CHAPTER 4
SAFE MAINTENANCE IN AVIATION RESOURCE AND TRAINING CENTER

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4.1 INTRODUCTION

With the constant pressure of down-sizing, corporations and the government find themselves in positions of having to train their personnel to perform broader ranges of tasks. Airlines, repair stations, and FAA Flight Standards also face these pressures. Personnel are expected to be more skilled in more areas while fewer dollars are available to meet these training needs. Distance Education is enjoying a revitalization of interest among corporate and government leaders because they recognize the potential benefits as low-cost solutions to their training needs. Distance education is an instructional approach where people engage in educational activities without having to be at the site where the instruction is occurring. Instruction, resources, and students can be distributed across many different locations, and are usually connected together by technologies, such as computer networks, satellite dishes, and telephone lines.

One approach to distance education is to capitalize on the technical capabilities of the World Wide Web (WWW) to create resource and training centers for continuing education of professionals. The SMART Center (Safe Maintenance in Aviation Resource and Training Center) is an example of such an approach for the delivery of On-the-Job Training (OJT). The focus of the Center is to train aviation maintenance personnel issues in Maintenance Resource Management (MRM).

Human factors research in aviation has traditionally been concerned with the successful interaction between person and system, where system was generally considered to be a machine. In recent years human factors research has broaden the scope of the system to include successful interaction between individuals, groups, teams, and the environment in which personnel work. Accidents related to a breakdown of human communication and team work prompted the aviation industry to institute Crew Resource Management (CRM) to explicitly train flight crews to work together as a team. Industry is now recognizing that communication, situation awareness, and team work are essential to reduce errors and increase efficiencies in aviation maintenance operations.[1] Maintenance Resource Management (MRM) is a new training initiative promoted by the aviation industry to address shortfalls in communication, situation awareness, and team work among maintenance personnel.

A web-based training center, by virtue of being a central and public repository of research and training, lends itself to setting standards for MRM practice. The interactive nature of the Web can support live interaction, asymmetric interaction, and the dynamic evolution of information, and also can serve the aviation community as a forum for discussing issues unique to MRM.

The primary goal of the SMART Center project is to first create and service a web-based training center and then evaluate its feasibility and utility. The first phase of the research completed the development of the SMART Center infrastructure and the implementation of an on-line computer-based training course for MRM training. Access to the SMART Center and the MRM course is reached through the Human Factors in Aviation Maintenance and Inspection Web site at http://www.hfskyway.com.

A second goal is to develop standards for quality web-based training and delivery over the Internet. Web-based training is becoming pervasive as a training medium. The range in sophistication and quality between training products, however, varies greatly. At the close of the first phase of the project a classification system was developed. The classification system identifies a) types of features and level of sophistication in the delivery methods, b) course development standards, and c) administrative standards. This classification system was derived as a result of implementing the SMART Center infrastructure and observing the work of other developers attempting to create information centers on the Web. The classification system is presented and discussed throughout the body of this chapter.

4.2 DESCIPTION OF THE SMART CENTER

4.2.1 A Walk through the SMART Center

After entering the SMART Center, Aviation Maintenance Technicians (AMTs) find themselves looking at a map of a virtual school. The map (Figure 4.1) divides the school into four conceptual areas: Administration, Classes, Resources, and Recreation.

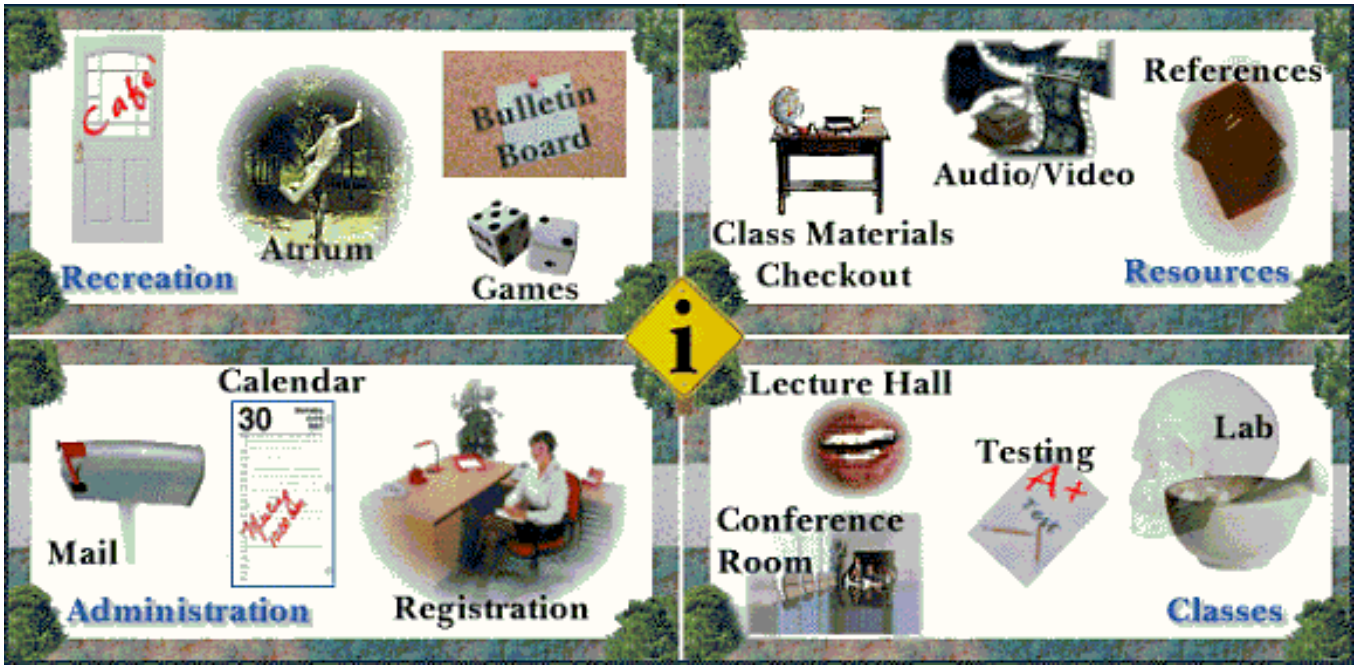

Figure 4.1. SMART Center Map

If an individual wants to participate in a course, he/she first goes to the administrative area (Figure 4.2) to see the courses offered and to sign up for a course. When an AMT registers for the MRM course, he/she is placed on the course mailing list. Once registered, the participant has access to class materials and activities. The class mailing list allows AMTs and instructors to send or receive mail and to submit or receive assignments. The Calendar facility informs AMTs of current events relevant to the course.

Figure 4.2. SMART Center Administration Area

AMTs visit the Resource Area (Figure 4.3) to pick up course materials, listen to prerecorded lectures, or view articles from online libraries. A typical lecture may be a Power Point slide-show with a prerecorded audio lecture or a video of the instructor. AMTs can browse other related sites and databases through links from the reference section of the Resource Area.

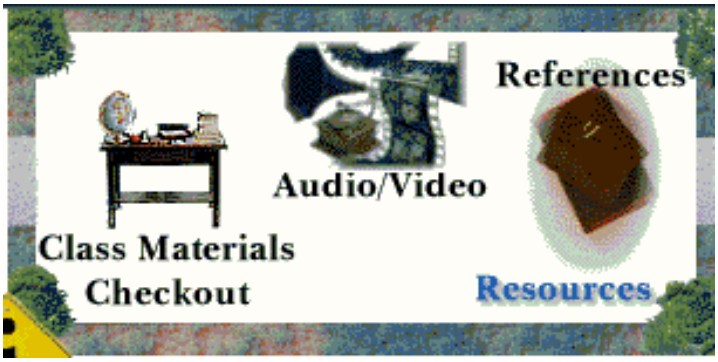

Figure 4.3. SMART Center Resource Area

Interactive classes occur in the Lecture Hall, Lab, and/or Conference Room of the Classroom Area (Figure 4.4). The CBT Lab is where interactive multimedia Computer-Based Training (CBT) can be found.

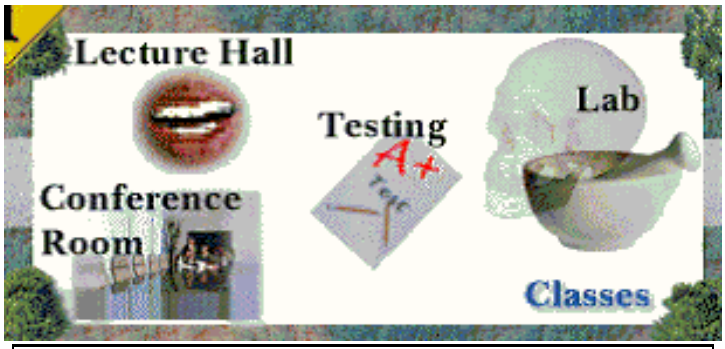

Figure 4.4. SMART Center Classes Area

The MRM-CBT, developed for the SMART Center and also available on the FAA/AAM CD98, is a prototype course that incorporates various multimedia tools bound together into an “electronic book.” The CBT provides course participants with a basic introduction to eight specific MRM concepts. The concepts are Airline Safety, Human Error, Human Factors, Worker Safety, Communication, Situation Awareness, Teamwork and Performance Management (Leadership).

A course participant can work her way through the basic concepts of the MRM course at her own pace. This is a good way to prepare prior to a class lecture or to review class material after the basic concepts have been presented in another context. For each unit a pretest is given followed with feedback showing how well the participant did. The participant can then review the material. He may review all the material for the unit or just the material he got wrong. Concepts are organized in outline form and the text and graphic displays are augmented with video and audio where appropriate. When the participant is ready he can be tested again. Once he has reached criterion that unit is checked off as mastered. Progress through the course is recorded so that when the participant returns to the CBT Lab he can continue where he left off.

Real-time lectures can be given through real audio-, video-, or text-based chat sessions. The type and sophistication of the equipment required for the class will change with the type of activity that is planned for the class. Text-based conference sessions require no additional equipment, while real-time audio or video sessions require additional equipment and protocols. Real-time interactive audio and video has not yet been implemented in the SMART Center. For the MRM course, a participant might be directed to first view an introductory video, followed by at least one pass through the basic concepts of the unit in the CBT Lab, before attending a live interactive chat session with the instructor. During the chat session participants can ask the instructor about specific concepts covered in the CBT Lab. After the chat session the participants are expected to reach criterion in the unit before the next unit is due to start.

The Recreational Area (Figure 4.5) is where more informal interactions may occur. The Cafe is a meeting place for interest groups to gather and chat. Announcements for new classes and other community activities can be posted on bulletin boards. Educational games can be launched from the Game Room, and in the Atrium participants can submit works of interest to be reviewed. If accepted these works will be posted in the atrium for public access.

Figure 4.5. SMART Center Recreation Area

4.2.2 What Makes the SMART Center Unique

Table 4.1 summarizes the key features that comprise the SMART Center. What makes the SMART Center unique is that it can function as both a training center and as a job aid. As a training center the SMART Center supports real time and asynchronous interaction as well as exploratory and structured learning. Lectures, conferencing, and interest groups are examples of real time interaction. E-mail is an example of asynchronous interaction. Lectures and testing could provide formal classroom structure, while a CBT Lab could provide an exploratory or troubleshooting environment. Decentralized collaborative teaching is possible with this type of instructional vehicle. The lectures in each unit in a course could be given by a different expert. And if recorded, that lecture can be accessed as needed. The continuity of the course can then be coordinated through CBT and an instructional administrator. If done well, this type of instructional vehicle provides a very consistent training resource worldwide. Finally, the training site is always open and available.

Table 4.1. Key Features of the SMART Center
On-line Registration
Calendar of Events
Real time or canned video and audio lectures
Informal discussions via chat groups, bulletin boards and email list server
Interactive Multimedia CBT and job aids (e.g. FAR glossary)
Archive and access important documents, articles, applications, class materials, media clips through direct display, email, ftp.
On-line testing with immediate feedback and record keeping.
Participant submission of candidate work for resource archives

As a job aid the SMART Center can function as both a central knowledge base and a communication center. Large databases, digital libraries, directories of services, and publications can be accessed. Information appears to be centrally located, yet can actually be distributed across many sites. Resources are not limited to the access of print information; resources can also be a location where ideas are exchanged through e-mail discussion groups, teleconferencing, or through video or audio. Knowledge is not easily lost. A class missed can be viewed at any time. Knowledge is not static. The body of information naturally evolves with the interests and perspectives of the participants as they interact, formally and informally, through different types of media. Training, communication, and the daily work routine are no longer distinct activities but become closely coupled with each other.

4.2.3 Limits to the Technology

Not everything about web-based training is a positive. The band-width expected to carry all this highly interactive multimedia material could be huge and costly or slower than mud if not well designed. Video beyond short clips of talking heads is generally impractical. Interactive video or text conferencing could be unwieldy if not carefully orchestrated. We must not lose the content for the technology. Often simple solutions can be very effective. High technology does not necessarily mean higher learning. Many relatively low technological activities have been found to be more effective in instructional activities than some of their high technology counterparts.2 For example, electronic mail is a very successful educational medium, while satellite conferencing has had mixed reviews. Though satellite broadcasts are able to reach large numbers, the medium is lacking in the interactive aspects of a class that are important for sustained comprehension and skill development. Electronic mail is better suited to support the interactive aspects of a distance education class. Participation in e-mail based classes tends to be very high. Since e-mail is an asynchronous medium, participants have time to reflect on their correspondence. As a result, the quality of the interaction is also high. Administration of distance education courses in general require more overhead than traditional training. Participants of such courses need to be self-motivated individuals.

If these limits are taken into account and planned for, then the potential for consistent reusable training, a living growing resource, and a thriving communication center is a real possibility.

4.3 CLASSIFICATION OF WEB-BASED TRAINING

4.3.1 Web-Based Training Features

Table 4.2 shows the features that comprise a classification system for web-based training. Each higher level contains all the features of the lower levels. Most basic web sites found on the Internet fall into Level 2 of the classification system. That is, the sites have both text and graphics with non-linear links for navigating through the pages. Level 1 systems, found at some government sites, are all text-based with a simpler navigation mechanism consisting of a table of contents and page-turning navigation. As one moves higher in the classification system, the interactivity of the site increases. Level 3 provides participants with asynchronous interaction such as e-mail, bulletin boards, student registration, and an ability for full-text document search. Level 4 provides students with what most people would recognize as multimedia supported Computer-Based Training. Video, audio, or animation is supported. Real time text-based interaction, in the form of chat rooms and on-line testing or adventure games, is available. Students are tracked and a record of their progress is provided. This is the level where one would see the use of Java or Active X applications. Level 5 distinguishes itself in two ways. One is the ability to do real-time video or audio conferencing. The other is volume. The site is organized like a university or campus where complete certification or complete degree programs are possible. Finally, Level 6 adds intelligence to the operation. A word about what is meant by intelligence. In order for a developer to claim his/her system demonstrates intelligent behavior, it must exhibit the following features: it must collect and organize data; it must review that information and make modifications to its structure (e.g., modify its rule base) which in turn changes its conduct in response to its environment. Examples of such sophistication would be intelligent tutors, expert systems, or intelligent agents that help coach, organize, or administer instruction.

Table 4.2. Web-Based Training Classification System

Level	Features	Examples
1	• Text based HTML • Page turning links • Table of Contents	• Some government sites
2	• Level 1 + • Graphics • Hyperlinking	• Hyperlinked books • Most Web sites

3	• Level 2 + • Asynchronous interaction • Search capability • Student registration • Well structured navigation and site design	• On-line registration • Email, Bulletin Boards, List Servers • Site search full text document search • Ftp materials • Order forms
4	• Level 3 + • Automated multimedia Computer Based Training (CBT) with interactive database access • Real-time text interaction • Student tracking • Streaming video and audio	• On-line testing • Chat groups • MOOs, MUDs, adventure games (text) • Maintenance Resource Management CBT (Active X -interactive database access) • Ergonomics Audit Program (Java) • Turbine Repair Automated Control System (Active X) • Federal Aviation Regulations Multimedia Glossary (Java – multi-threaded database access)
5	• Level 4 + • Real-time interaction • Campus organization • Full degree programs with multiple courses	• Real-time lectures and demos • Virtual University
6	• Level 5 + • Intelligent Tutoring/ Expert systems • Intelligent agents for coaching/ site organization • Real-time interactive simulation	• Destributed simulation • Intelligent coaching • Ask the expert • Automate FAQ Maintenance

Based on this classification system, the SMART Center falls within Level 4. It is actually designed to accommodate a full training curriculum for aviation maintenance technicians but current lacks the requisite volume in terms of courses and administrative support to completely meet Level 5 classification.

In the next section the SMART Center, representing a Level 4 web-based training site, is described.

4.3.2 Administering a Web-Based Training Center

There are four management systems that need to be in place to administer a Web-Based Training Center (WBT) such as the SMART Center: System administration, Course development, Course delivery, and Course administration. Each system has its own automated work environment and set of procedures that facilitate the management of that aspect of the training process.

4.3.2.1 Course Development

Course development is the process by which the educator develops the course content of the material used in this new environment. This includes tools necessary to convert the current course material into a form which can be represented in this new environment. The course development environment should accommodate the tools (e.g., word processing, spread sheets, data bases, or slide presentations) instructors and trainers are accustomed to using. In some cases, instructional templates should be developed to facilitate course development and to ensure consistent quality in presentation of materials. More importantly, the course development environment should provide a straight-forward mechanism for posting course materials to the WBT Center. When real time lectures are part of a course, protocols for managing the interaction need to be developed.

Table 4.3 classifies the standards that need to be in place for course development. Level 1 is simple. One needs a mechanism for converting text-based electronic documents into HTML files. Many word processors now have this capability. Methods for converting and linking more sophisticated documents using a suite of HTML development packages are introduced at Level 2. In an effort to standardize instructional material, standard instruction templates should be developed. With the introduction of asynchronous interaction at Level 3, protocols for appropriate conduct and flow of information should be established. Also a standard template for developing and processing forms should be distributed. At Level 4, one now needs tools and protocols for developing and delivering multimedia CBT. At Level 5, because of the large volume, standardized production procedures, equipment and tools, as well as protocols for real-time interactions are all needed. At Level 6, implementation of standards for development and maintenance of intelligent features is necessary.

Table 4.3. Classification of Course Development of Web-Based Delivery

Level	Course Development
1	• Convert text-based documents into HTML files
2	• Level 1 + • Convert and link text with embedded graphic documents • Instruction templates • HTML development packages • Graphic development tools

3
- Level 2 +
- Protocols for asynchronous interaction
- Forms development

4
- Level 3 +
- Protocols for automated delivery
- Multimedia development tools
- Off-the-shelf or custom course development packages
- Off-the-shelf or custom delivery system

5
- Level 4 +
- Protocols for real-time delivery
- Standardized production procedures
- Standardized equipment and tools

6
- Level 5 +
- Standards for development intelligent features

4.3.2.2 Course Delivery

The course delivery mechanism is the most developed aspect of web-based training. Many trainees are already familiar with the point-and-click environment of a Web browser. The WBT interface should present a coherent pedagogical structure that allows users to easily navigate and access information and to participate in the activities of the course. Typical questions that should be asked during the design phase of a web-based training course are: “How does one create an environment where a sense of active engagement is the norm?” “How does one insure both independent activity and joint participation are productive?”

The primary devices required for sending and receiving web-based training are the computer, a telephone line, and a modem. Because of the nature of multimedia information, the receiving computer must have graphics, sound, and telecommunications capability. The minimum requirements for a receiving computer are a 486 processor, 16 megabytes of memory, and at least 500 megabytes of disk space for storage of the operating system, communications software, and applications software. To accommodate the transfer of large data sets across the Internet in reasonable time, the modem should have a minimum speed of 28.8 KB.

4.3.2.3 Course Administration

Course administration consists of the tools necessary for the educator to properly administer the course activities. Additionally, the course administrator may develop, post, and, in some cases, present the course content in real time. Course activities also include posting assignments and tests, grading assignments and tests, and consulting with trainees. A large part of the design and implementation effort for a successful web-based training center is building functional components to support instructor posting of multimedia documents as well as the development of automatic updating of databases that store archived materials and test results.

Distance education courses tend to require more administrative time on the part of the instructor than traditional courses. This is due to the increased correspondence between instructors and trainees, and the more detailed feedback instructors tend to give trainees on assignments.[3] As distance education courses mature, the time spent on content preparation and presentation should diminish, since the course content will have been developed and posted on the site. Correspondence with trainees on assignments and tests will continue to be the central activity of instructors.

Table 4.4 outlines what is required administratively for our classification of web-based training. At Level 1, one only needs a system directory structure for the HTML files. At Level 2, minimum security should be implemented and protocols for posting materials developed. At Level 3, a moderately sophisticated registration and security system should be in place. Protocols for accommodating courseware developed by common office tools and a mechanism for maintaining full-text search capabilities should be in place. Level 4 introduces fairly sophisticated database capabilities. These facilitate the ability to automatically track student progress and post and grade assignments. Protocols for access to students records by instructors should also be in place. Level 5 requires the ability to handle large scale tracking of student and administrative information as well as protocols for administration of real time delivery. Finally, Level 6 requires protocols for maintaining intelligent features.

Table 4.4. Classification for Course Administration of Web-Based Training

1	• Post HTML pages to directory
2	• Level 1 + • Minimal security • Protocol for posting materials
3	• Level 2 + • Security, registration • Accommodate office tools (e.g. word, PowerPoint, e-mail) • Maintain search capability
4	• Level 3 + • Automatic tracking student progress • Posting/grading assignments • Protocol for access to student records
5	• Level 4 + • Protocols for administration real-time delivery • Large scale tracking student and administrative information

- Level 5 +
- Protocols for maintaining intelligent features

4.3.2.4 System Administration

System administration keeps the WBT Center physically running. System administration makes sure the hardware and software can handle such things as simultaneous connections and information through-put. Other administrative duties include registration of students, tracking students for accounting purposes, and security.

High speed communications is a must to deliver WBT. The operating systems for these communication servers must be capable of handling multiple connections in order to efficiently disseminate the required material. For example, a T1 Internet connection can handle roughly 200-300 simultaneous connections from student PCs. The maximum number of connections could be higher for a more "text" based system and may have to be reduced for a system utilizing a large amount of video.

A typical distance learning class size will have a large effect on the type of system necessary to support the distance learning environment. The greater the number of students connecting simultaneously, the more important it will be to consider the system's capacity. Typical systems are Unix systems, although a Windows NT server can handle modest systems. The more powerful the communication system the greater the number of students that can connect to the WBT Center. For the SMART Center a Sun workstation with a communications capacity of 56 kilobytes is used. This is a minimum system capacity supporting a single class of 15-20 students.

4.4 FUTURE WORK

The first phase of the research completed the development of the SMART Center infrastructure and the implementation of an on-line computer-based training course for MRM training. During phase two of the research an on-line MRM seminar will be conducted. Participants in the seminar will be invited to evaluate the seminar and the SMART Center site.

A second goal is to develop standards for quality Web-Based Training and delivery over the Internet. Exclusive classification of web-based training is difficult because many sites will find they have features across classification levels. Developers will also find that they may meet one classification in the area of features but not in the area of course development or course administration. This classification system does give one a rule of thumb for assessing where the sophistication of a site primarily falls. With a classification scheme in place developers will be able to identify and implement training standards. Clients will be better able to identify their training needs as well as compare the costs they are incurring vs. the levels of sophistication and value added they will receive.

More important than classifying the features of a site, is the honest assessment of standards and protocols for developing and administering a site. How ad-hoc are the production procedures? For most of us the honest answer is pretty ad-hoc. The next step is to begin to define those standards and protocols (i.e., write them down) followed by a conscious effort to implement them. During the second phase of the SMART Center research project the classification scheme will be used as guidelines for developing production standards for web-based training.

4.5 FUTURE TRENDS

We are coming to realize that while the way we do business has changed, the nature of our work is not any easier. Computers and networks provide access to data which can be interpreted and manipulated by personnel from anywhere in the country. However, we are all experiencing information overload from too much, poorly organized, data. The next phase of the information age will be to create vehicles designed to make our information-intensive work seamless, efficient, less error prone and, hopefully, easier. Information will be organized so that it is easy to access specific information quickly. Job aids will be designed to facilitate both information access, entry, and analysis. Training will be task specific and completed as needed. One trend that will become more pronounced is the merging of information access and manipulation, job aids and on-the-job training. These separate enterprises will become less and less distinguishable. Job aids will facilitate information access and manipulation while training will become an elaborate coaching or help mechanism to the job aid. Sometimes one will be aware that one is progressing through an organized course. At other times one will only be aware that one has access to progressively more specific information or more complete guidelines. Electronic Performance Support Systems (EPSS) is the terminology used to describe these new emerging technologies tailored for the information age.[4] A web-based EPSS is seen as a viable technical approach to meeting the goals of these future work flow trends.

4.6 REFERENCES

1. Graham, D. B., & Kuenzi, J. K. (1997). Error control systems at Northwest Airlines. In *Meeting Proceedings Eleventh Federal Aviation Administration Meeting on Human Factors Issues in Aircraft Maintenance and Inspection: Human error in aviation maintenance* (pp. 29-35). Washington, DC: Federal Aviation Administration/Office of Aviation Medicine.

2. Eurich, N. P. (1990.) “Part1: The learning resources.” *The Learning Industry: Education for Adult Workers.* Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

3. Wilson, B. “Providing Courses on the Internet,” *An Informational Report Prepared for the Union/District Workload Committee,* College of Marin, CA. December, 1996.

4. Gery, F. J. Electronic Performance Support Systems: How and Why to Remake the workplace through the Strategic Application of Technology. Ziff Communications Co. Cambridge, MA.