NEW TECHNOLOGY FOR THE SCHOOLHOUSE AND FLIGHTLINE MAINTENANCE ENVIRONMENTS

William B. Johnson, Ph.D.
Jeffrey E. Norton
and
Leonard G. Utsman
Galaxy Scientific Corporation

1.0 INTRODUCTION

Resource requirements are high to develop computer-based training or automated job aides. It is also expensive to develop on-line documentation. A cost vs. benefit analysis is more likely to favor new technology when the same system can be used across multiple functions within a technical environment. The integration of training, job aiding, and on-line information is discussed in this paper. The software technologies of intelligent tutoring, expert-system job aiding, and multimedia information storage/ retrieval will be described. Example systems are from the aviation and electric power generation maintenance environments.

2.0 INTEGRATED INFORMATION

There are specific knowledge, skills, attitudes and other characteristics necessary for a human to perform a job task. While certain human characteristics necessary for job performance are innate, most are developed through training, experience, or merely by the worker asking "how to do the job." An integrated information system (IIS) (Johnson, et al, 1992) can provide training/experience, real-time job-aiding, and also offer a manual so that the worker can "look-up" the information as appropriate.

Integrated information systems should make the worker oblivious to the differences between training and the work environment. To accomplish this, IISs must share the same sources of knowledge for training and for working. The worker must consider IISs as "information", not as either training or job aiding.

IISs must be developed by a multi-disciplinary team comprised of researchers with experience in training, job aiding, and information retrieval. Therefore IIS design and development must involve such disciplines as training, industrial/systems engineering, human factors, logistics, information retrieval, and appropriate subject matter expertise.

2.1 COST JUSTIFICATION

Multiple use of information helps to amortize the information development and maintenances costs. The Air Transport Association (ATA) Maintenance Training Committee has recognized this fact. Currently each airline creates a "Training Manual" from the manufacturers' "Description and Operation Manual." ATA insists that the major manufacturers supply an "Information Manual" that will fulfill training and operation requirements. The manufacturers are preparing such documentation in digital and hardcopy format.

The fault trees included in the manufacturers' Fault Isolation Manuals (FIMs) show the kind of rule-based information that can be used for real-time job aiding and for training. Using the FIMs on-line, for training and for aiding, ensures that technicians are familiar with the procedures and with the computer. Thus, when the information is needed, under the time pressure of the job, the technician will know how to access information quickly.

Another IIS cost savings can be found in how personnel are used. The IIS technology can multiply the potential of the technician. Generalists can access the information formerly known only to the specialist. Also, less experienced personnel will have access to job aids, thus increasing their capability.

3.0 HYPERMEDIA: PROVIDING CONTINUITY BETWEEN TRAINING AND JOB AIDING

Whether on the job or in the training environment, the aviation maintenance technician typically requires an assortment of documentation: fault isolation manuals, description and operation manuals, maintenance manuals, parts lists, etc. Frequently, the mechanic must jump from one manual to the next, folding and unfolding schematics along the way. Hypermedia information systems can integrate all of these information sources into a seamless document.

Hypermedia systems combine text, graphics, audio, and video into the same system. The technician can electronically jump from manual to manual, avoiding the cumbersome task of marking previous locations in each document. With the press of a button, the technician can see schematics or line drawings. Hypermedia systems also provide various ways to access information. The technician may access a document from an index or table of contents, as well as via a direct link from another document. Section 3.2 provides an example of a hypermedia system with many of these characteristics.

Hypermedia provides a critical link between training and job aiding. A shared hypermedia information source provides continuity for the students as they move from the classroom to the flightline.

4.0 EXAMPLES OF INTEGRATED INFORMATION

Advances in hardware and software technology have enabled developers to combine training, aiding, and information retrieval technology in the same system. Table 1 shows projects that strive to integrate these technologies. A description of each of these systems follows. While the examples are specific to selected domains, the technology approaches are generic and broadly applicable to any training, aiding, or information system.

Table 1. Integrated Information Systems in Development

System Name	User	Type of Information	Sponsor
Gas Turbine Information Systems	Electric Plant Technicians	Manuals, Training Simulation, Expert System Job Aid	Electric Power Research Institute
Aviation Human Factors Publications	Engineers, Scientists	FAA Human Factors Publications, System Training, Hypermedia, Information Sources	FAA Office of Aviation Medicine
Environmental Control Simulation	Aircraft Technicians	Intelligent Simulation, Diagnostics Advice, Technical Documentation	FAA Office of Aviation Medicine
Radar Simulation	Airway Facilities Technicians	Intelligent Simulation, Diagnostics Advice, Technical Documentation	FAA Airways Facilities
Automatic Valve Simulation	Nuclear Power Plant Technicians	Intelligent Simulation, Diagnostic Advice, Technical Documentation	Electric Power Research Institute (Nuclear)

4.1 GAS TURBINE INFORMATION SYSTEM

The Gas Turbine Generation Division of the Electric Power Research Institute (EPRI) created a robust expert system job aid from 1988-91 (Bloom, 1989). The system provided real-time job aiding for troubleshooting gas turbines during start-up. Unfortunately, the technicians did not train with this job aid. Thus, in stressful emergency situations they did not have time to learn how to use the job aid. Therefore, even though the job aid contained useful knowledge, the technicians rarely used the system.

The Gas Turbine Information System (GTIS) redesigns the original job aid to provide training, aiding, and on-line documentation. Figure 1 shows a screen from the GTIS. The system operates on a dual 80386 processor. One of the processors is dedicated to delivery of digital video interactive (DVI) information. The DVI is used mostly to deliver training information about general gas turbine principles and other engine-specific information. The second processor delivers the simulation, tutoring, job aiding, and the technical manual.

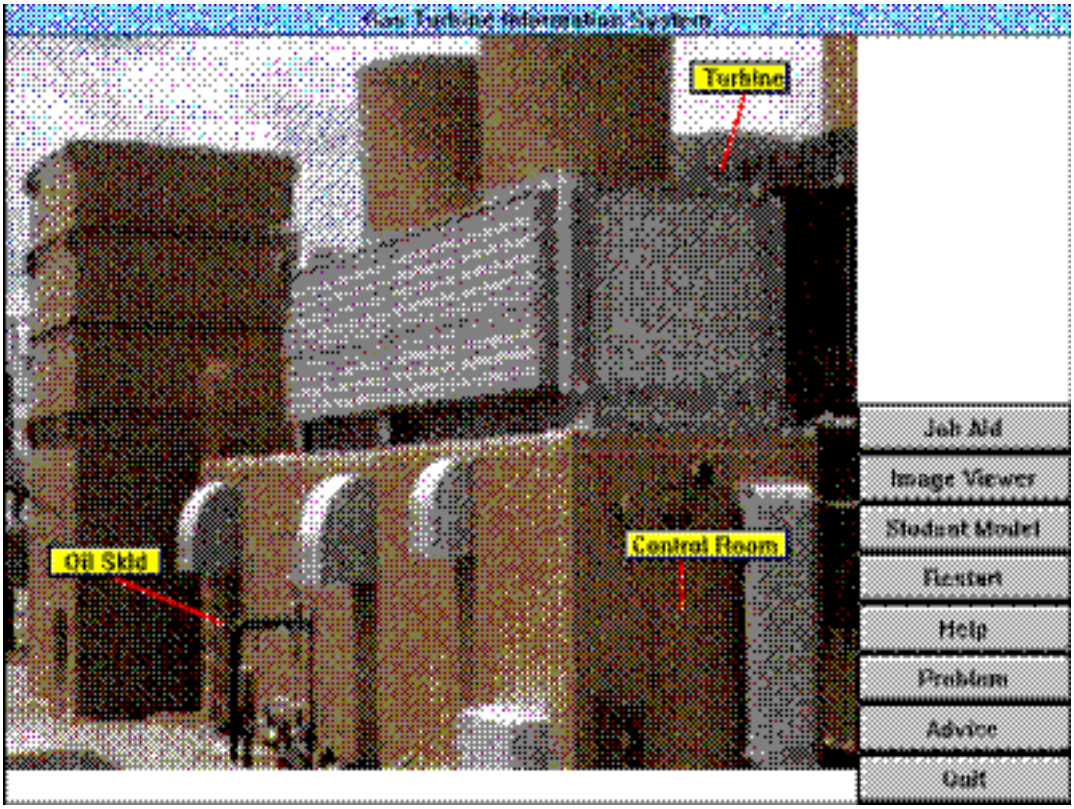

Figure 1 GTIS Student Interface

GTIS permits the user to simulate operation of the gas turbine for diagnostic training. The simulation is "intelligent" in that it creates a model of the users actions as needed. Since the users become familiar with the system during training, it is very natural for them to switch the system to a real-time job aid when needed for plant troubleshooting.

GTIS research and development addresses on-line documentation. When completed, the system will contain a complete set of technical manuals with a hypermedia interface.

4.2 AVIATION HUMAN FACTORS PUBLICATION

The Federal Aviation Administration, Office of Aviation Medicine (OAM), is developing a hypermedia information system for all documents published in the three-year history of the program. Figure 2 shows a screen from that information system. The hypermedia system contains links to figures, tables, photographs, and other documents. The OAM hypermedia information research has been instrumental in software design for other integrated information systems being developed at Galaxy Scientific Corporation. At the end of the project, this complete hypermedia, research system will be distributed on a CD-ROM. The project has resulted in specifications for delivery of text and graphical information and the creation of the hypermedia display and linking system.

Figure 2 FAA Hypermedia System

Even though the current effort concentrates on the integration of research papers, the hypermedia system has also been used to access aircraft maintenance documents. The system is also being used to distribute 4 on-line papers, including this one, at the 1992 Annual Meeting of the Human Factors Society.

4.3 ENVIRONMENTAL CONTROL SIMULATION

The environmental control simulation (ECS), also developed for the Office of Aviation Medicine, demonstrates intelligent tutoring systems and, more importantly, intelligent simulation (Johnson, 1990). The ECS models the Boeing 767 air conditioning system. From the main menu, shown in Figure 3, the user can access all instrumentation and hardware available in the aircraft.

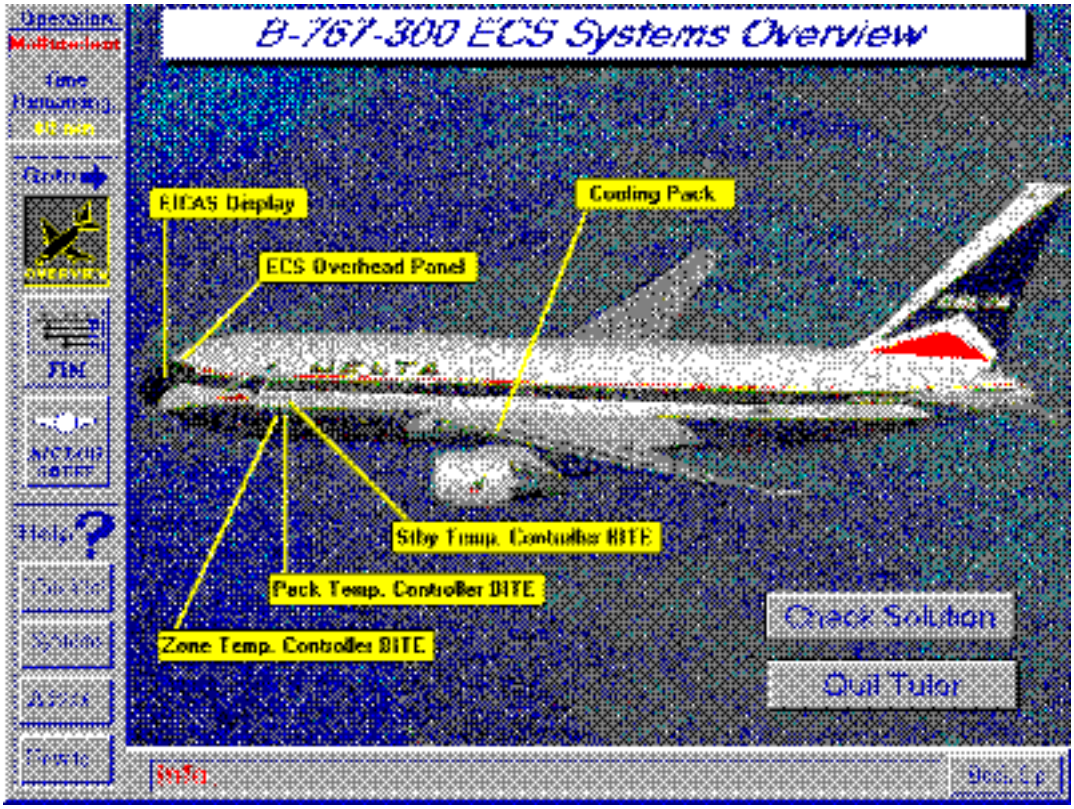

Figure 3 ECS Main Screen

Applying intelligent tutoring system design (Polson & Richardson, 1989, Massey, et al, 1988) to a simulation environment has resulted in an intelligent simulation. The system observes user interaction with the simulation to provide appropriate feedback and advice. As shown in Figure 4, the system also permits the user to access the fault isolation manuals from the computer. The ECS has integrated training and information system functionality, but has not yet attempted the transition to job aiding. This transition can be accomplished with relative ease due to the software design of the current system. As previously discussed, this aircraft-specific example is generalizable to many maintenance training applications.

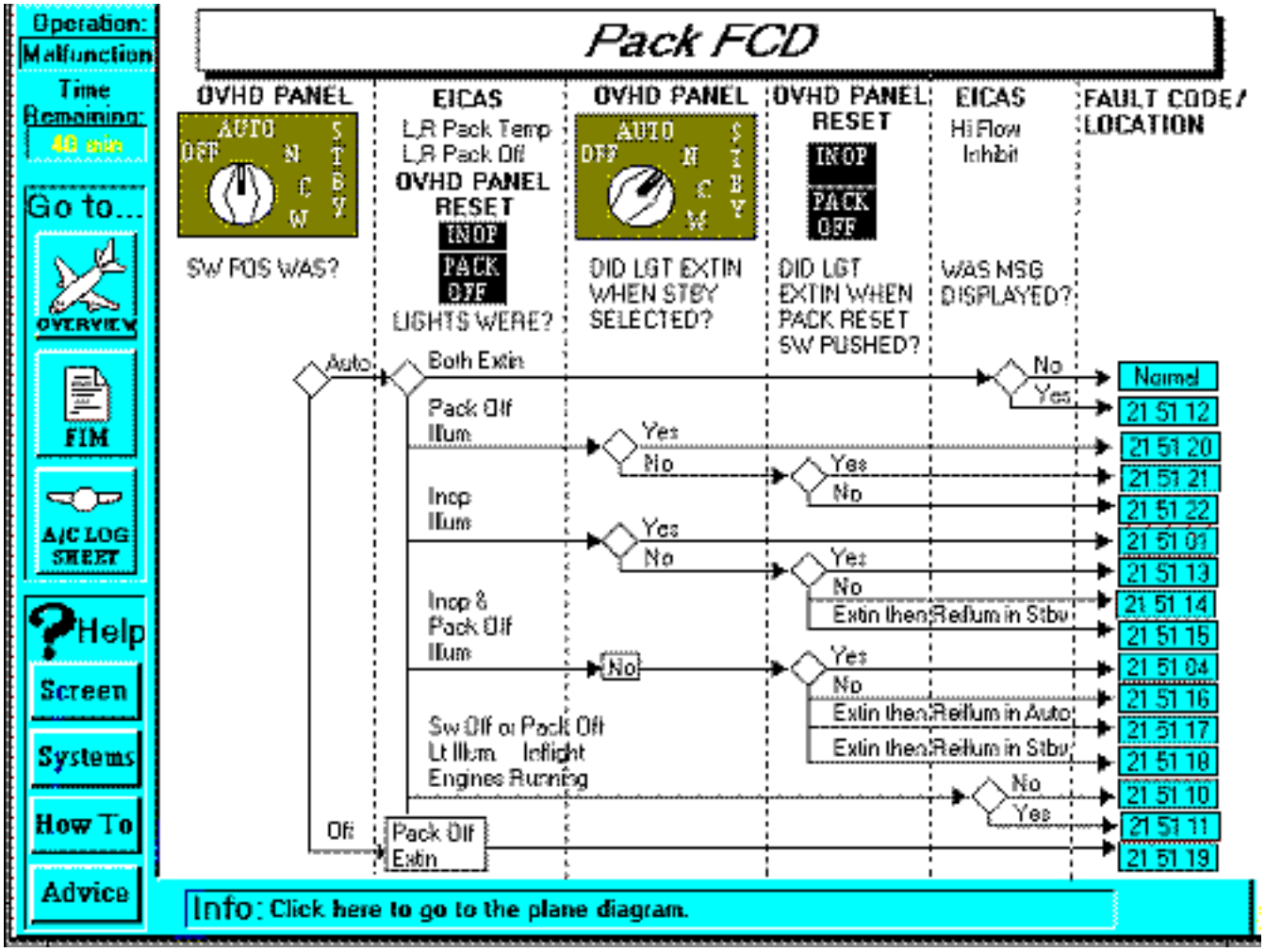

Figure 4 ECS Fault Isolation Manual

4.4 MICROCOMPUTER INTELLIGENCE FOR TECHNICAL TRAINING (MITT)

Microcomputer Intelligence for Technical Training (MITT) has been described extensively elsewhere (Wiederholt, et al. (1992), Johnson, et al. (1988)). The MITT tutor design and the MITT Writer authoring system, sponsored by the US Air Force Armstrong Laboratory, has resulted in the development of numerous intelligent tutors for technical training. The tutors described in the following two sections are advanced technology derivatives of MITT.

4.4.1 Radar Simulation Tutor

The FAA Technical Center, in Atlantic City, New Jersey has a charter to apply Advanced Technology to training and aiding of Airway Facilities (AF) technicians. The radar tutor is a direct response to that charter (Jones & Jackson, in press).

The population of AF technicians is very senior. In many FAA facilities, most of the technicians are eligible for retirement. New technicians are often overwhelmed by the variety and volume of systems for which they must be trained. In most cases new technicians spend 75% of their first year, away from home, training at the FAA Academy in Oklahoma City. Upon return from training, continuing training is needed to ensure readiness.

The Radar Simulation tutor, pictured in Figure 5, permits the user to operate the system for maintenance in a simulation environment. The system was originally designed to use the MITT tutor format, but has evolved to provide additional interface, feedback, and on-line information system capabilities within a Microsoft Windows environment.

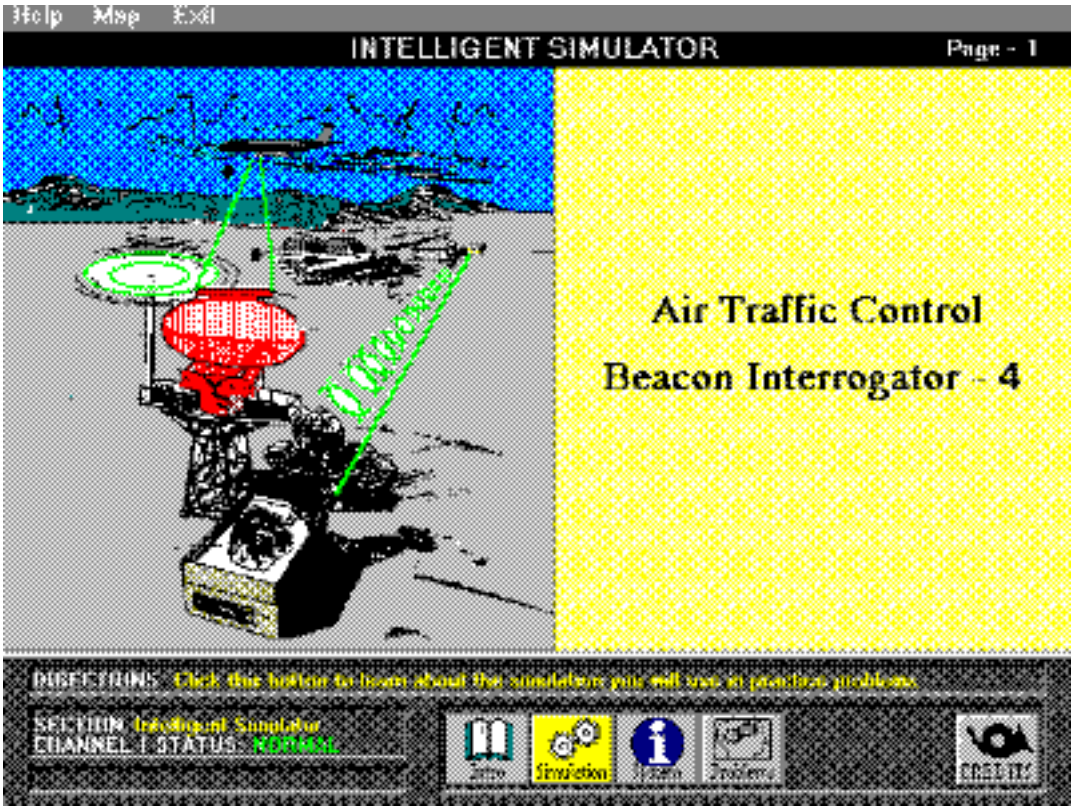

Figure 5 Radar Simulation Screen

The Radar Simulation tutor permits the student to perform tests and to seek advice. System design will permit the entire tutor to operate on the Pen computer for future application as a job-aid.

4.4.2 Automatic Valve Simulator

Motor-operated valves (MOV) have been a continuing operational and maintenance problem in US Nuclear electric power plants (NRC, 1989). The MOV Tutor, shown in Figure 6 ,which uses the MITT technology, permits the user to see and learn about MOVs. The trainer also simulates diagnostic scenarios on which the technician may practice. Finally, the system contains all necessary MOV documentation to ensure real time job aiding as needed. As a part of this research a specification for a Microsoft Windows- based authoring system is also in development.

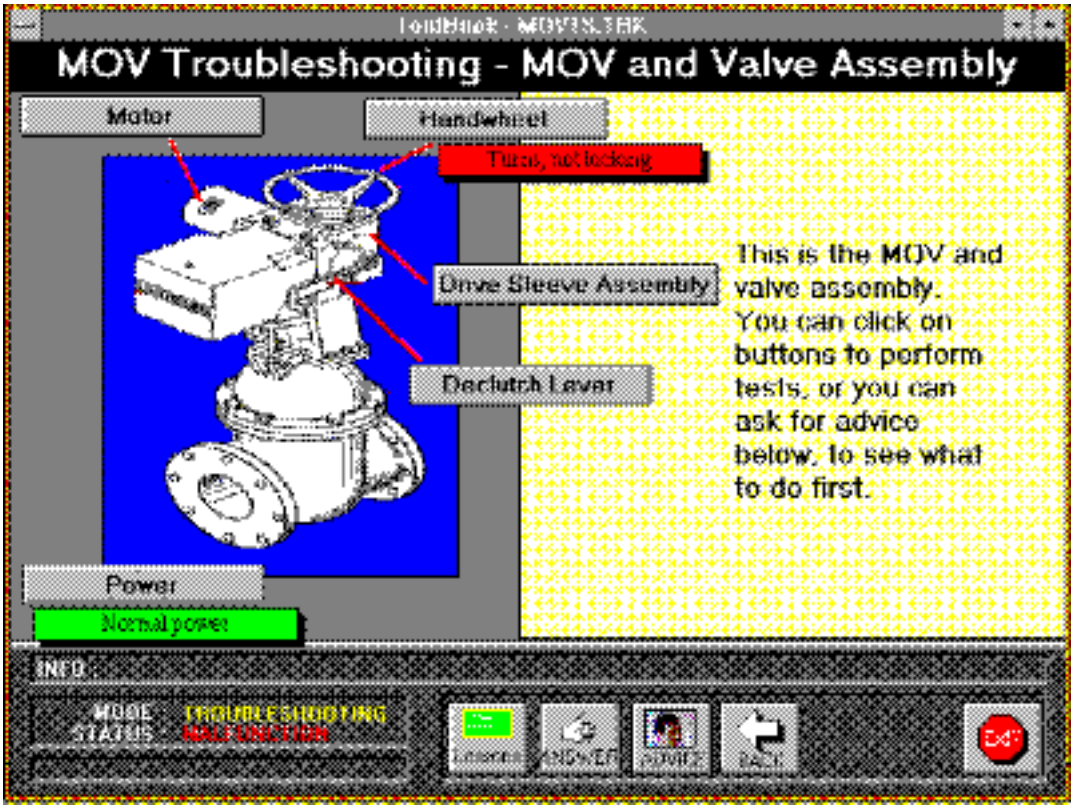

Figure 6 MOV Screen

5.0 SUMMARY

Current and future job and equipment design increases the numbers of workers that will require simultaneous training, aiding, and information retrieval. Therefore, designers and developers, using readily available hardware and software, must create integrated information systems. As described previously, the integration of these three capabilities will justify the time and cost of development.

This paper has described five systems that demonstrate the feasibility of integrated systems. The result has been very successful. Sources of funding support have increased considerably since the user base has increased and will continue to grow. All customers, including trainers, and in-plant personnel are able to multiply their capability with these tools. The systems are closing the gap between "resident" training and "on-the-job" training. Clearly this positive trend is indicative of the future.

6.0 ACKNOWLEDGEMENTS

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