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16. Abstract This report summarizes the Year 2 activities under Implementation Project 5-4969-01, "Wireline ITS Communications Training." The overall objectives of the project were to modify the workshop offerings developed in a previous project to an eight-hour format, and teach the workshop materials at 10 locations across the state, including a pilot workshop. Year 2 activities included teaching the workshops and preparing the final deliverable for the Texas Department of Transportation (TxDOT).					
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**WIRELINE ITS COMMUNICATIONS TRAINING:  
YEAR 2 REPORT OF ACTIVITIES**

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## **DISCLAIMER**

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. The researcher in charge of the project was Robert E. Brydia.

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# **INTRODUCTION**

## **SIGNIFICANCE OF PROJECT**

The telephone was the true beginning of a worldwide revolution in communications. Within 15 years of its invention in 1876, the number of telephones in use in the United States exploded to more than five million. Long distance communications were not only possible; they flourished. The next 100 years saw the continued evolution of communications, as new methods, technologies, and devices produced not only technological breakthroughs, but life-altering impacts on daily life. Today, the communications environment is complex and changes rapidly with new advances.

The primary concept and application of intelligent transportation systems (ITS) are the use of technology to improve the safety and efficiency of transportation systems. At the heart of these technology applications is the need for communications. Communication provides the capability to move data and video from one location to another within the transportation system, allowing for better decisions, improved management, and increased information.

TxDOT engineers are responsible for the design, evaluation, and implementation of ITS solutions across the entire state. These installations occur with vast differences in requirements, expectations, and constraints. Over time, as the available communication options have expanded, it has become more difficult to have a comprehensive overview of the basics as well as a thorough understanding of the pros and cons of the different technologies.

## **PRIOR EFFORTS**

Texas Department of Transportation (TxDOT) Project 0-4969, performed during fiscal year (FY) 2005, developed the basic methodology for examining the array of communication alternatives and guiding engineers toward the most appropriate solutions. A pilot workshop developed as part of the project was rated very highly and recommended for implementation across the state.

Given the strong results from the pilot workshop, TxDOT decided to proceed with an implementation project to provide a wider opportunity for disseminating the information across the state. The implementation project (5-4969-01) originated in March 2006 and ends in August 2007. The work tasks across the project timeframe include:

- Task 1 — Modify workshop materials,
- Task 2 — Conduct pilot workshop,
- Task 3 — Update workshop materials as appropriate,
- Task 4 — Plan and schedule formal workshops,
- Task 5 — Document FY06 activities,
- Task 6 — Conduct formal workshops,
- Task 7 — Document FY07 activities, and
- Task 8 — Provide TxDOT with workshop materials.

Tasks 1-5 were performed in FY06 and are covered in Report 5-4969-01-1. This report covers tasks 6-8, performed during the second year of the implementation project.

## **STATUS OF YEAR 2 TASKS**

### **TASK 6 — CONDUCT FORMAL WORKSHOPS**

#### **Typical Audience**

The typical audience for the workshop is TxDOT employees who have some level of overview or responsibility for ITS, but with little or no background in the area of communications. The workshop materials provide an overview of communication concepts and their application to wireline ITS technologies. The materials are not intended to provide comprehensive training in all aspects of communications. The level of information contained in the materials should be applicable to employees across the state.

#### **Course Materials**

The complete set of workshop materials includes the following:

- Participant's notebook,
- PowerPoint® slides, and
- Instructor's notebook.

These items all work in combination to provide TxDOT with a complete set of materials that can be used to teach the course in the future.

#### **Course Objectives**

The objectives of the course material are twofold:

- to establish a fundamental level of understanding of wireline communication concepts and technologies, and
- to convey and explain a comprehensive process for assessing communication needs for ITS deployments.

#### **Participant's Notebook**

The participant's notebook contains a significant amount of fundamental knowledge pertaining to communications. The notebook also contains the design methodologies and detailed explanations of each section. The notebook concludes with case studies demonstrating

the use of the design methodologies and a glossary of terms used throughout the material. The eight chapters of the participant's notebook are:

- Chapter 1 — Introduction,
- Chapter 2 — The Basics of Wireline Communications,
- Chapter 3 — Understanding Telecommunications Technology,
- Chapter 4 — Technology Choices,
- Chapter 5 — System Design/Evaluation,
- Chapter 6 — Design/Evaluation Methodologies,
- Chapter 7 — Case Studies, and
- Chapter 8 — Glossary.

Figure 1 shows two sample pages from the participant's notebook. The notebook was designed with many features such as wide margins for taking notes, call-outs for critical information, and the use of color, where warranted, to provide additional clarity to the material.

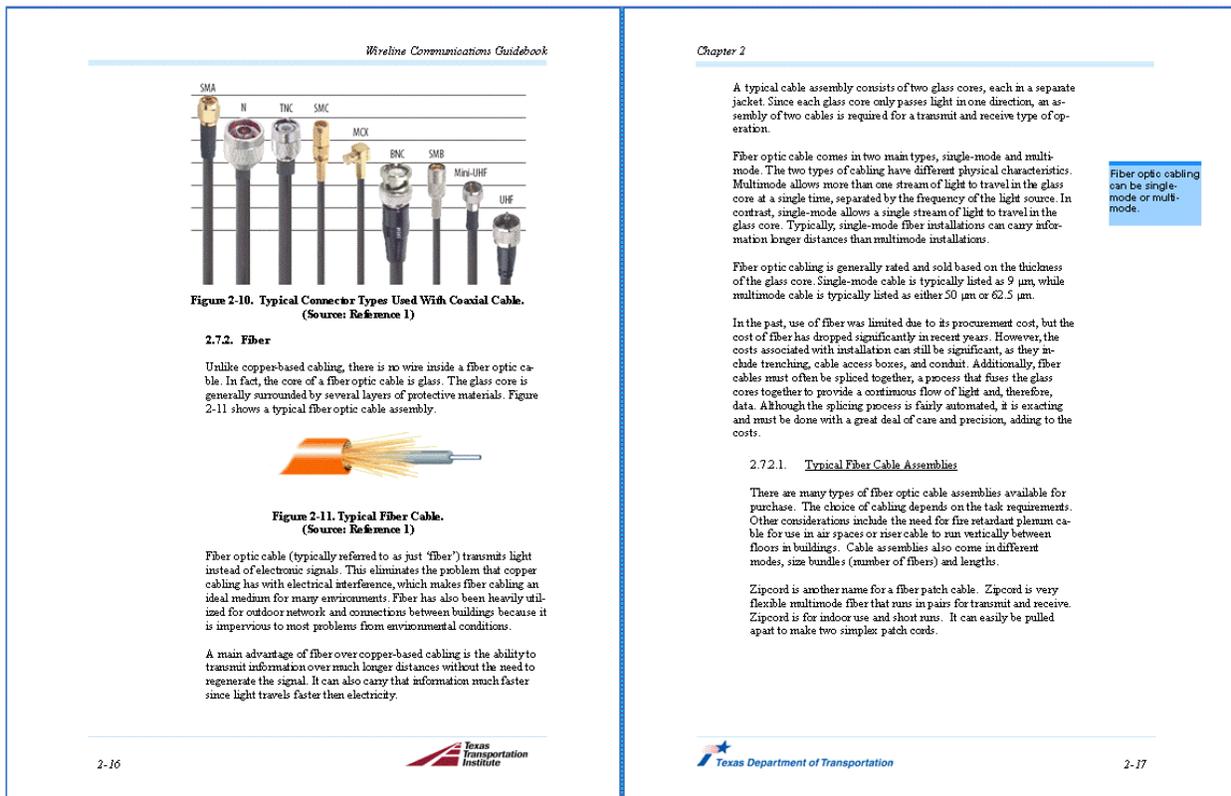


Figure 1. Sample Pages from Participant's Notebook.

It is anticipated that the participant's notebook will be a handy shelf reference for many aspects of designing communication systems and understanding communication fundamentals. For that reason, the document was written to have complete information in every major section, even if it is repeated from previous or similar sections.

### **PowerPoint® Slides**

The PowerPoint slides are the heart of the teaching materials prepared for this workshop. Some of the chapters from the participant's notebook were combined into teaching modules for course presentation. The following listing shows how the slide modules equate to chapters from the participant's notebook:

- Module 1 — Chapter 1
- Module 2 — Chapter 2
- Module 3 — Chapter 3
- Module 4 — Chapter 4
- Module 5 — Chapters 5 and 6
- Module 6 — Chapter 7

Chapter 8 is the glossary and is intended for reference, not formal presentation.

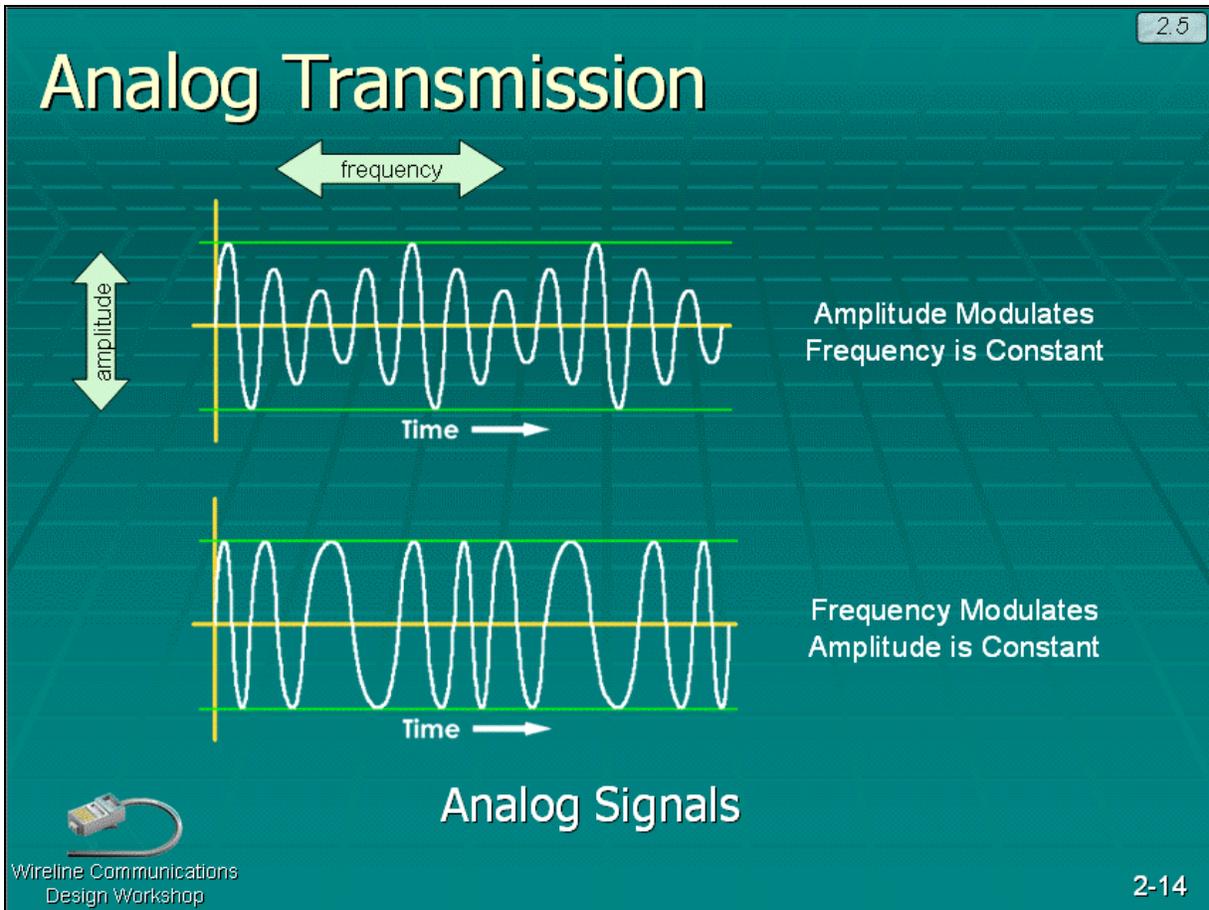
A set of learning objectives was created for each module that identifies the tasks that each participant should be able to accomplish at the end of the module. [Table 1](#) identifies the module learning objectives.

**Table 1. Module Learning Objectives.**

Module		Learning Objectives
1.	Introduction	N/A
2.	Basics of Wireline Communication	<ol style="list-style-type: none"> <li>1. Understand the basic concepts of communications.</li> <li>2. Recognize and be able to discuss the various media types and typical connectors.</li> <li>3. Understand the typical “units” associated with sending and receiving communications.</li> </ol>
3.	Understanding Telecommunication Protocols and Topologies	<ol style="list-style-type: none"> <li>1. Describe the basic traits of a protocol and the performance of some of the more commonly used protocols.</li> <li>2. Recognize and understand the differences between the types of network topologies.</li> <li>3. Understand special communication topics including spanning tree protocol, tunneling, video encoding, security, and hardened equipment.</li> </ol>
4.	Technology Choices	<ol style="list-style-type: none"> <li>1. Summarize the different types of communication technologies.</li> <li>2. Differentiate the costs and uses of each technology.</li> <li>3. Identify supported protocols for each technology.</li> </ol>
5.	System Design/Evaluation Methodologies	<ol style="list-style-type: none"> <li>1. Understand the components of the evaluation methodology for assessing communications alternatives.</li> <li>2. Use the methodology to arrive at a solution set.</li> <li>3. Evaluate the pros, cons, and constraints of the solution set.</li> </ol>
6.	Flow Charts, Case Studies, and Class Exercise	<ol style="list-style-type: none"> <li>1. Apply the methodology to case studies.</li> <li>2. Apply the methodology to real-world applications.</li> </ol>

Each module is composed of individual PowerPoint slides. Each slide was designed to convey a discrete unit of information and build upon the previous slide. In many cases, slides have been created that are interactive, to help elicit class interaction with the instructor.

A typical PowerPoint slide is shown in [Figure 2](#). Each slide is branded with the name of the workshop and a page number to help the instructor keep track of the progress of the class materials.

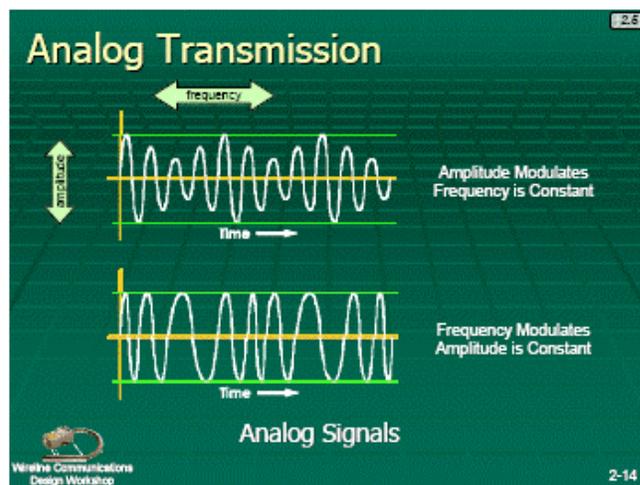


**Figure 2. Typical PowerPoint Slide Used for Workshop Instruction.**

### **Instructor's Notebook**

The instructor's notebook for this workshop was designed to be an easy reference guide for the workshop instructor. The front matter of the instructor's notebook details the objectives of the learning modules and the typical workshop agenda. The primary use of the instructor's notebook, however, is to convey pertinent information related to each slide used during the course.

This information is relayed through the use of instructor's notes entered on slide pages. Each note has a standard format that includes the headings Key Message, Details, Key Questions, and Other Information. [Figure 3](#) shows a typical page from the instructor's notebook.

**Key Message:**

In communications, information is either digital or analog.

**Details:**

Analog signals can take on any value.

**Key Questions:**

**Ask** if anyone knows the difference between the two analog signals at the top of the page.

**Answer:**

The top signal is amplitude modulation (AM). The amplitude (height of wave) changes, but the frequency (width of wave) does not.

The bottom signal is frequency modulation (FM). The frequency changes, but the amplitude does not.

**Other Information:**

The frequency and amplitude arrows build on mouse clicks.

**Figure 3. Typical Instructor's Note Page.**

## Workshop Agenda

The workshop was designed to be taught in approximately eight hours. Not every topic can be discussed in detail. It is important to remember that the participant's notebook was also written to be a shelf reference. Figure 4 shows the course outline and agenda along with suggested timeframes. The instructor should note the break times since these will decrease the amount of time available to teach course material.

<b>Wireline Communications Design Workshop</b>	
<b>Course Outline</b>	
8:00 – 8:15	<b>Welcome</b> Introductions Review course objectives
8:15 – 9:15	<b>Basics of wireline communications</b> A brief history Analog and digital Wireline media
9:15 – 11:45	<b>Understanding telecommunication protocols and topologies</b> What is a protocol? Common protocols Topologies Video compression Other topics
11:45 – 1:00	<b>Lunch break</b>
1:00 – 2:00	<b>Technology choices</b> Considerations Costs Supported protocols Cross-tabulation summaries
2:00 – 3:00	<b>System design and evaluation</b> Determining bandwidth needs Determining distance limitations Cost constraints System evaluation components
3:00 – 3:30	<b>Flow charts</b> Overview of design and evaluation process
3:30 – 4:15	<b>Case studies and class exercises</b> Design Evaluation
4:15 – 4:30	<b>Workshop review / questions</b>

There will be two short breaks in both the morning and afternoon.

**Figure 4. Wireline Communications Design Workshop — Course Outline and Agenda.**

## Equipment Requirements

Workshop presentations will be delivered primarily through computerized slides projected by a liquid crystal display (LCD) projector, or equivalent, plus flipcharts and wall charts. The following equipment is needed for presenting the course materials:

- computer (LCD) projector with minimum 1024×768 resolution;
- large projection screen (7-ft width minimum);
- pointing device (electronic or mechanical);
- computer with at least 300 MHz CPU, 128 MB of RAM (256 if Windows XP is used), 100 MB hard-disk space available, and external mouse; and
- Microsoft PowerPoint 2000 or later.

## Locations

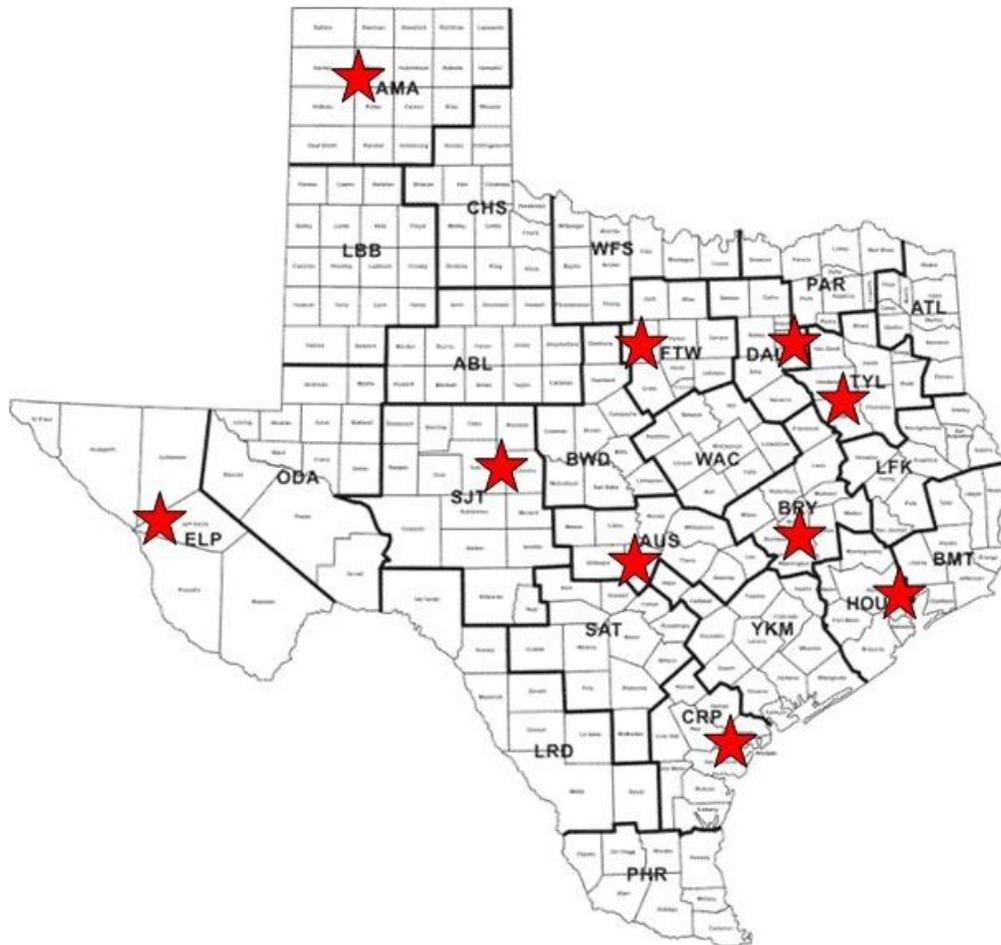
The implementation contract called for the conduct of 10 courses. The first course was to be used as a pilot of the expanded materials since the format went from four hours to eight hours of classroom instruction. The other courses were taught at various locations around the state, as determined by the implementation project team in Task 4. [Table 2](#) details both the dates and the locations where the course was taught over the lifetime of the implementation project.

**Table 2. Locations of 5-4969-01 Courses.**

<b>Date</b>	<b>Location</b>
9/28/2006	TxDOT Traffic Operations, Cedar Park, Texas
11/14/2006	Bryan District
12/4/2006	El Paso District
2/13/2007	Houston District
2/27/2006	Amarillo District
3/7/2007	Corpus Christi District
3/20/2007	Fort Worth District
3/21/2007	Dallas District
4/11/2007	Tyler District
6/26/2007	San Angelo District

The course locations represent a varied cross section of TxDOT districts. In some locations, traffic management centers (TMCs) are just emerging, as ITS projects are deployed. In other locations, TMCs and ITS have been a staple of TxDOT's services for many years. Regardless of the location, the intent of the course was to provide engineers with a consistent methodology for evaluating and selecting communication technologies for use within ITS deployments.

Figure 5 shows a graphical view of the course locations across the state. While it is evident that the course was not taught in each TxDOT district, neighboring districts would often travel to a nearby site to partake in the course.



**Figure 5. 5-4969-01 Course Locations.**

## Workshop Results

Attendees at the workshop were asked to fill out evaluations to provide feedback to the instructors about the quality of the workshop and the materials, as well as future training needs. The first, or overall, evaluation focused on the workshop as a whole, including objectives, teaching, quality, etc. The second, or module, evaluation focused specifically on the participant's notebook and asked respondents to rate the quality of each section, or module.

### *Overall Evaluation*

The first evaluation form asked participants to answer seven general questions pertaining to the workshop. The questions, presented below, were rated on a scale of 1 to 3, with 1 representing "Yes," 2 representing "Somewhat," and 3 representing "No."

Table 3 shows the results of this evaluation. The 109 participants filled out the overall evaluation. The results show that the workshop was very well received, met the objectives, and communicated information to participants in a clear, concise, and informative manner.

**Table 3. Results of Overall Workshop Evaluation.**

Question	Score
1. Did the workshop meet your expectations?	1.21
2. Did the workshop description match the subject matter presented?	1.15
3. Were the workshop objectives met?	1.06
4. Was the workshop presented at the correct level of difficulty?	1.19
5. Was the information presented in an informative manner?	1.04
6. Was the overall quality and usefulness of the materials (e.g., written materials, videos, etc.) appropriately geared to providing that information?	1.12
7. Do you feel that the time spent on this course was beneficial?	1.23

### *Module Evaluation*

The second evaluation form asked participants to rate the quality and effectiveness of the workshop modules. Each module was rated on a scale of 1 to 5, with 1 representing "Very Good," 2 representing "Good," 3 representing "Average," 4 representing "Poor," and 5 representing "Very Poor."

Table 4 shows the results of the evaluation. Note that Table 4 does not include a line item for the introductory materials in Module 1. The results clearly show the materials were well received and that participants rated the overall quality and information transferred with very high scores.

**Table 4. Results of Workshop Module Evaluation.**

<b>Module</b>	<b>Score</b>
Basics of Wireline Communication	1.52
Understanding Telecommunication Protocols and Topologies	1.57
Technology Choices	1.54
System Design/Evaluation Methodologies	1.66
Flow Charts, Case Studies, and Class Exercise	1.67

*Additional Comments*

Throughout the workshops, participants had the opportunity to provide comments on the evaluation forms, outside of the answers to the specific questions detailed in the prior sections. The vast majority of these comments related to the need for additional training ideas. Some comments also suggested clarification points or additional topics for coverage in the course materials. While all of the comments could not be addressed given the constraints of time and funding, the final deliverables of the project were enhanced with several additional clarifications or technical details based on participant comments.

**TASK 7 — DOCUMENT FY07 ACTIVITIES**

This report serves as the documentation of FY07 activities.

**TASK 8 — PROVIDE TXDOT WITH WORKSHOP MATERIALS**

The final versions of all workshop materials were provided to TxDOT on a CD-ROM. Figure 6 shows a picture of the CD-ROM cover. The CD-ROM was formatted to play in any standard computer with no additional hardware or software necessary.

Manuals were provided to TxDOT in portable document format (PDF) with a single file containing a printable cover, a printable spine for use with a three-ring binder, and the technical materials for the notebook.



**Figure 6. CD-ROM Containing 5-4969-01 Workshop Materials.**

The CD-ROM contains three directories as follows:

- Instructor's\_Notebook — contains a PDF assembly of the instructor's notebook,
- Participant's\_Notebook — contains a PDF assembly of the participant's notebook, and
- PowerPoint\_Slides — contains all the PowerPoint slide modules and supporting materials for course instruction.

The CD-ROM also contains the technical report document page (TRDP), which covers the entire deliverable.