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A Multimedia Manual on the World Wide Web for Telecommunications Equipment

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Abstract— **An interactive multimedia educational manual on the Internet through the World Wide Web for commercial optical fiber telecommunications equipment is described. *The Telecommunications Laboratory Manual* is a vehicle for enhancing engineering education with realistic laboratory or virtual laboratory experience. The manual provides a brief system tutorial, operating instructions, on-line help, and multimedia experimental demonstrations. It incorporates block diagrams, photographic images, and hypertext links that are mouse clickable, allowing users to access documents or links describing components or processes in any order. An experimental section guides students through laboratory experiences, demonstrates selected equipment characteristics, and provides for direct instructor contact through e-mail. Other remote resources on the Internet are linked to create a global multimedia library. This paper describes the manual, its multimedia design, its use in the curriculum, and its further potential.**

I. Introduction

NEW ADVANCES in multimedia and the Internet have great potential to aid education and research. The World Wide Web (WWW) offers the capability to share multimedia resources to create a global multimedia library. The WWW is a distributed, hypermedia information retrieval system [1] with multimedia capabilities that include scaleable fonts, graphics, audio, and video clips. The WWW encompasses other Internet formats such as Telnet, Gopher, File Transfer Protocol (FTP), e-mail, and newsgroups. In addition, Web browsers such as Mosaic and Netscape can be configured to load documents from the Internet into windows applications such as MathCad. Information can be made available on the WWW by creating a publicly accessible directory on a machine that acts as a WWW server. According to *Newsweek*, as many as 30 million people from 92 countries have access to the Internet [2] and the majority of these users should have text browsers for using the WWW.

The educational use of computers has advanced beyond word processing and numerical calculations to include integrated data acquisition and analysis [3], intelligent tutorials [4], interactive video [5], and virtual instruments [6]. The Internet, and particularly the WWW, integrate electronic communication, multimedia, and information retrieval and are finding educational applications. The spread of WWW information sites and electronic communication for industry, institutions, and individuals is one indication of their usefulness. Any computer-based educational application, however, must be tailored to the technology to be truly effective [7].

This paper presents a WWW-based multimedia manual for a commercial telecommunications station. It is an example of how the Internet can be used as an interactive, multimedia aid for education. *The Telecommunications Laboratory Manual* describes a fiber-optic station with multiplexing, optical transmission/reception, and signal regeneration using Collins DLT-2300 and DST-2300 models manufactured by Rockwell. The equipment is in the Advanced Optical Communications Laboratory at the University of Missouri-Rolla (UM-Rolla) and was donated by WilTel Business Systems (now part of LDDS WorldCom Network Services). The manual is currently on the WWW and can be accessed from any computer connected to the Internet by using a WWW browser such as Mosaic or Netscape. Its Internet address is "http://www.ee.umr.edu/~watkins/main.html." The paper describes the manual, its multimedia design, its use in the curriculum, and its further potential.

II. Outline of the Manual

The Telecommunications Laboratory Manual is an aid for electrical engineering students in the Fiber and Integrated Optics and the Fiber Optic Communication Systems courses at UM-Rolla. Its purpose is to provide an interactive educational experience with a commercial fiber-optic telecommunications station. The station consists of two racks of electronic circuit boards including multiplexers/demultiplexers, transmitter/receiver pairs, and signal regenerators. The students are "reading to do" [8]. The manual contains multimedia documents and links that are divided into a component operation section, an experiments section, an operating instructions and help section, and an index as shown in Fig. 1.

The component operation section details the function and interconnections of each component board in the station. The introductory document displays a block diagram of the signal flow path in the telecommunications station as shown in Fig. 2, a photographic image of the equipment rack with the front panel removed, and a menu of text buttons. The block diagram, image, and text links are "mouse clickable," allowing users to access documents or links describing the component or process in any order. Each component document has detailed

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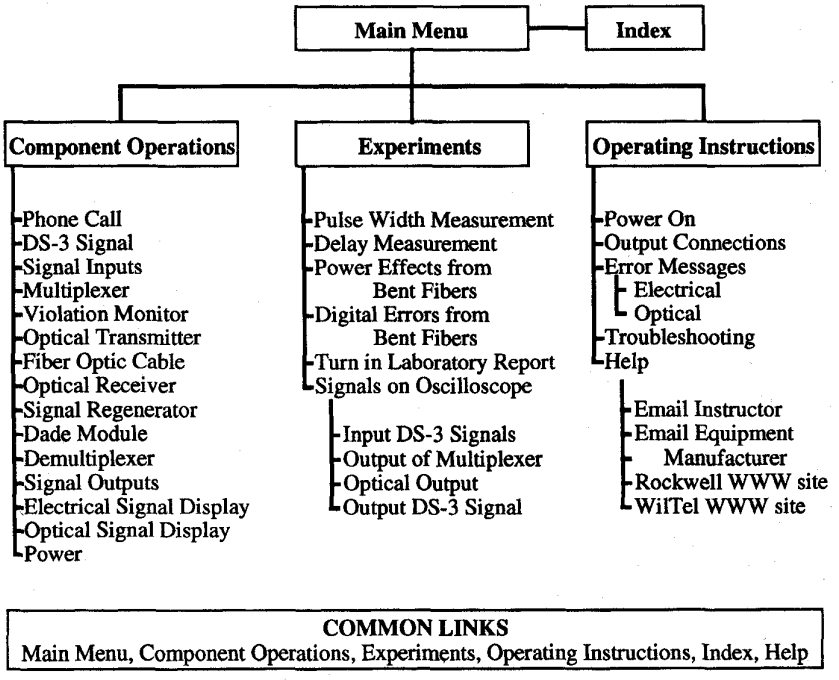

Fig. 1. Structure of the multimedia manual. Each item listed in this outline represents either a document or a link to another location on the Internet.

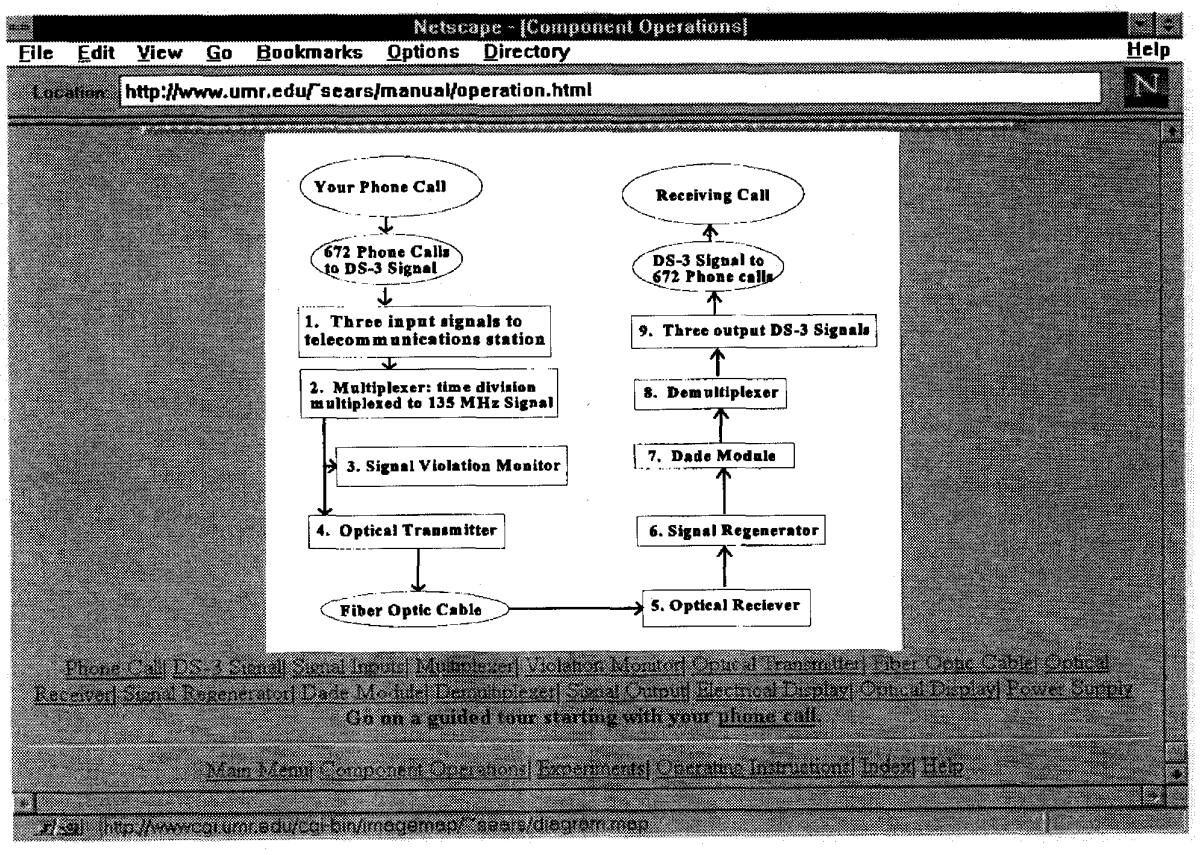

Fig. 2. Main document for Component Operations in the manual as viewed by Netscape. Users may select any block in the flow diagram of the telecommunications station to find out more information about that step or select a guided tour of the equipment.

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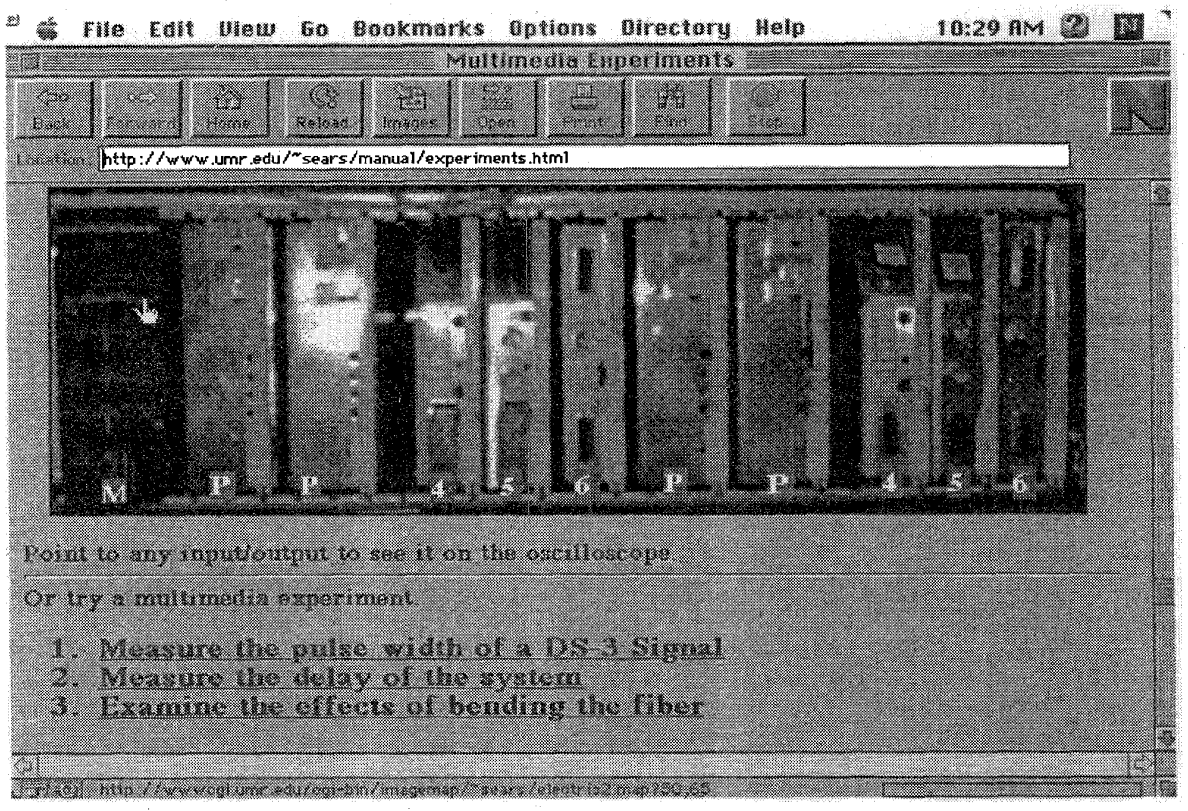

Fig. 3. Main document for Multimedia Experiments in the manual. Users may select any output terminal in the image to see an oscilloscope trace of the signal at that point or select a multimedia experiment.

functional and interconnection information and a photographic image of the circuit board. The user can also choose to follow a guided tour of the documents in which a standard telephone signal [9], [10] is traced through the components in order.

The experiments section provides a virtual laboratory. The introductory document displays the image of the electrical and optical rack shown in Fig. 3. Users can access a description and image of the corresponding oscilloscope trace for any output terminal. A clickable list of virtual multimedia experiments follows the graphic. The document pages for each experiment detail the setup and display the actual oscilloscope results as shown in Fig. 4. After viewing the multimedia experiments, users can select an option at the bottom of the page to submit electronic laboratory reports. Some of the experiments available include: 1) measuring the pulse width of a DS-3 signal using an oscilloscope; 2) measuring the temporal delay of the telecommunications system using an oscilloscope; and 3) measuring the decrease in optical power output and the errors generated by bending the optical fiber.

The final section includes the required operating instructions and the on-line help documents for the laboratory experiments. A comment and questions feature is included in which e-mail can be automatically sent to the course instructor. Also, WWW links are provided to remote Internet sites such as the manufacturer Rockwell and telecommunication service provider LDDS WorldCom Network Services (under the WilTel link).

A universal menu of text links is included in each document, as in Fig. 2. Users can immediately access the main menu, component operations, experiments, operating instructions, the index, and help from any document. Also, the user access order is retained in common browsers, allowing users to backtrack to any previously viewed document. The intention is to provide maximum flexibility in accessing desired information.

III. Design of the Manual

The laboratory manual was written using Hypertext Markup Language (HTML) [11] and is currently made available on the Internet from a Unix platform. HTML is a high-level language that uses calling functions and linked Internet documents. The HTML code for a portion of the main document for the experiments section is shown in Table I. The code produces the output shown in Fig. 3. Code inside the brackets "⟨⟩" is considered a command, while that outside of the brackets is printed as text. The code in bold creates the hypertext links that appear as underlined text in Fig. 3. Links to other documents are shown embedded in the commands, e.g., the multimedia experiment for the effects of bending the fiber at address "bent.html" in the last line of code. The HTML documents are stored as regular ASCII text files on a WWW server.

The code of the manual has a modular format. Each document outlined in Fig. 1 has a separate file that is connected through the links. Text links, such as the list of multimedia

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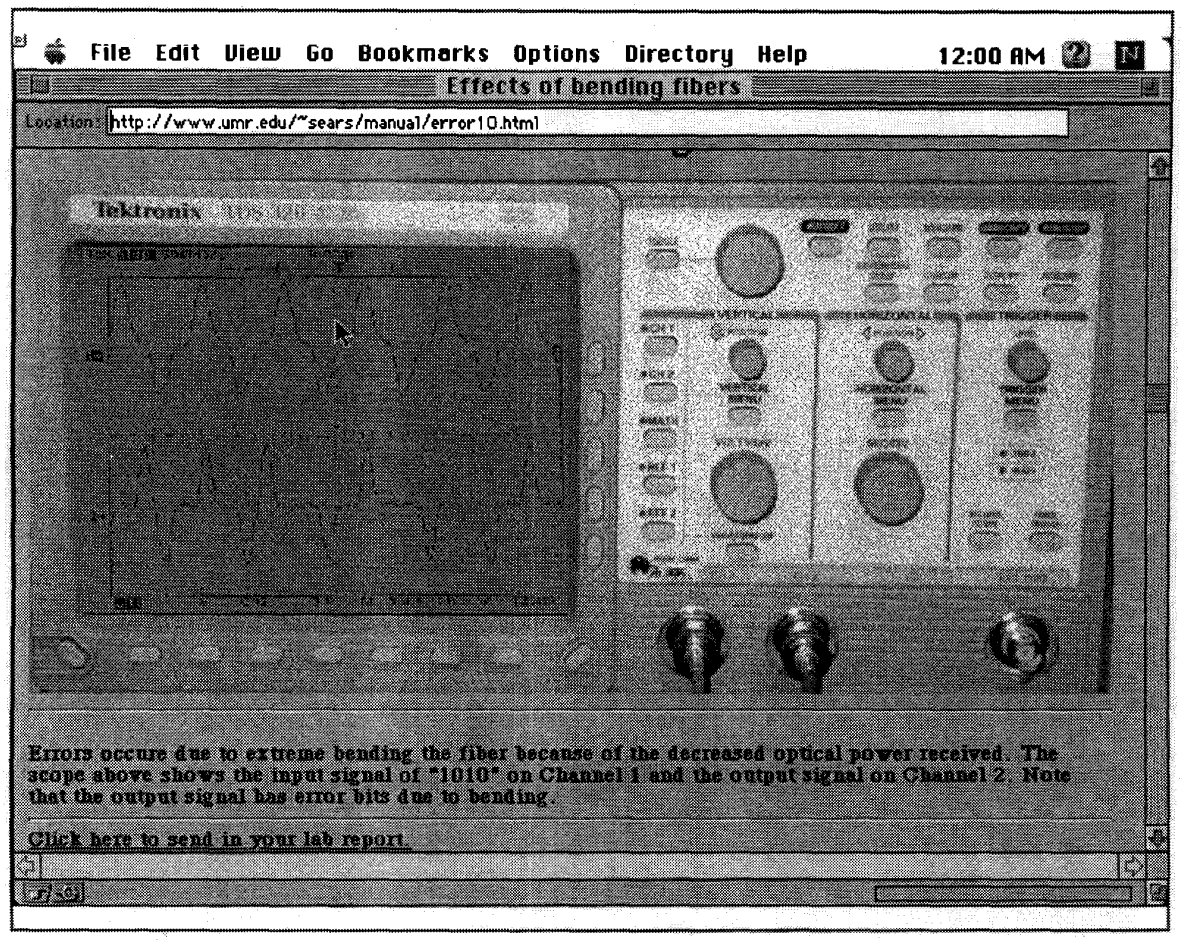

Fig. 4. Document for Effect of Bending Fibers demonstration in the manual. Users see the output of the system on the oscilloscope when the fiber cable is bent. The underlined link is an option to e-mail a laboratory report.

experiments in Table I and Fig. 3, are displayed as highlighted text that is clicked to access. Two other useful link types are described below.

1) "Clickable" Images: Users point and "click" with the mouse to an image location (see. Fig. 3). A standard function "ismap" is called that records the location where the user pointed and compares it to a "map" file that has different shapes defined on the figure. Each shape links to a different document on the Internet [11]. These map files can be created with programs that are available on the Internet, such as Webmap.

2) Response Form for Experiments: A standard function "mailto" is called for routine messages. Custom blanks are added to a form with standard functions in the browser. The input from these blanks are then assigned to variables passed to a Unix program that can send the input in the form of e-mail.

The remote WilTel (now LDDS WorldCom Network Services) WWW link under the help menu in the Operating Instructions section (see Fig. 1) contains a glossary search feature. The Telecom Glossary [12] on the Internet has definitions of common telecommunications terms. A form is set up using HTML, which has an input blank for the user to submit the search topic. The form then calls a script on LDDS WorldComs server that searches through their database. This link provides a significant manual resource not resident at UM-Rolla.

IV. Use of the Manual

The Telecommunications Laboratory Manual was written to effectively incorporate experience with a commercial telecommunications station into two senior elective/introductory graduate courses. The goal was to develop a single interactive WWW manual to prepare students for actually operating the equipment, to guide them during laboratory experiments, and to demonstrate course content in realistic virtual experiments. A personal computer with a WWW browser and Internet connection is located next to the equipment for in-laboratory use.

The three usage goals are accomplished in the manual. Since only one station is available, the time available for each student to physically operate the equipment is limited. The manual allows the students to realistically prepare for the laboratory time at their convenience. The multimedia aspect, especially the use

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TABLE I
EXAMPLE OF HTML CODE WITH EXPLANATORY COMMENTS

HTML CODE	COMMENTS
<A HREF="http://wwwcgi.umr.edu/ cgi-bin/imagemap/~sears/electric2.map"> <IMG SRC="http://www.umr.edu/~sears/ manual/gifs/electric.gif" ISMAP> <A HREF="http://wwwcgi.umr.edu/ cgi-bin/imagemap/~sears/optic2.map"> <IMG SRC="http://www.umr.edu/ ~sears/manual/gifs/optic.gif" ISMAP></A>	*Displays panel of station and calls a standard function ISMAP which identifies link desired by image map location.*
	Ends center justification.
<hr>	*Displays horizontal line.*
<h3>	*Selects a list ordered by number in heading font 3.*
	Identifies first list item.
Measure the pulse width of a DS-3 Signal	*Creates a hypertext link to the file "width.html."*
	Ends text for link.
Measure the delay of the system	*Creates a hypertext link as above.*
li>**Examine the effects of bending the fiber**	*Creates a hypertext link as above.*

TABLE II
REMOTE WWW RESOURCES THAT COULD BE LINKED TO THE MULTIMEDIA MANUAL. TELECOM LIBRARY: TELECOM GLOSSARY

WWW SITE	ADDRESS
Rockwell International	http://www.rockwell.com
LDDS WorldCom Network Services	http://www.wiltel.com
Telecom Glossary	http://www.wiltel.com/glossary/
Dallas Semiconductor Data Sheets	http://www.dalsemi.com/DocControl/ index.html
Honeywell Data Sheets	http://webster.ssec.honeywell.com/ datasheets/
Motorola Data Sheets	http://motserv.indirect.com/cgi-bin/msg
Chip Directory (circuit layouts)	http://www.geo.mtu.edu/chipdir/ index.html
Circuit Cookbook (circuit layouts and SPICE models)	ftp://nyquist.ee.ualberta.ca/pub/cookbook/
Part Net (electronic component directory)	http://part.net

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of photographic images, promotes understanding and increases confidence in making the right connections. The on-line help and e-mail features allow students to work more independently and to make reports more easily. Communication is not limited to the instructor, but includes the equipment manufacturer, other students, etc. Virtual experiments demonstrate aspects of the equipment without requiring laboratory time and allow student repetition of the demonstration. These interactive experiences can be used as a part of regular homework assignments and allow difficult experiments to be demonstrated reliably.

The manual possesses advantages over conventional paper manuals. The multimedia aspect can provide meaningful learning experiences. Additions and correction of errors to the manual can be made and implemented immediately. Links to remote sites increase the usefulness of the information. The manual also opens the possibility for off-campus use. Since the manual is available to the public, it could play a role in continuing education for practicing engineers wishing to learn more about telecommunications systems. This industrial connection should encourage cooperation with industry and help keep the manual current.

V. Future Applications

The Telecommunications Laboratory Manual can be enhanced by expanding the multimedia features, the interactivity, and the remote links. Because of the modular design and straightforward code, revisions and expansion are not difficult to make. The manual will become more useful as additional Internet resources are developed and as other computer applications are integrated with WWW browsers.

Development of the manual is continuing to improve multimedia features and interactivity. To illustrate the practical effect of bending loss in optical fiber, sound clips of someone speaking over a fiber-optic cable that is progressively bent will be included. The virtual experiments will be improved so that users are instructed to make a specific measurement. They would have to point to the right connections on the equipment and select the right settings on the oscilloscope before the manual brings up the output. On-line quizzes will be used to test users' understanding after performing multimedia experiments. Multiple-choice questions could be asked, and the users could receive immediate feedback as to the results of their quiz. Another possibility would be to add links that contain pages in MathCad format which could be accessed using the WWW browser from Mathsoft, which reads equations and graphs in MathCad format.

A strength of the multimedia manual is the capability to interconnect with other information. Table II outlines some of the resources currently on the WWW that can be used in conjunction with the manual. The current limitation with these resources is that most of them are relatively new and incomplete, but as the resources are expanded, they could be connected to the multimedia manual. For example, users interested in the multiplexer on the station could link to the Telecom Glossary [12] from LDDS WorldCom Network Services for a telecomunications definition, then link to the Motorolas data sheets for individual component specifications on the multiplexer, then link Circuit Cookbook to get a Spice model of the circuit and simulate the circuit on their own computer. Eventually, a global multimedia library could include virtually all component specifications.

VI. Conclusion

The Telecommunications Laboratory Manual demonstrates the potential for the WWW and the Internet to improve science and engineering education. The manual provides in-depth exposure and training with equipment that may be too expensive or too time-consuming to otherwise provide. The multimedia capability and access to wide-ranging resources will aid the learning process. The University of Missouri–Rolla uses the manual to guide students in optical fiber technology courses as they use the telecommunication equipment in laboratory experiments and to demonstrate additional aspects of the technology in virtual experiments. Students have greater opportunity to learn at their own pace and convenience.

The WWW and the Internet can provide an avenue for assistance and cooperation among universities, industry, and professional societies. One university could set up standard multimedia experiments for basic circuit analysis, which schools from across the world could use, and other universities could provide support for other courses. Industry and professional societies could provide supplementary resources such as component specifications. This global multimedia library would serve formal education as well as provide exposure for high school students with Internet access and working professions needing on-the-job training. Current obstacles to create such a global library are a lack of awareness of the tools available and a lack of incentives to develop multimedia applications.

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[12] LDDS WorldCom Network Services, *LDDS WorldCom Telecom Library: Telecom Glossary*, WWW: http://www.wiltel.com/glossary/.

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