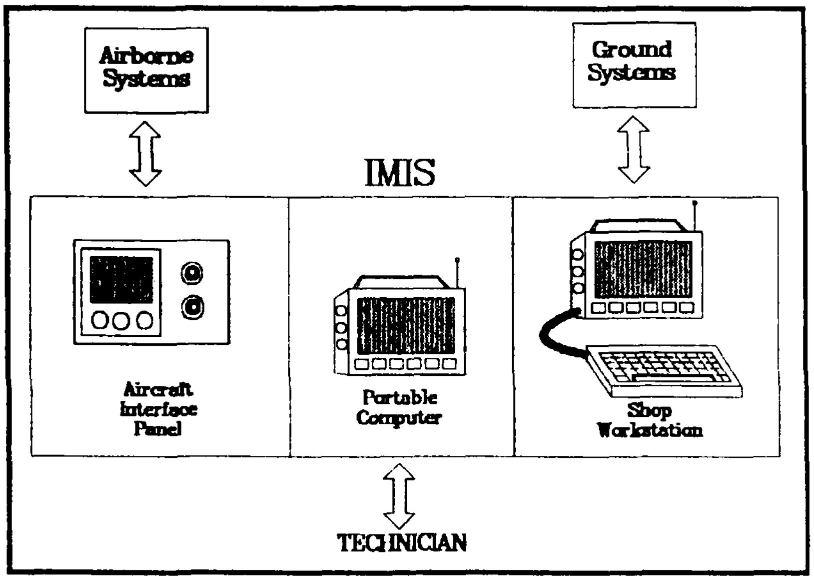

Figure 1. Integrated Maintenance Information System.

Based on previous maintenance evaluations and scenarios (Gunning, 1984; Johnson, 1981), IMIS was divided into four major subsystems: (a) the technician's portable computer/display; (b) an aircraft maintenance panel connected to on-board computers and sensors; (c) a maintenance workstation connected to various ground-based computer systems; and (d) sophisticated integration software that will combine information from multiple sources and present the data in a consistent way to the technician. IMIS functionality is fully outlined in the *Operational Concept Document for the Integrated Maintenance Information System*, Appendix B.

The technician's primary interface with the IMIS will be a compact, light-weight, battery-powered portable computer that is rugged enough for flightline use (Figure 2). A library of removable memory cartridges will store all the technical order information and diagnostic aids needed for a single weapon system. The memory cartridges will be designed for fast and easy updating. A digital radio link will be capable of transmitting and receiving both voice inputs and binary data. Advanced digital transmission techniques will allow multiple users on the same frequency, thereby reducing the radio frequency clutter on the flightline. A high-resolution, flat-panel display will display data clearly under all lighting conditions. The human-computer interface will be designed for ease of operation to eliminate the need for the user to have typing skills. The portable computer will have sufficient processing power to quickly display complex graphics and provide rapid responses to the technician's requests. Interactive troubleshooting routines and artificial intelligence - based diagnostic aids will

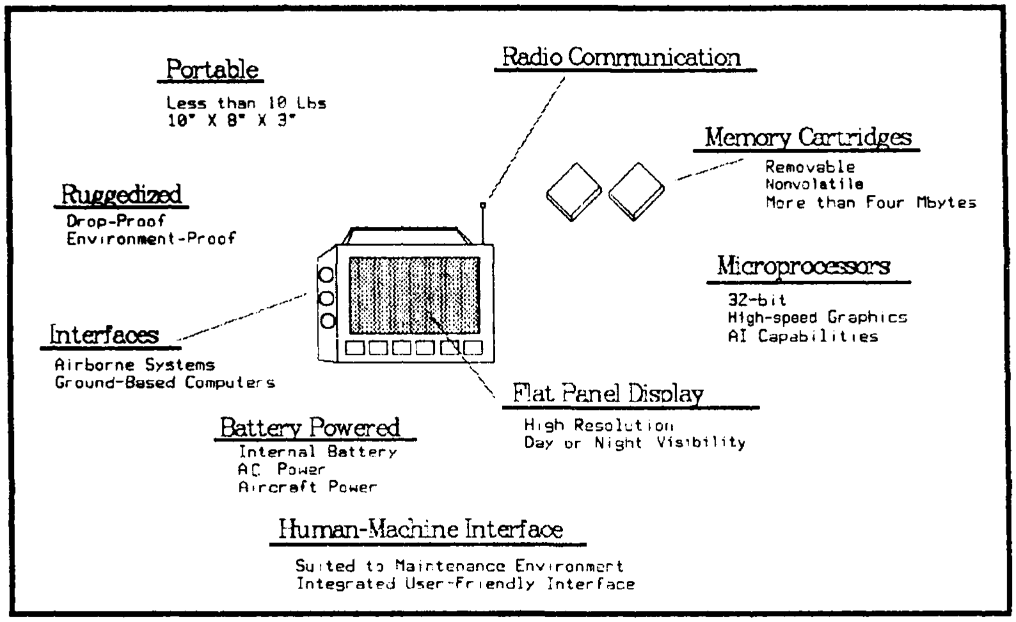

Figure 2. Portable Maintenance Computer Concept.

provide advice for difficult fault-isolation problems.

The technician will be able to accomplish most aircraft maintenance tasks without climbing into the cockpit. An aircraft maintenance panel on the outside of the aircraft will provide the interface to on-aircraft systems (Figure 3). The maintenance panel will allow the technician to interact with aircraft systems easily and will reduce the need to climb into the cockpit. This panel will consist of a control and display unit and an interface connector for the IMIS portable unit. The aircraft maintenance panel will be used to retrieve data on configuration and subsystem status, interrogate built-in-test and on-board diagnostics, and upload and download mission software. The panel may also be used in conjunction with the portable unit for extended diagnostics and troubleshooting.

The technician will interface with ground-based systems through a maintenance workstation (Figure 4). The desktop workstation will include a full keyboard and an interface computer. The interface computer will have the protocol software required to access the other available data systems. The portable computer will connect to the workstation and provide the display and co-processor for the workstation. The workstation will provide the technician with the capability to access and exchange information with systems such as CAMS and ATOS. The workstation can serve many users simultaneously, to reduce waiting.

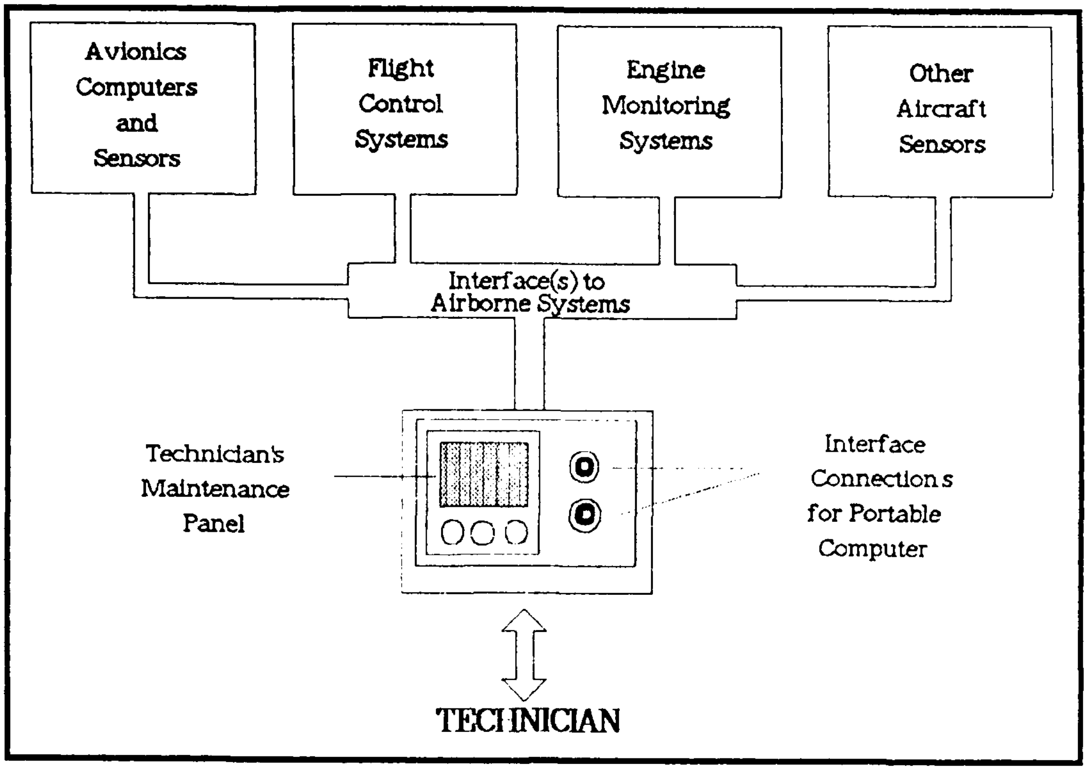

Figure 3. Aircraft Maintenance Panel.

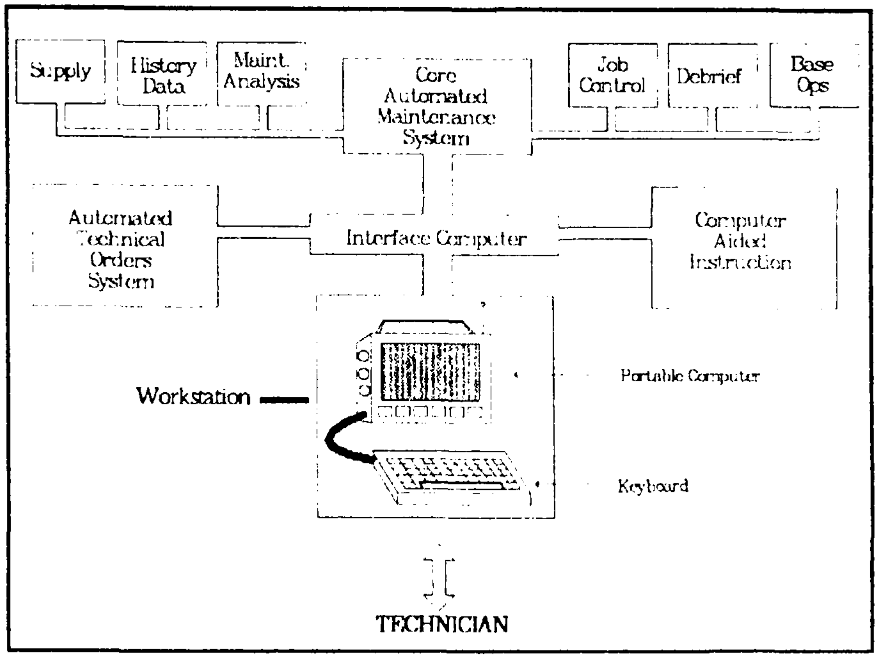

Figure 4. Maintenance Workstation.

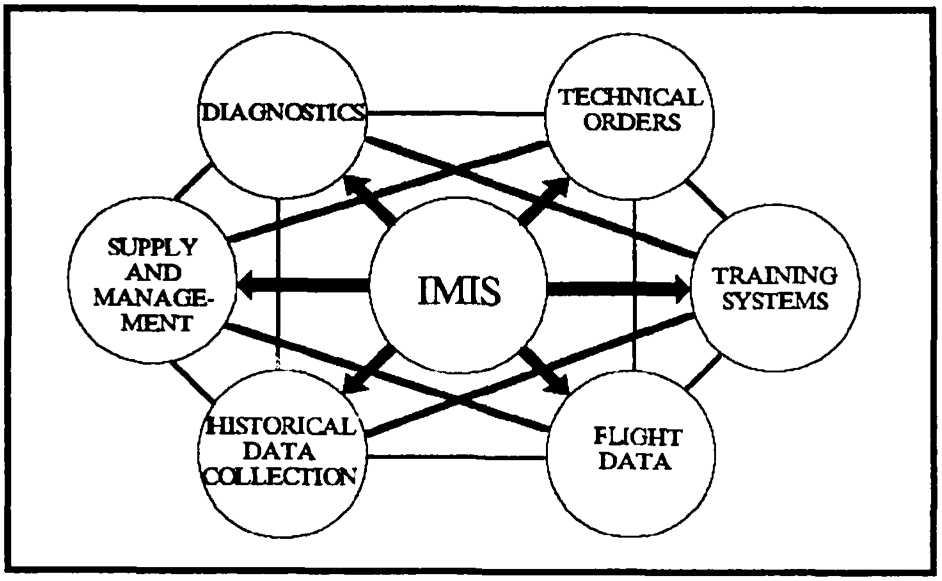

Figure 5. IMIS Information Integration.

The most beneficial feature of the IMIS for the technician will be the integration of information. Instead of dealing with several automated systems and accessing separate groups of information through several devices, the technician will access all information through a single device (Figure 5). At a superficial level, the system will integrate information by employing standard commands and display formats. At a deeper level, through sophisticated software, the system will integrate information from all available sources to provide a coordinated maintenance package.

Plans are presently in progress to establish a contract to develop the IMIS prototype. This effort will be based on past and current research by AFHRL in the automation of technical data and diagnostic processes. The major IMIS technology development efforts are described in the following sections.

III. AUTOMATED JOB AIDING

Due to the increasing complexity and number of modern weapon systems, the Air Force is faced with an ever-growing number of paper-based technical orders (TOs). This has greatly increased costs and distribution problems. In addition, it has compounded problems associated with ensuring accurate data and the lengthy correction times involved. To improve the accuracy of technical data and efficiency of its distribution, the Air Force is moving toward the digital storage, distribution, and presentation of TO data. The IMIS will demonstrate the ability to present technical information to the maintenance technician in a timely manner and to tailor the information to fit the needs of technicians of varying levels of expertise. AFHRL has done extensive research to develop the technology required for automated technical data. This research has included a feasibility study of automated TOs, as well as studies to develop the man-machine interface techniques required for an effective system, to examine data base architecture and data authoring, and to determine the information content and presentation format requirements for an automated TO system.

Feasibility of Automated Technical Orders

For many years, AFHRL has conducted research to improve the performance of maintenance technicians by improving TOs. Although new techniques for presenting TOs were found to significantly improve the technician's performance, these techniques increased the volume and complexity of TOs. Automation of the TO system was recognized as a potential solution for this problem. It was believed that an automated TO system would alleviate the problems with large numbers of pages of technical data and would have the potential to significantly reduce the costs of maintaining the data. In addition, it was believed that an automated technical data system would make performance-aiding techniques (which had been considered to be impractical) feasible and would further improve the performance of maintenance personnel.

In 1977, a study was initiated to examine the feasibility of, and develop the basic requirements for, the delivery of technical data via an automated technical data system (Frazier, 1979). The objectives of the effort were: (a) to systematically examine the feasibility of creating and implementing an automated technical data system; (b) to establish the requirements for a Computer-based Maintenance Aiding System (CMAS); (c) to establish the human factors requirement for a CMAS system; (d) to develop a system design concept that will ensure the system is easy to use, is favorably accepted by the technicians, and enhances performance; and (e) to conduct a preliminary test, in a laboratory environment, of the concepts developed.

The major emphasis in the study was to develop design concepts that would ensure the system would be usable and well accepted by the technicians, and would enhance performance. Man-machine interface techniques, data presentation formats, and data content were given primary consideration. The basic requirements identified in the study included:

1. Data should be presented in multiple levels of detail (or tracks) which provide the technician with all the information needed and no more. With this approach, the novice technician is presented very detailed instructions, whereas the experienced technician receives instructions with minimal detail.

2. All of the information required should be provided in one place. Thus, if a procedure references another procedure, the system should automatically recall the appropriate

data at the proper time.

3. Pools of supplemental or reference information should be readily available. For example, a technician who does not remember how to use a given piece of test equipment should be able to retrieve instructions on its use from a menu of options.

4. Maintenance procedures should be presented in a step-by-step format supported by illustrations keyed to the text.

5. Graphics should be presented in a simplified form, to make it easier to find and use the information. This form will also reduce storage requirements and clutter.

6. Special function keys should be used to facilitate interaction with the computer and reduce requirements for typing skills.

These concepts were incorporated and tested in subsequent field tests, with very positive results. Feedback from maintenance technicians proved essential for the develcpment of specifications on automated job aiding. Specific technology development efforts, and tests of automated TOs and job aiding, are discussed below.

Computer-based Maintenance Aiding System (CMAS)

CMAS was developed to test information presentation and human-computer interface techniques for intermediate-level maintenance. The CMAS test systems allowed investigation of automated maintenance instructions under actual field operating conditions. Specific concepts tested were multiple levels of detail, various facilities for accessing TO data, presentation of diagrams larger than the screen, function key utility, human interaction, and presentation of troubleshooting procedures. The enthusiasm of the maintenance technicians who used the CMAS demonstrated the need and validated the approach for enhanced job aiding capability in today's maintenance arena.

In a contract effort, a CMAS prototype (now designated CMAS I) was developed and later tested at Offutt AFB, Nebraska, in December 1984. The development and evaluation of the system provided useful information with regard to computer size, response time, use of color, and graphics display. CMAS I also tested the concept of providing maintenance instructions at differing levels of detail to best support the technicians' task proficiency. The technicians could freely switch from one level to any other level during a procedure. This allowed experienced technicians to access additional details on an as-needed basis while novice technicians proceeded at a level that best suited their capabilities. (In the future, movement from a lower level to a higher level might be limited by technician skill level so that novice technicians would be prohibited from using information that does not support their proficiency.) The computer system used required too much space on the workbench, and the time delays between frames of information were too great, approximately 10 seconds. Consequently, CMAS I did not gain user acceptance and was considered unsuitable for its proposed use.

In an effort to improve the acceptability of CMAS I, while incorporating its strengths, AFHRL developed CMAS II in-house. The commercially available GRID Compass II computer was selected to host the CMAS II system. The GRID was chosen for its small size and its powerful capabilities which made it an ideal candidate for a CMAS prototype. The TO information used for the field test applied to the RT-728A/APX-64 radio receiver-transmitter. The checkout and analysis section of the selected TO was automated. The selected data were analyzed to determine what additional sections were needed to support the checkout. These additional sections included portions of Theory of Operation, Illustrated Parts Breakdown, Schematics, and Troubleshooting. Troubleshooting routines were developed by an experienced technician. Figure 6 provides a sample screen presentation.

The first field test of CMAS II took place at Grissom AFB, Indiana. CMAS II proved more successful than the first prototype. The GRID computer occupied much less space on the technician's workbench, and the frames were presented much faster (approximately every 2 seconds). Eight technicians of varying skill levels were asked to check out and troubleshoot a radio module in which faults were inserted. As in CMAS I, two levels of detail were implemented. CMAS II also afforded multiple methods for efficient access of information. The access methods included menus, function keys, and direct access on the technician's

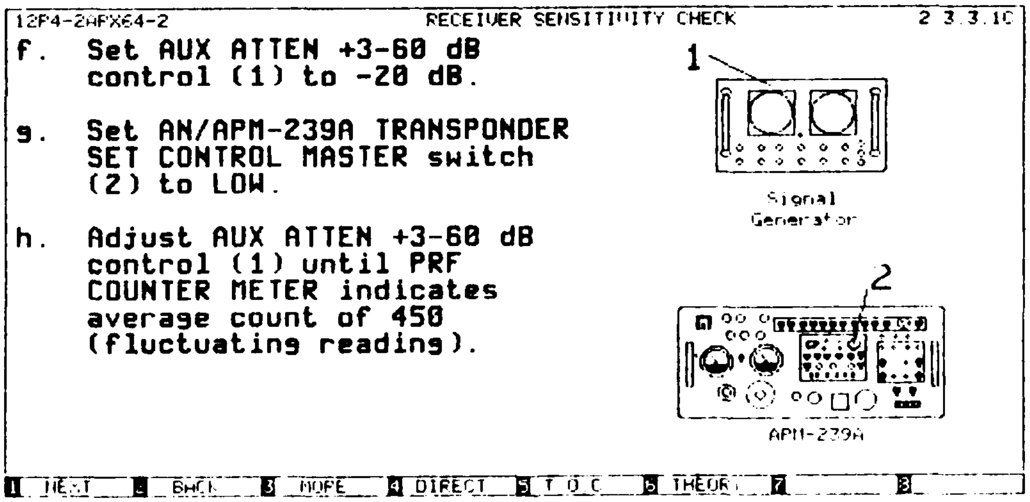

Figure 6. Sample CMAS II Screen (reduced 40%).

request or response to a question. A keyboard was constrained to simulate a keypad by allowing input only through programmable function keys and cursor control keys. This allowed efficient information access without the need for typing skills. To allow technicians to use large illustrations on a limited viewing area, continuous scrolling of the display was available.

All of the technicians isolated the fault using CMAS II, and their feedback was enthusiastic. The technicians liked the ease of the computer in accessing the data, and they commented favorably on the option of using different levels of detail. Negative feedback pertained largely to the inability of the 512x256-pixel screen to display an entire schematic. Technicians would have liked to follow the signal path from start to finish, but the screen could display only a portion of the path. A solution might be a fast zoom capabilty or a window inset showing a magnified portion of the schematic where the cursor is located.

CMAS II contained troubleshooting procedures not contained in the original TO. These procedures guided the technician to the identification of the fault by a series of questions based on a fault-isolation decision tree. The procedures used in the field test were those outlined by a technician experienced in maintaining the subsystem which the automated TO supported. The expert troubleshooting procedure, combined with the interactive access to maintenance instructions, allowed technicians with no prior experience on the subsystem to identify the fault.

Due to the favorable response to CMAS II, the Navy Personnel Research and Development Center (NPRDC) requested the use of the system to aid their own research in automated job aiding. The result was a joint Air Force/Navy/Marine evaluation of the CMAS II using an enhanced data base. The performance results were similar to those obtained at Grissom AFB, and the system was again well received by the technicians. Specific results indicated that maintenance technicians were able to accomplish troubleshooting tasks in less than half the time it took using paper-based technical manuals. The computer also enabled the technicians to test an average of 65% more test points in that time. Also, it was determined that novices using the computer could troubleshoot 12% faster than experienced technicians, whereas it took the novices an average of 15% longer to troubleshoot using paper manuals.

The results of the development and subsequent field test of the CMAS program were documented in two draft specifications (Evans, 1986a, 1986b). The Technical Data Content Specification established requirements for the content and formatting of data to be presented via electronic media. The Technical Data System Functional Specification established the system delivery functions, basic hardware/software capabilities, and the system performance requirements. These documents provided a baseline for continued research in maintenance performance aiding with automated information.

On-equipment Job Aiding Field Test

Although prior demonstrations have focused on intermediate shop aids, in the spring of 1988, AFHRL will run a test of automated job aiding for routine organizational-level (flightline) maintenance on an F-16. The test will be an extension of the intermediate-level maintenance CMAS study. Data will be developed in-house for display on a rugged portable computer called the Portable Computer-based Maintenance Aiding System (PCMAS). (The functional specifications of the PCMAS are discussed in section VII, Hardware Development.) The emphasis of the field test will be to identify the particular needs of the flightline maintenance technician with regard to the quality of the information delivered; the size, portability, and durability of the computer; and the readability of the display. The output of the field test will contribute to the draft Technical Data Content Specification of the CMAS program and provide input to the specifications for the IMIS portable computer.

IV. AUTHORING AND PRESENTATION SYSTEM (APS)

In designing the CMAS program, it was recognized that the manner in which the data base is created and maintained will have a significant influence on the success of an automated technical data system. Efficient techniques must be available to create the data and incorporate the complex coding required for the display of technical data on a screen. Further, these data must be stored in such a way that they can be displayed on a variety of computer systems without change. In addition, it would be desirable to be able to produce printed copies of the data from the same data base. With these requirements in mind, an analysis was made of technical data requirements, data base management techniques, and data coding techniques. A data Authoring and Presentation System (APS) was then developed which will allow the technical data to be displayed on various displays and printed according to specified formats without change to the data base. The data base developed using the APS is known as a "neutral" data base, since it is independent of the computer system that will be used to display it.

The resulting data base includes both the technical data to be displayed and the codes to control the display of the data on the screen. It was recognized that creating the data base with the embedded codes manually would be an extremely labor-intensive task. An authoring system was needed that would aid the author in creating the data and at the same time automatically input the necessary codes. Also, versatile software was needed to allow the display of the data on different display systems. The APS effort was initiated to meet these needs.

The APS project is addressing three areas important to the success of the full IMIS as follows:

1. A data base structure capable of representing the complex data relationships found in

digital maintenance information created for interactive use;

2. Authoring system software to reduce the time and effort required to design and produce the data; and

3. Presentation system software to provide access to, and interact with, the information contained in the data base.

The data base used by the authoring system of APS provides the flexibility required to represent the complex interrelated data found in TOs. The data base can contain many types of TOs written for many different configurations of a weapon system as well as many kinds of weapon systems. The TOs will be authored using a scheme similar to the Maintenance Integrated Data Access System (MIDAS), which assigns indices to the various levels of indenture of the text. During presentation, sections or paragraphs can be located using the MIDAS-like indices. The basic structure of the data in the APS data base is nodes of a hierarchical tree. At each node of the tree is a paragraph of technical information. Supporting information such as tables, graphics, or cautions are attached to the paragraph by the author through simple commands. APS maintains the relationship of each paragraph with its neighboring paragraphs, its chapter, and its section. This relational tree structure allows different presentation sessions to display varying amounts of information, depending on the user's needs.

The APS will be used to develop and present technical data for the on-equipment job-aiding field test discussed in the previous section.

V. AIRCRAFT BATTLE DAMAGE ASSESSMENT (ABDA) FIELD TEST

A critical task in combat operations is the assessment of aircraft battle damage so that the aircraft can be quickly repaired and returned to operation. Current ABDA procedures require an experienced technician with extensive knowledge about the aircraft to determine which components or systems need to be checked and repaired. The assessor relies heavily on the aircraft and system TOs for information to accomplish this assessment. The necessary information is usually scattered throughout a number of TOs and is often hard to find. As a result, the ABDA task is often time-consuming. The problem is likely to be compounded by the fact that fully qualified battle damage assessors may not always be available in a combat situation. The use of specialized ABDA data presented by the IMIS portable computer is believed to provide a partial solution to these problems. With the IMIS system, it will be possible to develop a specialized data base for ABDA which will readily provide the technician with the specific information needed. In addition, the system can be designed to make it possible for less-experienced technicians to effectively conduct assessments.

Studies have been conducted to examine the potential uses of an automated ABDA system and to establish preliminary requirements for such a system (Chenzoff, 1986; Wilper & Eschenbrenner, 1983). In addition, a study for a Digital Aircraft Damage Assessment and Repair (DADAR) system was recently completed to examine techniques for using computer graphics to assess damage (Williamson & Hecker, 1986). The DADAR system provided detailed graphics depicting the components of a specified zone of the aircraft. The technician was able to selectively "remove" components from the graphic to "see" what other components remained hidden behind the removed components. The graphics were also keyed to parts information, which allowed the assessor to initially recall parts information by placing the cursor on the items of interest. Another study is in progress to examine non-graphics techniques for presenting specialized ABDA data.

A full-scale evaluation of the use of the PCMAS portable computer as an automated ABDA aid is planned for Fiscal Year 1988. In this study, ABDA data will be developed for a section of an operational aircraft. The system will then be evaluated by having technicians assess actual damage to an aircraft inflicted by cannon fire from the Air Force Flight Dynamics Laboratory Threat Simulator. The results of this evaluation will be used to establish the requirements for the ABDA capabilities of the IMIS.

VI. IMIS DIAGNOSTIC DEMONSTRATIONS

An important function of the IMIS will be its ability to aid the maintenance technician in the troubleshooting of sophisticated weapon systems. Several ongoing projects are studying ways to better process the mass of diagnostic information so that a single technician can understand it and use it to troubleshoot a weapon system more efficiently. By delivering quality information, the IMIS will improve the maintenance technicians' performance and enhance their interest and expertise in fault-isolation tasks.

Maintenance Diagnostic Aiding System (MDAS)

In November 1985, AFHRL began preliminary development of a Maintenance Diagnostic Aiding System (MDAS). The basis of this tool is a system that closely models how equipment behaves under failure and offers the best diagnostic or repair activities to the technician during troubleshooting. Work at this stage examined the graphical presentation of fault-isolation and repair information to the flightline technician using a small portable computer. Initial research identified the data needed to efficiently rectify an aircraft system and the data's availability in the maintenance and logistics environments. A sample MDAS screen is presented as Figure 7.

The heart of the modeling system is associations between faults and symptoms. Symptoms observed by both the pilot and the technician are compared to an association matrix to determine the initial set of suspected failures. Each line replaceable unit (LRU) is represented

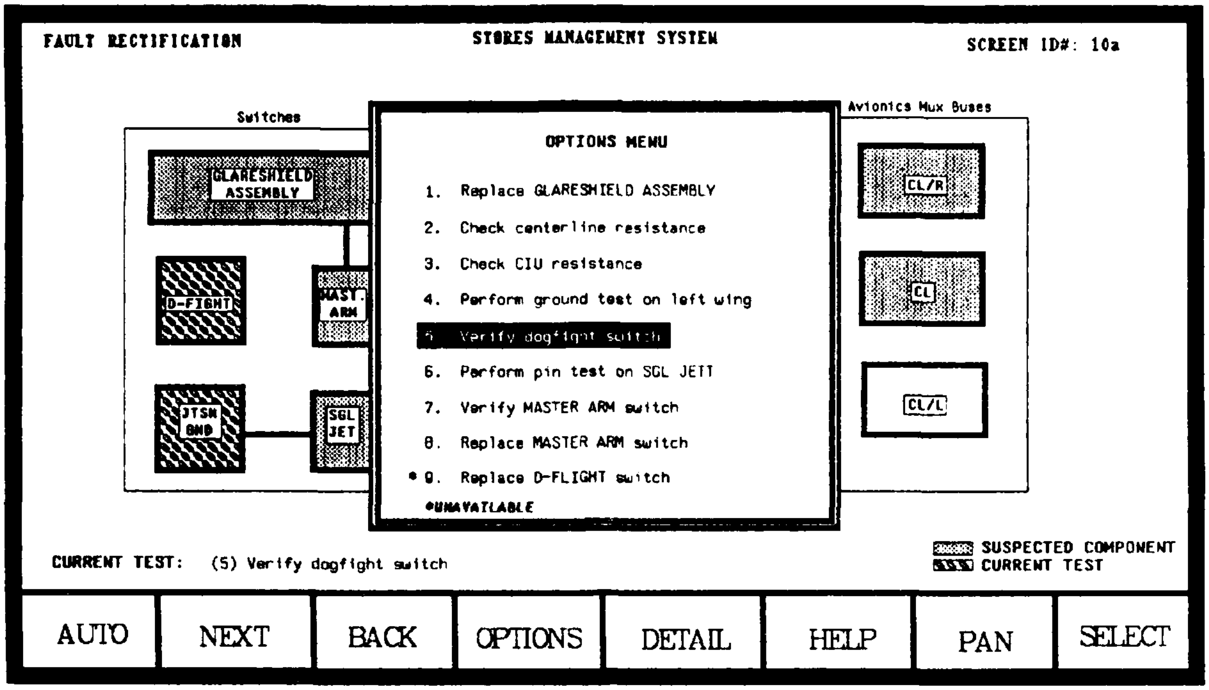

Figure 7. Sample MDAS Screen.

in MDAS as a set of faults. It is these faults which are actually diagnosed. Therefore, when a faulty LRU is removed from an aircraft, knowledge of the particular fault within the LRU is sent with the LRU to depot.

MDAS rank-orders available tests by finding the test which splits the set of suspected faults so that the probability of failure for those faults being tested is approximately equal to the probability of failure of those not tested. Probabilities are based on Mean Time To Failure. Test times are then considered so that tests requiring the shortest time are moved to the top of the list of recommended tests, all other things equal. Test time is determined by the time needed to access the test location and the time required to set up for the test. If a test becomes available because, for example, a panel has been removed to access a different test, the access time is only charged for the first test, not both.

Tests used for fault isolation include monitor-type tests such as voltage or resistance measurements and built-in-tests. Before any of these tests are recommended to the user, however, other actions such as alignments, adjustments, and swaps are evaluated to determine if they might be better at that time. If, for example, it is fairly certain that a particular component is failed, rectification time can be reduced by swapping the component without wasting the time to run a verification test first. However, if the time to perform the swap is much greater than the time to run the test, the test would be recommended first.

The algorithms and the data requirements developed in the preliminary work were refined in a contract effort completed in September 1986. This effort established requirements for an elaborate troubleshooting model to address:

1. multiple-outcome (non-binary) tests,

2. availability of resources on base,

3. ability to focus troubleshooting on mission-critical components,

4. calculation of estimated maintenance time, and

5. training/simulation.

A performance analysis of MDAS running against six diagnostic techniques from the open literature (Cohn & Ott, 1971; Hartmann, Varshney, Mehrotra, & Gerberich, 1982; Pattipati, Alexandridis, & Deckert, 1985; Sheskin, 1978) and two technical manual troubleshooting trees, showed significant improvements in rectification time and Retest OK (RTOK) rates for MDAS. MDAS outperformed the other techniques in most of the performance tests.

A follow-on task from April through September 1987, will

1. evaluate human interface options;

2. incorporate the ability to isolate multiple faults;

3. develop plans for data collection for a testbed system, the stores management system, on the F-16A/B aircraft; and

4. evaluate the tradeoffs between the use of the proposed B1-B offensive radar External Support System and the use of a portable diagnostic aid with the existing built-in-test and Central Integrated Test System (CITS).

The strength of any diagnostic aiding system lies in the data which describe the failure behavior of the system under test. Data are therefore a primary focus of this diagnostic effort. Although technical manuals were the primary source of data for early MDAS development, the follow-on task will begin to collect data from many other sources, including expert maintenance technicians, design engineers, failure modes and effects analyses, built-in-test and automatic test equipment documentation, and testability analyses. A goal of the IMIS diagnostic demonstration is to establish an information flow between system design and diagnostics so that (a) diagnostic data collection becomes an inherent part of the acquisition process and (b) diagnostic feedback from the field can be used for design improvements. The results of the MDAS task will support a demonstration on an F-16 in mid-1988.

F-16 Demonstration

AFHRL is conducting a contractual task to examine the requirements for interactive diagnostics on the Air Force F-16 using aircraft subsystem capabilities and manual tests. The contractor will develop an interface so that a portable computer can control the 1553B system bus on the F-16. This interface will allow the diagnostic aiding program to screen on-aircraft data and run built-in tests. The contractor will also develop diagnostic and technical order data for selected systems on the F-16A/B using the draft specifications of CMAS and APS. AFHRL will supply the portable computer which will host the data, control software, and interface software for a demonstration of the diagnostics concept on an F-16. AFHRL will conduct this demonstration in 1988.

F-18 Demonstration

Another diagnostic demonstration, using the Navy F/A-18C/D aircraft, is planned in conjunction with the Human Factors Laboratory of NPRDC, and the Naval Air Systems Command. The F/A-18 aircraft was selected because of its advanced system architecture and fault-reporting capability. These capabilities will allow a unique examination of the benefits of a portable diagnostic aid used with a sophisticated on-aircraft fault-detection network.

Like the F-16 effort, it will be necessary to implement a system bus interface for the F/A-18, as well as develop diagnostic and technical order information for selected systems on the aircraft. Again, the automated technical information will be developed using the draft specifications of the CMAS and APS projects. The effort will include an in-depth examination of human interface requirements for the portable computer, based on previous research at AFHRL. AFHRL will supply the portable computer for the F/A-18 demonstration, which is scheduled for mid-1988.

X-29 Monitoring Effort

This in-house effort, which began in June 1986, is examining techniques to automate the screening of large amounts of data generated by the experimental X-29 aircraft. The process can be characterized as one of observing a data stream for the occurrence of events which are recognized as symptoms of malfunctioning equipment. The recognized symptoms can then be input t. a fault-isolation routine or to call up appropriate rectification information if no additional diagnostic processing is required. AFHRL is attempting to answer the questions of how frequently such events occur, how much data need to be screened, how sophisticated the processing needs to be, and what the tradeoffs among these factors are. Also, the accessibility and value of the data are limited by the current design of the X-29 aircraft. AFHRL will provide general design guidelines for improving the fit between monitored aircraft parameters and their use as symptoms for a diagnostic aiding system. The lessons learned from this program will play an important role in the development of the IMIS interactive diagnostic capability. The effort is expected to be completed in February 1988.

VII. HARDWARE DEVELOPMENT

At the center of the overall IMIS concept demonstration program is a small portable computer that is capable of presenting text and complex graphics to the maintenance technician. Two AFHRL efforts that are examining the hardware specifications needed to meet the functional requirements of the IMIS concept are the PCMAS effort and an in-house hardware research and development (R&D) effort. The results of these efforts will directly influence the development of the full IMIS hardware. A comparison of these two efforts, along with the anticipated portable IMIS, is presented in Table 1.

TABLE 1: Comparison of Three Portable Computer Developments

	PCMAS	In-house portable[a]	IMIS portable[a]
Dimensions(inches)	15x12x3	12x8x3	10x8x2.5
Weight(lbs)	13	8	5
Power(watts)	46	25	12
Memory (megabytes)	4.5	5.5	18.5
Internal	3.5	2.5	2.5
Cartridge	1.0	3.0	16.0
Processor	32bit/10MHz (Motorola 68010)	32bit/16MHz (Motorola 68020)	32bit/30MHz (To Be Decided)
Display	EL(mono)/512x256	LCD(gray-scale)/640x480	LCD(color)/640x480
Features:			
Voice Recognition	X	X	X
1553B Interface	X	X	X
Radio Link		X	X
Internal Battery		X	X
Touchscreen			X

[a] Design Goals

Portable Computer-based Maintenance Aiding System (PCMAS)

The PCMAS is an advanced portable computer designed to demonstrate the concept of presenting automated technical data to maintenance technicians in a flightline environment. The PCMAS will be a flexible research tool for AFHRL to test various hardware and software aspects important to the full IMIS development. It will help establish information requirements for a portable system for operational use. The PCMAS will be the portable computer used for the flightline diagnostic demonstrations on the F-16 and F/A-18 aircraft during 1988.

The PCMAS will demonstrate several important IMIS concepts. In the shop, the PCMAS will be connected to peripherals to simulate a maintenance workstation. This will demonstrate the exchange of information between base-level information management systems and the portable computer. It will replace paper TOs by presenting technical information stored on memory cartridges. Finally, the PCMAS will provide the vehicle to perform interactive aircraft diagnostics through an aircraft 1553 data bus interface.

The functional block diagram of the PCMAS is shown in Figure 8. The PCMAS features the Motorola 68010 processor with 3.5 megabytes of on-board memory and a plug-in memory cartridge of 1 megabyte. It uses an electroluminescent (EL) display with high resolution. It has the capability to run on an external battery pack, aircraft power, or standard 110-VAC power. Two ports allow the device to interface with peripherals in the shop and the 1553B aircraft data bus. The PCMAS uses a version of the UNIX operating system which allows multiple processing and presentation of multiple windows.

The PCMAS capability demonstrations will begin in the fall of 1987.

In-house Hardware Development

AFHRL is studying advanced computer technologies for possible application to future IMIS hardware development. The in-house effort will test and evaluate new technologies to maximize the performance and capabilities of the IMIS portable computer, while minimizing the computer's size, weight, and power requirements.

A prototype portable computer is being fabricated from an in-house design. The computer will be based on the Motorola 68020 microprocessor. The computer will have up to 5.5 megabytes of memory (2.5 megabytes on-board and 3 megabytes from the plug-in cartridge). The operating system will be PDOS, which offers the functional requirements needed without the software overhead costs of UNIX. Power requirements will be greatly reduced by using a Liquid Crystal Display (LCD) active matrix screen instead of conventional high-resolution display screens. The LCD active matrix screen gives high resolution at one-tenth the power requirements of an EL screen. Further power reduction will come from the use of CMOS circuitry, which features low power consumption.

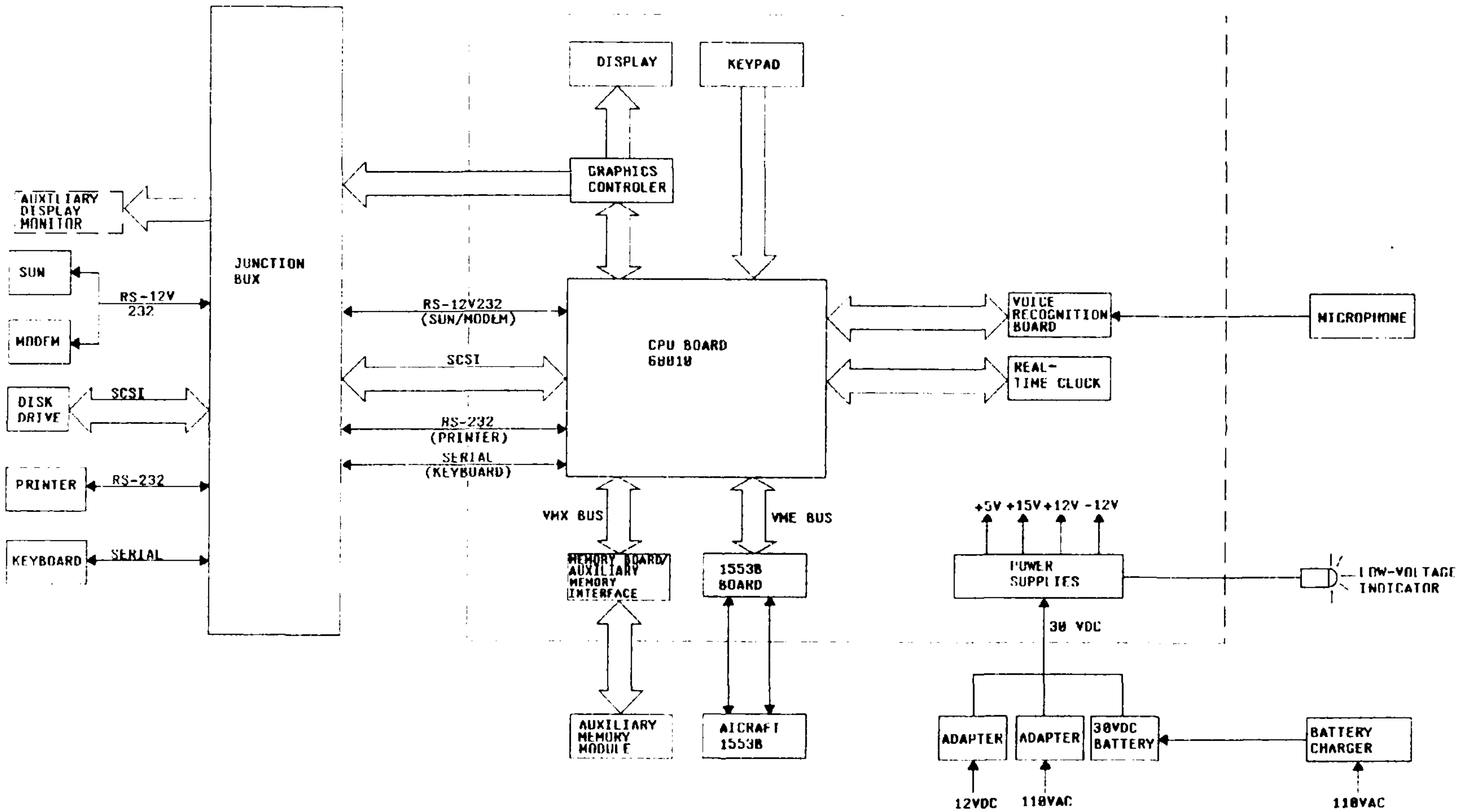

Figure 8. PCMAS Functional Block Diagram.

To reduce the number and size of the circuit boards inside the unit, surface mount technology will be used. Integrated circuit chips commonly come in a dual in-line package that requires mounting on both sides of a printed circuit board. The smaller surface mount chips require mounting on only one side of the printed circuit board, leaving the second side of the board available for another circuit. Through surface mount technology, more than twice the density of dual in-line packaging can be achieved.

The in-house effort will also be investigating battery and radio transceiver technology. Several emerging battery technologies offer strong potential for meeting the IMIS power, run-time, and weight requirements. Examples include the high-density lithium and silver oxide rechargeable batteries. The radio link on the IMIS portable must be capable of handling both voice inputs and digital data. The investigation of this technology will determine whether a secure, reliable communication link can be established within the power and size constraints of a portable computer.

VIII. TRAINING STUDY

In addition to investigating the use of IMIS and its impact on base-level maintenance, AFHRL is also exploring the use of IMIS technology for training. It is believed that IMIS can have a significant impact on maintenance training in several areas. The direct interface of IMIS with automated technical data will provide training opportunities which have not previously existed. For example, with the IMIS, it would be possible for technicians working on a task to directly access training materials related to it. This capability would be convenient in the instance where the technicians find they need "real-time" supplemental training on materials related to the task (such as the use of test equipment) or instances where they want to increase their knowledge of related topics. Another potential application of IMIS for training would be in the area of training technicians for troubleshooting. Technicians could directly access the IMIS diagnostics data base and use those data to simulate troubleshooting the system. In addition to serving as a training aid, the IMIS will contribute to the management of the base-level maintenance training. The IMIS interface with CAMS and related management systems will simplify the processes of scheduling training and maintaining training records. Preliminary studies have been completed. Follow-on work will further define training applications of IMIS. The results of the first effort are summarized in the following paragraphs.

IMIS Training Scenarios

AFHRL is investigating the impact and use of the IMIS on base-level maintenance training. Maintenance technicians and instructors at MacDill AFB, Florida, were asked to provide insight to current maintenance training procedures, techniques, and requirements. Then, several specific scenarios were developed to aid in the IMIS training concept formulation (Brandt, Jernigan, & Dierker, 1986).

Current maintenance training employs conventional techniques such as lectures, demonstrations, and correspondence courses. Limited use of computer-assisted instruction (CAI) is made with software-driven training simulators. Videotapes are often available for self-study. Diagnostics training includes insertion of faults into the equipment by an instructor, followed by fault isolation by the student using paper job guides. The faults may or may not correspond with commonly occurring faults in the real world. Also, the students' ability to question why the job guide is leading down a certain path is limited to hypotheses by the instructor rather than information provided by the designer of the job guide.

Administrative requirements for maintenance training records are extensive. After specific training is accomplished, the course completion is recorded manually in each student's record. Then, the completion is usually input to the Maintenance Management Information Control System (MMICS) training subsystem. This process requires a dedicated staff to maintain the records.

The IMIS, having its maintenance data in a hierarchical, relational format, could use these maintenance data for training. This could be accomplished at the press of a "button" which would tell the computer to go into a training mode. If a large class needed to view the instruction, the IMIS portable could be connected to a large CRT monitor.

The IMIS performs several functions for maintenance which could be used directly with training. Highlighted signal flows could lead the student through a complex circuit diagram. A full recording of keystrokes, and the ability to back up over previous steps in the maintenance procedure, would enable the student (and the instructor) to analyze the steps taken and perhaps try an alternative approach. IMIS could test students' proficiency in troubleshooting, give the students their scores (which would also be automatically transferred to the MMICS system), and offer an explanation of the errors.

For diagnostics instruction, either the computer or the instructor could recommend a fault for the students to target. In both cases, the only difference from routine troubleshooting would be that the computer would automatically input the test results since it knows what path to take to isolate the fault. Otherwise, students could take the computer's choice of a test or choose one of their own, and they could ask the computer for explanations at any time, just as in actual troubleshooting.

Future training studies for the IMIS concept will evaluate in more detail precisely what tasks can and should be trained, and the scenarios mentioned above will be refined.

IX. THE IMIS PROJECT

The objective of the IMIS project is to conduct research to verify the feasibility of the IMIS operational concept (Appendix B). The effort will use carefully developed software and hardware prototypes that are based on AFHRL's previous research in automated maintenance job aiding, diagnostics, and hardware technology. The final product will be specifications that will enable weapon system acquisition organizations to adapt this maintenance concept to new weapon systems and subsystems.

The development of a full IMIS demonstration will proceed in four phases. During the first phase, a structured analysis methodology will be used to determine the information system architecture. This architecture will define requirements for users' information needs, for interfaces, and for functional implementation. The second phase will be the hardware and software analysis, design, and review. During the third phase, hardware fabrication, software programming, and system tests and reviews will occur. Finally, in the fourth phase, the system will be evaluated in the operational environment by Air Force maintenance technicians. The field test will evaluate a representative cross-section of the maintenance activities and functional capabilities identified in Appendix B to ensure a thorough demonstration of the IMIS concept.

X. CONCLUSION

The IMIS is funded as part of the Computer-aided Logistics Support (CALS) initiative of the Air Force Systems Command. The system is being designed to support present and future aircraft designs including modular, reconfigurable avionics systems. The R&D also supports future Air Force maintenance concepts including reduction of job specialties and small unit manning capabilities (AFHRL Project SUMMA, Small Unit Maintenance Manpower Analysis). The IMIS will make it possible for a single technician to perform complex maintenance tasks on many different systems. The IMIS training capabilities will enable supervisors to tailor the technician's training to meet the needs of specific job assignments.

The final output of the IMIS program will not be a list of "how to" specifications for building a duplicate IMIS system. Rather, the output will be specifications for the functional requirements for such a system, concentrating on what information future maintenance technicians will need and how to present the information to them. These specifications will allow weapon system program offices to adapt the IMIS maintenance concept to their weapon systems and take full advantage of state-of-the-art technology.

The IMIS project will be the culmination of a complex, thorough R&D program combining the skills and studies of numerous people and their projects. The IMIS will be only the beginning for this new Air Force maintenance concept. The IMIS will optimize the use of available manpower, enhance technical performance, improve training, and reduce the support equipment and documentation needed for deployment. It will serve as the technician's single, integrated source of all the technical information required to perform modern aircraft maintenance. The AFHRL believes that the IMIS will improve maintenance capability, productivity, and morale.

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APPENDIX A: LIST OF ACRONYMS

ABDA	Aircraft Battle Damage Assessment
AFHRL	Air Force Human Resources Laboratory
APS	Authoring and Presentation System
ATOS	Automated Technical Order System
CAI	Computer-Assisted Instruction
CALS	Computer-Aided Logistics Support
CAMS	Core Automated Maintenance System
CEMS	Comprehensive Engine Management System
CITS	Central Integrated Test System
CMAS	Computer-based Maintenance Aiding System
CMOS	Complementary Metal-oxide Semiconductor
DADAR	Digital Aircraft Assessment and Repair
EL	Electroluminescent
IMIS	Integrated Maintenance Information System
LCD	Liquid Crystal Display
LRU	Line Replaceable Unit
MDAS	Maintenance Diagnostic Aiding System
MIDAS	Maintenance Integrated Data Access System
MMICS	Maintenance Management Information Control System
NPRDC	Navy Personnel Research and Development Center
PCMAS	Portable Computer-based Maintenance Aiding System

RTOK	Retest OK
SUMMA	Small Unit Maintenance Manpower Analysis
TO	Technical Order

APPENDIX B:

OPERATIONAL CONCEPT DOCUMENT

FOR THE

INTEGRATED MAINTENANCE INFORMATION SYSTEM

(IMIS)

15 December 1986

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IMIS OPERATIONAL CONCEPT DOCUMENT
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1. SCOPE

1.1 Identification. This Operational Concept Document describes the proposed mission of the Integrated Maintenance Information System (IMIS) and its operational and support environments. It also describes the functions and characteristics of the system.

1.2 Objective. The objective of the Integrated Maintenance Information System (IMIS) is to improve the capabilities of aircraft maintenance organizations by providing Air Force technicians an effective information system for intermediate and flightline maintenance. The improved information system increases the performance capabilities of the technicians which will result in an increased sortie-generation capability. IMIS entails the computer and information technology needed to meet the following specific objectives.

1.2.1. Integrate multiple maintenance information sources into a single easy-to-use information system.

1.2.2. Tailor information to meet the specific needs of the task and the technician.

1.2.3. Provide on-the-job training aids for new systems and proficiency training on existing systems.

1.2.4. Eliminate time-consuming paperwork and tasks through automation.

1.2.5. Improve on-aircraft diagnostics and reduce "Can Not Duplicates" (CNDs) and "Retest OKs" (RTOKs).

1.2.6. Improve the quality of maintenance performance by taking advantage of the computer's ability to interact with the technician.

1.2.7. Maximize the utilization of available manpower resources by providing information in standard, generic formats independent of the subsystem and supporting general technical capabilities at various skill levels.

1.2.8. Improve the maintenance capability for dispersed operations by packaging the needed maintenance information into a highly portable, deployable system.

1.2.9. Provide the capability to support maintenance performance in future scenarios of consolidated specialties.

1.3 Introduction. IMIS is a maintenance aiding system that communicates with other maintenance computer systems, both on-aircraft and ground-based, to provide a single source of information to meet the requirements of maintenance

MIL-H-46855: Human engineering requirements for military systems, equipment and facilities

MIL-STD-210: Climatic extremes for military equipment

MIL-STD-454: Standard general requirements for electrical equipment

3. MISSION

3.1 Mission Need Requirements. The Air Force is currently developing several computer systems for organizational-level maintenance. Unless integration occurs, the Air Force of the future will have several computer systems with various updating requirements on the flightline. Confusion will occur due to incompatible hardware, data requirements, and required expertise to operate and maintain the computers.

The problem is compounded by the massive paper-based technical order (TO) system, which is often inaccurate and difficult to use. These documents are written to support only one level of expertise, which often confuses novice technicians while hindering the experienced. The TOs often do not include troubleshooting techniques, and those which do are rigidly structured and do not adapt to various circumstances and available symptom information. The paper TOs are also expensive to deploy and difficult to use in harsh weather conditions.

Finally, future dispersed combat maintenance concepts require technicians with general skills capable of maintaining numerous subsystems. Due to the complexity of the technology, these generalists will require complete, current, and consistent maintenance information to support their work. That information is presently in numerous incompatible formats and styles, even across subsystems of a single weapon system.

These deficiencies can cause improper maintenance, resulting in weapon system malfunctions, inadequate performance, equipment damage or loss, and even personnel injury or death. These degradations in weapon system and unit readiness limit the ability of combat organizations to accomplish their assigned missions.

3.2 Primary Mission. IMIS, as the name suggests, is the integration system for all maintenance information. IMIS is the technician's tool to access, integrate, format, and present all information required to complete a maintenance task. The system acts as the technician's TO and maintenance data collection device. It is their interface to diagnostic capabilities on the aircraft; and, when available, their interface to ground-based technical and maintenance management information systems so they need to learn the hardware and software protocols of only one device. IMIS also serves as a training aid, providing OJT advice during actual work and fulfilling its information presentation role during training simulations.

3.3. Expected Operational Environment. There are many circumstances which are currently changing the Air Force's aircraft maintenance concept. Improved maintenance capabilities demand effective requirements determination and asset management. Future support concepts, such as IMIS, must consider future maintenance limitations including reduced personnel availability (numbers and skills); uncertainties in support demand rates (component removal and spares usage); limited airlift capabilities to dispersed, unimproved locations; and operation and maintenance in a combat environment.

The IMIS concept has the potential to serve as a maintenance aid in almost any maintenance environment, from depot facilities to deployed locations to space stations. The primary need for the Air Force is to support organizational-level maintenance activities wherever they take place. The most difficult maintenance situations arise in the Tactical Air Forces, due to the necessity of those forces to deploy rapidly to austere locations and fly high sortie rates with limited logistical support. IMIS must be able to survive the environment and aid the performance of technicians without hindering deployment capabilities.

3.3.1 Main Operating Base Environment. Even at the main operating bases (MOBs), the Tactical Air Forces' maintenance concept is designed to meet its combat operational needs. The MOB structure maintains the decentralization and small unit autonomy necessary for dispersed operations. The maintenance complex is organized into direct and indirect sortie-producing elements. This arrangement provides a sharper distinction between on-equipment and off-equipment maintenance.

The basic maintenance unit is the aircraft maintenance unit (AMU). The Air Force provides the AMU with people, material, and authority to generate high sortie rates in peace or combat to meet specific unit requirements. Aircraft generation squadrons (AGSs) are formed by grouping two or more AMUs. People assigned to the AGS perform the on-equipment maintenance of assigned aircraft. These maintenance activities include launch, service, on-equipment repair, and recovery of primary mission aircraft. The AMUs are normally organized into aircraft flights, a specialist flight, a weapons flight, and support elements.

The component repair squadrons (CRSs) and equipment maintenance squadrons (EMSs) handle the off-equipment support for the AGS within a wing. They may also dispatch specialists for some on-equipment work.

The CRS primarily does off-equipment repair of aircraft and support equipment components; maintenance beyond the capability of the AGS(s) and the EMS: fabrication of parts; maintenance and operation of aircrew training devices; and repair and calibration of test, measurement, and diagnostic equipment. The squadron is functionally divided into six branches: accessory maintenance, propulsion, conventional avionics, integrated avionics, aircrew training devices (ATD) and test, measurement, and diagnostic equipment.

The EMS is responsible for the maintenance of flightline support equipment (FLSE) and munitions. The EMS also accomplishes aircraft phased inspections, nondestructive inspection and corrosion control, structural repair, aircraft repair/reclamation, and transient aircraft maintenance.

The coordinating and controlling function for the MOB is the Maintenance Operations Division . This division manages maintenance capabilities, allocates resources, and coordinates with operations and supply. The Maintenance Operations Center (MOC), the primary branch of the Maintenance Operations Division, directs and monitors the implementation of the flying schedule, as well as scheduled and unscheduled maintenance. Although the AMUs, CRSs, and EMSs set priorities for their production efforts, the MOC has overall command and control of the maintenance effort to ensure mission readiness among the decentralized operations. The exchange of information must be timely and in sufficient detail to allow maintenance operations to redirect the work force and re-establish priorities if objectives are not being met.

3.3.2. Dispersed Combat Environment. The overall goal of Air Force logistics support is to maintain the combat efficiency of weapon systems while sustaining a high sortie rate for an extended period of time. In the future, the Air Force will have to contend with greater air base vulnerability, reduced response time, greater deployment distance, unfavorable force ratios, and austere operating locations. Maintenance and supply operations will have to be sufficiently lean, robust, and flexible to permit rapid deployment over the long distances and sustain sortie generation in the austere locations and hostile environments. These factors increase the need for forward combat forces to be streamlined and operate with fewer support resources, such as aerospace ground equipment, available spares, and flightline specialists. The maintenance concept must maximize aircraft/system/subsystem availability and squadron/unit autonomy. Maintenance should be accomplished as close to the aircraft as feasible based on the host aircraft's design and support concept.

The ability to provide combat-configured support at vast numbers of dispersed operating locations (DOLs) is fundamental to the support strategy. The Air Force's future Air Base Support Concept greatly expands the number of war-fighting locations by expanding main operating bases to unimproved DOLs without adequate electrical power, controlled environment, support equipment, or facilities. Maintenance capabilities at the DOLs will be limited to direct on-equipment maintenance such as servicing, turnaround, inspections, programming, weapons loading, and minor repairs. The maintenance must ensure proper component removals to limit unnecessary usage of limited spares.

The personnel and equipment deployed to the DOLs must be capable of operating in various climatic conditions including temperature extremes, dust/dirt/sand, snow and ice, humidity, heavy rain and lightning, and exposure to ocean salt. They must also be capable of operating in hostile combat environments which require chemical/biological defenses and emitted energy shielding. These requirements include special protective clothing and equipment which reduce normal visual, auditory, and tactile (touch) capabilities. The combat environment will likely affect personnel physical endurance and stress levels. Other limitations may be placed on the maintenance environment. For example, maintenance may be required during periods when electric and hydraulic power generators and aircraft engines may not be operated. Also, maintenance may be permitted only during periods of darkness under extremely low lighting conditions. The IMIS maintenance concept must be capable of operation in this hostile environment without adversely impacting personnel or aircraft effectiveness.

3.4. Support Environment

IMIS is primarily an organizational-level maintenance aid, and its associated maintenance philosophy should not hinder its use. The IMIS equipment is rugged and reliable, yet easy to maintain. There is no change in manning or supply procedures and no additional support equipment requirements to support IMIS.

The portable computer is extremely reliable and easy to maintain. It has a mean time between failure (MTBF) of over 2,500 hours. The device performs a functionality Self-Test (ST) upon power-up and has selectable BIT capabilities capable of isolating faults to the removable module level. The stand-alone BIT is capable of fault detection and isolation of 95% of all digital failures and isolation of 90% of all detected failures to a digital function. The line replaceable modules can be removed and replaced without soldering or cutting wires.

No special tools or test equipment is needed for fault isolation or repair of the portable device at the base level. The device requires minimum preventive maintenance; and all corrective actions, beginning with initiation of BIT, can be completed in less than 30 minutes. The portable device is designed to be maintained by the technicians who use it. Therefore, the modules are designed for positive identification of replacement modules and module locations to prevent installation of modules in other than the proper location. Technical information for checkout and repair of a portable device can be accessed through another working portable.

4. SYSTEM FUNCTIONS AND CHARACTERISTICS

4.1 Basic System Functional Operation

IMIS will function as a stand-alone unit, a front-end delivery device for other systems, or a combination of both. In the stand-alone mode, all data will come from removable memory modules. Each module will contain enough data to accomplish a certain task, which may be remove/replace, troubleshooting, routine maintenance instructions, or a diagnostic test. When possible, IMIS will utilize existing systems and programs resident on these systems through the workstation. Some examples of this would be historical data analysis, flight data analysis, job scheduling, or a training sequence for a new system.

Some of the systems with which IMIS must interface are CAMS, REMIS, and ATOS. CAMS will be the source for job scheduling, historical data, and supply information. REMIS will contain equipment maintenance information, and ATOS will be the source for any TOs needed. IMIS will automatically retrieve the needed information from other data bases and present it to the technician in a timely, easy-to-use format in a manner that should be transparent to the user.

When practical, IMIS will utilize a radio link from the flightline to the workstation, greatly increasing the amount of information available on the flightline. This will prevent multiple trips back to the workstation for forgotten or new information when needed. It will also provide a link to job control for new schedules and to update ongoing work status and the capability to see historical data on the flightline.

4.2 System Functions.

4.2.1. Debriefing. IMIS provides a data collection and analysis unit and technical aid for technicians during pilot/aircrew debriefing. IMIS will accept, correlate and analyze aircrew-observed symptoms. The system is also equipped to read and analyze in-flight recorded failures and parameters resident on data transfer units carried in by the aircrew. IMIS uses the information from manual input or automated sources to guide the maintenance technicians, through appropriate questions for the aircrew, to identification of possible failures and/or additional symptoms.

IMIS accesses the historical data base and compares the debriefing information with historical data to identify unusual parts usage, repeat discrepancies, and trends. It also predicts the availability of the weapon system based on time to troubleshoot and repair. The system aids in assignment of needed specialists and recommends parts, tools, and test equipment the technicians should take out to complete the work.

The appropriate portions of debriefing information are compiled, reformatted, and stored in the historical data files. The debriefing information is also retained in the memory of the portable unit for reference during the maintenance actions.

4.2.2. Maintenance Instructions. IMIS is the TO delivery device for all phases of maintenance. It is capable of adaptively guiding the user through the entire fault-isolation and troubleshooting sequence, from identification to restoration to checkout and documentation. During the repair activities, IMIS provides the technicians with the technical data required for remove and replace and other maintenance actions. When the diagnosis is derived by the technician using IMIS, the integrated information tools of IMIS assemble and deliver the applicable technical orders for the repair of the problem.

Instructions are presented at the appropriate level of complexity for the level of maintenance and expertise of the technician. The system is able to learn and adapt to how particular individuals like to use information in given maintenance situations, and able to accommodate those preferences to the maximum extent possible. There are times when there are insufficient data for a positive isolation of a fault. The technician, however, still receives the TOs to best support repair based on the information available. The system also aids the technician in searching for the appropriate TOs and presents the TOs on request.

The instructions are either presented in a sequential manner or randomly accessed by use of menus or direct access techniques. The sequential mode may also be used to display related data from directly within the same maintenance instructions or to reference an auxiliary memory module where that information resides. The system provides the capability to switch between maintenance, diagnostics, and battle damage assessment data as appropriate to the task.

The information to support repair actions is designed to fit the requirements of the specific application. IMIS assembles the required information into work packets (job guides), with the data integrated into the appropriate sequence. The TOs are delivered with integrated text and graphics formatted to optimize repair in the maintenance environment. The system has the capability to present the information at multiple levels of detail, to best support the training and experience level of the technician performing the task. Users have the option to change to various levels of detail, depending on their information needs and expertise. Levels of less detail may be locked out according to the technician's level of expertise.

4.2.3. Diagnostics. The integrated diagnostics scenario includes interactive troubleshooting guidance, explanation of diagnostic decisions, capability for the technician to override the computer's suggested actions, selection and presentation of appropriate TOs, and automated recording of troubleshooting and repair actions. IMIS provides integrated diagnostic tools to help detect and isolate failed components down to the level of repair allowed for the particular application. These tools include an interface to the weapon system to provide access to BIT information; on-equipment sensors; in-flight recorded parameter, environmental, and failure data; and specifications data. The tools will also include historical maintenance data analysis and trending algorithms, diagnostic expert system software programs, and intelligent explanation facilities. The diagnostic tools are integrated with supporting TO information to allow thorough troubleshooting and repair.

The software will analyze the available data and provide fault-isolation information or fault-isolation procedures (when the automated techniques are inadequate or unavailable), plus instructions to repair the failures once isolated. IMIS will analyze information from all its sources and provide the technician with an explanation of likely failures and probable causes of failures. The technician can request the system explain its logic for suggesting a particular test or as to how information to be gained from conducting another test might aid the diagnosis.

The IMIS diagnostic function accepts input of symptoms either manually or automatically. IMIS processes and analyzes the symptoms and related data (such as historical reliabilities and trends, equipment configuration, environmental recordings, etc.) and recommends a test or tests to isolate the failure. The isolation procedures may be troubleshooting instructions, test generation and monitoring, or remove and replace instructions, as appropriate. The technician has the option to override the recommended test and initiate another. The system will accept the manual input and present the necessary technical information to support the technician's option. The system provides the capability to maintain and display a dynamic functional graphic presentation of a subsystem, its test points, and its components, as well as maintaining a log of progress, actions, results, etc. taken thus far in diagnosing/isolating the fault.

The stand-alone capability of IMIS is a very important feature. When physical compatibility with the existing systems is impractical or unavailable, IMIS allows the technician to manually input data gathered during troubleshooting. The troubleshooting is directed by the maintenance TO instructions displayed on the portable computer. Although the amount of information gathered in the manual mode will probably be less than the automated on-equipment systems provide, IMIS will still support maintenance the best it can with available information.

For the new Modular Advanced Systems Avionics (MASA), IMIS has appropriate adaptors to allow it to act as an off-line tester. IMIS uses its diagnostic tools, plus the diagnostic and processing capabilities built into the modules, to perform functional checks of the module. This capability allows technicians to validate failures or confirm serviceability of a module without routing it through the standard repair cycle. More complete diagnostics and repair will be performed at the intermediate or depot level after validation.

IMIS is also used in the intermediate-level repair shops. In this case, the IMIS diagnostic tools assist the technician in performing benchtop troubleshooting using the same or similar data as the on-aircraft scenario. Again, the IMIS portable computer operates autonomously or acts as a front-end display and processor for other shop equipment such as automated test equipment (ATE).

IMIS diagnostics are designed to provide the technicians with comprehensive diagnostic aids that isolate failures with reasonable certainty both on-aircraft and in the intermediate shops. The best application of this capability is for emerging weapon systems such as the Advanced Tactical Fighter (ATF). For existing weapon systems, IMIS diagnostics provide a level of capability commensurate with the data available through those systems.

4.2.4 Maintenance Data Collection. The interactive computer capabilities of IMIS aid the technicians in recording maintenance data for the historical data and maintenance analysis systems such as CAMS. The technician and computer combine to collect all information required. During the maintenance process, IMIS selects and stores the appropriate pieces of information such as serial numbers, work unit codes, system/subsystem operating time, part numbers, malfunction codes, and repair codes. The system either automatically, or through prompts to the technician, collects additional information such as the employee number, skill level, job control number, crew size, and work center number. The portable computer has an internal clock which allows it to keep a record of the time needed to complete a task.

IMIS prompts the technician for review and validation of the recorded information after completion of a task. The system is capable of performing both syntax and content validity checks of the information as it is collected. At the IMIS workstation, the information is automatically formatted for storage in the on-line maintenance data collection system.

4.2.5. Weapon System Configuration Support. At the organizational or intermediate level and during dispersed operations, IMIS assists the technicians in managing the aircraft system configuration to ensure the weapon system is mission capable. The portable computer of IMIS or the on-aircraft maintenance panel are capable of uploading and downloading information or executable instructions pertaining to system and subsystem configuration. This capability allows the technicians to update system computers, which monitor weapon system capabilities for the flight crew, as to current equipment configuration (including redundancies), health, and predicted minimum life.

Following a mission, IMIS queries the weapon system as to its current configuration and health. The information obtained is analyzed or transmitted to other data systems for analysis, thus providing mission planners information about effectiveness and capabilities and allowing them to adjust mission parameters or plans to best support the next mission. The information also aids technicians to assess what maintenance, if any, is necessary to return the aircraft to fully mission capable status. IMIS takes into account the current configuration and the capabilities needed for the assigned mission in providing its assessment.

4.2.6. Aircraft Battle Damage Assessment and Repair. IMIS is rugged and deployable and, therefore, is the technician's information system in the combat environment. In that environment, IMIS also serves as a battle damage assessment and repair aid for the weapon system. The technician inputs the location of the damage, and the assessor aid program presents a series of graphic displays of the structural members, wire bundles, hydraulic lines, mechanisms, and electronic components which reside in the damaged area. Then the system presents functional test options which aid the technician in determining the extent of the damage, the degradation in mission capability, and an indication of the extent of repairs required. These options include appropriate quick checks to determine integrity or operability; system serviceability criteria; and data which allow accurate assessments of the time, procedures, and resources required for repairs.

During the battle damage assessment, the system is capable of accessing and presenting associated technical order or troubleshooting information to facilitate fast, efficient checkout of the weapon system. The graphics processor rapidly displays two- and three-dimensional graphics from a static isometric orientation. These graphics are views from predetermined angles of successive layers of structural, mechanical, electrical, hydraulic, and other components. The system also provides two-dimensional locator diagrams, schematics, block diagrams, wiring diagrams, system flow charts, etc. which can aid in quick assessment of the damage.

4.2.7. Maintenance Management. IMIS is the technician's interface to available information systems such as historical data, maintenance analysis, and maintenance scheduling. The system assists in assessing needs, planning maintenance schedules, assigning tasks, recording maintenance actions, analyzing maintenance performance, and tracking personnel and unit manning. The ground workstation link to the Local Area Network (LAN) improves communication and coordination throughout the maintenance complex. All data handling and analysis capabilities of the on-line information systems are available for use through the IMIS workstation.

IMIS receives the technician's work assignments from maintenance scheduling and automatically accesses any on-line reliability data, performance trends, etc. needed to support the assigned task. During the maintenance process, IMIS allows communication between the technician and maintenance control and subsystem shops. The portable computer also allows easy recording of maintenance actions, with full syntax and content error checking. This information is processed by the workstation interface computer and formatted for transfer to on-line historical data recording systems. The flightline maintenance personnel access the flying and maintenance schedule information using IMIS. IMIS accesses the LAN to allow coordination with other unit schedulers for the use of shared resources such as specialists, support equipment, and special facilities. IMIS helps the flightline maintenance units complete and transmit maintenance information concerning unscheduled maintenance, along with time change TP item requirements (TCTOs) and calendar/special inspection requirements for assigned aircraft.

IMIS also enables the flightline expediter to direct, control, and coordinate scheduled and unscheduled maintenance and update work status to maintenance control. Working with maintenance control, the expediter uses IMIS to track all personnel dispatched to assigned aircraft and to coordinate job starts and completions.

The system allows maintenance supervisors to access and analyze on-line information concerning manning, unit capabilities, scheduling conflicts, and resource needs. The supervision can coordinate with maintenance control and flightline expediters to ensure enough people with appropriate skills are available. The supervisor can also access on-line systems to review aircraft status, personnel availability, specialist requirements, training schedules, preplanned maintenance, deferred jobs, and workshift schedules. These capabilities increase the supervisors' abilities to manage resources, and personnel and to ensure quality maintenance from their units.

4.2.8. Supply. IMIS allows the technician to interface with the supply computer. Once a fault is isolated and a repair action decided upon, IMIS can query the supply computer for stock availability of the part(s), order (or backorder) the part(s), and document the usage information into the supply and maintenance computers. IMIS enables technicians to gain immediate, real-time access to supply information such as stock availability, back -order status, and suitable substitutions. IMIS checks the technician's authorization and prompts the technician for additional information needed for approval. If parts ordering must be approved by the branch or shop supervisor, IMIS will automatically route the information about the technician, job, and part(s) to that person.

The technicians can easily identify the required part(s) during maintenance by entering the serial number, work unit code, and nomenclature, or by identifying the part in an illustrated parts breakdown (IPB). (In the future, this may be done by running a light pen over a bar code on the old unit.) The information may also be delivered at the appropriate point in a stream of maintenance information (remove and replace, troubleshooting). There is no longer a requirement to look up part numbers or national stock numbers in TO tables or microfiche readers.

The capabilities of interfacing with the supply system allow managers real-time monitoring of parts usage and maintenance/supply transactions. Supervisors or expeditors also have quick access to the current status of all parts or back-orders for their assigned weapon systems.

The IMIS technical information data base structure allows easy updating of parts information and ensures that the information throughout the data base is consistent. A change in parts information is entered once and the relational data structure updates all references to that information.

4.2.9 Operations Scheduling. The IMIS system, on the LAN, provides valuable information collected during debriefing and maintenance actions to the mission planners. The operations schedulers determine mission needs which allow IMIS to prioritize maintenance actions based on the criticality of mission-essential equipment. The information collected and processed by IMIS gives the operations schedulers real-time access to maintenance status and scheduling and weapon system availability.

4.2.10. Support Equipment. IMIS interfaces with the support equipment information in much the same manner as the weapon system information. The system allows maintenance control personnel, aerospace ground equipment (AGE) maintainers, and aircraft technicians to access information concerning powered and non-powered support equipment. That information includes: availability, maintenance and inspection schedules, location, delivery and pickup, and configuration.

4.2.11. Training. IMIS is a valuable training device by itself and acts as the technicians' access device for computer-aided instruction facilities in the maintenance complex. The diagnostic routines and troubleshooting guides used by IMIS include explanation and tutorial capabilities. This feature allows the IMIS to suggest the next-best test, along with its "reasoning" for selecting that test. The technician will always have the capability to override the system's recommendation, at which time the system will explain the expected results and benefits of the technician's choice. This will allow the technicians to improve their diagnostic and troubleshooting skills with the aid of an on-the-job training device.

Technicians can use IMIS as a training aid to complete automated training packages and practice troubleshooting through computer simulation. Intelligent training software packages tailor computer-aided instructions to fit the individual needs of the technicians. Automatic transaction logging allows the computer to identify strengths and weaknesses in the technician's procedures. IMIS serves as the interface and display for available automated training systems. The computer-aided instruction allows technicians to practice troubleshooting with the tool IMIS they use on the flightline. Dynamic equipment simulations allow technicians to learn new systems and practice on old systems in an integrated environment of animated graphic models, interactive video displays, and audio presentations. These simulations allow the technicians to try various options and make mistakes without endangering themselves or the aircraft systems.

The system helps instructors and supervisors to track training progress and determine study areas which need additional attention. Training sessions and simulations can be recorded for grading and discussion between technicians and instructors. The system can then assist the supervisors in task assignments based on the level of expertise and capabilities of their technicians and planning additional training for less-experienced personnel.

4.2.12. Maintenance Analysis and Quality Assurance. IMIS is an integral part of the maintenance data collection and analysis process. Information systems available in the maintenance complex (i.e., CAMS and REMIS) have the capabilities to sort, file, and analyze the raw data generated by daily maintenance activities. IMIS accesses those capabilities and presents the products and reports from those systems in a format readily understood by the users. The users may be flightline technicians, expediters, schedulers, supervisors, or trainers. IMIS enables them to prepare one-time or recurring studies, summaries, briefings, and presentations tailored for their application.

IMIS is also used to help assure quality maintenance. Quality maintenance is the responsibility of individual maintenance technicians, supervisors, and commanders. IMIS acts as a self-inspection and quality assurance (QA) tool to assess aircraft/equipment condition and personnel proficiency. IMIS is used as the access and processing device for QA reviews of maintenance actions, data collection, and scheduled inspections. IMIS helps to collect, categorize, and analyze information used by QA personnel to determine the underlying causes of poor maintenance. It also aids the QA personnel to access, analyze and correct faulty TOs or diagnostic routines and recommend remedial or corrective actions.

4.3 Hardware/Software Characteristics

4.3.1. Portable Computer/Display. The technician's primary interface with IMIS is an extremely portable, multiple-powered unit rugged enough for flightline use. This computer is of reasonable size, shape, and weight to allow it to be carried and positioned by the technician during a variety of aircraft maintenance tasks. The maximum dimensions are 12" x 10" x 3.5", and the unit does not weigh more than 6 pounds, including an internal battery. The computer has high-speed, high-performance, flexible processor or multiprocessor capabilities. It has the processing power to quickly display complex graphics and provide rapid response to the technician's request.

The portable device has sufficient storage capacity built in and available plug-in cartridges to maintain technical data for a major section of the weapon system. A library of removable memory cartridges will store all the technical order information and diagnostic aids needed for the weapon system. The cartridges can accommodate enough data for the complete maintenance of a complex subsystem including routine maintenance instructions, fault-isolation and diagnostic routines, historical reliability data, supply information, and battle damage assessment aids. The cartridges contain a minimum of 8 MBytes of data storage capability. The memory cartridges are nonvolatile and designed for fast, easy, and accurate updating. The cartridges will be updated from the Automated Technical Order System (ATOS) using IMIS as a workstation (see section 4.3.3). The cartridges are small enough that at least three will fit easily into a technician's utility uniform (fatigues) pocket. The portable unit also has a minimum of 4 MBytes on-board memory to accept historical data such as reliabilities from the ground-based information systems, in-flight recorded faults and parameters from the aircraft systems, maintenance actions recorded during troubleshooting and repair, and portions of data from previous cartridges.

A high-resolution, flat-panel display will show clear illustrations under multiple lighting conditions. The minimum active display area is 6.0" 8.5" with a resolution of at least 80 pixels per inch horizontally and vertically. The view angle perpendicular to the screen is distortion-free to more than 45%, with less than 5% loss in image intensity. This applies to a viewing distance of 5 feet. The technician's input interfaces are designed to fit the work environment where typing is impractical. The system is operated by voice activation and or simple manual actions. The manual input is in a position easily accessible by the user and with minimum obstruction of the display by the hand during use. The manual input allows easy interaction by a technician in a chemical warfare ensemble or arctic protective clothing.

The system is capable of providing sequential instructions for maintenance and troubleshooting. Interactive troubleshooting routines and artificial intelligence-based diagnostic aids provide advice for difficult maintenance problems. The central processor and coprocessors access and present information rapidly. The system displays text-only frames and frames with moderate graphics such as line drawings within 1 second, more detailed graphics and text frames including line drawings larger than screen size (for use with pan or scroll) within 2 seconds. The system is capable of retrieving, generating, and displaying a 20,000-vector graphic from memory within 5 seconds.

The portable computer's internal electronics allow rapid processing of data through 32-bit processors which operate at low power and generate very little heat. The portable contains appropriate electronics and signal processors for interfacing with the aircraft systems. It also contains a low-power radio frequency receiver/transmitter for digital communications with other computers through the workstation. IMIS contains the capability for various forms of user interaction including voice recognition and manual interaction (such as programmable keys or touch screen). The portable computer, most often, operates on self-contained battery power. The battery is removable and rechargable. The battery will sustain continuous nondegraded operation for over 5 hours without recharging. The portable gives an indication of remaining battery charge upon request, and automatically when less than 20% charge remains. The portable unit also has the capability to run on common AC and aircraft AC or aircraft battery power. All power conversion capabilities are self-contained; so, only an adapter cable is required.

The portable computer is sufficiently rugged to withstand the rigors of flightline use. It is operable in a wide range of temperatures and functions in high humidity, precipitation, and arid desert conditions including blowing dirt and sand. It is protected from the potentially damaging effects of fluids such as fuel, hydraulic fluids, or beverages. The computer resists the corrosive vapors of a biochemical environment and the possibly harmful effects of active electrical fields such as those found around generators, radio and radar transmitters, and operating engines. It controls pressure changes, as well as electrical arcs in the absence of a ground to prevent explosion.

The portable computer is vibration and shock resistant. It may be placed in a loose cargo enviroment, free to bounce, scuff, or collide with other items of cargo or the sides of the vehicle. Protection against vibration will prevent loosening of fasteners, wire chafing, intermittent electrical contacts, shorting, seal deformation, component fatigue, and cracking. The computer is shock resistant up to forty (40) g's during a transient duration of 6-9 msec. The effective transient duration is the minimum length of time which contains all shock magnitudes exceeding 1/3 of the peak magnitude associated with the shock event. Table 1 lists the environmental limits for operating and non-operating conditions of the portable computer.

Table 1. Evironmental Limitations

Environment	Limits Operating	Limits Non-Operating
High Temperature (ambient and including effects of solar radiation)	160°F	160°F
Low Temperature	-65°F	-80°F
Relative Humidity	95%@80°F	95%@100°F
Rainfall	1.0 in/hr	1.0 in/hr
Sand and Dust	1.32X10-4 lb/f^3	1.32X10-4lb/f^3
Shock	40g's	40g's
Altitude	10,000f	50,000f

The portable device has input/output I/O ports, adaptors and protocol capabilities to interface with various systems and equipment. The primary interfaces are to aircraft ST and BIT capabilities and the ground workstation. The adaptors also allow the portable device to act as an off-line tester for MASA modules and as a front-end ATE processor for conventional avionics which must be supported by an intermediate level of maintenance.

4.3.2. Aircraft Interface Panel. The technicians accomplish most of their maintenance tasks without ever climbing into the cockpit. An aircraft interface panel, on the outside of the aircraft, provides the interface with on-board diagnostic computer systems. The interface panel consists of a small display device, a keypad, and plug port for the portable computer. This panel is used to upload and download mission configuration and/or capability information, monitor BITs, and obtain basic inspection and servicing information.

The plug port at the interface panel, along with others at various locations on the weapon system, allows the technician to accomplish those same tasks with the portable computer. The ports also allow the portable unit to interrogate the on-board systems, retrieve flight information, and input test signals for interactive diagnosis and troubleshooting. In future integrated avionics systems (redundant, self-reconfiguring avionics), the portable computer and/or interface panel display alerts the technician to the systems current configuration and remaining redundancy for following missions. The panel meets all the performance, reliability, and maintainability criteria of the other airborne systems.

4.3.3. Ground-based Workstation. The technicians interface with ground-based systems through a maintenance workstation. The desk top workstation will have a full keyboard, printer, interface computer, and data base. The technician's portable computer connects to the workstation to provide the display, cartridge co-processor, and memory receptacle for the workstation. The interface computer contains protocol and interface software to access other available information systems. The workstation is sturdy enough to withstand the rigors of nearly continuous use. It is able to operate in an unrestricted environment (does not require special environmental conditions) within a fairly wide temperature and humidity range. This system is also protected against dirt, dust, sand, and fluids common to the maintenance environment. The workstation requires minimum preventive maintenance, and the mean time between failure exceeds 2,000 hours. The workstation, tied into the Logistics Information Management Support System (LIMSS) local area network at the base, accesses on-line systems such as CAMS and the ATOS. Information from those systems is temporarily stored in the data base to reduce the traffic on the network and the other systems' processors. When new information is loaded or present information updated, the interface computer puts it in the format of the main data storage system and transmits it to that system.

The workstation allows the technician quick, easy access to all on-line data. The interface computer stores information on the relationship of data in various data bases. The technicians use menu selections (point and push) and natural language (English) queries to access the information. The workstation does automatic translation of the technician's query into the query syntax of the appropriate on-line system. The workstation provides spelling checking and synonym lists to make the process easier.

4.3.4 Integration Software. The most beneficial feature for the technician is the integration of information to support the task at hand. Instead of dealing with several automated systems and accessing separate groups of information, the technician accesses all the necessary information through one device. Through the sophisticated software, the system integrates information from all available sources and provides a systematic, coordinated maintenance aid package. The ortable computer will function independently to display most of the information the technician needs for on-equipment maintenance. Even if the base-level computer systems are unavailable or the aircraft systems are not functioning, the computer will be able to display technical order information and diagnostic aids to the technicians.

At the lowest level, the IMIS portable computer operating environment consists of single-user, multitasked workstations, each with an identical software operating system. One level up from there, IMIS acts as an interface and front-end processor for other base-level networks and systems. The workstations of this level create data bases by integrating subsets of the data extracted from the other systems. The data base management system employed by IMIS creates an application system for user interaction. The application system allows the users, through a sophisticated 'ad hoc' query language, to recall, modify, and store data pertinent to their application. The application system and its query language do not require the user to have knowledge of programming, data structures, or computer data handling techniques. The software ensures data integrity and data security automatically so the user gets timely and accurate data.

The software is modifiable, maintainable, and extensible in order to handle an increasing number of users, an increasing number of tasks, an increasing volume of data to be handled and maintained, and increasing complexity of data. The software is also easily maintained and updated. The operating system is a standard, off-the-shelf commercial product or a modified version of a commercial product. The operating system is able to support a variety of standard high-order languages such as ADA, LISP, PASCAL, and 'C.' The software supports powerful and flexible capabilities such data base management, relational data bases, multitasking, and artificial intelligence or expert system technologies. The software comes with complete and detailed documentation to facilitate application, expansion, and maintenance.

IMIS will be a very powerful tool for the maintenance technician, yet will also be very user friendly. All aspects of operation will be analyzed and assessed by Human Factors Engineers to ensure ease of training and use. The man-machine interface will be tailored to the technician's needs, with all commands in natural language, eliminating the need to learn a new computer language. The limited keyboard will eliminate the need for typing skills, yet provide quick, easy access to desired information, and the portable device will be lightweight enough so as not to cause fatigue from normal use.

5.0 NOTES

5.1 Assumptions and Constraints

5.1.1 Assumptions

5.1.1.1 Weapon System Interface: The existence of weapon system built-in-test and diagnostic capabilities accessible for interactive troubleshooting is assumed. This also assumes that the on-equipment diagnostics will be more capable of fault isolation through better BIT coverage and fault occurrence, environmental and system configuration recordings.

5.1.1.2 Core Automated Maintenance System: CAMS is the base-level maintenance historical data collection and analysis system currently being installed at operational bases. That system will consitute the data collection, scheduling information, unit manning information, supply interface, and much of the maintenance analysis for IMIS.

5.1.1.3 Automated Technical Order System: ATOS is the Air Force system for digital storage and delivery of technical orders. The full implementation of IMIS depends on ATOS to make the technical orders available in a digital form for electronic delivery and display. ATOS will become available at the base level in Phase III of the ATOS development and deployment program. IMIS is viewed as the ATOS Phase III base-level electronic delivery device.

5.1.1.4 Local Area Network: The full capabilities of IMIS depend on the existence of a LAN which allows access to base-level maintenance and management information systems. That network will probably be the LIMSS which will allow interoperability between CAMS, ATOS, REMIS, and other information systems on base or available through the Defense Data Network (DDN).

5.1.2 Constraints:

5.1.2.1 Scope: The development and evaluation of IMIS is targeted at the base-level aircraft maintenance technicians. Although the IMIS concept can apply to other maintenance levels and activities, they are not being fully addressed during this study.

5.1.2.2 Performance: The goal of IMIS is to improve the capabilities of base-level maintenance technicians. Comparative measures, including time to accomplish the task, number of errors, time to recover from error, time to gather associated information, etc. will be used to test performance with IMIS against present techniques. Subjective measures of technician acceptance and user-friendliness are also applicable.

The field performance evaluations will be limited and controlled. The quantitative measurement capability, therefore, will be difficult to extend to organizational performance measures such as fully mission capable rates, aircraft generation rates, maintenance man-hours per flight hours, mean time between failure rates, and incorrect part cycling rates. These rates will be monitored and analyzed, but the constraints on the testing and the effects of the numerous other variables involved in mission performance make it very difficult to trace any improvement directly to the limited experimentation.

5.1.2.3 Product: The product of the IMIS program is a means for technicians to access and manage the technical information they must handle. The program is oriented toward developing a concept and not toward developing new programming techniques or hardware.

5.1.2.4 Interfaces: There are numerous Air Force programs underway to improve the diagnosis and repair capabilities of technicians for specific systems. IMIS must be available to those programs as a means of presenting the information to technicians. Carefully planned and coordinated efforts must be made to ensure that the other programs understand the role of IMIS and that IMIS supports their needs as an information delivery device.

5.2 GLOSSARY OF ACRONYMS

AC	Alternating Current
AFHRL	Air Force Human Resources Laboratory
AFR	Air Force Regulation
AGE	Aerospace Ground Equipment
AGS	Aircraft Generation Squadron
AMU	Aircraft Maintenance Unit
ATD	Aircrew Training Device
ATE	Automatic Test Equipment
ATF	Advanced Tactical Fighter
ATOS	Automated Technical Order System
BIT	Built-in Test
CAMS	Core Automated Maintenance System
CND	Can Not Duplicate
CRS	Component Repair Squadron
DDN	Defense Data Network
DOL	Dispersed Operating Location
EMS	Equipment Maintenance Squadron
FLSE	Flight Line Support Equipment
IMIS	Integrated Maintenance Information System
I/O	Input/Output
IPB	Illustrated Parts Breakdown
LAN	Local Area Network
LIMSS	Logistics Information Management Support System
MASA	Modular Advanced Systems Avionics
MOB	Main Operating Base
MOC	Maintenance Operations Center
MTBF	Mean Time Between Failures
OJT	On-the-Job Training
QA	Quality Assurance
REMIS	Reliability and Maintainability Information System
RTOK	Retest OK
ST	Self-Test
TO	Technical Order
USAFER	US Air Forces in Europe Regulation

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