



**IDEA**

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**Innovations Deserving  
Exploratory Analysis Programs**

*Transit IDEA Program*

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## **Development of Electrical Maintenance Training Module for Bus Transit Technicians**

Final Report for  
Transit IDEA Project 62

Prepared by:  
Robert H. Mann  
CDX Global  
Jones and Bartlett Learning  
Sudbury, Massachusetts

*June 2013*

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**TRANSPORTATION RESEARCH BOARD**  
*OF THE NATIONAL ACADEMIES*

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This IDEA project was funded by the Transit IDEA Program.

The TRB currently manages the following three IDEA programs:

- NCHRP IDEA Program, which focuses on advances in the design, construction, and maintenance of highway systems, is funded by American Association of State Highway and Transportation Officials (AASHTO) as part of the National Cooperative Highway Research Program (NCHRP).
- Safety IDEA Program, which focuses on innovative approaches for improving railroad safety and performance. The Safety IDEA program is funded by the Federal Railroad Administration (FRA).
- The Transit IDEA Program, which supports development and testing of innovative concepts and methods for advancing transit practice, is funded by the Federal Transit Administration (FTA) as part of the Transit Cooperative Research Program (TCRP).

Management of the three IDEA programs is coordinated to promote the development and testing of innovative concepts, methods, and technologies.

For information on the IDEA programs, check the IDEA website ([www.trb.org/idea](http://www.trb.org/idea)). For questions, contact the IDEA programs office by telephone at (202) 334-3310.

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National Research Council

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- Kevin Jesser and Ian Andrew, Subject Matter Experts, Jones and Bartlett Learning

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## **Executive Summary**

This project developed an internet-based electrical training module for transit technicians to meet a growing demand for increased understanding of modern transit bus electrical systems.

The mass transit bus industry is undergoing rapid technological changes that focus on alternative fuel technologies and complex electrical systems. Diesel-electric hybrid buses, for example, are becoming increasingly common in bus fleets. The new buses have electrical systems that are often unfamiliar to technicians who are employed from other industries, such as automotive or heavy vehicle or equipment trades.

There is also little bus-specific training going on in trade schools and community colleges in the US, so transit maintenance training managers have to rely on manufacturer-specific service information taught on the job, leaving a gap in fundamental knowledge of how multiplexing bus electrical systems work. Transit managers and mechanics, working with the American Public Transportation Association (APTA) Bus Maintenance Training Committee (BMTTC), have identified the knowledge of modern bus electrical systems as critical to plugging the technician job skills gap.

The current Occupational Outlook Handbook prepared by the US Department of Labor, Bureau of Labor Statistics, confirms the need for a strong background in electronics for diesel technicians, as indicated by the following quote from the Handbook:

*Diesel maintenance is becoming increasingly complex, as more electronic components are used to control the operation of an engine. For example, microprocessors now regulate and manage fuel injection and engine timing, increasing the engine's efficiency. Also, new emissions standards may require mechanics to retrofit engines with emissions control systems, such as emission filters and catalysts, to comply with pollution regulations. In modern maintenance shops, diesel service technicians use hand-held or laptop computers to diagnose problems and adjust engine functions.*

The knowledge gap for bus maintenance technicians centers on the fundamental understanding of how to integrate multiplexing electrical systems with ladder logic and electrical schematics to troubleshoot and repair electrical faults. During a series of meetings, transit agency maintenance

managers agreed that many transit service technicians could benefit from an enhanced understanding of these concepts and that the industry needed a broad electrical training program. In this project, CDX Global worked closely with APTA's Bus Maintenance Training Committee members to incorporate their ideas in content and design of the training module that was developed in this project.

After consulting extensively with transit training managers, a course was designed that resulted in the creation of the training module titled "CDX Bus: Modern Electrical Systems."

CDX adapted its pedagogical model of "Know-See-Do-Prove" to the bus transit industry because of its successful application in the automotive industry.

That model takes into account the learning styles of technicians in a blended learning approach where theoretical concepts are explained in computer-based courses and then matched with hands-on training. This approach successfully accelerates retention of principles and concepts, and lays the groundwork for more specific manufacturer training.

Following an extensive worldwide review by maintenance training managers and technicians, "CDX Bus: Modern Electrical Systems" is now available through the Jones and Bartlett Learning website on a yearly subscription basis with redeemable access codes.

The user interface for the course is designed to be straightforward and easy to navigate because most technicians will be accessing this material from work. It can also be updated quickly with any changes from stakeholders, making it ideal for keeping up with new technologies.

Jones and Bartlett Learning is now in the process of marketing the availability of this course through transit agencies, including the SCR TTC (Southern California Regional Transit Training Consortium, <http://www.scrttc.com/>.) Jones and Bartlett is working with SCR TTC on a formal distribution agreement to make the CDX bus electrical course available to its twelve member transit agencies. The course is also being reviewed by Veolia Transportation.



## IDEA Product, Concept, Investigation and Implementation

### IDEA Product

The product that was developed in this project is a stand-alone electrical course delivered on the internet. The completed course introduction page is shown in Figure 1 below.

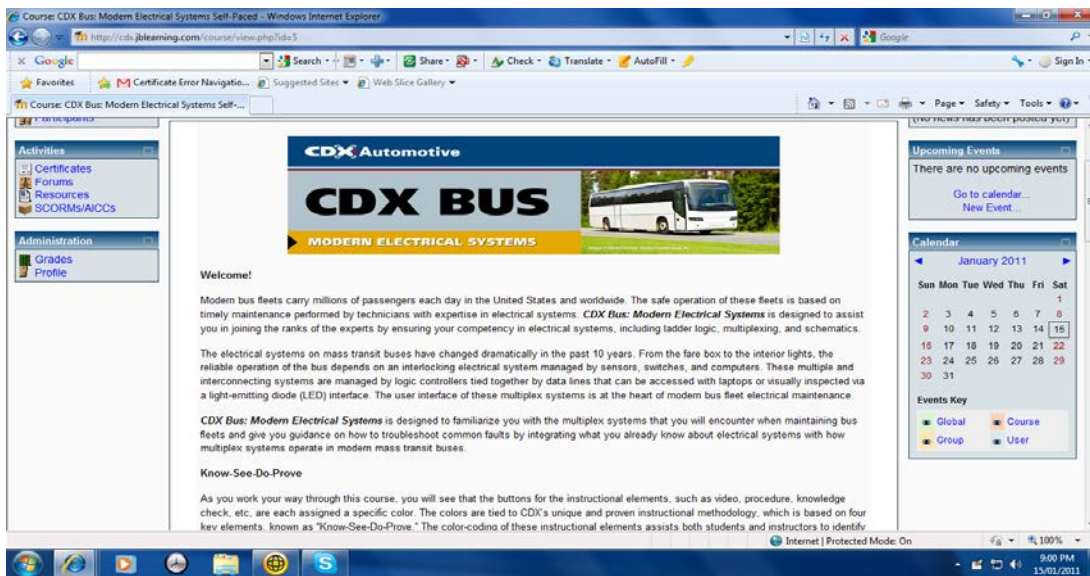


Figure 1: Completed Course Introduction Page

This product is available to all transit agencies in order to facilitate on-the-job training. The product could be used for home study. In the U.S., it will have particular application for those technicians wanting to study for the Automotive Service Excellence (ASE) electrical exam for bus technicians. The product will also be particularly useful to smaller transit agencies that do not have access to a training department.

## Concept and Innovation

The concept of this product is based around evidence that technicians learn better and faster when using highly visual training materials in the reinforced pedagogical model of Know-See-Do-Prove (Figure 2). “Know” equates to theories or concepts, “See” is the practical workshop applications of that theory, and “Do” and “Prove” are the assessment tools.

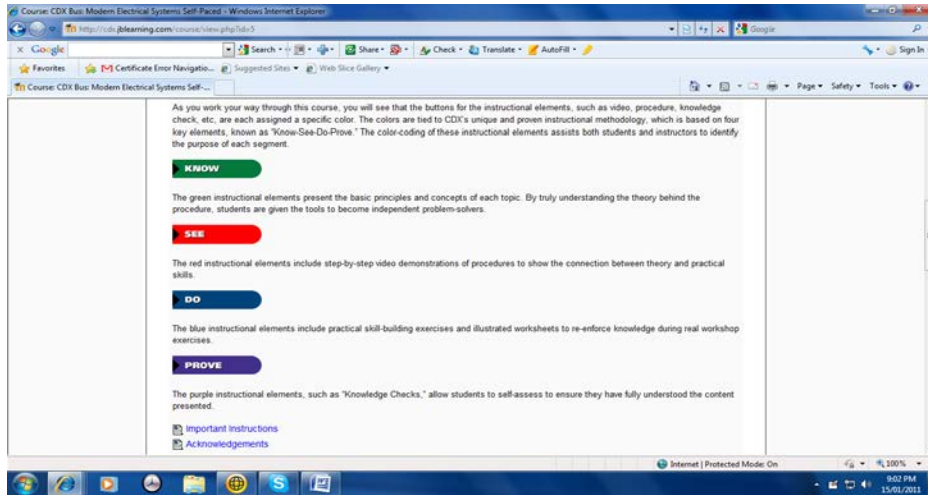


Figure 2: Know-See-Do-Prove Instructional Model

For this project, CDX has employed a series of short videos, interactive reinforcing activities, and online testing to give technicians the tools to learn where time is of the essence (Figures 3 and 4).

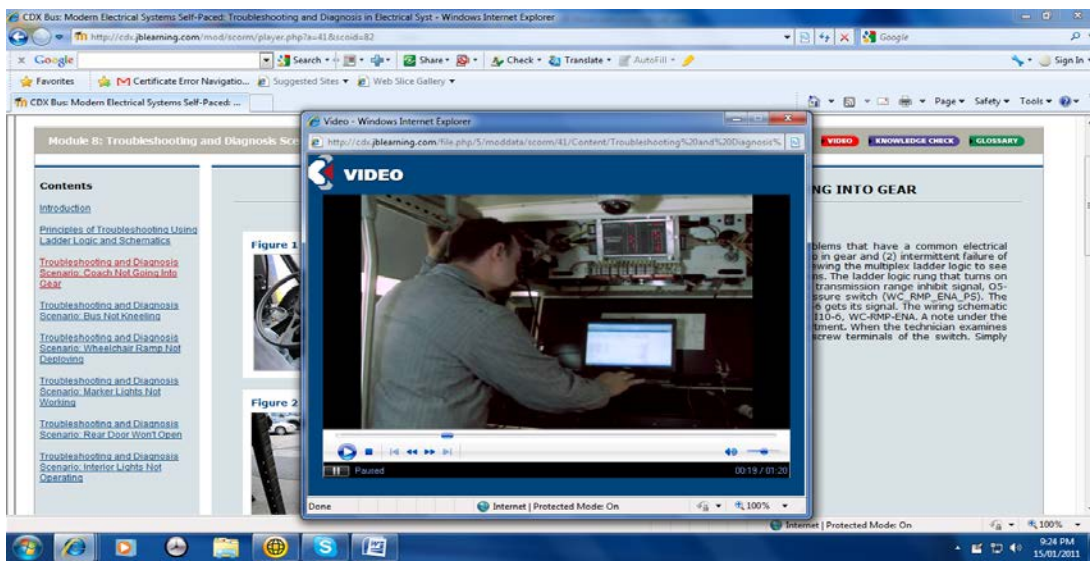
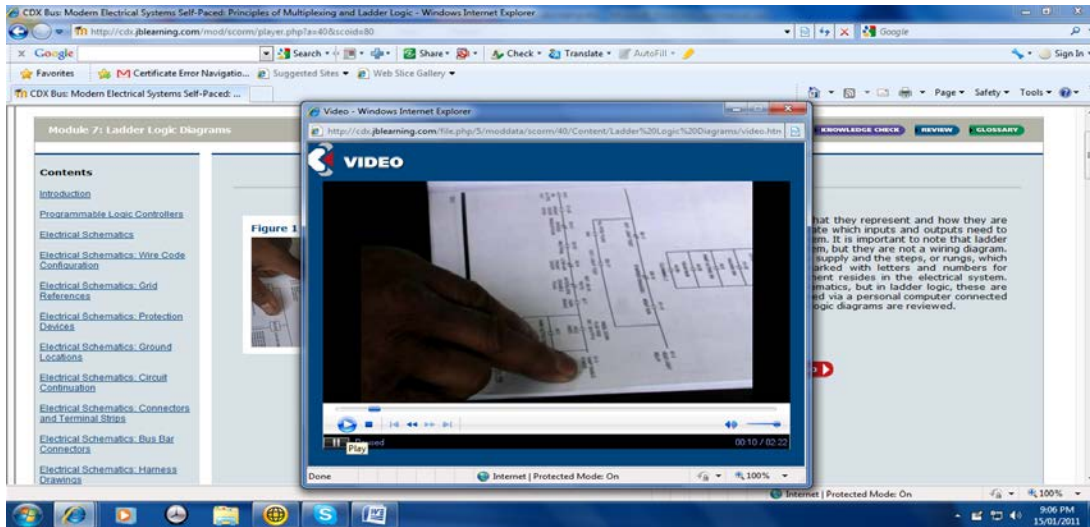
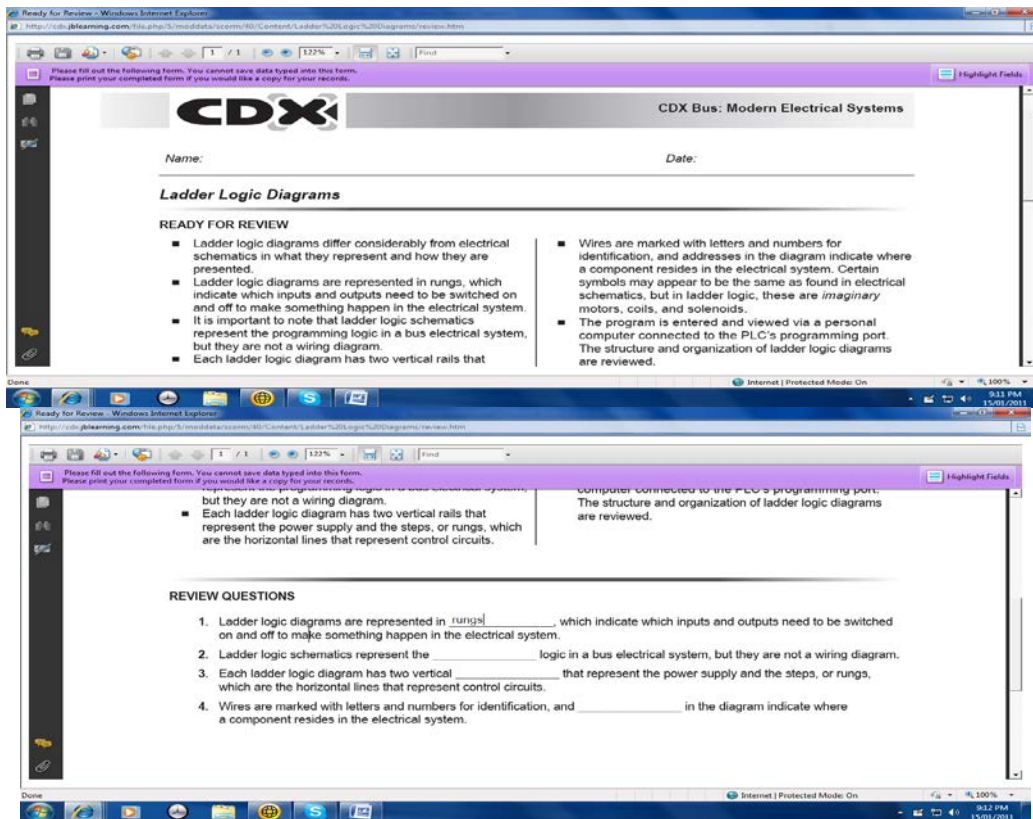


Figure 3: Example of Video from Multiplexing Topic

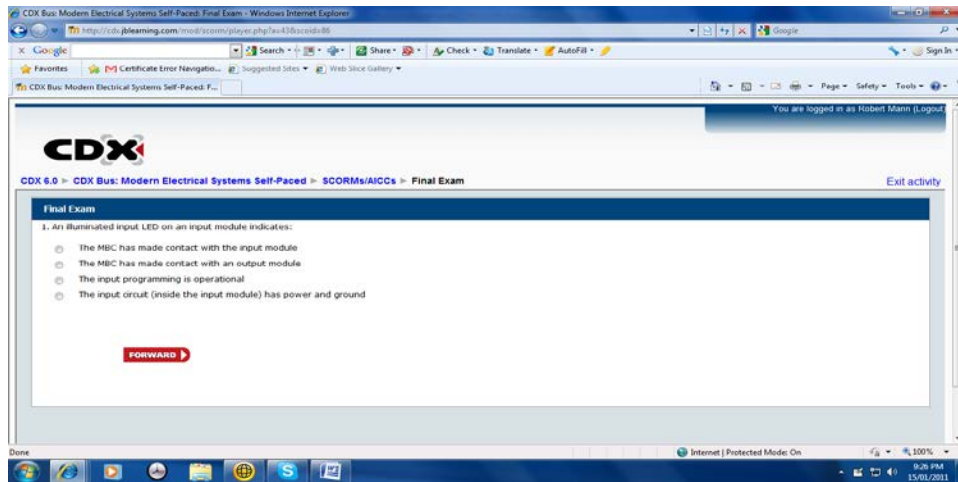


**Figure 4: Example of Video from Ladder Logic Topic**

Each video is followed by a reinforcing interactive self-test, such as the fill-in-the-blank missing word problem, and randomized test banks that must be passed before a course completion certificate is issued (Figures 5 and 6).



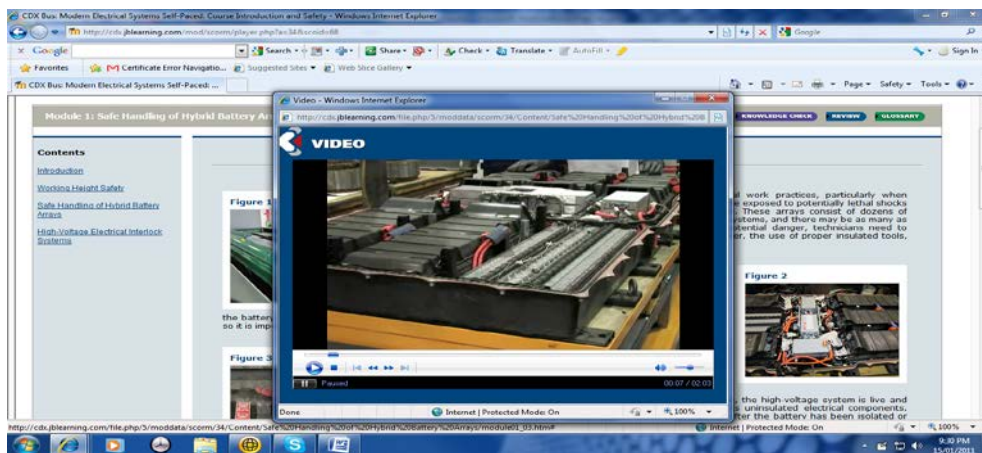
**Figure 5: Fill-in-the-Blank Interactive Review**



**Figure 6: Randomized Final Test Question**

The innovation of this program is twofold: the design concept of the training materials and the dynamic delivery platform.

First, CDX has employed digital production technology to create content that can be changed very quickly. By combining digital still images (Figure 7) with digital video, the company can literally make adjustments to content within a matter of hours.



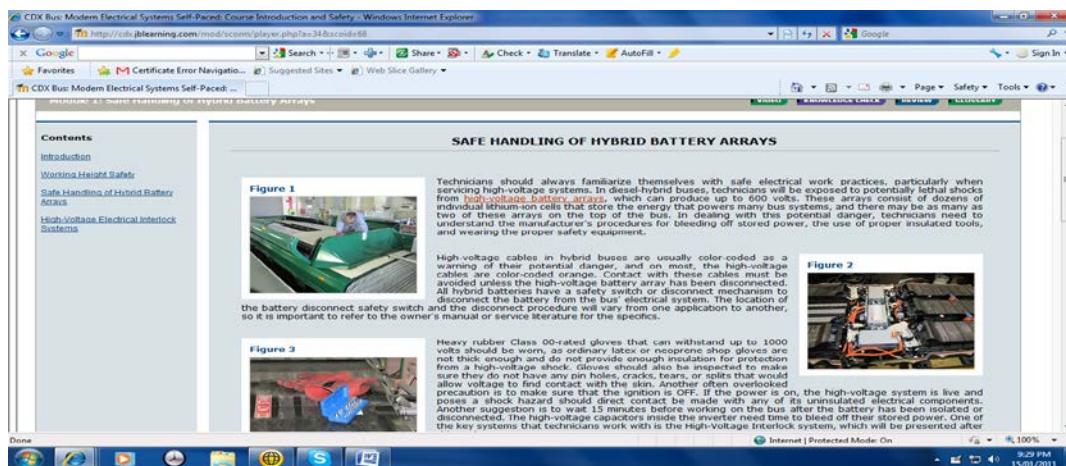
**Figure 7: Digital Still of Hybrid Battery Array Used in Video**

The second innovation is the building of the course inside a dynamic internet platform called Moodle. Moodle is a free, off-the-shelf Learning Management System that allows courseware authors to effectively create custom content and integrate existing training materials from transit

agencies. Moodle also has tracking, testing, and reporting functionality that can be customized to each transit agency to meet their technician training needs.

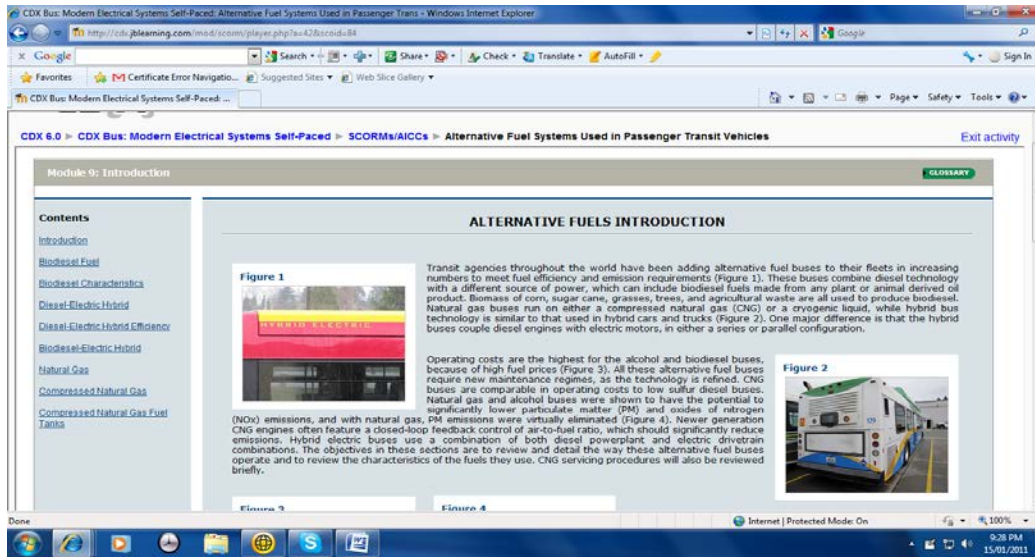
This second innovation is important, since technologies in the mass transit industry change rapidly and the workforce involving in maintaining equipment needs to be familiar with those changes. This just-in-time digital production is a critical component to technological changes, particularly since transit managers generally do not have the time or resources to create their own training materials.

For example, CDX provides the background information about the safe handling of hybrid battery arrays (Figure 8), which can be supplemented with information from specific diesel-hybrid manufacturers.



**Figure 8: Safe Handling of Hybrid Battery Arrays**

The other benefit of this just-in-time publishing can be found in the course's Alternative Fuel section, where course authors were able to include information on bio-diesel and electric-hybrid buses within two days of visiting a site in Colorado where those alternative fuel buses were in daily operation (Figure 9). This kind of flexibility is not available on more traditional forms of published training materials.



**Figure 9: Alternative Fuels Topic Area**

### *Investigation*

This project resulted from initial meetings with the APTA Bus Maintenance Training Committee (BMTTC). CDX attended three of those meetings in Pittsburgh, San Diego and Chicago, and also worked closely with individual training managers at King County Metro, Pierce Transit, and Santa Clara Valley Transportation Authority, California on content development and scope.

The development of this product continues to rely on the direct participation of transit agencies in getting the word out about the availability of this course and defining the way it is implemented on a local level.

Stage 1 involved the production work necessary to complete the learning module, including completion of the following tasks:

- Filming of new material,
- Scripting of new material,
- Editing of new material,
- Designing of delivery system,
- Designing of test bank, and
- Creating navigation documentation.

### Filming and Still photography

More than 240 minutes of raw video footage and approximately 1,200 still images were collected at three transit agencies: King County Metro, Pierce County Transit, and Santa Clara Valley Transit Authority.

King County has a fleet of diesel hybrid-electric buses that is one of the most modern in the US and has advanced electronics to maintain those vehicles. Pierce Transit runs a fleet of CNG buses and has been an excellent source of information on operating those fleets. Valley Transit Authority in Santa Clara, California, has a very good training facility to teach ladder logic and multiplexing.

The end result of working with these transit agencies has been the collection of current technical material that can be shared by agencies throughout the country.

Draft scripts were completed before the filming began and were revised as the filming progressed. This process proved invaluable because the content could be altered to reflect details that may have been omitted during the initial scripting process. New material was added to the program based on the script revisions made during the filming, resulting in a more current and accurate program for industry stakeholders.

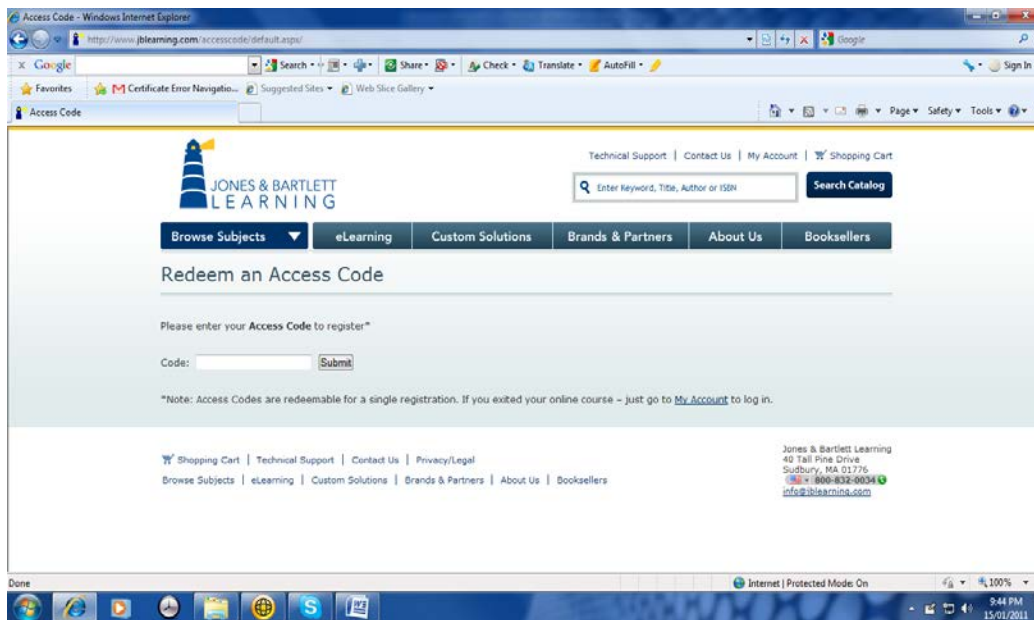
The draft scripts were reviewed by training staff of the Chicago Transit Authority, Southeastern Pennsylvania Transportation Authority (SEPTA), Santa Clara Valley Transit Authority, and King County Metro before the filming began, and also by subject matter experts from Jones and Bartlett Learning.

### Designing of Delivery System

Stakeholders were given two months to review the course and report their feedback via email. The reviewers accessed the course through the Jones and Bartlett development site, which presented some challenges with streaming video and limited bandwidth at transit agency sites. Stage 1 of this project resulted in the release of the first version of the module for review.

A review opportunity arose when CDX was contacted by the Southern California Regional Transit Training Consortium (SCR TTC). SCR TTC has twelve transit agency members from the greater southern California region.

Key transit managers in the SCR TTC were given the opportunity to review the CDX training module and provide feedback.



**Figure x: Course Entry Page on Jones and Bartlett Website**

### *Plans for Implementation*

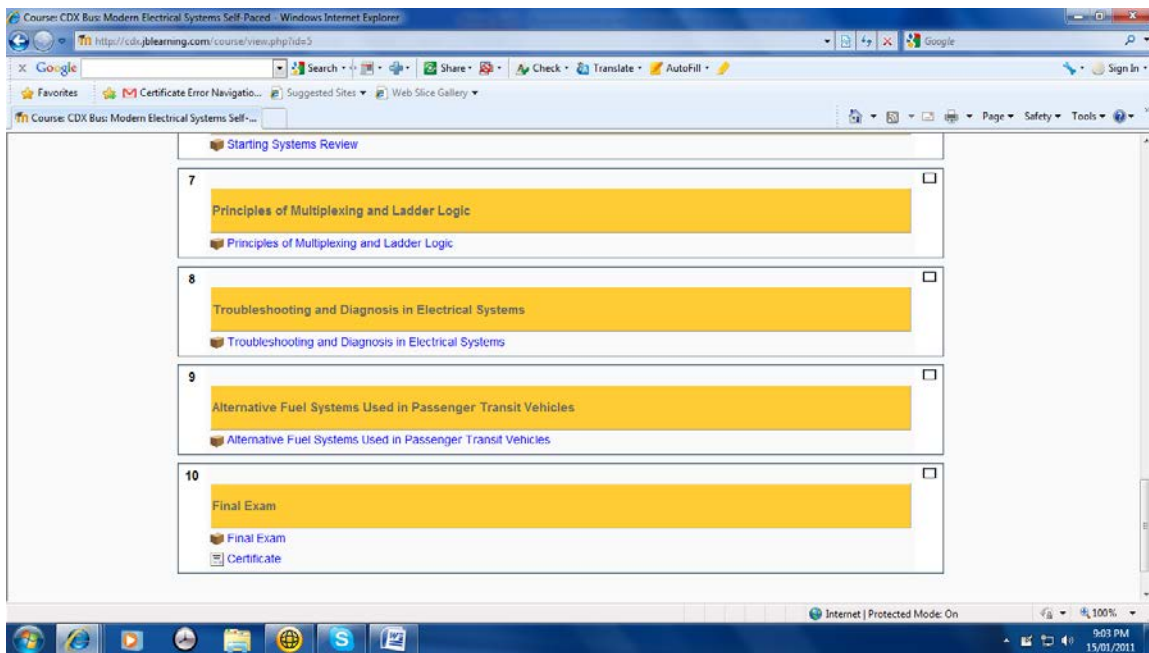
The first stage of the implementation plan is complete. Members of the Expert Review Panel for this project were given logons and provided the principal investigator with feedback on the program from the following viewpoints:

- Technical content accuracy
- Does it work? Can you see and hear the videos? Do they stream properly? Do the Knowledge Checks and DVOM simulations work?
- Content usefulness for technicians



- Test questions (Accuracy, testing the right things?)
- Flow of the course
- Overall impression to meet industry demands

A number of changes were made to the final product to make it easier to use, including putting the content into a book format in the Moodle delivery platform. Ease of navigation was the motivation for that redesign. Users can drill into the content through a series of sequential links that start with the book module (Figure 10), proceeding to the table of contents links (Figure 11), and then end with individual topics with forward and back buttons (Figure 12).



**Figure 10: Moodle Book Format**

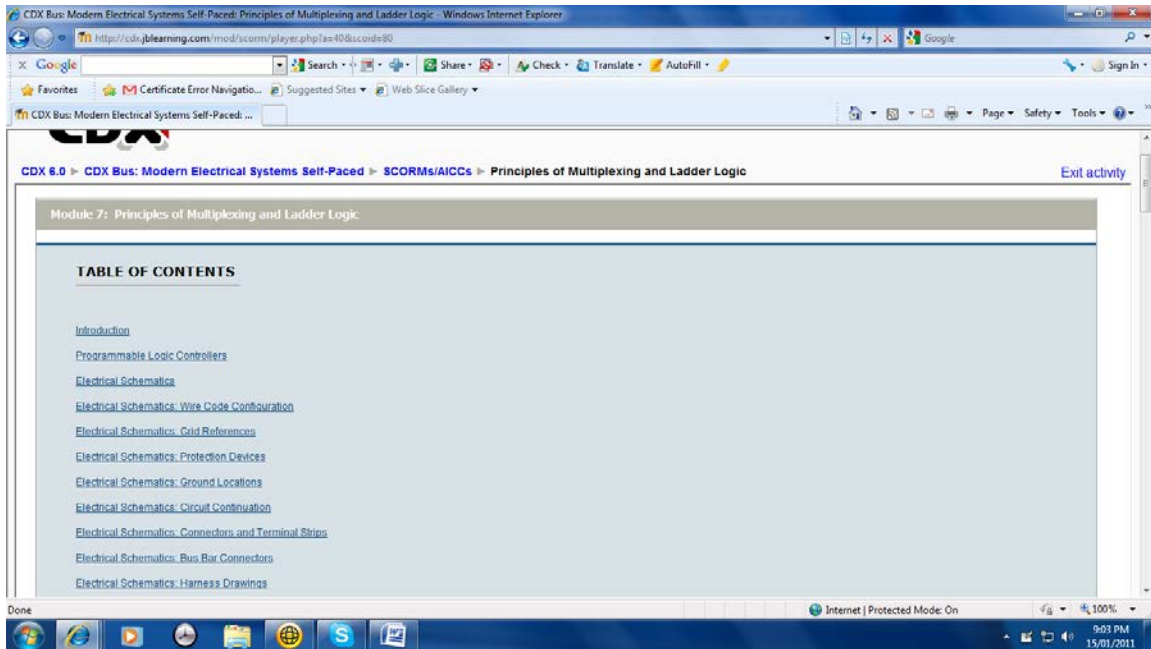
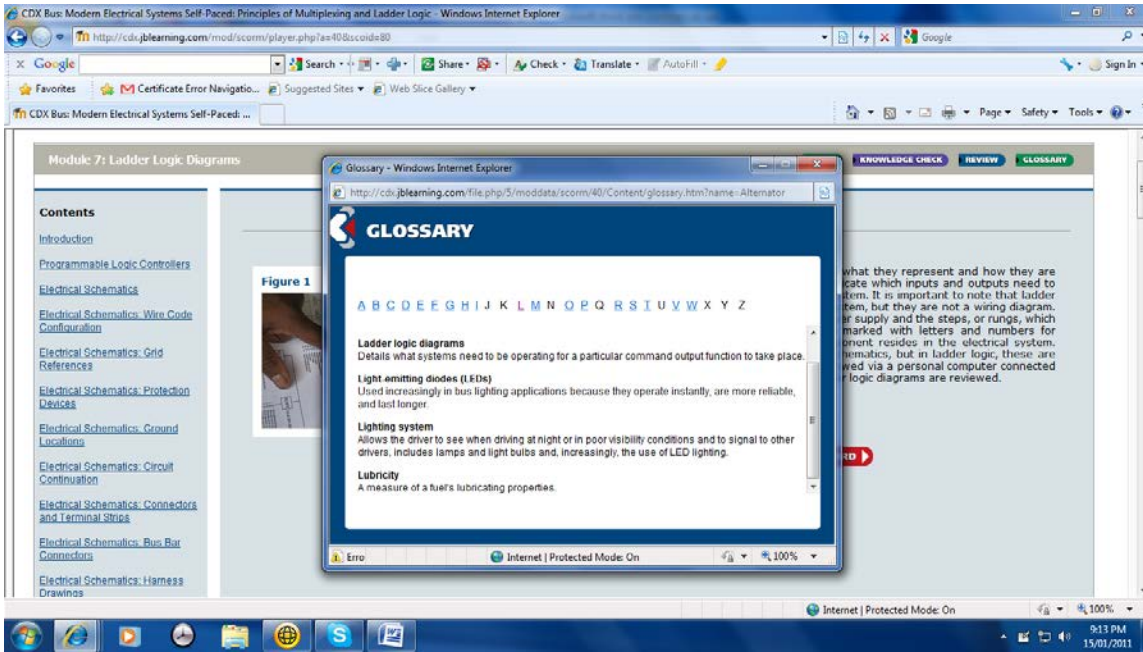


Figure 11: Table of Contents Links



Figure 12: Topic Links with Forward and Back Buttons and Drop-Down Fast Links

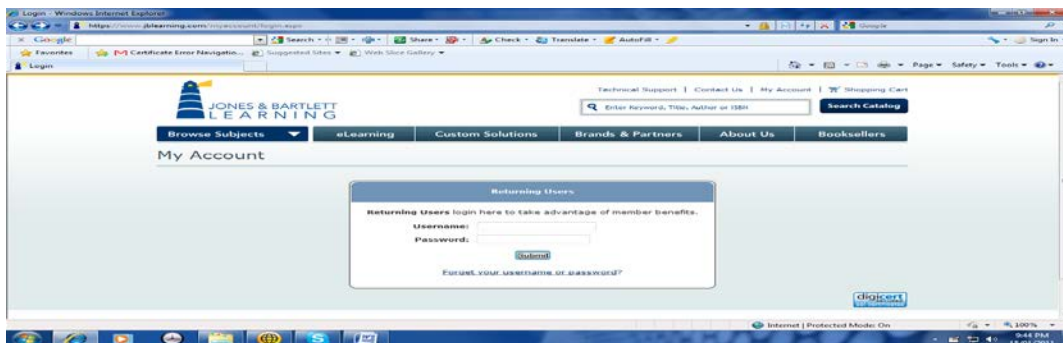
A glossary was also added to the course content to familiarize technicians with acronyms that may not be familiar (Figure 13, below).



**Figure 13: Glossary of Terms**

The overall impression of the program is that it is an excellent bridging tool for technicians who are entering the bus transit technician field. This would include technicians from other trades, as well as students graduating from community college programs who are not receiving transit specific training. It would also be useful as introductory course for technicians wanting to learn the principles and concepts required to work on modern bus electrical systems before going into manufacturer-specific training.

In order to facilitate access to the final course, Jones and Bartlett Learning have made the course accessible through their web portal through a redeemable access code (Figure 14).



**Figure 14: Jones and Bartlett Logon Page for CDX Bus Electrical Course**

In terms of distribution, CDX is in discussions with the SCR TTC to distribute the CDX course to its members. CDX continues to work with transit agencies to promote the availability of the course.

## **Conclusions**

Training is a top priority for the bus transit industry. The incorporation of internet-based training into a standard training regime at many transit systems is relatively new. This is particularly true for smaller transit agencies that do not have access to an in-house training department.

Electrical systems training is a priority for transit agencies that are relying on alternative fuel technologies to meet federal and state low emissions requirements. While these electrical systems vary depending on the manufacturer, there is a general foundation of knowledge that can be communicated.

The training module is now available for transit agencies to use.

## **Principal Investigator Profile**

Robert H. Mann was the Principal Investigator for this Transit IDEA project. Mr. Mann worked for CDX Global from the start of this project. CDX Global was acquired by Jones and Bartlett Learning during the course of the project. Mr. Mann is Global Business Development Manager at Jones and Bartlett Learning.

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## **Glossary**

APTA - American Public Transportation Association

BMTC - Bus Maintenance Training Committee

SCRRTC- Southern California Regional Transit Training Consortium

Ladder Logic - Electrical diagram representing engineering behind electrical systems on buses.

Multiplexing - Computer networks on bus that centralize operation of bus electrical systems.