

Electronic Performance Support Systems for Maintenance Tasks

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Abstract

As systems increase in complexity while our workforce experience level decreases, performance support tools will become imperative to aid the user in task completion. The next generation support tools will integrate interactive troubleshooting aids, diagnostics, Maintenance Management Information Systems (MMIS), technical data, and training to significantly improve the maintainer's ability to effectively and efficiently complete a repair task. Such systems can be the basis for continuous improvement of maintenance processes, having a positive impact on total ownership and support costs. Configuration management and failure history can also be used to reinforce the integration of the total supply chain, including links to provide data on parts availability. Recent advances in digital technology make technical data, interactive training, and improved diagnostics readily available for maintainers at the repair site. This improves the identification of specific failure increases and results in successful resolution. This paper outlines the architecture of an electronic performance support system (EPSS) and its application in a single instance using aircraft maintenance as a case example.

Keywords

Maintainer's Electronic Performance Support Systems, EPSS, IETM, Maintenance, Diagnostics and Troubleshooting, Training.

Introduction

Traditional maintenance environments consist of paper-based manuals, limited in-class training, and face-to-face communications. Since maintenance employees must use these conventional resources to diagnose and troubleshoot while completing repairs, repair turnaround times are often lengthy and costly.

Our research attempts to identify alternative and innovative approaches to traditional maintenance environments so that we may better support employees in technical environments and consequently reduce the number of errors and decrease the cost of maintenance repairs.

Although our study focuses on maintenance environments, our research is applicable to many other areas including medical informatics, and instructional technology.

An Electronic Performance Support System (EPSS) integrates information databases, advice and individual learning experiences, with troubleshooting and diagnostic tools into a common computing interface. An EPSS provides immediate access to these resources. EPSS units enable workers to function at high performance levels with little support from other people. In essence, EPSS units allow workers to take all of the information they need to the job site and to access various information databases through well-integrated, easy-to-navigate interfaces.

Electronic performance support systems first became widely known in the early 1990s with the publication of a book authored by Gloria Gery entitled *Electronic Performance Support Systems* [1]. Several companies now offer commercially available EPSS systems, and organizations such as Digital Equipment Corporation and General Motors are using them in their repair and support operations.

Providing maintainers with access to necessary information at the repair point requires that we integrate several commercial, off-the-shelf products with modified and newly developed software. For on-site maintenance, commercial off-the-shelf hardware and operating system software must be portable (i.e. hand-held, man portable, or wearable). Unless already available in digital format, technical manuals and training information must be digitized and either hosted on the hardware or be accessible via client-server or internet access. Other MEPSS™ features and modifications are illustrated in Figure 1 and include:

- Hyperlinks to databases and information systems
- GUI interfaces for ease in navigating to/from the accessible information
- Voice-activation software for controlling system operation and maintaining a hands-free maintenance environment must be tailored for the particular operating environment
- Wireless links from the portable device to the central server, if appropriate for normal operating environment)
- On-line Electronic Signature and Quality assurance review
- Unobtrusive tracking which captures technician performance in executing maintenance tasks

- Accessible communications interfaces which allow technicians to comment on the technical instructions, troubleshooting procedures, instructional material and system performance must be created
- Software to capture, store and provide intelligent agent retrieval and transmission of comments from maintenance technicians



Figure 1. An example of a handheld wireless EPSS with a GUI design, wireless microphone, and stylus.

4 System Overview

Our EPSS systems focus on environments that require technical information for rapid repair completion. These systems incorporate single entry point access to the following components:

- Troubleshooting information
- Parts/Supply database
- Maintenance records
- Technical manuals
- Standardized training materials
- Access to subject matter experts (SME)

To match the needs of both users and the environment, an EPSS must provide the following functionality:

- On-demand, task-specific information
- Tracking user performance and activity
- Case-based reasoning
- Customizable interface and database tools

- Computer-based training (CBT)
- Synchronous and asynchronous knowledge sharing tools

These functional components are critical in aviation maintenance since there is a significant decrease in qualified and experienced mechanics.

US Navy P-3 MEPSS

False removal of the Navy's P-3 engine driven compressor (EDC) is the highest cost action for this aircraft. In an attempt to decrease costs and false removals, we are building an EPSS to aid technicians in troubleshooting EDCs. Users expected to employ the system are trained mechanics with various skill levels. However, since many technicians receive limited or no training our EPSS will act not only a decision support tool, but also a training device to augment formal classroom curriculum.

Current problems with military systems, that have some EPSS qualities or functionality, fall into three categories: hardware, software and human-computer interaction issues. Technicians desire online, timely access to all technical publications, including parts ordering, work orders and training. Devices have to have high resolution displays, be portable, rugged, lightweight, and have a long battery life. Interfaces have to be easy to read, databases have to be easy to search and update, and private information has to remain private. However, users site a need for access to other maintainers' notes and tips concerning typical procedures. When considering the above, several areas of concern became apparent

- Integration with existing sources of information, e.g. parts inventory, maintenance repair history, current work orders
- Routine system (EPSS) updates
- Process flow must follow current procedures
- Pass down features must allow users to build a reference library – problems arise in approval process
- Cost and size of the system will determine the number of on-site, portable systems
- All interface and protocol requirements must fall under Military Standard (MIL-STD) guidelines as documented.

Scenario: MEPSS for MARTA Bus Mechanics

The following scenario outline how a MEPSS may be employed in a typical maintenance environment.

Introduction

MARTA (Metro Atlanta Rapid Transit Authority) mechanics are expected to perform advanced troubleshooting and failure analysis in order to determine the cause of failure of all major systems on MARTA vehicles, as well as related clerical and upkeep tasks. Our analysis of the MARTA workplace environment uncovered a complex web of decisions, actions and common paths as well as many disadvantages that could hinder mechanics' performance, including:

- For a mechanic to accomplish any single repair or maintenance task requires both a change of venue and division of attention; increasing both the amount of time and the possibility for human error.
- Information, as it is currently stored, is either difficult to locate or difficult to interpret, therefore making mechanics less inclined to utilize the present system
- Mechanics are not always able to communicate with fellow mechanics, supervisors and parts distributors
- Repair history is not archived
- Paper manuals can easily be damaged
- 80% of training lost after 1 month (low memory retention)
- Bus systems are getting increasingly complex and therefore require more detailed documentation for proper repairs. This results in larger manual libraries

After considering a menu-based tablet, an icon-based tablet, and an augmented reality environment, we selected to prototype a portable, hand-held robust device based on our user feedback. Upon talking to our users about our potential design spaces, we made several changes/additions to our requirements and usability criteria:

Bus Repair History: Mechanics also mentioned that having up-to-date information, such as, who last worked on a bus, when, and what the problem and resolution were, is important. We decided that our system must include a way to automatically document the work being performed and who is performing the work.

View Transformation of Parts: Users indicated that they would like to rotate and transform 3D objects and images included in the system. . A paper-based system does not allow users to view parts from multiple angles, and they pointed out the importance of being able to see the "other side" of the part.

Safety: We found that our users wanted to avoid wearing any kind of wearable computer. Users were concerned that the system may accidentally fall into a piece of equipment that they were currently maintaining and cause a safety hazard.

5.0 Summary

The requirements for building an EPSS must begin with a user and environmental analysis. Using this analysis, we can design the interface, identify data sources, appropriate training aids, and determine the objective of the support system before design begins.

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Biographies

Dr. Gisele Welch is a Senior Research Engineer and the Director of Logistics and Maintenance Applied Research Center at the Georgia Tech Research Institute. She is currently investigating electronic performance support systems as applied to the maintenance environment.

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