Chapter Four
The FAA Aviation Maintenance Human Factors Hypermedia System

4.0 INTRODUCTION

The Federal Aviation Administration (FAA) Aviation Maintenance Hypermedia Information System (HIS) is part of the Office of Aviation Medicine (AAM) Human Factors in Aviation Maintenance Research (HFAMR) program. The goal of the HIS project is to create new tools and methods for information access and use and to provide these tools and methods for support of other HFAMR activities (e.g., training and job aiding systems). These tools and methods provide the vital information access component for any computer-based aviation maintenance integrated information system (Johnson and Norton, 1992).

In its present state the HIS provides an environment to create and explore large collections of related information. The HIS provides a simple, yet powerful, way of creating and following associations between related pieces of information. Using the HIS, the user can browse and view information in a variety of ways. This flexible method of information access and utilization is not available to users of conventional text retrieval systems.

Publications and presentations from the HFAMR program are being placed into the HIS for the initial domain. This material includes presentations from the first five Human Factors in Aviation Maintenance Conferences, as well as complete material from the HFAMR Phase I (Shepherd, et al., 1991) and Phase II Progress Reports. The result is an on-line document that employs the latest hypermedia software technology. More importantly, software tools and methods have been constructed that provide the ability to quickly store, locate, and deliver information for a variety of aviation maintenance tasks.

4.1 PRACTICAL ASPECTS OF HYPERMEDIA

The fundamental nature of computer-based hypermedia is to structure information in a fashion that can be quickly and randomly located. Conventional forms of media delivery (e.g., books, television, video, audio tapes, etc.) tend to be linear in nature. The reader of this linear information typically starts at the beginning of a presentation and progresses along a predetermined path (e.g., turning to the next page in a book, or being forced to sit through commercials while watching TV). The reader or viewer of this information often has little choice in determining what information comes next.

Hypermedia, on the other hand, arranges information in a form in which a reader or viewer can "bounce" around between different segments of information (similar to a reader of a mystery book flipping to the end of the story; or a reader of a technical manual first looking up a term in a index, and then going to the correct page in the manual). This idea of associations, or links, between segments of information is a core feature of hypermedia systems. An example of a typical hypermedia system is illustrated in Figure 4.1.

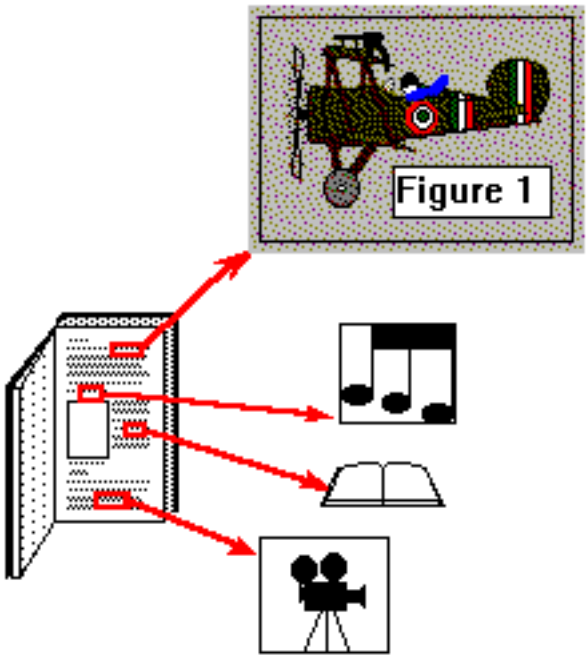

Figure 4.1 A Typical Hypermedia System

For example, a hypermedia version of a car maintenance manual would first present the reader with a diagram of a car. From this diagram, the reader would point to a particular portion of the car (e.g., the engine) and request more information. The hypermedia system would then display a diagram of the engine. The reader would point to an engine component (e.g., the battery) and the hypermedia system would then present a verbal description of the battery and list possible troubleshooting advice dealing with common battery problems.

For the purposes of this paper, the term "hypermedia" is used because the research is not restricting the usage of this system to only text - "hypertext." The scope of this system has been extended to include text, still images, graphical animation, audio, and video - "hypermedia".

One of the advantages of using hypermedia technology is its strong support for easy access to items stored in large collections of information. Typically, structures of large collections of information are complex. This leads to various indexing schemes that are used to aid readers in locating information (e. g., tables of contents and indices for books, Dewey Decimal and Library of Congress indexing for libraries). Even with these schemes however, someone searching for a particular piece of information may still have limited success in locating the desired information. Hypermedia systems extend the indexing of information by providing associations, or links, between particular related pieces of information. The idea is to provide readers with the ability to access a general location in the information base using various indexes and searching schemes. Then the reader can browse the general locations using specific associations to locate the desired information. To support browsing and exploration of information, the presence of anchors (also often called buttons) is employed to signal the reader that related information is available (Duchastel, 1990).

The Intermedia project at Brown University is a very good example of hypermedia technology being implemented for a large information space. Over a thousand pieces, or "nodes," of information are connected by over two thousand links. Intermedia presents the user with a graphical information browser, a set of graphical editors for text, graphics, timelines, animations, and videodisc data, a browser for link information, and the ability to create and traverse links between any two selections in any document in the system (Haan, Kahn, Riley, Coombs, and Meyrowitz, 1992). The Intermedia system illustrates the ease in which information can be placed into hypermedia systems and how that information can immediately benefit other users of the system.

The Artifact-Based Collaboration (ABC) project at the University of North Carolina (Smith and Smith, 1991) is a good example of hypermedia technology being used to support groups of individuals working together to build large, complex structures. ABC has five components that include a graph server, a set of graph browsers, a set of data application programs, a shared window conferencing facility, and real-time video and audio. ABC also demonstrates the ability of hypermedia technology to assimilate new information and to quickly disseminate the information for immediate use.

4.2 THE FAA HYPERMEDIA SYSTEM

The overall goal of the FAA Hypermedia Information System (HIS) development is to study the prospects and problems of creating an electronic document. The project will also determine how these technologies can be used to improve the delivery of information to support aviation maintenance. Although focused on one particular discipline, this development should produce results that help to guide the development of many kinds of future aviation maintenance support applications, hereafter referred to as FAA integrated information systems.

4.2.1 Research Phases

The development of the HIS is divided into two phases that will be conducted over a two year period. The work began in July of 1991. The first eight months (Phase I) were dedicated to the prototype design and development. The results of this phase have been:

1. A functional on-line version of the Third FAA meeting on Human Factors Issues in Aircraft Maintenance and Inspection. This version is functionally equivalent to the final version to be implemented in 1992.
2. Specifications to authors of future FAA HF conference papers to aid the incorporation of new information into the HIS.
3. Reusable technology base for indexing and retrieving hypermedia text and graphics.

The second phase is currently under development and is divided into four tasks. The first task focuses on incorporating the remaining four conference proceedings into the HIS and includes the production of a CD-ROM version of the HIS. The second task focuses on enhancement of the Hypermedia technology base. The third task will involve support for the transition of Hypertext technology to FAA integrated information system research. The fourth task will focus on demonstrating and reporting research results to fellow HF team members, the project sponsor, and the HF community.

4.2.2 Features of the Hypermedia Information System

The Hypermedia Information System (HIS) was designed with a variety of features to aid a reader of the document in locating and using the information contained in the system. Most of these features were derived by analyzing the eventual information needs of the readers of the HIS, as well as reviewing state-of-the-art information retrieval and hypermedia systems. These features are discussed in the subsequent sections.

4.2.2.1 Information Browsing

The HIS allows readers to browse through the information contained in the on-line database. That is, the user is allowed to leisurely wander through the information, selecting items of interest and inspecting various topics that pique the interest of the reader. For example, some readers might browse the information looking only at the pictures that may have some relevancy to the topic at hand. Other readers might choose to view only the titles and authors of individual papers, searching for a topic that may have some application to their current task.

The HIS supports this browsing operation in two ways. First, the information is loosely structured in the database, allowing the HIS to present the same information in many different ways. Second, the HIS provides mechanisms to the readers in which they can easily locate additional information related to the current topic. For example, while reading a conference paper stored in the HIS, a reader might come across a reference to a related photograph. The HIS allows the reader to select this reference to view the actual photograph.

This method of linking, or associating, information can easily extend to other objects stored in the HIS. For example, readers can point to references to videos, animations, text, sound, etc. and request to see (or hear) this information. The HIS is able to retrieve these items and display them to the reader. This linking capability allows the reader to freely move about the information contained in the HIS, literally wandering and exploring at will.

The HIS supports linking through the use of buttons and icons (see Figure 4.2). Buttons allow the reader to activate certain links, while icons provide some sort of visual clue to the reader as to what the button will do when it is activated. Usually icons are a picture of some object (e.g., a video camera to represent video). However, text can also serve as an icon (e.g., the words FIGURE 62 represent the actual figure). The HIS supports both text and graphics as icons to support the reader in determining when a button is present, and what that button will do when it is activated. The HIS also contains an overview diagram of the information contained in the database (Figure 4.3). This overview diagram allows a reader to view the entire HIS database at once. Using the overview diagram, the reader can gain a perspective of how one piece of information is related to other information. Also from the overview, the reader can select any piece of information and go directly to it, without having to browse through the system.

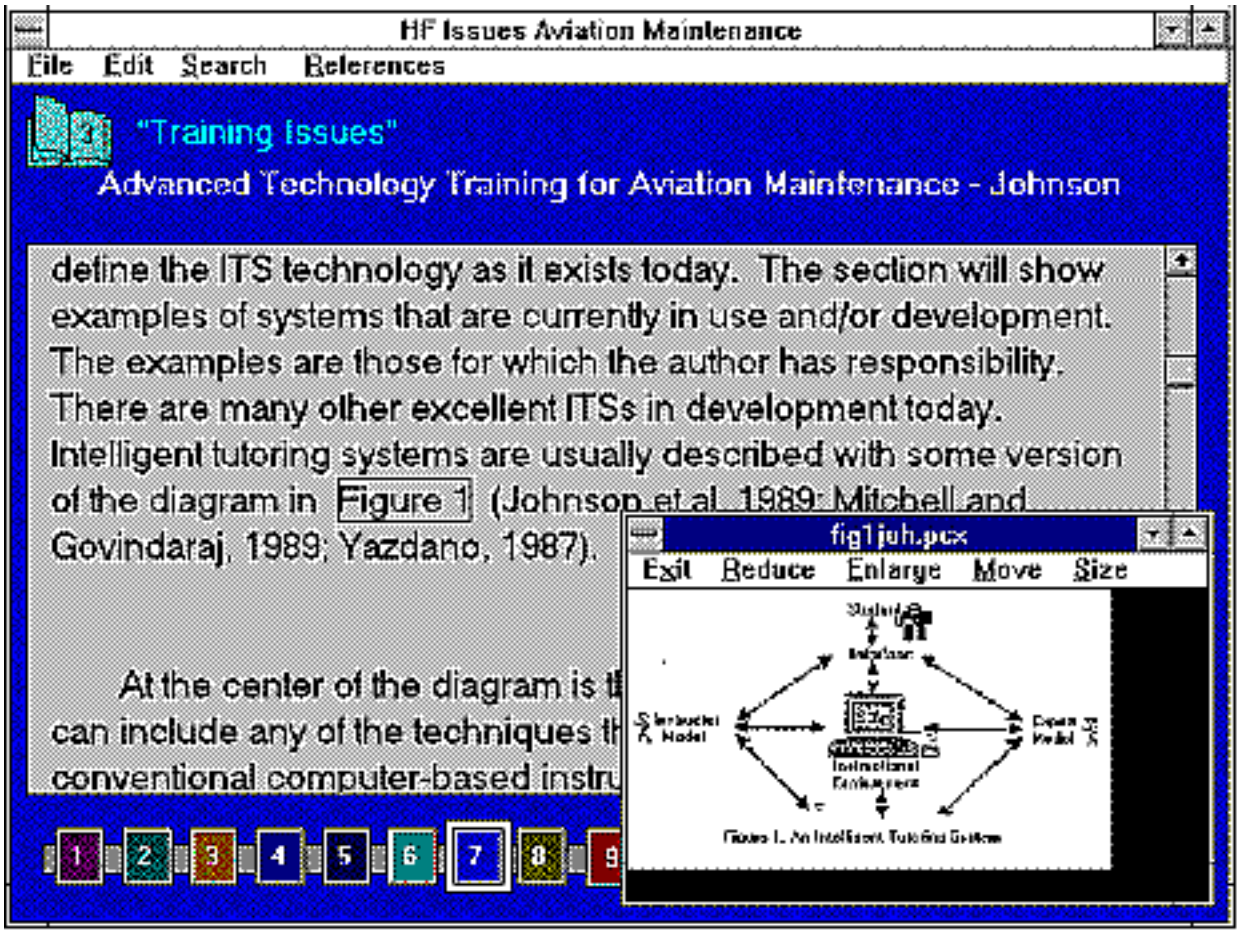

Figure 4.2 Buttons and icons allow readers to access related information

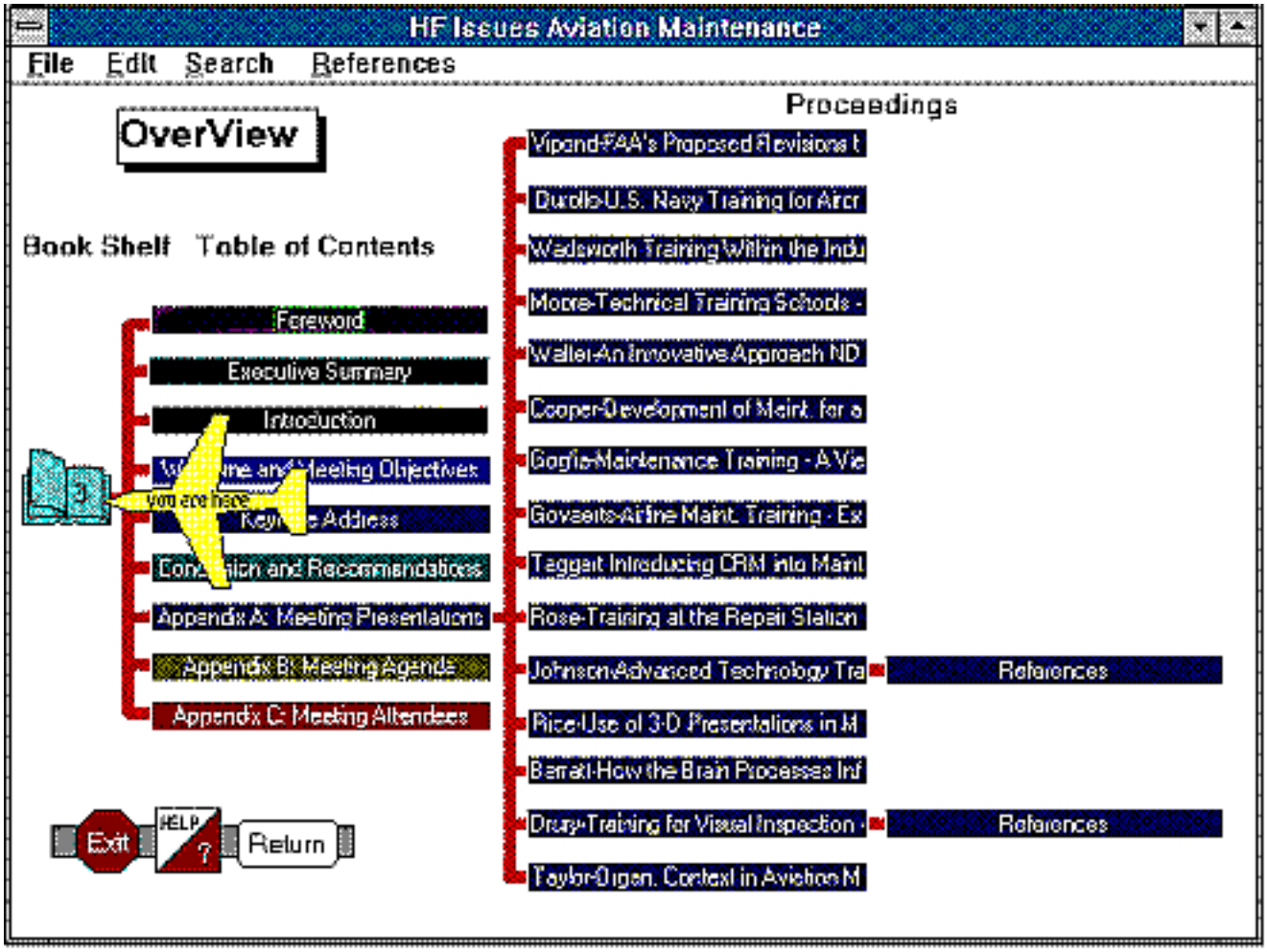

Figure 4.3 The Overview Diagram

4.2.2.2 Information Searching

Often a reader will come to the HIS with a specific idea of what information is needed. The chances of locating the exact piece of needed information simply by browsing are fairly low, even in relatively small documents. Even if a reader happens to come across one piece of relevant information, there might be additional information that the reader might miss. An even worse scenario is when a reader has a request for information that is not contained in the HIS. The reader might browse indefinitely without finding a relevant piece of information. The reader would not be able to tell if their lack of success was due to their bad luck in browsing or to the fact that the information did not exist at all.

To overcome these problems, the HIS provides a facility for conducting direct searches for information. The HIS contains an index into the information that aids readers by allowing them to search the index, rather than the information for a piece of information. The index contains both the search items and the location of those items in the HIS system. This technique is similar to the uses one might find in the local telephone listings. For example to locate the residence of your friend Timothy Handson, you could use the telephone listings to locate all of the entries for Timothy Handson. Once you have found the correct entry, you are able to get the address of his residence and then go to his home. This directed search method is much more efficient than browsing.

The HIS system works in a fashion to the telephone listing analogy. The HIS system contains many indices indicating exactly what each piece of information is, including what type of information it is (i. e., text, video, graphics, sound), and where it is located (i.e., exactly what conference paper, what paragraph, and what sentence). Readers using the HIS would enter a description of the information that they are looking for, and the HIS uses these indices to tell the reader where this information is located. The reader can directly "jump" to this information, bypassing the entire browsing process.

In the present HIS system, the reader initiates a search by entering a query, or a description of the desired information, into the system (Figure 4.4). This query is made up of individual terms and boolean operators on those terms. For example, search terms could include: Airplane, Human Factors, Helicopter, Navigation, etc. Any word is a valid search term. The reader also uses boolean operators (AND, OR, NOT) to indicate relationships between multiple search terms. For example, a possible query could be Computer AND Training, indicating that reader is looking for a piece of information that is related to both computers and training.

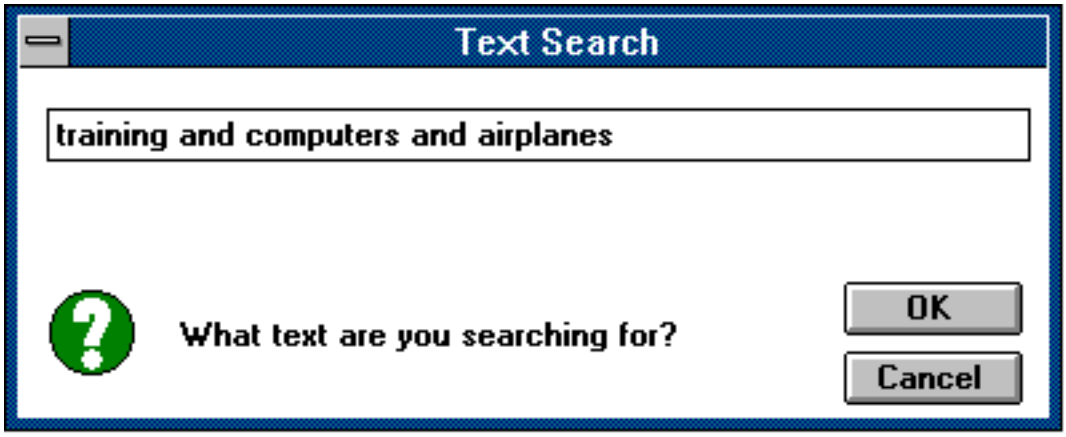

Figure 4.4 Entering Search Terms

The HIS uses this query to search the indices for related information. In the case of the example query above, the HIS would first look for information related to computers, then look for information related to training, and would then look for pieces of information that were in both of those wsets. The results of this search are then presented back to the reader (see Figure 4.5). Often, there are multiple pieces of information that match a readers query (e.g., just as there might be multiple listing for Timothy Handson in the telephone book). In this case, the readers are shown all of these matching pieces of information, and are allowed to browse through those that they feel could be relevant.

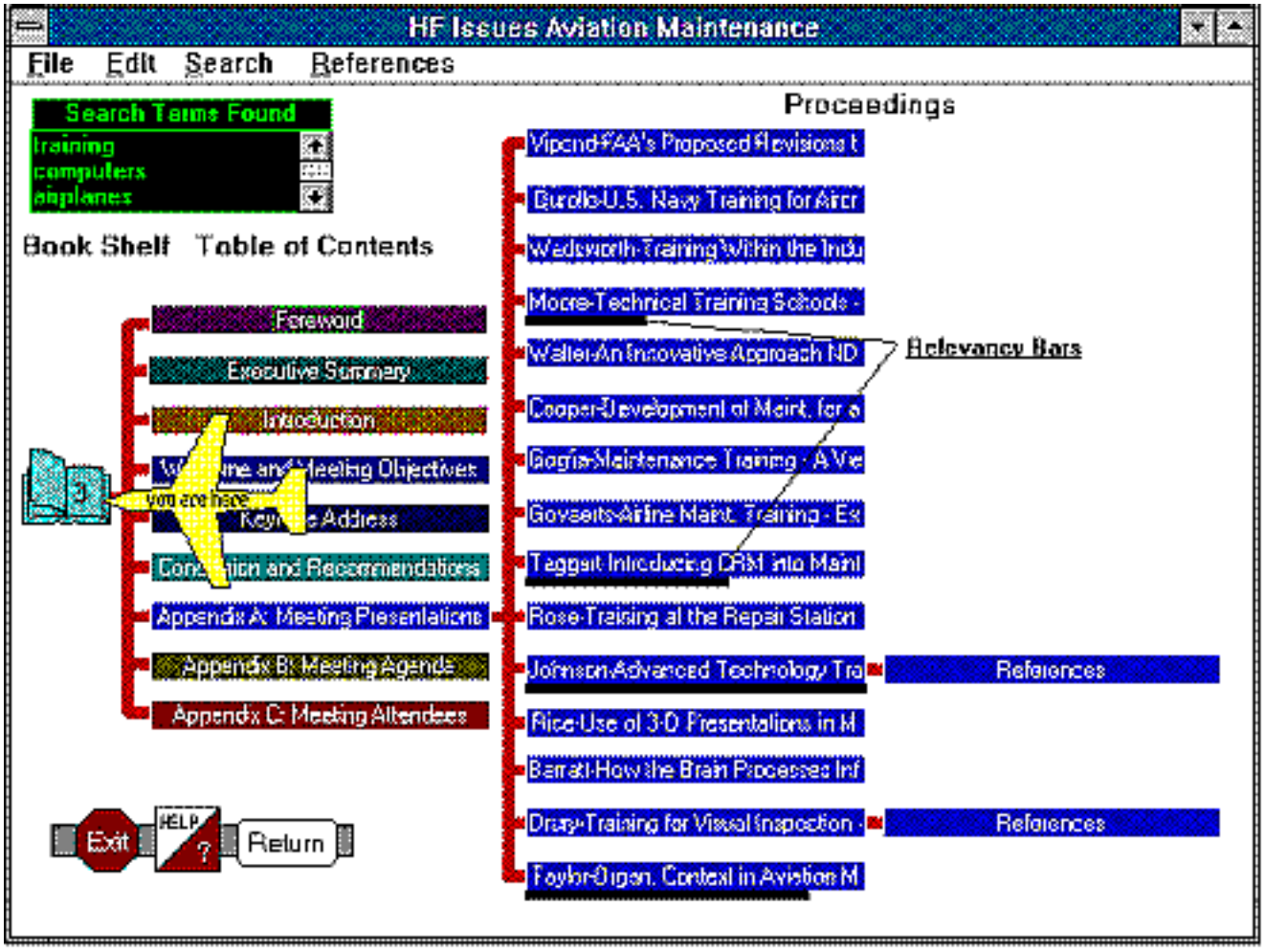

Figure 4.5 Search results are shown on the overview diagram by highlighting matching items

4.2.2.3 Search Aiding

When the HIS finds multiple matches to a query, these matches are presented to the reader for review. The HIS also aids the reader in determining which matches are likely to be most relevant to their query by providing relevancy bars along with the query results (see Figure 4.5). The magnitude of each relevancy bar indicates the likelihood of that document being most relevant; the longer that bar, the more relevant the document is likely to be to the reader.

Another search aiding technique is allowing the reader to refine and edit previous queries. Entering a search query is usually not a one-time process. Sometimes a query is too broad, in that too many pieces of information are retrieved for the reader to handle at a time. Sometimes, a query is too narrow, yielding little or no matches to the query. Readers can refine queries either by adding or deleting search terms. The HIS retains previous queries to aid the reader in determining which queries to expand.

The HIS also aids the reader by expanding and refining queries. To be implemented in future versions of the HIS, a term thesaurus will be included to help the reader in locating additional terms that might be relevant to the desired information. These terms can the be used by the reader as part of subsequent queries into the information.

4.2.3 System Architecture

The HIS operates on an IBM PC-compatible desktop platform with 4 Megabytes of system memory, a Microsoft Mouse (or compatible), and Microsoft Windows 3.1. Initial versions of the HIS can run off of the system's hard disk, but future versions will require a CD-ROM reader to use the system, due to the large amount of information contained in the system. The overall software architecture is shown in Figure 4.6. The system was constructed using a variety of development tools, including: Microsoft Windows 3.1, Asymetrix Toolbook, Borland C++ Compiler, and Raima Corporation DB_Vista.

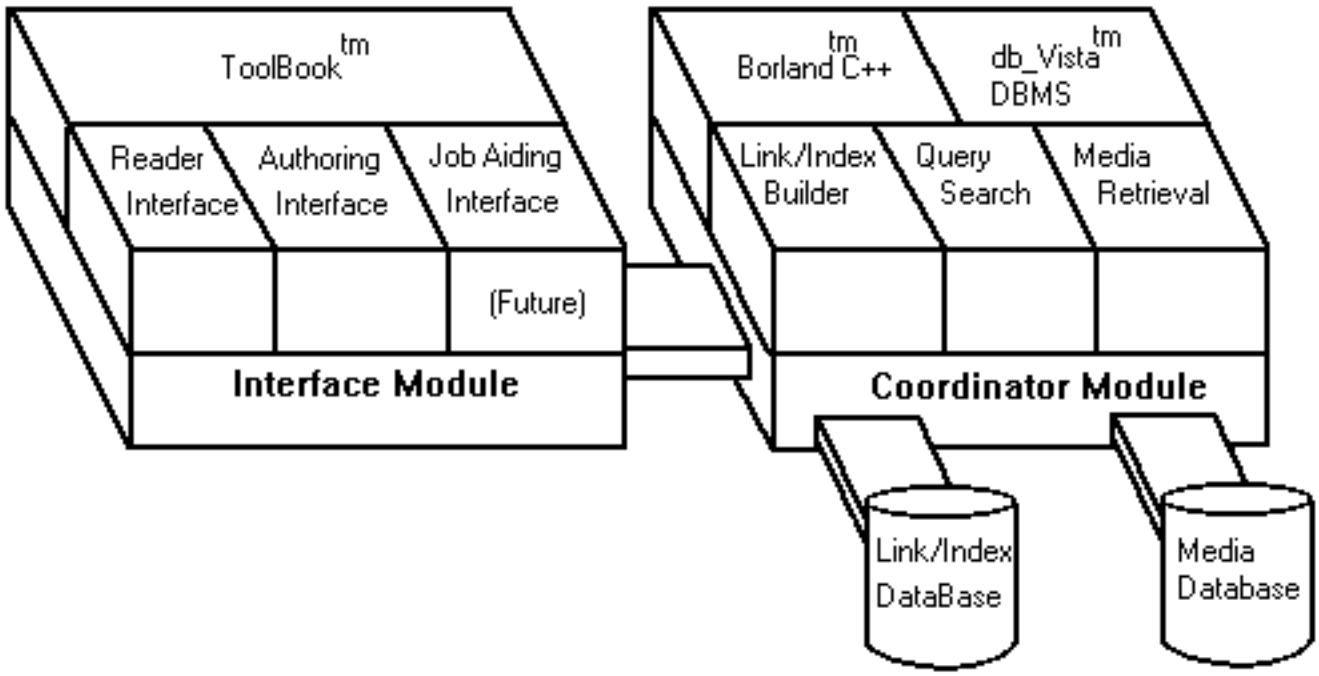

Figure 4.6 The Overall Architecture of HIS

These tools were used to construct two distinct environments. The first environment is the reader interface, which was described in earlier sections. The reader interface allows users of the information to search and browse the information contained in the HIS. The second environment, the author interface, contains tools that allow authors to place information into the HIS. These tools include editors, link builders, indexers, and database manipulation tools. Future versions of the HIS will allow access to these tools from the reader interface, thus allowing readers to store and index information in addition to the material already contained in the HIS.

The HIS contains two distinct databases. The first database, the Media Database, contains the actual information to be retrieved by the user. This material includes graphics, text, and eventually sound, animations, and other multimedia information. The second database, the Link/Index Database, contains information to help the HIS search for and retrieve information. The Link/Index database contains information regarding file location, search term location, document information, graphic information, and link structures.

4.3 CURRENT RESEARCH STATUS AND FUTURE PLANS

Phase I has produced a working prototype of HIS. It includes an on-line version of the 3rd FAA Human Factors in Aviation Maintenance meeting. This prototype is available for distribution. Directions for future research include:

1. Provide one operation for indexing the HIS information. Presently, three distinct operations are required to store this information. By integrating these three steps into a common environment, these three operations can be performed simultaneously.
2. Improve navigational strategies to allow readers to return to information already seen. Similar to the idea of "bookmarks," this strategy will allow readers to quickly mark and return to important information.
3. Improve searching strategies by providing feedback to the users regarding the effectiveness of their searches. Aids such as on-line thesauruses, enhanced search control, and relevancy feedback can be used to improve searching by even the most novice user.
4. Integrate the authoring and reader interfaces. This integration will allow future users of the HIS to incorporate relevant information into the HIS system and will allow them to rapidly associate this information with material already stored in the HIS.
5. Incorporate additional media types such as video, animations, and sound.

The technology provided by this research will be used to support the information retrieval needs across a variety of FAA and airline maintenance software support systems. Already, various training systems have benefitted from incorporating the HIS technology into these systems. Students are now able to quickly access information when it is needed during a training session. Current plans include the incorporation of the HIS technology into the various maintenance job aiding systems as well. Anticipated benefits of this marriage between hypermedia and job aiding include quicker access to information, exposure to material that might have been overlooked using conventional information access systems, and subsequent reduction of maintenance personnel error.

4.4 REFERENCES

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