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US DOT OST-R Tier 1 University Transportation Center

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Continuing Education for the Railway Industry

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DISCLAIMER

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TECHNICAL SUMMARY

Title

Continuing Education for the Railway Industry

Introduction

Workforce development is a critical issue in the railway industry, particularly for small railroad companies and industrial (plant) railroads. Turnover in a rapidly aging workforce threatens to degrade relevant expertise in the railroad industry. New railroad hires often have little knowledge of proper practices, and the opportunity for learning by working alongside experienced workers is decreasing. Recognizing these issues, a small number of U.S. universities and community colleges offer rail related continuing education. The University of Tennessee, Knoxville (UTK) is one such institution.

Description of Activities

The UTK Center for Transportation Research (UTK-CTR) offers a series of instructor led continuing education courses on railway topics. Current courses address track inspection (three classes), bridge Inspection (two classes), track design (one class), and track maintenance (one class). The intended class audience includes railroads (Class I, Class II, Class III, tourist, industrial), public transportation agencies (federal, state, local), regulators (federal, state), consultants, suppliers, educators, trade associations, and persons wanting to enter the railroad industry. In general, courses are instructor led in a classroom setting. Courses consist of a mixture of lectures, classroom exercises, and hands-on field exercises. Instructors are typically qualified university faculty members or retired subject matter experts. They present the course in a standard fashion following the prepared content package. Some courses include short topical lectures by invited speakers.

Outcomes

Between January 1, 2015 and December 31, 2019, UTK-CTR conducted 101 railroad continuing education courses, producing 30,263 contact hours of instruction. The courses included a mix of open-enrollment courses and custom courses for specific organizations. Course durations ranged from one half day to four and a half days.

During the grant, UTK-CTR developed two new courses—*Railroad Track Design* and *Railroad Track Maintenance*—and enhanced the content of others. Courses constituting safety related training under 49 CFR Part 234 have been submitted to the Federal Railroad Administration for review and approval.

Conclusions and Recommendations

The industry has supported the courses avidly, validating the original premise for their creation. Attendee evaluations of the courses have been overwhelmingly positive. Demand for courses has been

sufficient that the program is self-sustaining financially. Course feedback indicates a desire for additional classes covering rolling stock, communications, and signals

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SECTION 1: OVERVIEW

Turnover in a rapidly aging workforce threatens to degrade relevant expertise in the railroad industry. New railroad hires often have little knowledge of proper practices, and the opportunity for learning by working alongside experienced workers is decreasing.

With their large employee population, Class I railroads can justify internal training programs for many needs. Norfolk Southern Corporation, for example, has a corporate technical training center at McDonough, GA and Canadian National Railway operates a similar center at Homewood, IL. BNSF Railway conducts technical training in partnership with Johnson County Community College in Overland Park, KS. However, the smaller Class II and III railroads, public agencies, rail served industries, and transit railroads must generally look to external sources for workforce training and continuing education. Maintaining an internal training department is often not practical for such organizations.

Recognizing this need, a small number of U.S. universities and community colleges offer rail related continuing education. The University of Tennessee, Knoxville (UTK), a NURail member institution, is one such institution. Other four-year universities offering railroad continuing education include the University of Wisconsin-Madison, the University of Illinois at Urbana-Champaign (UIUC), the University of Delaware, and Michigan State University.

UTK's continuing education activity offers an excellent opportunity to introduce results of NURail research to practitioners. For example, crosstie related projects at UIUC, UTK, and the University of Kentucky (UK) are highly relevant to railroad track design, maintenance, and inspection courses.

1.1 Background

UTK first offered continuing education courses in railway topics during the late 1970s. Railway network rationalization threatened many branch and secondary main lines with abandonment, raising interest in short line railroads as a means of preserving service. UTK courses addressed topics such as evaluating rail service viability and operating small railroads. While successful, the program faded in the mid-1980s due to changes in management and faculty.

In 1992, seeing continuing education as a critical industry need, then-Administrator Gil Carmichael of the Federal Railroad Administration (FRA) and Elaine King, Rail Staff Officer at the Transportation Research Board, encouraged UTK to resume offering railway related workshops. Conditions were right, and the program has continued since that time.

UTK's rail continuing education activity presently resides within its Center for Transportation Research (CTR). Founded in 1972, CTR is one of the oldest university-based transportation research organizations in the U.S. It supports the University of Tennessee's land grant mission by providing research, service, and education focused on transportation and logistics. CTR's education activity, of interest in this study, consists of several programs offering continuing education to professionals involved in rail transportation, highway design and operations, transportation planning, and law enforcement. This project supports the rail transportation program.

Continuing education course topic selection is based on knowledge of audience needs, recommendations from industry advisors, and attendee post-class evaluations. Subject matter experts

prepare original course content. Courses often include classroom and field exercises or site visits. Class duration ranges from one day to four and a half days.

1.2 Project objectives

The project objectives were threefold:

1. Develop two new railroad continuing education classes to enhance the curriculum,
2. Incorporate NURail research findings into existing and new classes, and
3. Provide class offerings to the target audience.

Under NURail, CTR specifically proposed to broaden the program by adding courses on rail infrastructure design and maintenance. Other courses received content reflecting NURail research findings, serving a technology transfer function to the center. Note that general course content was also enhanced throughout the five-year period.

SECTION 2: COURSE DEVELOPMENT

At the start of the period, CTR rail classes addressed track inspection (three classes) and railroad bridge inspection (two classes). Based on feedback from attendees and the opinions of instructors, there was a demand for classes in railroad track design and railroad track maintenance. The two classes would complement existing track inspection classes.

2.1 Railroad Track Design

The railroad track design class consists of 11 modules as shown in Table 1 below. The presentation time is two and a half days. The time specified for each module provides for presentation, discussion, exercises, and short breaks.

The course syllabus is a condensation of a semester long course on the same topic. The contents address all types of railroads—conventional intercity freight and passenger, light rail transit, heavy rail transit, and high-speed rail. The modules present design criteria and standards for all railroad types.

Table 1. Railroad Track Design Syllabus

	Module	**Duration (hrs.)**
1.	Introduction	0.75
2.	Design controls	1.25
3.	Route location	1.75
4.	Track systems	1.75
5.	Special trackwork	1.25
6.	Track mechanics	3.25
7.	Basic track geometric design	3.25
8.	Advanced track geometric design	2.5
9.	Drainage	1.5
10.	Structures	1.5
11.	Electrification	1.25
		20.0

Course materials consist of a set of PowerPoint® slides for each module. Each slide set provides a comprehensive outline of the module topic areas, similar to lecture notes in a college level course. The slides include key formulas, figures, and tables, along with application examples. References to design manuals point attendees to original sources for more comprehensive information. Attendees receive a copy of the presentation slides.

Generally, the course addresses North American practice. The general intercity freight and passenger railroad standards reflect American Railway Engineering and Maintenance-of-Way Association (AREMA) recommended practices, those of several Class I railroads, and track safety standards of the Federal Railroad Administration (FRA). Transit design criteria follow recommendations of the American Public Transportation Association (APTA), AREMA, the Transportation Research Board, and several U.S. transit properties. High-speed rail (HSR) standards reflect those of the California High-Speed Rail Authority and HSR operators in several Asian countries.

Modules 6-9 present detailed analysis and design procedures for the track structure and track alignment. The preceding modules deliver a foundation upon which design decisions can be based. Modules 10 and 11 provide an overview of the subjects, but do not contain detailed design procedures. Each of these could be the subject of a separate class. Following sections provide a brief description of each module.

2.1.1 Module 1: Introduction

This course module contains no actual content. During this time, the instructor introduces the class, provides an outline of the content to be covered, and presents overall learning objectives. Materials are provided to attendees. Class participants share their backgrounds and expectations for the class. The instructors provide their backgrounds to the participants.

2.1.2 Module 2: Design controls

The module presents key elements that control railroad infrastructure design. The various types of railways are presented with their key characteristics that influence infrastructure. These include train length, vehicle loads, clearance envelope, propulsion system, performance requirements, alignment characteristics, right-of-way requirements, access control, station/terminal spacing, and station/terminal characteristics. The module presents characteristics of typical rolling stock and trains for North American services.

The module also presents the relationships between track alignment, rolling stock, propulsion, and train performance. Methods for examining these relationships analytically are provided.

2.1.3 Module 3: Route location

The contents of this module address economic, environmental, commercial, and operating factors relating to the location of a railway line. It describes the various types of studies involved in the location process. A portion of the module addresses tools and data sources useful in location studies. The module also presents the fundamentals of economic analysis for route evaluation and comparison.

2.1.4 Module 4: Track systems

This module describes the construction and individual components of the two predominant track systems: ballasted crosstie track and ballastless track. It presents the advantages and disadvantages of

each system, and presents typical examples of application. Attendees are presented with options for individual components, along with differences in component design between different railway types. The module concludes with information on initial cost and maintenance costs for various track designs and components.

2.1.5 Module 5: Special trackwork

Turnouts, track crossings, and other special trackwork are much more complex than the basic track structure. They present a variety of options in component selection. This module discusses the various types and designs of special trackwork and trackwork components. Typical applications, along with the advantages and disadvantages of various component options are listed. This information will allow the attendee to make better design decisions.

2.1.6 Module 6: Track mechanics

Module 6 describes the structural behavior of the two major track systems. Typical models for determining deflection, bending, and shear are defined as functions of applied load, track structure, and position. For ballasted crosstie track, the module provides a complete design procedure that follows AREMA recommendations. The basic design approaches for ballastless track are presented at overview level.

2.1.7 Module 7: Basic track geometric design

This module presents the fundamental concepts behind the centerline location of the track horizontal and vertical alignment. The presentation comprehensively addresses the theory of horizontal curves and spirals, along with their impacts on railroad operations. Vertical alignment design addresses the effects of grades and the selection of vertical curves. Attendees are presented with design criteria and examples to demonstrate design procedures. Content addresses ensuring the compatibility of horizontal and vertical alignments in the final design. The module concludes by presenting the basic concepts for cross-section design, including earthwork distribution for economic construction.

2.1.8 Module 8: Advanced track geometric design

Module 8 builds upon the content of the preceding module to show the attendee how to build groups of tracks to fulfill various operational needs. The content incorporates turnouts into the alignment design process to permit the layout of yards, terminals, sidings, parallel main tracks, junctions, and other facilities. The material addresses design considerations for yards and terminals, including track spacing, ladder design, and access.

2.1.9 Module 9: Drainage

Proper drainage is critical to railway infrastructure. This module addresses the hydraulic design of opens channels and culverts commonly used to handle water. Much of this follows basic design procedures common to other civil projects (e.g., airports, roads and streets, building sites), the module incorporates railroad industry approaches.

2.1.10 Module 10: Structures

This module addresses railroad bridges and tunnels. The content presents basic bridge types, along with typical applications. Components of the bridge superstructure and substructure are described. The

Cooper rating system is explained, along with relevant codes used in design. The detailed design of railroad bridges is not addressed, as this would be appropriate for a separate course.

2.1.11 Module 11: Electrification

The final course module provides an overview of electric traction system infrastructure, most commonly found in transit systems in North America, though popular for intercity freight and passenger railroads and high-speed passenger railroads elsewhere. The material provides an overview of AC and DC power systems, including common voltages. The main focus of the module, however, is on the trackside infrastructure used to provide power to the train. The main features of both third rail and overhead systems are presented, along with typical design details for each.

2.2 Railroad Track Maintenance

The railroad track maintenance class consists of nine modules presented over a two-day period. Table 2 lists the module topic areas. As is typical of CTR classes, the module time accounts for instruction, exercises, discussion, and short breaks.

Content for the module is based on North American intercity and transit railway practices. Sources include AREMA, various Class I railroads, and various transit properties.

Table 2. Railroad Track Maintenance Syllabus

	Module	**Duration (hrs.)**
1.	Introduction	0.5
2.	Track geometry	2.5
3.	Roadbed and right-of-way	1.5
4.	Rail, rail joints, and rail welds	2.0
5.	Crossties and rail fasteners	2.0
6.	Ballast	2.0
7.	Subgrade and earthwork	1.75
8.	Special trackwork	2.0
9.	Work planning and execution	1.75
		16.0

Course materials consist of PowerPoint® slides for each module along with a separate written manual that contains additional reference content. As in the track design class, each slide set provides a comprehensive outline of the module topic areas, including key concepts, illustrations, figures, and tables. The separate text manual gives more comprehensive information on selected topics. Each attendee receives a copy of the presentation slides and the text manual.

Since field demonstrations are generally impractical for this course, some modules use videos to show examples of work activities, especially those performed using on-track machines. Videos come from a variety of sources and are used with permission.

2.2.1 Module 1: Introduction

This course module introduces the class, provides an outline of the content to be covered, along with overall learning objectives. As with the track design class, materials are provided to attendees, class participants share their backgrounds and expectations for the class, and instructors provide their

backgrounds to the participants. The module content presents the basic functions of a railroad track, types of track systems, along with regulators and regulatory requirements to ensure track safety. The concept of track classes having associated maintenance and safety limits is introduced.

2.2.2 Module 2: Track geometry

Keeping track geometry within established limits is critical in track maintenance, particularly with ballasted crosstie track systems. This module presents the key track geometry parameters, along with representative maintenance and safety limits. Common causes for changes, measurement techniques, and approaches for repair are discussed for each geometry parameter.

2.2.3 Module 3: Roadbed and right-of-way

Providing adequate drainage and controlling vegetation are the main focus areas of this module. Controlling the flow of water and directing it away from the track is extremely important in track maintenance. The material presents approaches for ensuring that drainage facilities remain capable of handling the expected flow of water. Typical problems are discussed, along with maintenance and repair approaches. Vegetation control is a regulatory requirement. The material discusses why vegetation control is a safety issue. Methods for controlling or removing vegetation are then presented.

2.2.4 Module 4: Rail, rail joints, and rail welds

Because rail supports and guides the rolling stock, and is the most expensive component in the track structure, track owners should maintain track to maximize rail life, and must take prompt remedial action to address rail defects. Joints and welds used to fasten rail must be properly installed and maintained to function as intended. This module acquaints attendees with common maintenance issues related to rail, joints, and welds, and discusses approaches to addressing these issues.

2.2.5 Module 5: Crossties and rail fasteners

This module addresses maintenance of the track components that directly support the rails, along with the associated fasteners that secure the rails. While the primary focus is on crosstie track, the module also addresses ballastless track designs. The content addresses the various types of crosstie and rail fastening systems, along with common maintenance issues and ways to address them.

2.2.6 Module 6: Ballast

A good quality, free draining ballast material helps maintain track in proper surface and alignment. The module presents the basic maintenance procedures employed in maintaining track ballast. The content provides a discussion of desired ballast properties, placement of ballast, tamping, regulating, cleaning, and removal/replacement.

2.2.7 Module 7: Subgrade and earthwork

Failure of subgrade and/or associated earthwork can be both disruptive and costly to address. This module discusses typical types of failures associated with these elements and presents typical repair approaches. The content also addresses proper construction and preventive maintenance practices intended to head off problems.

2.2.8 Module 8: Special trackwork

Special trackwork consists of many individual components that are precisely fitted and often movable. These areas receive high forces compared with regular trackwork, making them susceptible to wear and damage. This module provides a list of special trackwork items to inspect, identifies typical failure modes, describes typical preventive maintenance, and provides recommendations on how to make repairs and adjustments.

2.2.9 Module 9: Work planning and execution

The final course module addressed the planning of track maintenance to minimize time and cost, while having the least possible impact on rail operations. Topic areas include estimating personnel, equipment, and materials requirements; developing a work schedule; staging equipment and materials; maintaining a safe workplace; and collecting and disposing of removed materials.

SECTION 3: PROGRAM STRUCTURE

This section discusses the structure of the railroad continuing education program as it presently exists. The two new courses described in Section 2 are among the program offerings.

3.1. Course delivery

At the time of this report, all courses have been instructor led in a classroom setting. Course delivery by distance education is possible for some classes, and facilities are available for this means of instruction. However, classes requiring “hands-on” exercises, such as railroad track inspection, are ill-suited to this instructional methodology. Given a choice, course sponsors have thus far preferred instructor led courses in a classroom versus distance delivery.

Instructors are typically qualified university faculty members or retired subject matter experts. They present the course in a standard fashion following the prepared content package. Though content delivery is largely via the instructor(s), some courses feature short topical lectures by invited speakers. As previously mentioned, courses may also employ video presentations to better illustrate key points.

Attendees receive course notebooks or bound texts that reflect course content. Typically, these contain all slides presented by the instructor. In addition, the course package may include additional reference materials, worksheets, written exercises, forms, and other relevant content. Figure 1 shows some typical course materials.

3.2 Course access

CTR courses may be either open enrollment or closed enrollment.

A closed enrollment course is held for a sponsor organization. The sponsor selects the course venue and provides the attendees. CTR can adapt the course to meet sponsor requirements (e.g., content, time duration, schedule, learning assessment, etc.). The sponsor controls the number of attendees in the class. Closed enrollment classes are not advertised and attendance is not open to the public.

CTR advertises and sponsors open enrollment class sessions throughout the year. Open enrollment classes are advertised and are open to any registrant paying the fixed course fee (UTK students are

admitted without charge on a space-available basis). The open enrollment class is financially attractive to organizations without the numbers to justify a dedicated class.

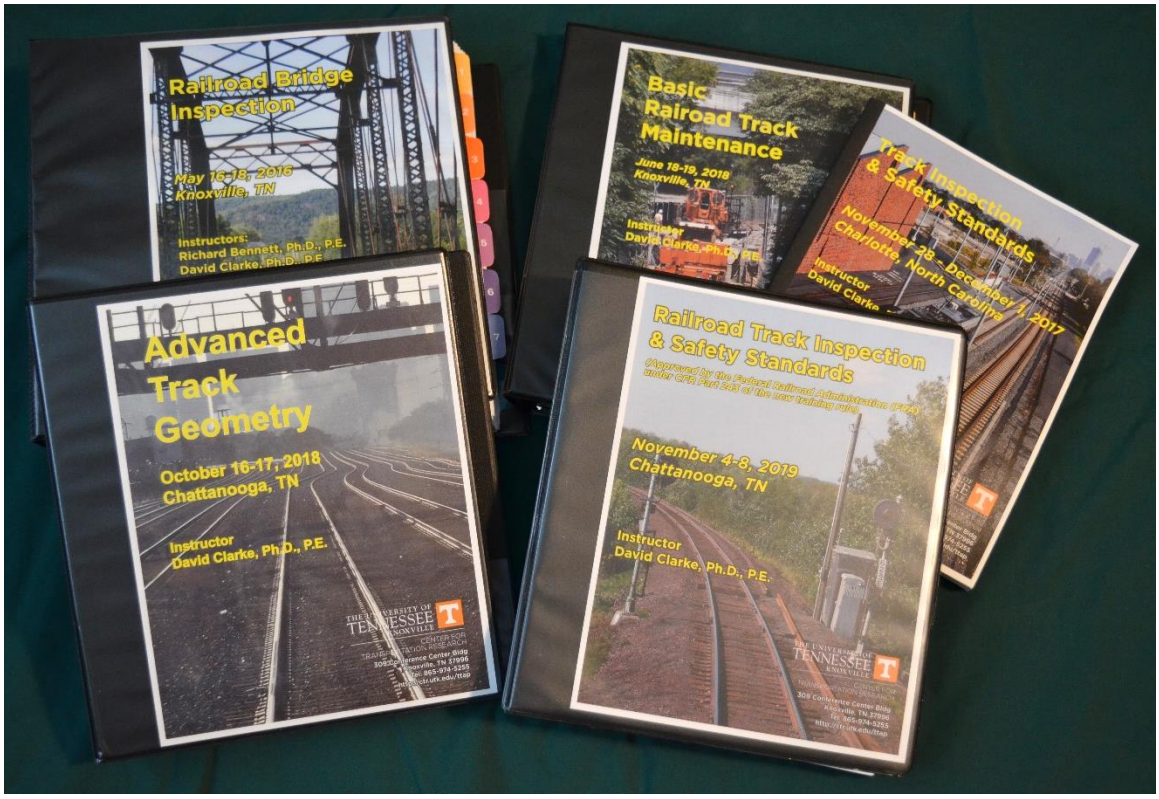

Figure 1. Examples of course materials

Open enrollment classes are announced on the CTR web site, in CTR e-newsletters, and in upcoming events columns of railroad industry trade journals. Both paid advertisements in trade journals and mailed course flyers were used in past years. These did not prove to be cost effective. On post-course evaluations, attendees overwhelmingly report using the web site to find open enrollment class offerings and dates. The web site is also the typical means by which potential closed enrollment class sponsors find CTR.

Prior class attendees receive e-newsletters containing information on upcoming classes. CTR solicits email addresses from class attendees during registration and in the post course evaluation. These are maintained in a registration database. With listed persons making job changes, corporate changes, etc., email addresses change and a portion of the mailings typically bounce back as undeliverable. The program has not, to date, purchased commercial email lists.

CTR partners with small railroads and operating railroad museums when open enrollment classes require field exercises. Typically, companies view hosting a class as contributing to the industry. In return, CTR often offers complementary course slots to the host. For example, the Tennessee Valley Railroad Museum (TVRM) in Chattanooga, Tennessee has hosted CTR classes for over 25 years. TVRM has a well outfitted room for instructional use in it administration building, and also makes its railroad and facilities available for course exercises. Wherever the location, course attendees follow all host and FRA safety rules while on host property.

Sponsors of closed enrollment classes make all arrangements for the class venue and any needed field exercise locations. CTR will, if necessary, provide audiovisual and computer equipment should the course venue not be equipped. When the sponsor is a railroad or transit agency, field exercise locations typically will be on company property. Some sponsored classes do require an external organization to provide the field exercise venue. CTR works with the sponsor to make these arrangements.

3.3 Financial model

The CTR continuing education program is completely self-financing. All courses must cover total costs; no university, NURail, or other external funds have been used for course development or expenses. Open enrollment courses typically produce a surplus, which CTR reinvests into the program; closed enrollment courses are provided at cost. CTR funded development of the Railroad Track Design and Railroad Track Maintenance classes as a match contribution to NURail funds used for other projects.

For open enrollment classes, CTR has an on-line registration system. Attendees may pay the course fee in advance by credit card or check. CTR will also invoice corporate participants for payment.

For closed enrollment classes, CTR gives the sponsor a cost estimate based on expected expenses. The budget estimate is based on instructor costs, travel to the course location, per diem, and provided supplies. Instructor time may include course preparation time if a class is customized. Based on the agreed upon course fee, the sponsor generally issues a purchase order. CTR then invoices against this purchase order when the class is completed.

3.4 Measurement tools

The program surveys attendees through course evaluations to obtain information about the learning experience. Some courses also have written examinations.

3.4.1 Course evaluations

Attendees receive a course evaluation near the conclusion of the event. The one-page form is developed specifically for the course. Completion is voluntary for the attendee, and the submission is anonymous. On average, 75-80 percent of the attendees complete the evaluation.

The form requests attendee evaluation of the instructors, venue, and course content, and each is the subject of multiple questions. The rating scale for each question falls on a zero to five scale, with five being the top level.

Typical instructor related items on the evaluation form are:

- Instructor's apparent familiarity with the subject matter
- The ability to understand the instructor (voice, grammar, etc.)
- Instructor's ability to convey his or her knowledge of the subject matter
- Instructor's ability to stimulate interest in the subject
- Instructor's organization and ability to follow a logical sequence of presentation
- Opportunities given to participants to ask questions and get satisfactory answers

- The degree to which participants were able to demonstrate comprehension of the course material through interaction, class discussion, workshop exercises, and other methods

Evaluations contain separate sections for each instructor. The form also provides an overall evaluation score for each instructor.

Evaluation forms also include a section for written comments and suggestions. Attendees are encouraged to suggest ideas for future classes, improvements to the class just attended, address the registration process, comment on the venue, etc. This information is narrative.

A course instructor gathers the submitted forms from the attendees and returns them with a course packet. Upon receipt, program staff use the submitted evaluations to develop a course summary. The summary provides the average for each scored question in the evaluation, along with a section of the most pertinent or common narrative comments. The instructor and CTR program director receive copies of the evaluation summary for review.

3.4.2 Examinations

Some courses employ graded written examinations as a learning measurement tool. Attendees take the examination at the conclusion of the formal course presentation. The purpose of the examination is to assess the degree to which participants achieved key learning objectives.

Examinations are typically given to attendees to work during the last evening of the class, although they may be administered during class time for sponsored classes. In either case, the exam is open book, though attendees are directed not to work together. Exams are handed out in paper form.

The typical exam consists of fifty questions that cover all major topic areas for the class. For ease in grading, questions are either multiple choice or short answer. The questions come from a pool maintained for the course that the exam covers. This permits questions to be varied between classes. Question order is also changed. These two measures hinder participants from copying older exams.

Those taking the exam are asked to copy answers to a score sheet that is handed in to the instructor for grading. On return to class the next day, attendees hand in their completed exam score sheet. The instructors grade these immediately, keeping a record of the frequency of incorrect answers for each test question. Individual scores are also recorded.

Once grading is complete, the instructors then explain each question that one or more attendees got incorrect. This is the true purpose of the exam—to identify concepts that attendees had trouble with and to provide additional explanation before the class ends.

3.7 Course logistics

This section describes some of the activities involved in facilitating a course offering.

3.7.1 Instructor arrangements

CTR maintains a pool of instructors qualified to teach a given class. When a class is scheduled, program staff must select a qualified instructor team. The selection depends on course location, instructor availability, and maintaining a balanced instructor course load.

Instructors may either be university employees (full-time or part-time) or outside contractors. University employees receive pay at the regular rate for time spent teaching, along with associated travel. Their lodging and per diem expenses are paid at General Services Administration (GSA) rates. Contractors receive a flat rate per class that covers instructional pay and all reasonable expenses.

After selecting instructors, staff will assist instructors with travel and lodging arrangements. Instructors who are university employees must receive travel authorization for travel outside Tennessee. University paid travel must comply with all applicable regulations.

For courses held within 400 miles of Knoxville, a university based instructor or program staff member will typically drive to the venue in a university owned van. The van is loaded with all necessary materials and equipment for the class. This saves instructor travel and shipping costs.

Staff provide the instructors with travel documents including tickets, vehicle reservations, host contact information, directions to lodging and venue, and any special instructions pertaining to the class.

3.7.2 Venue arrangements

Program staff make arrangements for the venue, either directly or in conjunction with the program sponsor. For open enrollment classes, key venue criteria are that it be sized appropriately, furnished for classroom seating, reasonably close to hotels and restaurants, equipped with suitable restroom and break facilities, and reasonably priced. For classes with hands-on exercises, the classroom should be convenient to the exercise location. In most sponsored classes, the sponsor provides the venue, or at least has a major say in its selection. Many have a dedicated training room or facility and choose to use this. Sometimes a sponsor prefers an off-site venue such as a hotel or conference center.

Most classes require the classroom to be equipped so that attendees can view the instructor's computer screen. Generally, this is accomplished via an LCD projector with suitable interface and a large projection screen, though large panel monitors are also an option. If the venue is not equipped, CTR can provide this equipment or arrange for it to be rented.

3.7.3 Materials and equipment

Printed course materials and equipment must be delivered to the venue prior to the class start date with sufficient allowance for in-transit delays. CTR normally assembles all printed course materials, generally in the form of notebooks or bound volumes. The copy count provides for the instructors and all attendees, with a few extra sets in case of last minute enrollees. Materials are packed securely in cardboard boxes.

For CTR hosted classes, course staff or instructors will deliver the materials when the course is local or within a short driving distance (e.g., Chattanooga or Nashville). Otherwise, staff send materials to the venue via ground parcel service. These boxes can be quite heavy, so postal service is not an option. If any materials remain after the class, these are either left with the course sponsor or brought back by the instructors.

The lead instructor for a class needs a class roster, blank evaluation forms, name tents, and certificates for attendees. The course registrar maintains the registration system. After registration closes for an open enrollment class, the registrar prints a list of the attendees and their affiliations. For closed enrollment classes, the sponsor provides the class roster to the registrar, who prints the list of names.

The registrar also arranges the printing of a course certificate for each attendee. The instructor packet is placed in one of the boxes containing course materials.

For courses requiring tools or equipment, course staff or instructors bring and return these when the course is local or within a short driving distance. Otherwise, the items are packed in heavy duty shipping cases and sent to the venue via ground transportation. When the class is complete, an instructor arranges for the carrier to pick up the cases and return them to CTR in Knoxville. Staff provide pre-printed shipping documents to simplify this process.

3.6 Post course activities

Following a course, a number of activities take place. Program staff collect the sign-in sheet, exam grades (if applicable), and evaluations from the instructors. They ensure that equipment returns and is replaced in inventory. They also assist the instructors with travel expense reimbursement claims.

Class records are updated if substitute persons attended or if there were last-minute cancellations. If names were misspelled in the original roster or a substitute attended, staff prepare new certificates and mail them to the affected attendees.

The final step in every course is to prepare the evaluation summaries. Information from the evaluations is entered into a standard spreadsheet template. The sheet summarizes each category. The analyst generates a report that is maintained for the files, with copies sent to the instructors and program manager.

3.7 Recordkeeping

For each class offering, CTR maintains a permanent attendee record. The record provides documentation that the attendee successfully completed the class. Such information is often needed to demonstrate employee qualifications.

For classes that have recorded examinations, the examination score is part of the record. At present, CTR does not set a minimum passing score. All attendees who complete the class receive a certificate, regardless of their exam score. Employers determine the passing score for their employees when the exam is part of a qualification requirement.

Course evaluation summaries are retained for the records. The individual evaluations are not.

SECTION 4: OUTCOMES

Between January 1, 2015 and December 31, 2019, UTK-CTR conducted 101 railroad continuing education courses at various locations across the U.S. Figure 2 shows the U.S. locations. Courses were also held at three locations in Mexico, one in Colombia, and one in Australia. Each of these was sponsored.

The classes in Mexico and Colombia employed Spanish translated materials. CTR staff converted the normal slides to Spanish, with sponsor assistance to ensure the accuracy of railroad technical terms and names. Revisions to the material also reflected metric units and other aspects of sponsor railroad practice.

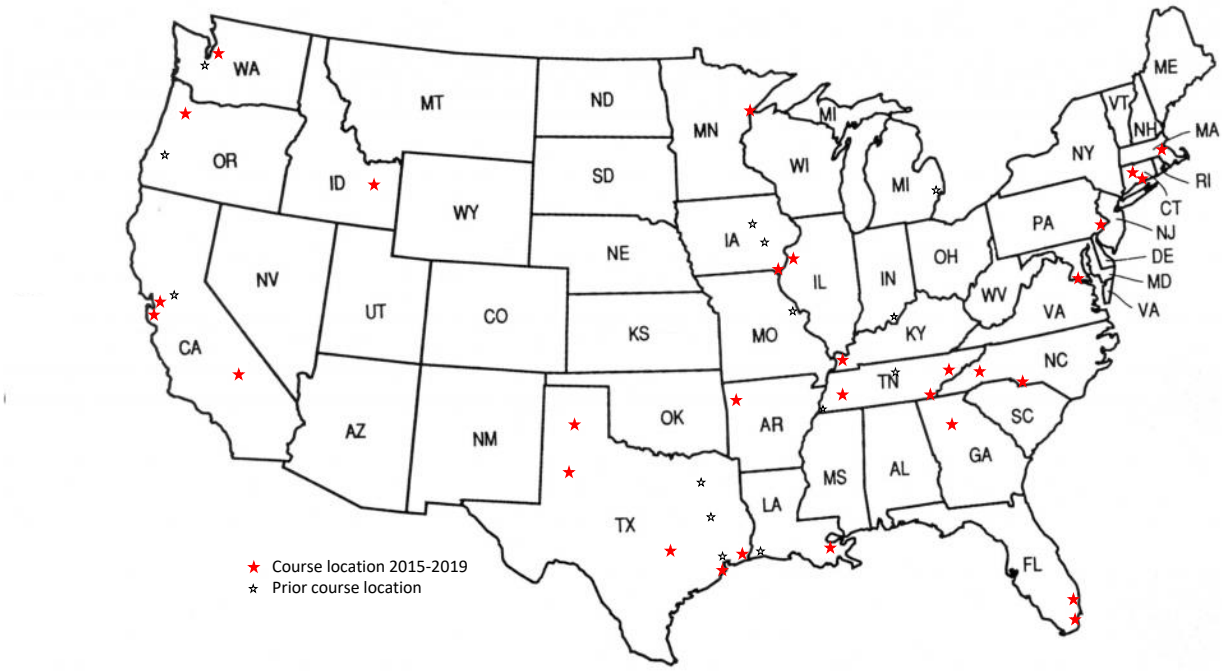

Figure 2. Location of courses within the U.S., 2015-2019

Though the instructors taught in English, a translator echoed their remarks in Spanish for the students. The translator also repeated attendee questions and comments in English for the instructor.

Figures 3 and 4 provide typical views from classes conducted during the period. They reflect the typical environment for both classroom and field exercises.

Figure 3. Dr. Richard Bennett teaching a bridge inspection class

Figure 4. Attendee group engaged in track measurement exercise

4.1 Program metrics

Figure 5 illustrates the distribution of classes by number offered. These included a mix of open-enrollment courses and custom courses for specific organizations.

Figure 6 shows the distribution of attendees by course topic. Altogether, the course generated 30,263 contact hours of instruction. Attendees represented railroads (Class I, Class II, Class III, tourist, industrial), public transportation agencies (federal, state, local), regulators (federal, state), consultants, suppliers, educators, and trade associations.

Overall course evaluation scores were highly satisfactory in all categories related to instruction. During the period, no course had an average overall score below 4.7 out of 5.0. The average instructor rating was 4.8 out of 5.0.

Financially, the program was self-sustaining during the period. Program generated funding covered all administrative and operating costs and accrued a modest surplus. These funds were contributed to support student and faculty travel to railroad related conferences and to help match NURail funding.

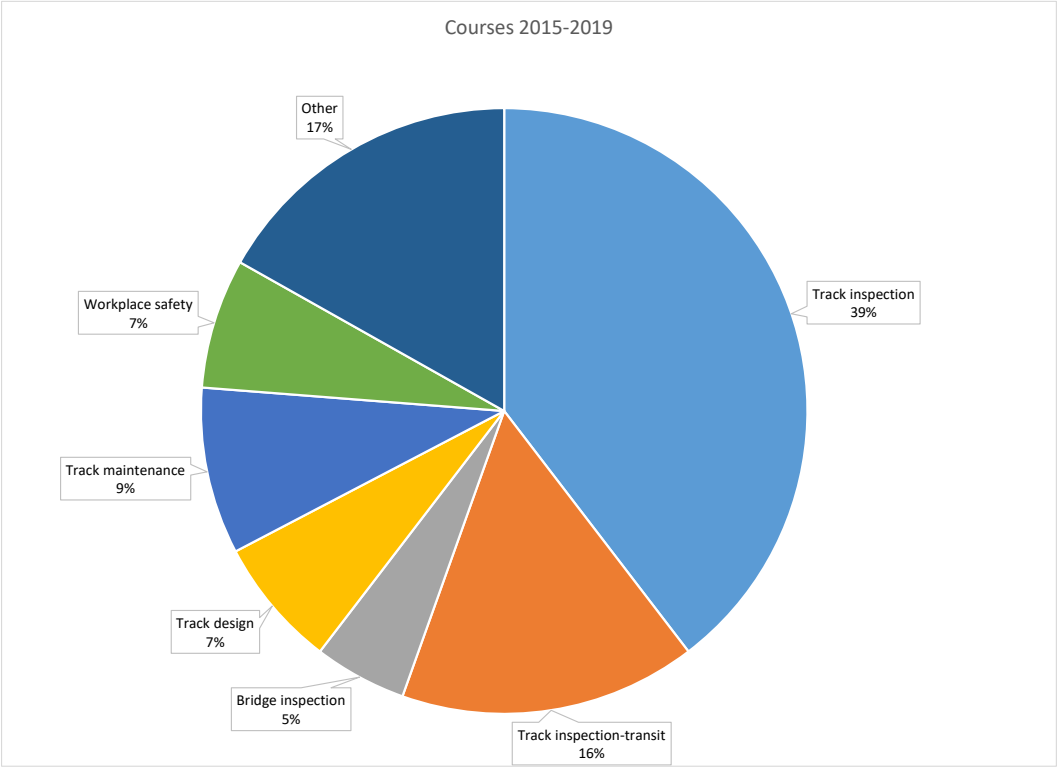

Figure 5. Railroad class distribution by topic area, 2015-2019

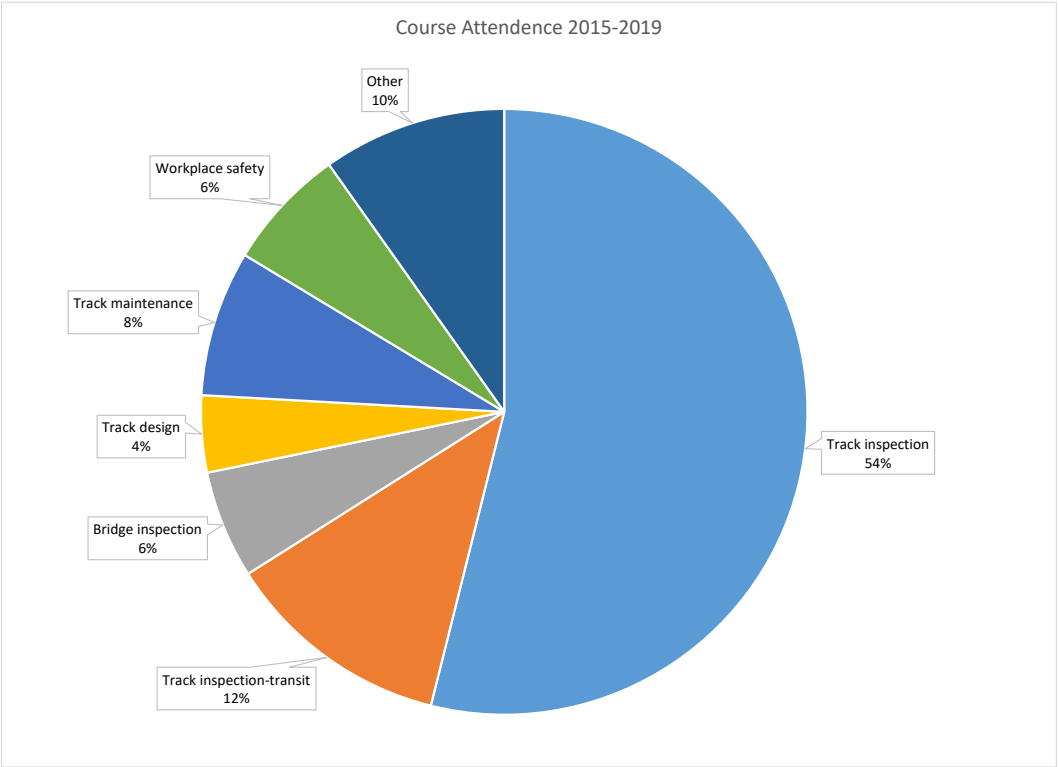

Figure 6. Railroad class enrollment percentage by topic area, 2015-2019

4.2 Delivery of new courses

The Railroad Track Design and Railroad Track Maintenance classes were taught eight and nine times, respectively, during the period. The overall evaluation ratings for both classes averaged 4.8 out of 5.0. Instructor ratings also averaged 4.8 out of 5.0 for both classes.

Experience shows that it takes four or five offerings to fine tune a class, and the two new classes were no exception. Course materials were refined during the period, so that each offering was an improvement over the previous one.

One noteworthy accomplishment was a presentation of the Railroad Track Design course in Melbourne, Victoria, Australia during October 2016. For this sponsored course, the material was converted to metric units and adapted to reflect Australian railroad practice. The audience consisted of engineers and consultants from several Australian states.

SECTION 5: FUTURE STEPS

Based on attendance at existing classes, supported by survey feedback, the continuing education program is serving a distinct need. Demand is strong and growing, and federal regulations requiring approved training for safety sensitive positions likely will help this trend continue. Also, some of the Class I railroads implementing Precision Scheduled Railroading are outsourcing at least some of the internal continuing education activities.

Based on this, CTR plans to expand the railroad program in a deliberate fashion. New classes are planned for development, limited mainly by the need to bootstrap such development using internal program funding. The program funding surplus also supports student activities, certain activities related to program administration (e.g., website maintenance, registration system), marketing activities, and NURail grant match. Thus, the ability to invest in new classes is constrained. Efforts to seek external grant funding for course development have, thus far, been unsuccessful. Sponsors have, however, been willing to fund costs for modifications to existing classes, though such modifications are not always applicable to other course presentations.

One limitation to providing more class offerings is instructor availability. Persons with the credentials, desire, instructional experience, and time to teach highly specialized classes are in short supply. Increasing the instructor pool is a key requisite to increasing the number of classes offered. Accordingly, CTR is on the lookout for such qualified persons. One complication is that FRA approval is needed for instructors in safety qualified classes.

Expanding the geographic diversity of instructor led course locations has long been a program goal. Having course locations throughout the country reduces travel costs for potential attendees. CTR plans to continue to establish ongoing course venues in key market areas.

Course marketing, as discussed earlier in the report, is largely limited to trade press announcements, the CTR web site, and email to prior course attendees. CTR has not used social media platforms like Facebook and Twitter to publicize the program. Given the widespread use of these platforms, particularly by a younger demographic, they could help to reach a wider audience. The program needs to investigate potential methods for engaging social media and for judging its effectiveness.

As part of a larger overall effort, CTR is revising the course registration and recordkeeping system presently in place. Much of this has to do with University imposed administrative requirements related to funds handling. However, the improvements are also intended to streamline the registration interface for attendees and minimize the potential for duplicate data base entries. Additionally, the new system will permit on-line payment via credit card. Presently, credit card payment is handled by phone or fax to protect card number confidentiality and avoid processing fees. Under the new system, the registration site will link to an external site for card processing, keeping cardholder information off University systems.

Another goal is to develop some method of teaching via distance learning technology. There are several issues to address. A major one is ensuring that such courses provide the same financial return as in-person classes. Experience shows that limiting attendance to registered persons can be a challenge with distance delivered courses. College distance learning courses avoid such problems because registered attendees seek course credit. Without valid registration, credit cannot be obtained. Continuing education classes are traditionally non-credit. Course attendance can be controlled by use of full-featured learning management systems like Canvas® or Blackboard®, but their most effective use involves adapting course content to take advantage of platform capabilities.

The cost of doing this is another issue. In addition, UTK has not used such platforms outside the traditional academic curriculum system, which they are heavily integrated into. Distance delivery also has difficulty with hands-on exercises, an important component in some classes. Finally, distance delivery seems most effective when attendees receive content in small doses spread over a long duration, rather than in large doses over a short duration, as with existing instructor led classes. For short webinar type presentations, or college classes that meet for 50 or 75 minutes several days per week, distance learning works well. However, professionals generally seem to prefer the large dose/short duration model as less disruptive to their overall work activities. This may also be true for instructors who are not full-time academics. For all these reasons, the distance model needs much further evaluation.

Finally, CTR plans to continue the important task of communicating railroad research results to practitioners. Research is of little practical use if it is not implemented, and the failure to recognize this is a common criticism. The transfer of technology has been a prime goal in supporting NURail. One method of doing this is to incorporate research findings directly into course content. Another is to have researchers involved in class instruction. CTR seeks to do both, and will continue to do so.