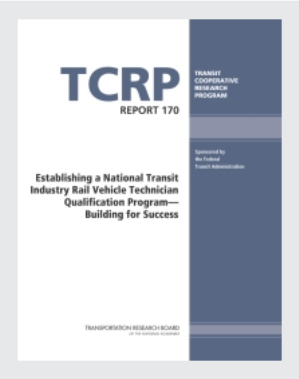


# Establishing a National Transit Industry Rail Vehicle Technician Qualification Program—Building for Success



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## AUTHORS

Transportation Learning Center

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP REPORT 170

# Establishing a National Transit Industry Rail Vehicle Technician Qualification Program—Building for Success

TRANSPORTATION LEARNING CENTER
Silver Spring, MD

Research sponsored by the Federal Transit Administration in cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

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## TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

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The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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# COOPERATIVE RESEARCH PROGRAMS

## CRP STAFF FOR TCRP REPORT 170

**Christopher W. Jenks,** *Director, Cooperative Research Programs*
**Cynthia Butler,** *Administrative Associate*
**Eileen P. Delaney,** *Director of Publications*
**Ellen M. Chafee,** *Editor*

## TCRP PROJECT E-07 PANEL
### Field of Maintenance

**John A. Costa,** *Amalgamated Transit Union, Scotch Plains, NJ* (Co-Chair)
**Jayendra N. Shah,** *MTA New York City Transit, Floral Park, NY* (Co-Chair)
**Jerry Blackman,** *Miami-Dade Transit, Miami, FL*
**James T. Brooks,** *Utah Transit Authority, Salt Lake City, UT*
**John H. Buckner,** *Southeastern Pennsylvania Transportation Authority, Philadelphia, PA*
**Mark Grove,** *Tri-County Metropolitan Transportation District, Gresham, OR*
**Frank L. Harris, II,** *Amalgamated Transit Union #732, Lithonia, GA*
**James Lindsay,** *LACMTA - Amalgamated Transit Union Local 1277, Los Angeles, CA*
**Phil Lowe,** *Transport Workers Union Local 234, Westville, NJ*
**James R. Plomin,** *Oak Park, IL*
**Jack Shaw, Jr.,** *Metro Transit, Marine on St. Croix, MN*
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**Paul L. Swanson,** *Metro Transit, Minneapolis, MN*
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**Jarrett W. Stoltzfus,** *FTA Liaison*
**Pamela Boswell,** *APTA Liaison*
**John A. Remark,** *Amalgamated Transit Union Liaison*
**Ed Watt,** *Amalgamated Transit Union Liaison*
**Jennifer L. Weeks,** *TRB Liaison*

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It is important to recognize the important contributions to this project from a number of industry leaders. Transit leaders especially concerned about rail car technician training have been working together in the National Training Standards Committee since 2006 through a joint working group co-chaired by Jayendra Shah of New York City Transit (NYCT) and John Costa of the Amalgamated Transit Union (ATU). The members of the National Rail Vehicle Training Standards Committee are listed in Appendix A of the contractor's final report. (Appendix A can be found by searching for *TCRP Report 170* on the TRB website.) Transportation Learning Center staff who contributed to this effort include Julie Deibel, Mark Dysart, John J. Schiavone, Brian J. Turner, and Xinge Wang. Contributors from Educational Data Systems, Inc., included Brian Lester and Ken Mall. The industrywide organizations contributing to this effort include APTA and the national transit unions, ATU and the Transport Workers Union (TWU), who worked with the Rail Vehicle Training Standards Committee in 2007 to develop a proposal for what became TCRP Project E-07, Establishing a National Transit Industry Rail Vehicle Technician Qualification Program: Building for Success.

# FOREWORD

By Christopher W. Jenks
Director, Cooperative Research Programs
Transportation Research Board

*TCRP Report 170* describes a system of qualification that has been developed for rail vehicle technicians that integrates national training standards, progressive classroom curricula and introductory courseware, on-the-job learning modules, an apprenticeship framework that combines well-designed sequences of learning, mentoring to support learners, and coordination of classroom and on-the-job learning. The qualification system also includes written and hands-on certification assessments to confirm that technicians have the practical knowledge and skills required to perform their jobs at the highest level of expertise. This qualification system is available for implementation through the Transportation Learning Center.

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The development and implementation of new rail vehicle technologies in transit systems around the country have had profound effects. While these technologies have greatly benefited customers and agencies alike, they also have led to difficulties. The internal training capacity of the transit industry has had trouble keeping up with the pace of innovation, and it has become increasingly difficult to hire new external applicants with the specialized skills needed for the new equipment. Upgrading the skills of the workforce that maintains this new technology and developing a system that does this on an ongoing basis is of the utmost importance to the industry.

A number of reports have analyzed the transit skills crisis. A common thread in their recommendations for resolving this skills crisis is that management and labor should work together in creating a joint system for developing the skills needed in this industry. The best approach is for all the major players in the transit industry, labor and management, to work in partnership to develop new approaches to training and certification.

Efforts have been underway to develop national standards for training in four transit rail occupations: rail signal maintainers, elevator-escalator, wayside power, and rail vehicle technicians. National standards for training and certification jointly developed and maintained by transit management and transit organized labor offer the best approach for meeting the skill needs of the transit industry for rail vehicle technicians and other maintenance occupations.

Under TCRP Project E-07, the Transportation Learning Center was asked to develop a system of training and certification for rail vehicle maintenance. The Transportation Learning Center developed all content and infrastructure necessary to deliver a system of qualification to transit rail systems. The system covers both training and certification aspects of the qualification system.

Appendices A through P of the contractor's final report for TCRP Project E-07 can be found by searching for *TCRP Report 170* on the TRB website. Appendix titles are the following:

- Appendix A: National Rail Vehicle Training Standards Committee—Membership List
- Appendix B: Building Capacity for Transit Training: International and Domestic Comparisons
- Appendix C: TCRP Project E-07 Multiyear Work Plan
- Appendix D: 200 Level Primers
- Appendix E: Learning by Doing: Hands-On Training for Transportation Technicians
- Appendix F: Mentoring Guidebook
- Appendix G: Rail Car Maintenance Technician Apprenticeship with the Department of Labor's Office of Apprenticeship
- Appendix H: Detailed Rail Car Maintenance Technician Progression Flowchart
- Appendix I: Rail Vehicle Technician Apprenticeship: Definitions of Levels of Qualification
- Appendix J: Written and Hands-On Assessment Process Checklist
- Appendix K: Qualification Assessment FAQs
- Appendix L: National Rail Car Hands-On Skills Assessment Tutorial
- Appendix M: Hands-On Assessment—Task Application Form
- Appendix N: Hands-On Assessment—Evaluator's Worksheet
- Appendix O: Hands-On Assessment—Candidate's Version
- Appendix P: Sample Written Assessment Tutorials

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Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

# Establishing a National Transit Industry Rail Vehicle Technician Qualification Program—Building for Success

Meeting the challenge of developing fully qualified transit rail car maintenance technicians is the goal of TCRP Project E-07, "Establishing a National Transit Industry Rail Vehicle Technician Qualification Program: Building for Success." The best answer, fine-tuned by the research team for this project, is a new multipart, industrywide *system* of qualification. This system of qualification integrates a number of related elements: national training standards; a progressive classroom curriculum and introductory courseware; on-the-job learning modules; and an apprenticeship framework that combines well-designed sequences of learning, mentoring to support learners, and coordination of classroom and on-the-job learning. All these components provide the foundation needed for written and hands-on assessments to confirm that technicians have the practical knowledge and skills required to perform their jobs at the highest level of expertise.

## The Skills Challenge and the Solution: An Integrated System of Qualification

A world class system of qualification is the best answer to transit's technical skills challenge resulting from retirements, expansion of transit rail, and advancements in technology. This industrywide, integrated system of qualification is the most cost-effective way for transit agencies to build the skills of a wave of new hires, equivalent to 88 percent of today's total transit workforce over the next 10 years. Building the skills of this new workforce is a priority for safety and service reliability as well as for transit economics.

The national leadership of the transit industry, including both management and labor at the highest levels, has recognized the urgency of these challenges. Transit leaders have come together over the past decade to develop an industrywide system of technical training that can be customized locally for quality, cost-effective implementation in transit agencies across the country. Customizable, industrywide solutions are being built that mobilize experience and knowledge across the transit industry and share development costs across many properties and with national transit organizations such as FTA, TCRP, and the U.S. Department of Labor. This approach is much more effective than the legacy system, which relies on the resources of individual agencies to determine what workers need to know, how to teach it effectively, and then how to confirm that they have mastered the necessary skills. Better skills and knowledge should translate into increased safety and reliability of equipment and service, a better state-of-good-repair, reduced risk and costs, more efficient maintenance and operations, and longer lived and more reliable capital equipment. These benefits lead to a substantially positive return on the agency's and industry's investment in developing human capital. In many

respects, TCRP's Project E-07 on qualification of rail car technicians is breaking the trail for parallel efforts by existing industry partnerships with FTA for transit elevator-escalator technicians and signals technicians and future efforts for other occupations in the years to come.

The foundation for this project's work is provided by the knowledgeable transit rail car subject matter experts (SMEs) on the TCRP Project E-07 panel and on the National Rail Vehicle Training Standards Committee. The two overlapping groups were recruited from 30 different agencies and local unions and included frontline rail car mechanics, training department staff, and maintenance supervisory personnel in an industry where more than 90 percent of the frontline workers are represented by unions and frontline workers make up 80 percent of the industry's workforce.

The first priority of TCRP Project E-07 and the National Rail Vehicle Training Standards Committee was to complete the work of developing the rail car industry training standards. Projects begun in 2004 and 2006 developed training standards for technicians in rail car, rail signals, traction power, and transit elevator-escalator, as well as in transit bus. The process ultimately identified over 1,300 technical learning objectives and organized them in a sequential curriculum of 42 training courses and 177 modules. These training standards were adopted as recommended practices in the APTA standards process in 2010.

These consensus rail vehicle industry training standards provide the foundation for developing a common framework of national training resources and systems that can be customized by agencies and training programs for use with particular fleets and equipment, as well as for specific local practices for maintenance, career ladder advancement, and training.

## Rail Car Technician System of Qualification Integrates Multiple Components

The research team developed a comprehensive integrated system of qualification for rail car technicians. The framework for a system of qualification was drawn from the positive experience of durable, high-quality national training systems for frontline technical workers in other U.S. industries and in other countries. The research team found a number of common features in these successful durable programs:

- Sectorwide national training partnerships involving employers and sector unions, sometimes with government and education partners
- Use of a data-driven system with stakeholder engagement to develop and maintain standards-based curriculum content
- Provision of a stable source of funding
- Training and certification for new hires through training and apprenticeship systems combining classroom learning with paid on-the-job learning
- Training and certification for lateral entrants and experienced incumbents.

The system of qualification developed under TCRP Project E-07 builds on these common features. The system was developed through expert stakeholder engagement and joint development of foundational national training standards and curriculum. Going beyond training standards and curriculum, the system is designed to integrate additional critical components including standards-based courseware, well-trained instructors and mentors, coordinated classroom and on-the-job learning, and a credential management system that can track the training that technicians have received and their success in assessments that measure their mastery of the skills and knowledge of their occupation. The national system is designed to support local customization to match the work systems and equipment in each transit location (see Figure S-1).


***Figure S-1. National and local qualification system.***

Rail car technicians will move through a progression of classroom and hands-on learning, from basic fundamentals (the 100 level) through intermediate, occupation-specific skills (the 200 level), to advanced skills in troubleshooting and diagnostics (the 300 level). Separate skills training will focus on the skills for component rebuilds and overhaul (the 250 level). At the 200 and 300 levels, specific learning frameworks address the needs of each of the 11 subsystems that make up modern transit rail cars plus diagnostics and troubleshooting. At the 200 level these instructional courses are the following:

- Course 201: Couplers
- Course 202: Trucks and Axles
- Course 203: Propulsion and Dynamic Braking
- Course 204: Auxiliary Inverters and Batteries
- Course 205: Friction Brakes
- Course 206: Heating, Ventilation, and Air Conditioning (HVAC)
- Course 207: Current Collection
- Course 208: Car Body
- Course 209: Doors
- Course 210: Communication Systems
- Course 211: Computer-Based Train Control
- Course 212: Monitoring, Diagnosing, and Troubleshooting

At the 100 level, existing courseware was collected on fundamental topics such as alternating current/direct current (AC/DC) fundamentals and basic hydraulic and pneumatic theory

and applications. That courseware has been validated against the national training standards and is available for sharing across the industry.

At the intermediate 200 level, SMEs from the National Rail Vehicle Training Standards Committee paired up with instructional designers at the Transportation Learning Center to develop primers on each of the 12 rail car subsystems and advanced topics in the 200 level courses. These primers follow a standardized format, which, on an introductory level, covers the learning objectives outlined in the national training standards in sections, including definitions and abbreviations, text by topic area, bibliography, relevant original equipment manufacturer (OEM) contact information, and the pertinent section of the national training standards for that primer. The primers are intended as introductory materials or study guides rather than as textbooks.

## Courseware Validated to the National Standards

For more detailed courseware assessment, the Transportation Learning Center has developed a self-evaluation process whereby transit agencies, vendors, or any third-party organization developing course materials can evaluate their courseware against the national training standards. Courseware evaluation through a local joint team can help identify deficient courseware and devise an approach to add the missing elements, especially in hands-on learning applications. The sharing of training materials across agencies greatly reduces the costs associated with each agency having to develop these materials on their own. Understanding the benefits, the Transportation Learning Center has developed a courseware sharing mechanism through its Transit Training Network (TTN) website (TransitTraining.net). TTN serves as a logical platform for sharing the collected materials among the transit community, including the 12 primers at the 200 level and the materials validated at the 100 level. In addition to courseware, TTN provides a library of other useful training documents to share including training standards, papers on various training subjects, research on training metrics, and other subjects.

## Apprenticeship

The research team sees registered apprenticeship as the most effective model for integrated training of frontline technicians. The proposal for a new national apprenticeship for transit rail vehicle technicians was submitted on behalf of this joint industry effort. It was approved by the U.S. Department of Labor in June 2013, providing a valuable new resource of registered apprenticeship for the transit industry. The national qualification system and U.S. Department of Labor registered apprenticeship developed through TCRP Project E-07 provide a common framework with flexibility for local customization by individual agencies.

## Qualification—Training, Assessment, and Grandparenting

The National Rail Vehicle Technician Qualification Program contains three successive levels of qualifications, built on the basis of national training standards and the Rail Vehicle Technician Apprenticeship as approved by the U.S. Department of Labor:

- 100 Level leading to Qualified Rail Vehicle Apprentice Technician (Craft titles used are for the National Qualification Program only. Actual local craft titles will be determined by local collective bargaining agreements.)
- 200 Level leading to Qualified Rail Vehicle Technician
- 300 Level leading to Qualified Rail Vehicle Master Technician

A necessary component of the qualification system is **grandparenting of incumbent technicians**. As new requirements are established for new hires, it is important to the program's success that implementation of the new system not punish technicians already on the job. It was the consensus view to follow the norm of protecting the status of incumbents that is seen in many industries introducing new systems of apprenticeship or qualification.

For new hires, participation in the detailed training curriculum is a prerequisite for any formal assessments. The rail car technician assessments have been carefully designed to include written *and* hands-on assessments. Detailed questions for assessments have been jointly developed and jointly piloted through the TCRP Project E-07 process. Employees who are judged by training coordinators to have had sufficient prior training in school or through experience in another job may complete the assessments and advance to the next level, based on locally agreed-upon criteria. Draft assessment questions and protocols were carefully piloted at six agencies to identify and remedy potential weaknesses.

At all levels, the purpose of assessments is to support success in learning and assist technicians in mastering the skills required in their jobs. As the title of TCRP Project E-07 emphasizes, the purpose of the entire system is "Building for Success." The goal of assessment is to assist technicians in learning their craft.

A technician who successfully completes the written assessment at the 100 level will be granted status as a Qualified Rail Vehicle Apprentice Technician. At the 200 and 300 levels, a technician may choose to pursue single or multiple qualification tracks within his or her work specialization. For 200 level topics, a technician who successfully completes the pair of written and hands-on assessments will be granted status as a Qualified Rail Vehicle Technician in the particular topic, for example, Qualified Rail Vehicle Technician in Couplers. A technician who obtains all 12 qualifications at the 200 level will be granted status as a Qualified Rail Vehicle Journeyperson. At the 300 level, a candidate who successfully completes hands-on assessment in one area will be granted status as a Qualified Rail Vehicle Master Technician in that area, for example, Qualified Rail Vehicle Master Technician in HVAC. Technicians may choose to pursue single or multiple qualification tracks based on their work specialization. A technician who obtains all 12 qualifications at the 300 level will be granted status as a Qualified Rail Vehicle Master Technician. All assessments will be provided when needed at the request of local training programs rather than on a predetermined national schedule.

A comprehensive web-based database system has been developed for tracking local training course completion, enrollment and completion of standardized national assessments, and achievement of national qualification status by rail vehicle technicians. Rail technicians who wish to participate in the national qualification program may create an online profile at the Rail Vehicle Qualification website.

## Moving Forward

The completion of TCRP Project E-07 is not the end, but rather an important milestone in the transit industry's development of a complete system of qualification. This project has broken important new ground for transit's emerging industrywide system of qualification, including in-depth tools for building effective mentoring; a credential management system for tracking the qualification experience of technicians across the industry; and a jointly developed set of assessments, both written and hands-on, to confirm that technicians have developed the necessary knowledge and skills.

The first step the industry can take toward implementing this new system is for existing local transit rail car apprenticeships to align themselves with the new framework for apprenticeship developed under TCRP Project E-07 and approved by the U.S. Department of Labor. Another

opportunity for moving forward is to engage with individual agencies, or groups of agencies, that are ready to enhance the quality of their technicians' skills.

The next chapter in developing a complete system of rail car training and apprenticeship will be the establishment of a transit rail car training consortium with a focus on training rail car training instructors and mentors to use the curriculum, classroom courseware, and on-the-job learning modules for effective qualification of the next generation of rail vehicle technicians.

CHAPTER 1

# Introduction and Overview

Meeting the challenge of developing fully qualified transit rail car maintenance technicians is the goal of TCRP Project E-07, "Establishing a National Transit Industry Rail Vehicle Technician Qualification Program: Building for Success." The best answer, fine-tuned by the research team working on this project, is a new multipart, industrywide *system* of qualification. This system brings together a broad range of training components including the following:

- National training standards
- Progressive classroom curriculum and courseware integrated with structured on-the-job learning
- A credential management system that keeps track of the worker's training experience and skills
- Apprenticeship frameworks with well-designed sequences of learning, support of learners by trained mentors, and specialized training for instructors

All these components provide the foundation needed for written and hands-on assessments to confirm that technicians have the practical knowledge and skills required to perform their jobs at the highest level of expertise. This new system is designed to apply fully to new hires, with incumbent workers "grandparented" to protect them from any harm from the transition to a new training system.

Working together over the past 7 years on the critical occupation of rail car maintenance technicians, the subject matter experts (SMEs) on the National Rail Vehicle Training Standards Committee and on the TCRP Project E-07 panel have developed the components of a highly efficient, cost-effective, and top-quality training system that can be applied throughout the industry for training on any skilled occupation. This system has been sponsored broadly by transit management and labor organizations in the industry and staffed by the Transportation Learning Center.

This new system of qualification for transit rail car technicians is part of the transit industry's broader project over the past dozen years to redesign and upgrade frontline workforce development, with a particular focus on technical maintenance occupations. In addition to addressing transit rail vehicle maintenance technicians, this larger effort has addressed four other technical occupations in rail and bus transit—maintenance technicians for transit elevator-escalator, signals and traction power on the rail side, and bus maintenance technicians and bus operators on the bus side.

Transit rail car maintenance technicians, as the largest group of maintenance technicians within the rapidly growing transit rail side of public transportation, provide an excellent focus for the in-depth development of transit rail's system of qualification. Over a 5-year period, TCRP Project E-07 has allowed industry experts to develop in-depth training tools that go beyond what has been developed so far for other transit technical maintenance occupations—signals, transit elevator-escalator, and traction power on the rail side and bus maintenance technicians and operators on the bus side. Importantly, rail car technician training also benefits from related work undertaken by the industry to develop training systems based on quality standards through ongoing industry-wide training consortia for transit elevator-escalator and signals technicians.

## The Problem: Demographic Transitions, Industry Growth, and New Technology

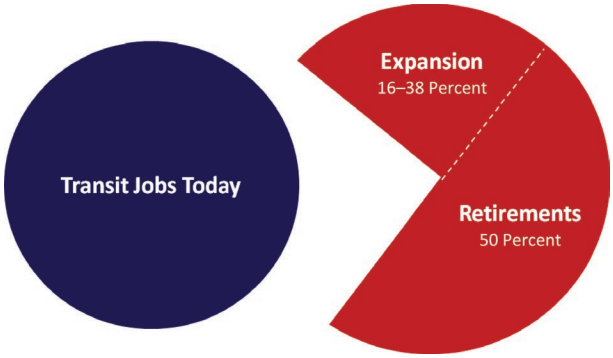
A world class system of qualification is needed because the industry is facing an unprecedented technical skills challenge. Demographic and technological change and growing demand for public transportation are creating a critical shortage of workforce skills. Among the industry's most acute skills shortages are those of frontline maintenance technicians in transit rail operations. The frontline skills challenge is driven by three factors: the pending retirements of many technicians who helped establish new rail transit systems, concentrated industry

growth in rail transit, and the growing prevalence of electronic and especially digital systems in rail transit.

Among transit rail's frontline technical occupations, rail car maintenance technicians are the largest group, with an estimated 6,200 employees across the industry. This large group provides a natural focus for this research. It should be remembered, of course, that other frontline occupations in transit rail are facing skills challenges that are just as severe, even though the workforces are not as large. Signals maintainers, traction power technicians, and transit elevator-escalator mechanics with top-quality skills are critical for passenger safety and reliable transit service.

For 20 years, TCRP research has shown that skilled transit mechanics are the industry's most difficult group to recruit (see Finegold, Robbins, and Galway 1998; McGlothin Davis and Corporate Strategies, Inc. 2002; and *Special Report 275*, 2003). There are few "feeder industries" that utilize transit's specialized technology and thus can prepare workers for transit's technical occupations; this is particularly true for transit rail car technicians. In addition, baby boomer retirements are already hitting the industry. U.S. DOT estimates that 50 percent of the transportation workforce will be retiring in the next 10 years (DOT Workforce Summit 2012). Sixty-three percent of the transit workforce is currently age 45 or older, with 12 percent 65 or older. Retiring technical workers are those with the greatest experience and, in many cases, the highest effective skill levels. These workers will need to be replaced with fully qualified personnel.

Rapid growth of the transit rail industry is heightening the technical skills challenge. The U.S. Department of Labor has projected that urban transit systems will expand their overall employment by 16 to 38 percent over the next 10 years



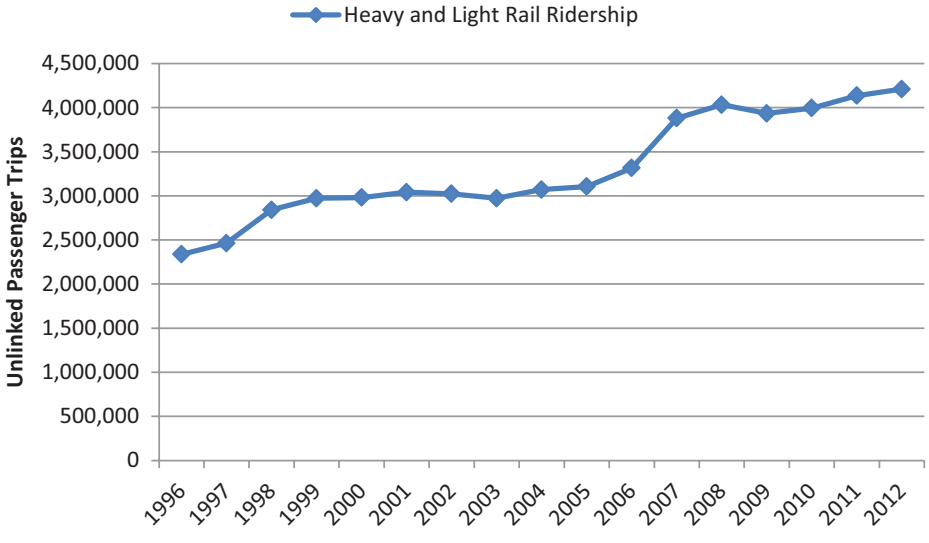

Source: Transportation Learning Center, based on data from the U.S. Department of Labor and U.S. DOT.

***Figure 1. Need to train equivalent of up to 88 percent of transit's total staff in the next 10 years.***

(Bureau of Labor Statistics n.d.), and a large share of that increase will inevitably be on the rail side of public transportation. These new jobs will require high skill levels.

The forecasted need to replace 50 percent of the transportation workforce combined with 16 to 38 percent employment growth in the transit industry means that in the next 10 years a workforce of up to 88 percent of today's total workforce will need to be hired and trained (see Figure 1). Transit rail is facing an even steeper challenge, given the rapid growth in transit rail—with ridership up 80 percent between 1996 and 2012 (see Figure 2) and new rail investments being made across the industry (APTA 2012).

While retirements and industry growth are creating an increasingly urgent need to hire and qualify new technicians, rapid technological innovation is continually raising the bar




Source: APTA.

***Figure 2. Increase in transit rail ridership 1996–2012.***

for the skills required of transit's frontline technicians. In particular, there have been dramatic increases in technological content in virtually every area of transit rail vehicles. Digital subsystems, programmable logic controllers, and multiplexed sensors and controls have already driven the skill requirements of today's frontline technicians far beyond what were needed 20 or even 10 years ago. Tomorrow's skill requirements will certainly continue this trend toward higher knowledge and technical proficiency.

Is the transit industry prepared for this massive workforce challenge? The honest answer is "No," and that "No" is not just for the industry as a whole. In the research team's engagement with transit agencies across the country, not a single one has said it is ready to hire and train a new skilled workforce on the scale and level of sophistication that will be required.

The new system of qualification developed under TCRP Project E-07 is designed to meet this major workforce challenge. The system will provide free access to a suite of training models and resources that will greatly increase the quality of transit training and skill while reducing the cost of that training. The system will also support a transition to a modern, high-performance, problem-solving culture in the transit industry, one that will build in continuous learning and continuous improvement in operations and maintenance.

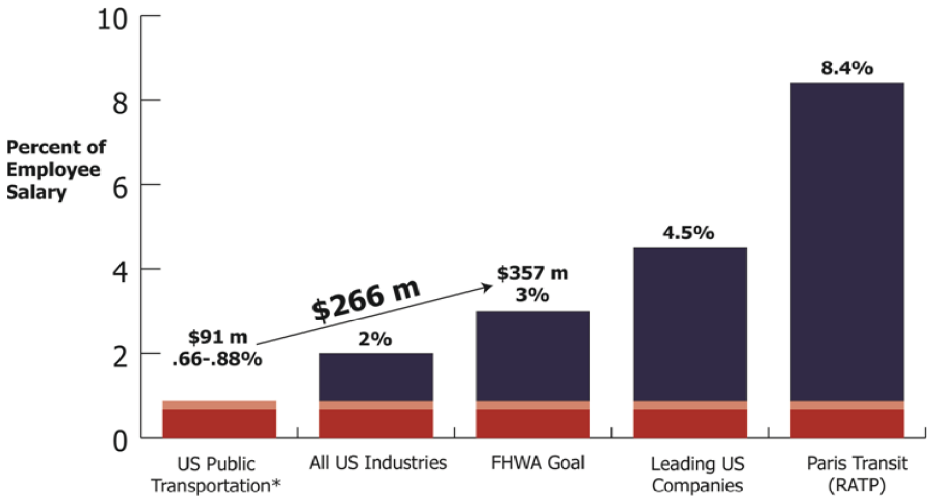
## Inadequate Investment in Human Capital

While many public transportation leaders have recognized the need for more and better training, inadequate resources have been invested to solve the problem. The industry's investment in training in general has been very low—one of the lowest among U.S. industries and far behind transit industries in other countries (see Figure 3).

The transit industry's legacy approach to technical training requires each transit agency to invent its own training system from the ground up, determining for themselves what technicians need to know and be able to do, how to teach them, how best to develop training materials and systems, and then how to determine whether the needed skills have been mastered. Without a consistent or standardized approach, training has been developed and delivered by individual agencies from scratch, with little if any interaction from other transit systems or the industry as a whole. One result of this go-it-alone approach to training is that although training costs for each custom-built program are high, the quality of training is low and the results are inconsistent across agencies.

All of this has led transit systems to significantly under invest in workforce training. In fact, the transit industry currently spends less than 1 percent of its payroll on workforce training—one of the lowest levels of investment in workforce skills of any U.S. industry. The most recent survey results (prior to the 2008 recession) indicate that transit's training investment falls between 0.66 and 0.88 percent of payroll (Transportation Learning Center 2010b).

Transit's human capital investment of less than 1 percent of payroll contrasts with an average among all U.S. industries of 2 percent of payroll invested in training. FHWA, noting the aging workforces and pending retirements in state departments of transportation (DOTs) recommended that they spend 3 percent of payroll on training their workforces, even without the prospect of a growing number of employees. (For transit workforce investment to reach the 3 percent level recommended by FHWA, the industry would have to spend




*Estimated by the Transportation Learning Center based on a 2010 survey of the transit industry

Source: Transportation Learning Center

***Figure 3. Transit lags in human capital investment.***

an additional $266 million on training annually.) The most successful U.S. companies spend between 4 and 5 percent of payroll on training. The regional transit system in Paris, France (RATP) invests over 8 percent of payroll in training the workforce for its very safe and reliable transit system.

One source of transit's under investment in workforce skills, or human capital, is that federal policy in the transit industry has provided very limited support for transit workforce development (see Figure 4).

Economists recognize human capital (durable workforce skills and knowledge) as a necessary match to physical capital—the industry's equipment (trains and buses) and structures (tracks, bridges, and stations). Capital equipment (physical capital) cannot operate well, safely, or reliably without the adequate human capital that is developed by recruiting and training a skilled workforce. The federal government invests about one thousand times as much in the transit industry's physical capital as it does in transit human capital. (Or, conversely, federal investment in transit's human capital investment is about 1/10 of 1 percent as much as its investment in physical capital.) The shortfall in federal human capital investment is even more extreme when it comes to meeting the training needs of transit's frontline workforce. Eighty percent of the transit workforce—the frontline transit technicians who deliver and maintain public transportation services—have received less than 20 percent of the limited funds available for transit workforce training. On a per-employee basis, that's less than 1/16 as much funding for training for these critical frontline technical employees as for white collar administrative staff.

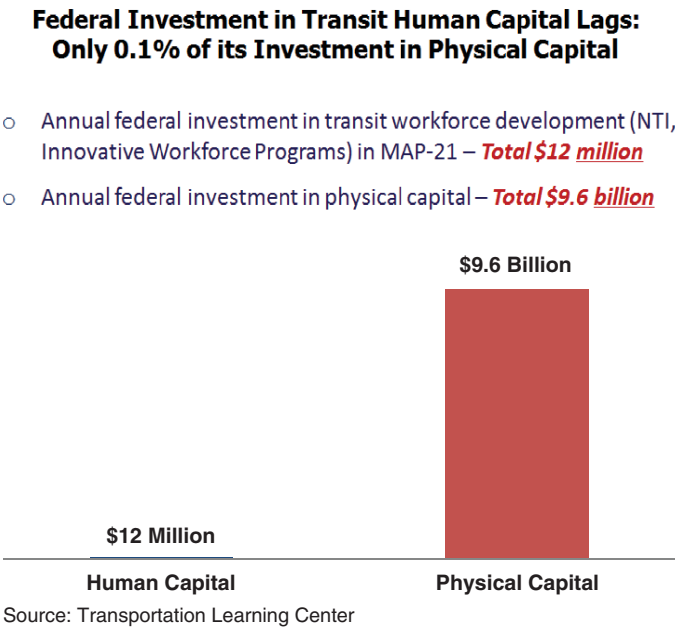



***Figure 4. Federal investment in transit human capital versus physical capital.***

These imbalances make the need for a cost-effective system of technical training for transit's frontline workforce all the more urgent.

## Transit Industry Initiatives to Build Effective Technical Training Systems

### Developing Industrywide Training Standards

Over the past 10 years, the leadership of all the major stakeholders in the U.S. transit industry has come together to create a standards-based partnership solution to the industry's technical skills challenge. APTA joined with the major transit labor unions—the Amalgamated Transit Union (ATU) and the Transport Workers Union (TWU)—and the leaders of over 40 different transit agencies and local unions to make this effort possible. This decade-long effort has been staffed and facilitated by the industry's jointly governed nonprofit for frontline workforce training, the Transportation Learning Center.

The first step, begun in 2004 and continued through 2009 with critical financial support from the U. S. Departments of Labor and Transportation, was to develop consensus industrywide training standards for five frontline technical transit occupations:

- Signals
- Traction power
- Transit elevator-escalator
- Rail car
- Bus technicians

For each of these frontline occupations, national joint training standards committees and related efforts were developed with volunteer SMEs drawn from knowledgeable frontline technicians, supervisors, and trainers from across the industry. National training standards committees were established for each of the five occupations listed above, with senior co-chairs drawn from labor and management. For these five "founding" training standards committees and a later one for bus operator training standards, dozens of transit agencies and their local unions designated SMEs to help develop quality national standards for transit technical training. For the first five technical occupations, the final training standards included 4,163 separate learning objectives in 728 modules and 132 courses (see Table 1 for breakdown).

The training standard for rail vehicle maintenance technicians reflected the complexity of modern transit rail cars. The classroom learning curriculum consists of 1,346 separate learning objectives in 42 courses and 177 modules that the

**Table 1. Transit training standards.**

| Maintenance Occupations | Courses | Modules | Learning Objectives |
|---|---|---|---|
| Bus Technician | 7 | 186 | 1,551 |
| Rail Car | 42 | 177 | 1,346 |
| Rail Signals | 27 | 86 | 467 |
| Traction Power | 17 | 36 | 232 |
| Transit Elevator/Escalator | 39 | 243 | 567 |
| **Total** | **132** | **728** | **4,163** |

SMEs felt were necessary for a person to become a top-notch rail vehicle maintainer across the 11 fundamental systems on rail vehicles, along with prerequisite fundamental skills and advanced diagnosis and troubleshooting (see Table 2).

The jointly developed training standards for rail car technicians and the other four original technical occupations were completed by 2009. All five were reviewed and formally adopted as recommended practices for the transit industry as part of the APTA standards process in 2010.

## Building on Training Standards to Develop Complete Technical Training Systems

Important as they are, industrywide training standards themselves cannot be used to deliver training. The standards identify detailed learning objectives and curricula designs that describe course and module content, but they don't detail how training should be delivered. What training standards do provide is the needed foundation for developing a common framework for training and for training materials that can be customized by agencies and training programs for use with particular fleets and equipment as well as for specific local practices for maintenance, career ladder advancement, and training.

Rail car maintenance technician was the first of three transit rail technical occupations that have made major progress on developing standards-based training systems since the new training standards were first developed (2006–2008). TCRP Project E-07, starting in 2008, has enabled the industry's rail vehicle training stakeholders to take the lead as the first of these standards-based initiatives, building on the new training standards to develop systems of standards-based training or, more broadly, qualification. Each of these early initiatives has followed its own path: Transit stakeholders for transit elevator-escalator maintenance technicians (starting in 2010) and signals technicians (starting in 2013) have developed industrywide training development consortia co-funded by member agencies and unions with partial match funding from the FTA. TCRP Project E-07, assisted by the larger National Rail Vehicle Training Standards Committee, has been able to frame out a comprehensive approach to a system of qualification programs that addresses standards-based training not only for rail vehicle technicians, but the full range of transit's frontline blue-collar occupations. The research conducted under TCRP Project E-07 has helped establish the design of a comprehensive, shared

**Table 2. Rail car technician training standards.**

| Topic Area | Courses | Modules | Learning Objectives |
|---|---|---|---|
| **Fundamental Skills** | 17 | 70 | 478 |
| 1. Couplers | 2 | 7 | 68 |
| 2. Trucks & Axles | 2 | 17 | 211 |
| 3. Propulsion & Dynamic Braking | 2 | 5 | 91 |
| 4. Auxiliary Inverters & Batteries | 2 | 9 | 34 |
| 5. Friction Brakes | 2 | 11 | 82 |
| 6. Heating, Ventilation, & Air Conditioning (HVAC) | 2 | 14 | 80 |
| 7. Current Collection & Distribution | 2 | 11 | 54 |
| 8. Car Body | 2 | 7 | 64 |
| 9. Doors | 2 | 5 | 39 |
| 10. Communication Systems | 2 | 6 | 67 |
| 11. Computer-Based Train Control (CBTC)—Automatic Train Protection (ATP), Automatic Train Operation (ATO) | 2 | 8 | 52 |
| 12. Diagnostics and Troubleshooting | 3 | 7 | 26 |
| **Total** | **42** | **177** | **1,346** |

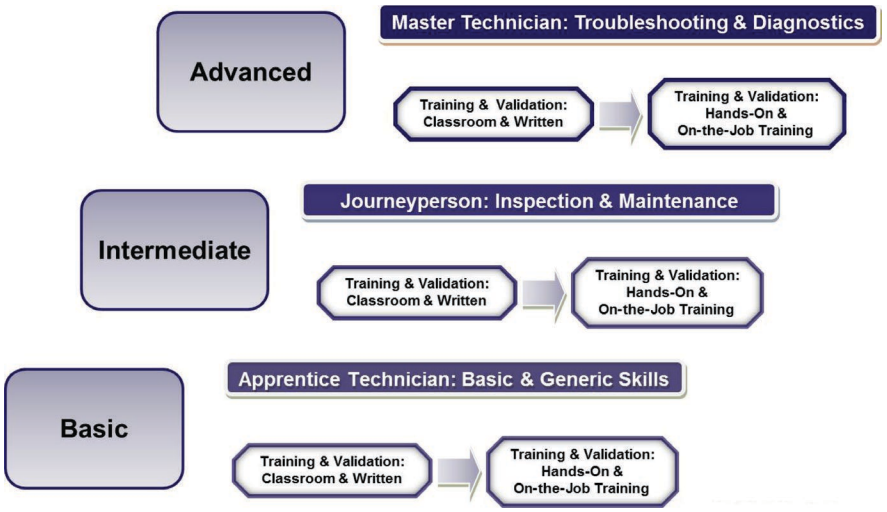



***Figure 5. Standards-based qualification system.***

framework for qualification that will strengthen all transit technical training systems going forward.

Each of these three early initiatives for developing systems of transit rail training have followed the same framework for consistent, high-quality occupational training that has been developed under TCRP Project E-07. The TCRP Project E-07 research team examined successful nationwide training programs for frontline blue-collar workers in other U.S. industries and in other countries. (See Appendix B to the contractor's final report. Appendix B: Building Capacity for Transit Training: International and Domestic Comparisons can be found by searching for *TCRP Report 170* on the TRB website.) These successful systems of training—or more broadly, qualification—have a number of critical features. They integrate classroom and on-the-job learning, and technicians advance through the system of learning through progressive stages of hands-on and classroom learning (See Figure 5).

With specialized content and support systems being developed by joint committees of SMEs, this general framework is currently under development not only for rail vehicle technicians but also for training in all transit frontline technical occupations.

## From Training to Qualification Systems

As the TCRP Project E-07 panel and National Rail Vehicle Training Standards Committee deepened their understanding of what constitutes quality training, they came to identify a number of critical components of a system of qualification. Taken together, these components constitute much more than "training" as that term is ordinarily used. In fact, they make up what most other countries identify as a "system of qualification," as shown in Figure 6.

Figure 6 shows how the standards-based qualification system is built up of interconnected components developed by industrywide SME stakeholder experts. The national qualification system provides resources for customized implementation at the local level. National training standards provide the foundation for developing the entire system of qualification. Standards-based curriculum and courseware are developed for classroom training, which is in turn integrated with on-the-job learning objectives fine-tuned to local equipment, job classifications, and practices. Specific training for trainers and mentors is developed so that they can effectively support learners at all levels. A national credential management system can track the training of industry technicians and confirm that they are prepared to validate the skills that they have developed. To ensure the success of the new system, incumbent technicians are exempt from new training requirements through the standard process of "grandparenting." Even as incumbents are engaged in new and better training, they are not required to pass through all the parts of the new systems being implemented for new hires. Tying all these pieces together is a national framework of apprenticeship—developed by industry stakeholders and registered with the U.S. Department of Labor—that provides ongoing consistency and a path to future college credit for the learning accomplished through the system of qualification.

Figure 6 also shows how the national qualification framework provides resources to support customized local implementation. Each agency needs a training system that matches its own specific fleet equipment, job classifications, and promotion systems. The national qualification system is designed to ensure quality and consistency in workforce qualification efforts that have been optimized for the particular conditions in each location. With national qualification frameworks and


***Figure 6. National and local qualification system.***

resources developed by SME committees for each occupation, each transit agency can access quality materials for this progression of classroom and on-the-job learning and customize them for their specific equipment and practices, including job classifications and progressions. Transit agencies can also utilize specific train-the-trainer and mentor training resources for each occupation. Individual locations are no longer left on their own to develop everything they need for quality training.

This interaction between national resources and local implementation is a two-way street. Broad local participation is what confers validity on national standards and resources, while local customization of national systems provides consistent, high-quality training at a greatly reduced cost.

The goals of these training systems across all the occupations are similar: developing consistently strong workforce skills for high-performance and maintenance operations (Finegold, Robbins, and Galway 1998). Attainment of these goals should translate into increased skills, increased safety and reliability of equipment and service, a better state-of-good-repair, reduced risk and costs, and a substantially positive return on the agency's and industry's investment in developing human capital.

Balanced participation by both managers and frontline workers—frontline technicians, training department staff, and maintenance supervisory personnel—is the best way to ensure that the products developed by the SME group accurately reflect industry needs, best practices, and expertise. Working together in this way also ensures that all stakeholders have an interest in the success of the project. All parties jointly "own" the final products at both the national and the local level. In this process of developing standards-based transit qualification systems, union and management representatives have worked together as fully productive partners.

## The National Rail Vehicle Training Standards Committee and TCRP Project E-07: Developing a National Qualification System for Rail Car Maintenance Technicians

The National Rail Vehicle Training Standards Committee was the forerunner to and later an advisory partner to the TCRP Project E-07 panel. The project panel, like the National Rail Vehicle Training Standards Committee, included an equal number of agency managers and frontline union workers. In an industry where more than 90 percent of the frontline workers are represented by unions and frontline workers make up 80 percent of the industry's workforce, frontline workers are natural stakeholders who are recognized as full partners in developing the system of qualification.

Once established, the TCRP Project E-07 panel worked closely with the National Rail Vehicle Training Standards Committee to further refine and implement the E-07 work plan. (See Appendix C of the contractor's final report. Appendix C: TCRP E-07 Multiyear Work Plan can be found by searching for *TCRP Report 170* on the TRB website.) Over the course of 5 years, the project produced a comprehensive qualification system, including a nationally recognized apprenticeship for transit rail car maintenance technicians, approved by the U.S. Department of Labor in 2013. The research team also looked into a set of related topics, including how high-quality, skills training is reliably developed through industry-wide programs in other countries and other industries. The resulting report is included as Appendix B of the contractor's final report (available by searching for *TCRP Report 170* on the TRB website). Appendix B: Building Capacity for Transit Training: International and Domestic Comparisons includes case profiles of national frameworks for industry training in Germany, Denmark, the Netherlands, the United Kingdom, Canada, and Australia, as well as case profiles for the U.S. building and construction crafts.

The research team and project panel ultimately developed a comprehensive, integrated system for the qualification of rail car technicians. The work drew on best practices in other industries with successful, long-lasting, institutionalized national programs for qualification of frontline technical workers. The new system of qualification is designed to be economically self-sustaining within a broader framework of training systems addressing multiple occupations within the transit industry.

The rail car system of qualification developed under TCRP Project E-07 is not yet complete. As shown in Figure 7, some components are only partially developed at this point.

As Figure 7 shows, more work is needed on advanced courseware development, a specific train-the-trainer program for rail vehicle instructors, and specifying the details of on-the-job learning goals and sequences for technician training. These areas of future work for training rail car

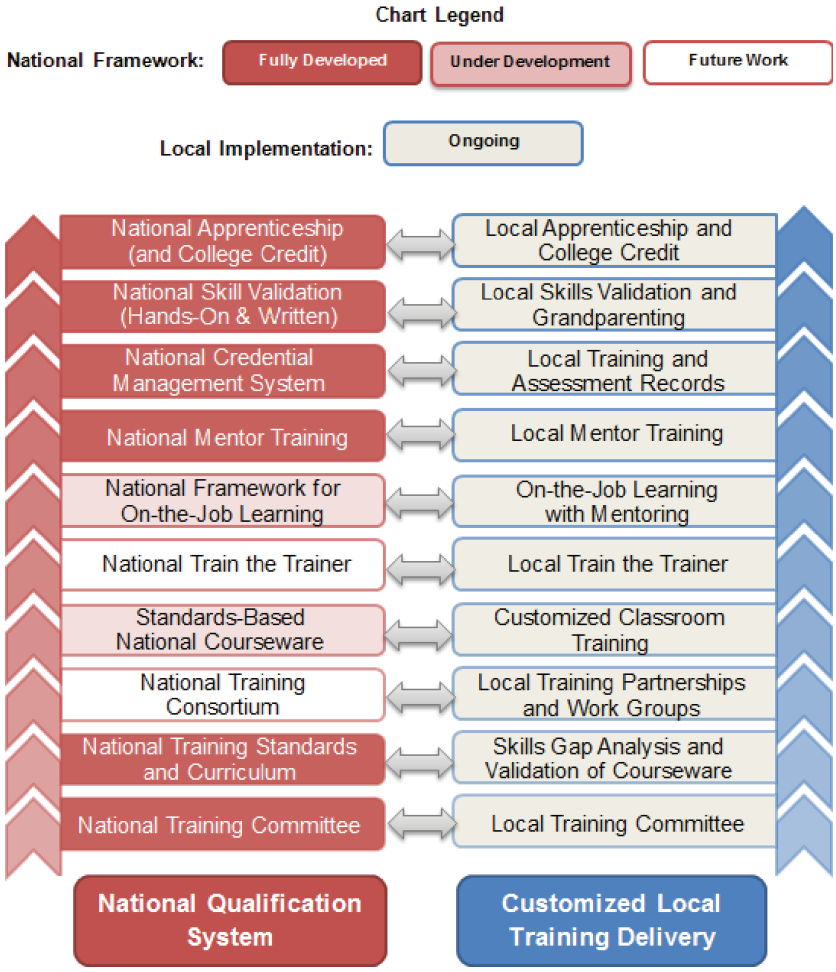



***Figure 7. National and local qualification system for rail vehicle technicians.***

technicians, fortunately, are being developed in parallel initiatives through the industrywide transit rail training consortia for signals and elevator-escalator maintenance. Future efforts in rail car training should therefore move more quickly and efficiently.

Conversely, the in-depth work conducted under TCRP Project E-07 has developed a number of components for the rail car system of qualification that are also directly applicable to qualification systems for other transit technical occupations. In particular, the work on mentor training, the development of hands-on skill assessments, the integration of the overall system of qualification, and, in particular, the national credential management systems are all available to advance the development of qualification systems in other technical occupations in transit. Research conducted under TCRP Project E-07 has not only benefited the rail car maintenance qualification program, it has also contributed to developing a national system for training highly qualified frontline technicians in all public transportation technical occupations.

## Next Steps

### Implementation of the System of Qualification for Rail Car Technicians

The next major step for the rail car technician system of qualification will be to promote and support implementation of TCRP Project E-07's standards-based qualification broadly within the transit rail industry. All the transit rail agencies participating in the TCRP Project E-07 panel or the National Rail Vehicle Training Standards Committee have already taken steps toward implementing major parts of the qualification system. Implementation in the industry needs to be broadened and deepened.

As of late 2013, there are at least six medium-sized and large transit systems with a commitment to formal implementation of the rail car technician qualification framework (see Chapters 4 and 5). An early step for these agencies will be the formal registration of their new or existing rail car apprenticeship programs under the framework developed through this project and formally recognized by the U.S. Department of Labor in June 2013. The new U.S. Department of Labor framework includes coordinated classroom and hands-on learning, local joint apprenticeship and training committees, mentoring, and other elements of the overall system of qualification. Other locations may move forward in partial steps by implementing different parts of the qualification framework.

Further momentum in implementing the standards-based system of qualification will be gained by engaging transit agencies and transit labor in organizing a transit rail car training consortium as first discussed among transit leaders in late 2013. With a similar structure to the existing elevator-escalator and signals training consortia, the proposed transit rail car consortium will fill in the remaining blanks in the system, with a focus on an instructor training course and further courseware development that will prepare instructors to use the curriculum, classroom courseware, and on-the-job-learning modules.

In the longer term, the complete transit rail car system of qualification will be integrated into a broader framework of standards-based systems of qualification across all the technical occupations.

### Developing a Comprehensive System of Training across all Technical Occupations

With development of comprehensive national systems of qualification underway for three critical technical occupations, the industry is within sight of developing a complete system of technical training resources that can be used throughout the industry for more effective training. The immediate next steps will be to extend the transit training consortium model to completing the qualification system for rail vehicle technicians and then to work toward new consortia for rail traction power systems and for bus maintenance, the other technical occupations for which national training standards have already been developed (see Figure 8).

Important elements still to be addressed for rail car technicians can be adapted from related tools already developed through the Transit Elevator-Escalator Training Consortium started in 2010 and being further developed through other related projects, including the industrywide Signals Training Consortium.

The traction power industrywide training standards were developed by the Traction Power Training Standards Committee between 2006 and 2009 and adopted as recommended practices by APTA in 2010. Traction power is necessary for reliable service and safety, and it is an area of critical skill shortages in the industry, with many transit rail agencies having a large number of vacancies that they cannot fill. With the continuing rapid growth of transit rail ridership, the industry has no alternative but to develop its own supply of skilled technicians for these jobs.

The need for a system of qualification for transit bus maintenance technicians is arguably even more urgent than transit's training needs on the rail side. Most of transit's existing training capacity is concentrated in larger agencies, and the larger agencies (with few exceptions) include rail as well as bus transportation. Training capacity is generally very limited in medium-sized transit agencies—almost exclusively bus transit agencies—and almost no training capacity exists in smaller bus transit agencies and paratransit services. APTA

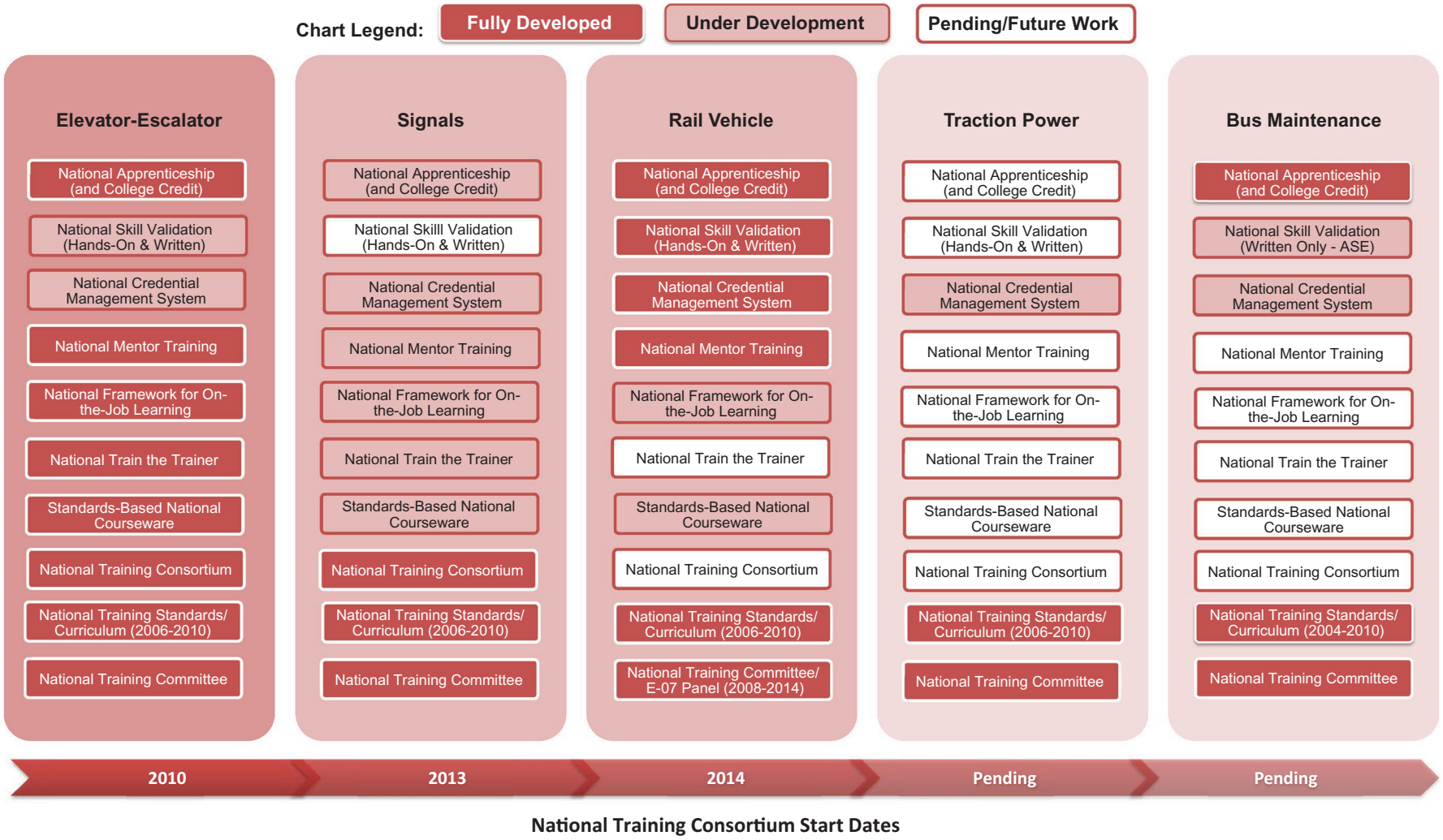



*Figure 8. Status of national qualification system development across transit technical occupations.*

adopted recommended practices for training bus maintenance technicians in their standards process in 2010, alongside the rail training standards. Nonetheless, the rest of a full system of qualification for bus technicians remains undeveloped, with the notable exception of written tests for the National Institute for Automotive Service Excellence (ASE) transit bus technician certification system. A bus training consortium developed on the model of the training consortia for rail technical occupations would provide important benefits to the industry and the riding public.

There are additional technical occupations whose training needs have yet to be addressed. Developing training standards and then standards-based systems of training/qualification for track workers and facilities maintenance technicians, two important occupations in rail transit, would help complete a full system of transit rail workforce qualification.

CHAPTER 2

# The Framework of Effective Rail Car Technician Training

## Building a National System of Qualification for Rail Car Technicians

When the TCRP system of qualification project was getting started in 2008, the then-existing foundation for industrywide transit rail training innovation consisted of the National Rail Vehicle Training Standards Committee and their partially completed national training standards. The first question facing the project was straightforward: how to identify the best qualification framework for providing training to rail car technicians and then assess technician abilities in a consistent manner.

The project identified the comparative method as the best way to study the features of successful national qualification systems for frontline technicians. The research team undertook structured case studies of durable and effective national qualification systems for frontline blue-collar technical occupations in the United States and in other countries. In the United States, the high-quality systems are primarily for construction crafts. These systems have been developed and sustained over many decades for electricians, sheet-metal workers, plumbers and pipefitters, structural iron workers, and heavy equipment operators. Several of these national occupational systems were studied in depth.

National frameworks for training and qualifying blue-collar technicians were also studied in a number of other countries, ranging from those with very effective systems that have been in place for more than 50 years (Austria, Germany, Switzerland, Denmark, and the Netherlands) as well as newer systems in Canada, Australia, and the United Kingdom. (The principal results of this research are summarized in Appendix B of the contractor's final report. Appendix B: Building Capacity for Transit Training: International and Domestic Comparisons can be found by searching for *TCRP Report 170* on the TRB website.)

The results of this comparative analysis showed strong underlying similarities across national training systems for frontline workers in other U.S. industries and in other countries:

- Sectorwide training partnerships involving employers and sector unions, sometimes with government and academic partners
- Use of a data-driven system with stakeholder engagement to develop and maintain standards-based curriculum content
- Provision of a stable source of funding
- Training and certification for new hires through training and apprenticeship systems combining classroom learning with paid on-the-job learning
- Training and certification for lateral entrants and experienced incumbents
- Training as an essential prerequisite to assessments and certification

The members of the National Rail Vehicle Training Standards Committee and the TCRP Project E-07 panel agreed that a similar structure could be built for the U.S. transit industry. The foundation provided by the industry's national training partnership and consensus training standards is a good one, as shown in Table 3.

The TCRP Project E-07 panel and the National Rail Vehicle Training Standards Committee agreed that a standards-based approach drawing on training partnerships at the national and local level offers the best approach for a robust system of qualification for transit rail car technicians. In the effective systems in other U.S. industries and other countries, quality results are achieved through a combination of components that includes "training" in the narrow sense but also goes further. These "systems of qualification" combine standards-based training with associated curriculum and courseware, coordination of classroom and on-the-job training, mentoring to support learning in the field, training of trainers and mentors in the effective use of the system, assessments to confirm that

**Table 3. Comparison of international and domestic training systems.**

| Region | Sector Partnerships: National and Statewide | Local Partnerships | Data-Driven Training: Classroom and On-the-Job Curriculum | Secure Funding | Youth and New Entrants: Training/Certification | Lateral Entrants: Training/Certification and Incumbents: Refresher Training |
|---|---|---|---|---|---|---|
| **International: Northern Europe Australia UK Canada** | Tripartite | Bipartite | National and/or regional for major industries & occupations | Secure blend of public and work-related funding via legislation and bargaining | Training and apprenticeship | Well provided in some countries (Denmark, the Netherlands, etc.) weaker in others |
| **United States: Industrywide Partnerships** | Bipartite | Bipartite | Through national and local joint apprenticeship and training committees (JATCs) | Negotiated in contracts | Strong apprenticeship training systems | Testing and fill-in-the-gap training, certification |
| **U.S. Transit: Traditional Baseline** | None | Few and unstable | None (or a few local uncoordinated initiatives) | No | Sporadic, local variation | Sporadic, local variation |
| **Recent U.S. Transit Innovations** | Bipartite – Transportation Learning Center; National Framework for Apprenticeship | PA, NY, UT, GA, Northern CA, and other states in the pipeline | Joint national training guidelines for five maintenance occupations 2008 | To be determined – could be addressed in reauthorization of federal transportation bill | Implement national guidelines with courseware sharing; third party | Testing and fill-in-the-gap training and certification under new apprenticeship |
| **Possible Future U.S. System** | Broader implementation | In all states | Completed guidelines for all occupations | Stable combination of public and bargained funds | Complete system, articulate with school programs | Extended |

skills have been learned, and an integrated credential management system to track the advancement of learners. All of this is capped by an industrywide apprenticeship that can be customized for local implementation. It is this comprehensive and integrated "system of qualification," rather than a smaller set of training components, that is the goal for rail vehicle technicians and other frontline technical workers in the transit industry.

## National Rail Vehicle Training Standards Committee

As shown in Figure 6 (Chapter 1) the process for creating a national system of qualification is rooted in an occupational National Rail Vehicle Training Standards Committee composed of SMEs from both labor and management. The National Rail Vehicle Training Standards Committee, which was formed prior to TCRP Project E-07 to develop national training standards, worked with the TCRP Project E-07 oversight panel to provide valuable guidance in developing the system of qualification. Individual labor-management representatives also served locally on the training committees at their own agencies to direct and customize training activities to suit their own equipment and operating environments.

## National Training Standards and Standards-Based Curriculum and Courseware

### Overview

The backbone of the system of qualification for rail car technicians is the consensus, industry-recognized, training standards for rail vehicle technicians. These training standards were developed by SMEs from both labor and management. The standards were finalized within the TCRP Project E-07 framework in 2009 and adopted within the APTA standards system in 2010. The standards contain all of the learning objectives that must be accomplished in order to be a top rail vehicle technician. These standards are being used to both validate pre-existing courseware and to create courseware from scratch using the learning objectives as the backbone of the material.

The national training standards reflect a system of progressive learning, from general skills at the 100 level, through occupation-specific skills at the 200 level, to advanced diagnostics and troubleshooting skills at the 300 level. For transit rail car technicians, the National Rail Vehicle Training Standards Committee introduced a level 250 into the curriculum for overhaul and rebuild of rail vehicle components,

which is a major feature of the public transportation rail industry.

Level 100—Fundamental Skills for Transit Maintenance
Level 200—Vehicle Operations Overview and Standard Maintenance of Rail Vehicles
Level 250—Overhaul and Rebuild of Rail Vehicles Components
Level 300—Advanced Theory of Operation and Troubleshooting of Systems

The National Rail Vehicle Training Standards Committee divided the curriculum and learning objectives at the 200 and 300 level to correspond to the 11 major subsystems that make up transit rail vehicles (see Table 4).

## Courseware Collected and Produced as Part of TCRP Project E-07

### *Courseware on Fundamental Topics*

With the training standards in hand, the Transportation Learning Center collected training materials used at participating locations including Los Angeles County Metropolitan Transportation Authority (LACMTA), Utah Transit Authority

**Table 4. Training standards and curriculum for rail car technicians.**

| | |
|---|---|
| **Level 100—Fundamental Skills for Transit Maintenance** | |
| 100 | Property Specific Orientation (including track safety, flagging, emergency evacuation) |
| 101 | Orientation and Background |
| 102 | Electrical and Job Safety |
| 103 | Tools and Material Handling |
| 104 | Basic Mathematics |
| 105 | Introduction to Electricity |
| 106 | Electrical Meters |
| 107 | Wiring Technologies and Equipment |
| 108 | Direct Current (DC) Fundamentals |
| 109 | Alternating Current (AC) Fundamentals |
| 110 | Basic Hydraulic and Pneumatic Theory and Applications |
| 111 | Basic Mechanical Theory and Application |
| 112 | AC Motors, DC Motors, and Generators |
| 113 | Introduction to Electrical Ladder Drawings |
| 114 | AC Circuit Analysis |
| 115 | Semiconductor Fundamentals |
| 116 | Digital Fundamentals |
| **Level 200—Vehicle Operations Overview and Standard Maintenance of Rail Vehicles** | |
| 200 | Vehicle Theory of Operation and Overview of Major Systems |
| 201 | Couplers—Introduction and Preventive Maintenance |
| 202 | Trucks and Axles—Introduction and Preventive Maintenance |
| 203 | Propulsion and Dynamic Braking—Introduction and Preventive Maintenance |
| 204 | Auxiliary Inverters and Batteries—Introduction and Preventive Maintenance |
| 205 | Friction Brakes—Introduction and Preventive Maintenance |
| 206 | HVAC—Introduction and Preventive Maintenance |
| 207 | Current Collection and Distribution—Introduction and Preventive Maintenance |
| 208 | Car Body—Introduction and Preventive Maintenance |
| 209 | Doors—Introduction and Preventive Maintenance |
| 210 | Communication Systems—Introduction and Preventive Maintenance |
| 211 | CBTC (ATP - ATO)—Introduction and Preventive Maintenance |
| 212 | Monitoring, Diagnosing, and Troubleshooting Overview |
| **Level 250—Overhaul and Rebuild of Rail Vehicle Components** | |
| **Level 300—Advanced Theory of Operation and Troubleshooting of Systems** | |
| 300 | Advanced Methods of Monitoring, Diagnosing, and Troubleshooting |
| 301 | Couplers—Advanced Theory of Operation and Troubleshooting |
| 302 | Trucks and Axles—Advanced Theory of Operation and Troubleshooting |
| 303 | Propulsion and Dynamic Braking—Advanced Theory of Operation and Troubleshooting |
| 304 | Auxiliary Inverters and Batteries—Advanced Theory of Operation and Troubleshooting |
| 305 | Friction Brakes—Advanced Theory of Operation and Troubleshooting |
| 306 | HVAC—Advanced Theory of Operation and Troubleshooting |
| 307 | Current Collection and Distribution—Advanced Theory of Operation and Troubleshooting |
| 308 | Car Body—Advanced Theory of Operation and Troubleshooting |
| 309 | Doors—Advanced Theory of System Operation and Troubleshooting |
| 310 | Communication Systems—Advanced Theory of Operation and Troubleshooting |
| 312 | CBTC (ATP - ATO)—Advanced Theory of Operation and Troubleshooting |

(UTA), Southeastern Pennsylvania Transportation Authority (SEPTA) and Sacramento Regional Transit (SacRT). The majority of this courseware covers only 100 level fundamental topics such as alternating current/direct current (AC/DC) Fundamentals and Basic Hydraulic and Pneumatic Theory and Applications.

Center staff validated the collected courseware to the national training standards (see section below on courseware validation). To further this process and take advantage of the peer interaction that was possible because of the project, the Transportation Learning Center facilitated a process where participating locations anonymously evaluated the instructional material that had been collected from other agencies. The training material along with the SME evaluations has been cataloged in a spreadsheet. A sample spreadsheet and SME evaluation are shown in Figures 9 and 10, respectively.

These files are currently being migrated to the Transit Training Network (TTN) at TransitTraining.net, a website developed by the Transportation Learning Center to provide a platform for industry occupational training committee members and local training practitioners to view the most updated industry training standards and share and rate courseware developed by committees or individual agencies.

### *Introductory Material on Fundamental Rail Car Maintenance Topics*

While the collection of courseware covering fundamental topics was of great benefit to the participating transit locations, members of the National Rail Vehicle Training Standards Committee found that there was a need to cover topics specific to rail vehicle maintenance in a manner that was specific to the mass transit environment. To handle this task, SMEs from the National Rail Vehicle Training Standards Committee paired up with instructional designers at the Transportation Learning Center to develop primers on 11 rail car subsystems for topic areas at the 200 level along with Monitoring, Diagnosing, and Troubleshooting. These primers follow a standardized format that on a very simplistic level covers the learning objectives outlined in the national training standards. Sections include definitions and abbreviations, text by topic area, bibliography, relevant original equipment manufacturer (OEM) contact information, and the pertinent section of the national training standards for that primer. The primers are intended as introductory materials and are not meant to be a textbook for the subject covered.

Completed primers are available on TTN and in Appendix D to the contractor's final report. (Appendix D: 200 Level Primers can be found by searching for TCRP Report 170 on the TRB website.):

- Course 201: Couplers
- Course 202: Trucks and Axles
- Course 203: Propulsion and Dynamic Braking
- Course 204: Auxiliary Inverters and Batteries
- Course 205: Friction Brakes
- Course 206: Heating, Ventilation, and Air Conditioning (HVAC)
- Course 207: Current Collection
- Course 208: Car Body
- Course 209: Doors
- Course 210: Communication Systems

| Module 110: Basic Hydraulic and Pneumatic Theory & Applications | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Material/Title** | **Source** | **Media** | **Cost** | **Notes** | **Center Assessment** | **SME Evaluation (Where available)** | | | | | |
| **Agency Provided Materials** | | | | | | | | | | | |
| Basic Technician Study Guide – Part A – Chapter 5 Hydraulics, pages 110-158 | Utah Transit Authority (UTA) | Manual in PDF | n/a - copyrighted | See Module 101 | See Module 101<br>Section on hydraulic brakes tailored for automotive applications<br>Also includes section on air brakes | Excellent | | | | | |
| Introduction to Mechanical and Pneumatic Systems | SEPTA | | | | | | | | | | |
| Industrial Hydraulics | SEPTA | PPT, 358 slides | $0 | Provides complete instruction on hydraulics | Extremely comprehensive<br>Excellent use of graphics | | | | | | |
| Hands-On Hydraulic Training Workbook | SEPTA - produced by Anthony LeBoutillier, schematics by Arthur Elsass, all rights reserved. 52001 | Workbook, 57 pages | copyrighted? If so, can we link to it? | Contains instructions for eighteen hands-on exercises. | Hands-on exercises are well documented but requires specific training aid (# S4-R)<br><br>Used by SEPTA | | | | | | |
| Hydraulic Course Lesson Plan | SEPTA | MS Word document, 3 pages | $0 | States goal, objective, requirements and preparation needed to conduct two-day hydraulics course. | Useful document to organize classroom and hands-on training with emphasis placed on safety<br>Used by SEPTA | Average | | | | | |
| Material Data Safety Sheet (MSDS) for Hydraulic Fluid | SEPTA as provided by: Graco Inc. Minneapolis, MN | PDF document, 11 pages | copyrighted? If so, can we link to it? | Provides safety information for handling hydraulic fluid | Makes good sense to provide required material-related safety information as part of training.<br><br>Used by SEPTA | Average | | | | | |
| **Third Party Material** | | | | | | | | | | | |
| | Lab-Volt | | | Lab-Volt offers a comprehensive course in fluid power consisting of two programs: the Hydraulics Training System, Model 6080, and the Pneumatics Training System, Model 6081 | | | | | | | |

101 102 103 104 105 106 107 108 109 **110** 111 112 113 114 11

***Figure 9. Screenshot of spreadsheet used to catalog collected training materials.***

LEVEL 100 COURSEWARE ASSESSMENTS

Name of Person Conducting Assessment:

Module: 110: Basic Hydraulic & Pneumatic Theory and Applications
Courseware Title: Hydraulic Course Lesson Plan
Source: SEPTA

Directions: Review the courseware identified above along with the learning objectives contained in the module (attached) and answer the following questions.

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1) On a scale of 1-5, does the courseware appear to address the learning objectives?
☐1 = addresses some LOs
☐2
☐3 = addresses about half the LOs
☒4
☐5 = addresses most of the LOs

2) On a scale of 1-5 how would you rate the overall usefulness of the courseware?
☐1 = not useful at all
☐2
☒3 = average
☐4
☐5 =excellent

3) Does the material appear to be suitable for students at introductory 100 Level?
☒Yes ☐ No

4) Does the material contain graphics and other illustrations?
☒None ☐Some ☐Extensive

If graphics are used, how would you rate their usefulness?
☐1 = not useful at all
☐2
☐3 = average
☐4
☐5 =excellent

***Figure 10. Peer assessment of courseware.***

- Course 211: Computer-Based Train Control (CBTC)
- Course 212: Monitoring, Diagnosing, and Troubleshooting

### *Courseware Validated to the National Standards*

Courseware, the materials used to provide training, is only complete and effective if it contains full and appropriate content. To ensure this, the Transportation Learning Center has developed a self-evaluation process through which transit agencies, vendors, or any third-party organization developing course materials can evaluate courseware against the national training standards. Such a tool allows training departments to determine just how complete their written training materials are. Because the standards were developed jointly by SMEs from labor and management, the learning objectives that make up the standards are true reflections of the knowledge and skills that need to be imparted during the training. Most transit rail agencies rely extensively on training materials provided by OEMs when rail cars are purchased. Without an evaluation against the national training standards, local training could miss the mark and fail to provide technicians with the instruction needed to effectively, efficiently, and safely repair and maintain transit equipment.

The process developed by the Transportation Learning Center is voluntary, intended as a simple methodology to make sure that training course materials exist and are documented. Instructors may have the ability to impart the appropriate learning objectives without these training materials on the basis of their years of experience. However, translating that knowledge into courseware that meets the learning objectives established by SMEs on a national level not only ensures that the materials are complete, but also that they can be updated and used by all instructors so that appropriate training content is being disseminated over time in a consistent manner. This is especially useful in cases where highly experienced instructors take other positions or retire and their training ability and knowledge goes out the door with them.

Courseware validation is much like taking an inventory to make sure all training materials are in place. Using a mechanic's toolbox as an analogy, determining exactly which tools should be included becomes subjective and arbitrary without a defined list of tasks to be covered. An "appropriate" set of screwdrivers

may mean a basic set of only five to a less proficient mechanic. However, to a group of SMEs convening to define a suitable toolbox, an appropriate set would include 15 such tools to accommodate the wide variety of fasteners existing on transit vehicles today. As with the mechanic's toolbox, a national focus regarding courseware ensures that the appropriate mix of learning objectives is included.

The process to validate courseware to the national training standards is straightforward. The process involves participation by labor and management representatives, typically an instructor who has delivered the course, and a mechanic who has taken the course. In the first step, they determine which course to validate and then identify all of the courseware used in delivering that course. The validation document is actually a checklist that contains all of the learning objectives identified in a particular standard. In the rail vehicle standard, the learning objectives in Course 201: Couplers Introduction and Preventive Maintenance include all of the skills and knowledge that need to be imparted during the training so students are able to

- Inspect linear actuators/motors
- Service actuators/motors
- Perform basic repairs on linear actuators/motors
- Replace linear actuators/motors

Placing learning objectives in a checklist format allows the joint labor-management validation team to take each one and indicate whether courseware exists to support it. Another column in the checklist is used to add any notes and indicate whether the particular learning objective is supported by hands-on exercises. Having both labor and management participate in the process ensures that the evaluation is balanced, that all missing course elements are identified, and that the approach to strengthen course materials involves both stakeholders. Sometimes a mechanic who has taken a course has a perspective on improving courseware that the instructor may not be aware of and vice versa.

Table 5 shows a portion of the brake standard being used to validate courseware. The first column lists the learning objective contained in the standard, while the second column is used to indicate whether courseware is available to support the learning objective. In some cases, the learning objective does not apply. It may be covered in another course. In other cases, because the standards are developed on a national basis and include a wide range of technologies and equipment, a particular learning objective may not apply to a particular agency. The third column is used to provide the courseware title where appropriate, include any notes or comments, and to indicate whether the learning objective is supported by any hands-on activity.

As noted in Table 5, some learning objectives are supported by courseware, some by both courseware and hands-on exercises, while others are missing courseware or the learning objective is not applicable because it is covered in another course. After determinations are made for each learning objective contained in the standards, the results are tabulated in an outcome summary table. Table 6 is a sample outcome summary table that shows the number of learning objectives applicable to the course being validated, those supported by courseware, and those supported by hands-on exercises.

Having this information allows the joint labor-management training team to identify deficient courseware and devise an approach to add the missing elements. It also allows the team to determine just how much hands-on applications are being used, if more are needed, and, if so, in what areas. Above all, the process gives both labor and management an opportunity to improve their training program in a collaborative manner, one that is consistent with nationally developed and recognized standards. The Transportation Learning Center has successfully used this process in several projects and is available to work with other agencies to do the same.

**Table 5. Sample courseware validation checklist.**

| 201 Couplers Introduction and Preventive Maintenance | | |
|---|---|---|
| **Learning Objectives** | **Is Courseware Available to Support the Learning Objective?** | **Courseware Title, Notes/Comments, Hands-On Application** |
| Inspect linear actuators/motors | Yes | #4 student manuals, automatic train control (ATC) student guide, heavy repair and maintenance on the Rohr books (1000 series books) |
| Service actuators/motors | No | Do not have updates on the 1000 system couplers, friction brake guide/schematics |
| Perform basic repairs on linear actuators/motors | N/A | Field trips (Greenbuilt shop-1 day, coupler shop) and hands-on (use gauges) |
| Replace linear actuators/motors | Yes | Coupler Head Trainline pins.pdf |

**Table 6. Sample courseware validation outcome summary.**

| Learning Objectives Applicable to this Course | Applicable Learning Objectives Supported by Courseware | Applicable Learning Objectives NOT Supported by Courseware | Applicable Learning Objectives Supported by Hands-on Instruction | Notes/Comments |
|---|---|---|---|---|
| 82 | 66 | 16 | 59 | The agency and union will review missing courseware elements and work to add the missing materials |
| **SCORE: 80 percent of learning objectives applicable to this course are supported by courseware** | | | **SCORE: 72 percent of learning objectives applicable to this course are supported by hands-on exercises** | |

Another benefit to the evaluation methodology is that by assigning a unique identifier to each learning objective contained in the standards, the Transportation Learning Center can more easily assist agencies to locate missing courseware elements. Using the example of the couplers course introduced above, by giving the "Inspect Linear Actuators/Motors" learning objective a unique identifier (e.g., Coupler-LO-23), courseware identified by other agencies that support the learning objective could be shared with others. If an agency needed courseware to address a specific learning objective, the Transportation Learning Center could initiate a search of its database that contains all completed assessments using the unique numeric identifier. Additional information on courseware sharing is provided below.

### *Courseware Sharing*

Courseware based on recognized standards is the foundation of training and consists of the written materials that instructors use to deliver training and that student technicians use as study guides. Unlike other industries where competition naturally restricts the ability to share training materials, public transit has no such limitations. Larger agencies, which typically have the resources to develop and obtain a wide range of courseware, are in a perfect position to share those materials with other agencies that could greatly benefit from this assistance. This is especially true since there is much commonality among transit equipment. The sharing of training materials across agencies greatly reduces the costs associated with each agency having to develop materials on their own.

Understanding the benefits of sharing courseware, the Transportation Learning Center has developed a courseware sharing mechanism through its TTN website (TransitTraining.net). Over the years and through its various projects, the Transportation Learning Center has been collecting courseware from a number of sources. Some of the courseware has been developed by transit agencies, others by OEMs or third-party organizations. In some cases, agencies participating in various Transportation Learning Center projects have validated their courseware to the national training standards, providing a more detailed analysis of the material. In other cases, the courseware has just been reviewed and summarized by the Transportation Learning Center. This courseware has been uploaded to a forum where users can comment and/or contribute their own materials (see Figure 11).

TTN serves as a logical platform for sharing the collected materials within the transit community. In some cases, the training materials could be used to provide instruction "as is." In the majority of cases, however, agencies will use only those segments of the courseware that enhance their own materials. Either way, agencies now have a place to locate courseware that they could apply to improve their training programs. In addition to courseware, TTN provides a library of other useful training documents to share including training standards, papers on various training subjects, research on training metrics, and other subjects.

Courseware listed on TTN is cataloged according to the same subject groupings used in the national training standards developed for bus, rail, elevator/escalator, and other transit subject areas.

After reviewing the summaries, agency personnel can download the material. Materials are only available to participating agencies and their designated employees through a secure login procedure monitored by the Transportation Learning Center.

Additional information on the Transportation Learning Center's TTN site and courseware sharing project is available by contacting the Transportation Learning Center at info@transportcenter.org or 301.565.4713.

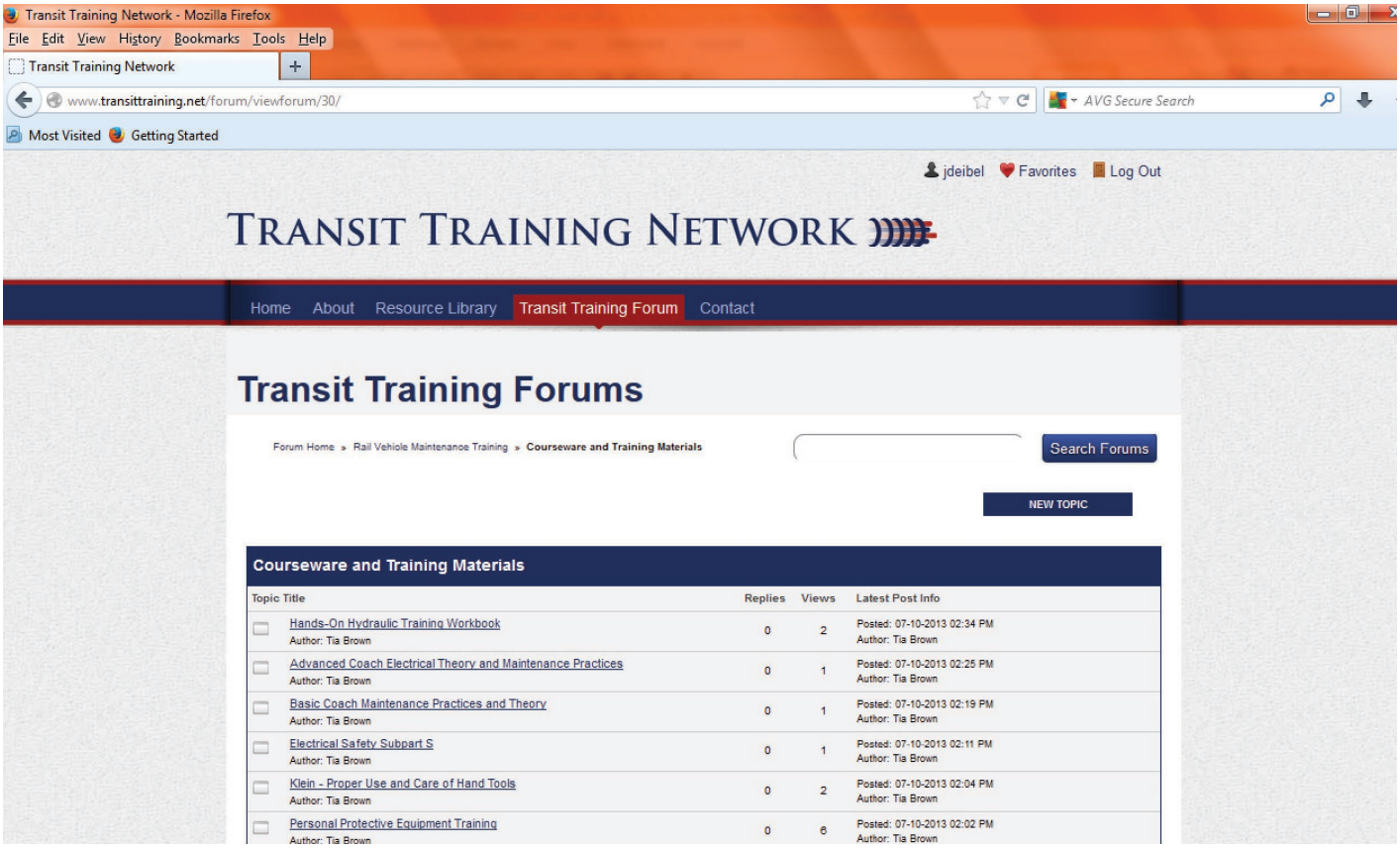



***Figure 11. Screenshot of TTN forum used to share rail vehicle courseware.***

## National Training Consortium

The standards-based system of qualification can be more easily implemented by recruiting transit rail stakeholders on an industrywide basis to occupational training consortia. This has already been done, with co-sponsorship by FTA, for transit elevator-escalator and signals training consortia. Creating a transit rail car consortium could lead to the development of all the components of a system of qualification as prioritized by the industry. Discussions are already underway with the U.S. transit rail industry for a rail car training consortium focused on developing instructors and mentors who can use effective instructional delivery methods to make both classroom and on-the-job learning more effective.

## Train-the-Trainer and Mentor Training Programs

### Instructor Qualifications and Effective Training Methods

The key to training delivery is the instructor and mentor charged with providing instruction. All too often instructors are former technicians who possess immense technical expertise but have not been adequately prepared for their new role as teachers. TCRP Project F-19, "A National Training and Certification Program for Transit Vehicle Maintenance Instructors" addresses this issue. The project seeks to develop a business plan for potential implementation of a vehicle maintenance instructor and mentor training and certification program. While many transit agencies have a process in place to identify key attributes for qualified instructors, few have programs in place to develop these attributes and adequately prepare instructors for their jobs. In the absence of such programs, one method to ensure that instructors have some preparation is to screen candidates for technical knowledge, work habits and desire, and then use local community colleges and courses offered by the National Transit Institute (NTI) to enhance communication skills.

As mentioned previously in this report, training programs that integrate classroom training approaches and interactive methods in the field that engage technicians will be the most effective in a technical training setting. The best prepared technical trainers go beyond their own technical knowledge.

### Traditional Classroom Lecture

A traditional model of classroom education is a lecture-based delivery method in which a professor/instructor who

has been deemed an SME speaks at length on the theory and application of the course content. Interaction is minimal so as not to disrupt the instructor's narrative and to allow students to take in the knowledge through listening and taking notes.

This traditional approach, however, teaches students to be passive observers in the workplace. Problems can result when technicians are trained solely with this delivery method. From a labor perspective, people taught to be passive will be less willing to take action to improve their work conditions. From a management perspective, passive employees tend to be less willing to demonstrate creative problem solving or to take on the challenges of new technology.

An integrated approach that focuses on providing the maximum opportunity for students to interact with each other and the instructor is widely believed to be the most successful at producing an effective transfer of learning from the classroom to the jobsite.

## Interactive Training Methods

The importance of interactive learning is not a new concept. It was Aristotle who observed "what we learn to do, we learn by doing." John Dewey asked in 1916, "Why is it that . . . learning by passive absorption . . . is still so entrenched in practice?" (Dewey 2010). Dewey saw education as an active, constructive process—a perspective that is especially relevant for front-line technicians. What Aristotle and Dewey understood about learning is 100-percent applicable to effective training of transit technicians.

Understanding the importance of learn-by-doing training in technical settings where technician's jobs are largely tactile in nature, the Transportation Learning Center developed a paper on the subject as part of TCRP Project E-07 that is available as Appendix E of the contractor's final report and can be found by searching for *TCRP Report 170* on the TRB website. Appendix E: Learning by Doing: Hands-On Training for Transportation Technicians provides important insight into how people learn and emphasizes that student technicians are better served by instructors who teach them to do things, rather than telling them how to do it. Among other topics, the paper discusses instructional system development (ISD), which supports learn-by-doing methods. ISD is a series of processes through which "what, where, how, and when" to teach the skills and knowledge needed to perform given job tasks can be determined. Through the implementation of ISD and current learning theory, the U.S. Navy has determined that lecture should be reserved for large group presentations lasting less than 30 minutes and that the most common method of instruction is interactive (U.S. Department of the Navy 1992).

Interactive training methods, which encompass a wide range of delivery approaches, are summarized below.

### *Displays and Mockups*

Using displays and mockups is an effective way to get students to interact with equipment they will be responsible for maintaining and repairing on a regular basis after the training concludes. A simple example would be the distribution of dust masks, gloves, and goggles to students while an instructor is providing classroom lecture on personal protective equipment (PPE). A more involved example would be passing around an electrical relay and switch in the classroom as part of a presentation describing electrical circuits. Other mockups include display boards where working system components (e.g., brakes or electrical circuits) are installed.

### *Lab Exercises*

Lab exercises typically involve electrical, electronic, pneumatic, and hydraulic applications, as well as other major vehicle systems. Unlike equipment simulation used to enhance classroom presentations, lab exercises are entirely hands-on and interactive, conducted in a dedicated room or "laboratory" where equipment is placed on tables or benches.

### *Computer Simulation*

The use of computers and software can play an important role in interactive training, supplementing classroom lecture with exercises that also engage students to learn. Computer simulations are available in nearly every subject area and can break up classroom lecture in an engaging way that enhances the learning process. Simulations can take static classroom presentations to a state of near reality.

### *Distance Learning*

Distance learning is another form of computer-based interactive delivery. It delivers training to students who are not physically present in a particular educational setting, providing access to learning when the source of information and the learners are separated by time and distance, or both.

### *Hands-On Vehicle and Component Exercises*

After students learn theory and application through classroom and various interactive activities, taking them to a vehicle or other equipment where components are installed gives them actual placement and orientation. Providing a more thorough demonstration of equipment placement reinforces the learning that has already taken place and puts everything in proper context.

### *Mentoring*

The final step in the interactive learning process is to have students work with a mentor. Mentoring provides an excellent

training opportunity because it links an experienced person (mentor) with a less experienced trainee to help foster the trainee's abilities, career development, and professional growth. Mentors provide an aspect to learning that other training cannot replicate. Mentors get to pass along years of experience and "tricks of the trade" that novice technicians can greatly benefit from, helping them to apply what they learned in the classroom and through lab exercises and computer simulations to a real-world workshop environment.

As part of TCRP Project E-07, the Transportation Learning Center has produced a Mentoring Guidebook to assist agencies develop their own mentoring program, which is available as Appendix F of the contractor's final report and can be found by searching for *TCRP Report 170* on the TRB website. Appendix F: Mentoring Guidebook outlines three types of mentoring approaches:

- Informal mentoring
- Self-mentoring
- Structured mentoring

Informal mentoring, also known as traditional mentoring, is loosely structured—tasks and outcomes are not defined. Self-mentoring is more of a strategy than a type of mentoring; instead of having an established mentoring program that seeks to promote the development of a trainee and enhance agency goals, the worker takes the initiative to cultivate his or her own professional growth. A structured mentoring process brings the mentor and trainee together to reach specific learning goals and to provide sufficient feedback to ensure that the goals are reached.

### Selecting Effective Methods of Training Delivery

Every learner will bring his or her own interests and background to the training experience, and not all individuals fit neatly into pre-designed training boxes. That said, there are several generalizations that can serve as guidelines in developing delivery methods to suit specific learners:

- A blended approach, involving a variety of teaching methods that actively engages participants in the learning process is appropriate and effective for training most technical workers.
- Learn-by-doing training methods involving mockups, lab work, and mentoring can enhance the learning experience and better prepare workers for the maintenance and repair jobs they ultimately will be responsible for.
- Transit employees who work in offices and have regular access to computers and Internet sites will have an easier time using online learning resources than technicians working on the shop floor who may not have access to computers or whose access is limited to entering vehicle repair data. Therefore, if computer-based training is to be provided to maintenance technicians, a classroom with computer access is needed.
- Younger employees or entry-level employees often have more familiarity with computers and connectivity than employees from the Baby Boom or Gen X cohorts. Basic instruction on how to use a mouse or find a website will not be needed for younger employees, whereas for some older workers instruction in these basic computer skills will be required for online learning.
- For tech-savvy younger workers, educational use of computerized media in which learners need to acquire the skills to physically interact with vehicles and equipment may be unfamiliar; learn-by-doing methods will need to be blended.
- Distance-based training holds promise as a future training delivery application, but it is more effective when done in conjunction with hands-on and on-the-job learning.
- Mentoring can be a highly effective training delivery method when done in a structured manner and explicitly integrated with classroom and on-the-job learning, as part of a formal apprenticeship program.
- Upper-level managers, especially those with graduate degrees, are more accustomed to learning in a classroom environment and on their own time and as a result may insist that frontline worker training take place in the same manner. That insistence will only serve to strain labor relations and lead to less than optimal outcomes for technical skill development. As mentioned previously, good training design begins with an understanding of the training audience.

Given these generalities, each organization must decide what makes for good training delivery to their transit employees who work as technicians. As stressed throughout this report section, the process begins with knowing the audience and understanding their particular learning style. For technicians who work with their hands, training needs to engage them in a way that allows them to immediately apply what they have learned in the classroom to activities that will be required of them in their work environment.

## Skills Validation

A key component of a complete system of qualification is the verification of knowledge gained and skills acquired at the end of classroom and hands-on training. In the Rail Vehicle Qualification program, a series of written and hands-on assessments have been designed to validate that technicians possess the practical knowledge and skills required to perform their jobs. Questions for the written assessments and task lists and scenarios for the hands-on assessments have been

developed by the SMEs on the National Rail Vehicle Training Standards Committee and subjected to rounds of validation by incumbent rail vehicle technicians at the participating agencies. These assessments track the sequencing of rail vehicle training standards and local training delivery. Detailed mapping of all available assessments and associated qualification areas is provided in Chapter 3.

## General Guidelines for Rail Vehicle Technician Qualification Assessments

To ensure that the newly established system of qualification will provide maximum benefits for both transit agencies and rail technicians, the following guidelines for the qualification assessments have been established:

- Incumbents in place at the beginning of the new system of qualification will be grandparented into the new system and not be required to take any qualification assessments, unless they want to acquire a portable credential in the case of employer changes.
- No worker will be forced through assessments without adequate training (local joint labor-management committees provide sign-off that the worker has received adequate training or work experience before taking assessment).
- Agencies will assume the costs of training and initial assessments (payment responsibility of assessment retakes will be determined at the local level).
- Individual results of all assessments will be confidential. Only aggregated results will be shared with agency and union representatives to show training gaps.

## Written Assessment of Knowledge

The Transportation Learning Center involved SME mechanics in devising written questions, determining passing score thresholds, and reviewing systems for assessment administration. Intensive processes were put in place to develop and validate the written assessment questions. Most of these questions are generic to all rail agency equipment and technologies. In cases where agency subsystems may be completely different because of the type of technology used, the written assessment is provided in two or more tracks. For example, in the written module of propulsion and dynamic braking, two tracks—AC and DC—are provided to include both questions covering general knowledge across these two technologies and more advanced questions specific to AC or DC. Completing either one successfully will make a technician eligible to move on to the propulsion and dynamic braking hands-on assessment and eventually achieve qualification status. A notation will be made on the certificate of qualification to mark any special tracks.

Written assessment results showing overall assessment results (pass or fail) and scores, as well as section scores, are sent confidentially and directly to the technicians to inform them of their areas of strength and weakness.

Aggregated analyses are shared with management and union at each site to show (1) agency training strengths, (2) areas that need training improvements, and (3) provide a general indication of the pass/fail rate. If the pass rate is low, data will be provided that support the need for additional training in a quantifiable way.

The written assessment question bank can be used to design pre- and post-assessments. In piloting the TCRP Project E-07 rail car qualification project, the Transportation Learning Center worked with Greater Cleveland Regional Transit Authority (GCRTA) and used the 200-level written assessment question bank to design pre- and post-assessments for trainees going through each training module as part of a new rail car apprenticeship program. Improvements in trainee test scores indicate that training has been effective in improving trainee knowledge in the target area.

## Hands-on Demonstration of Skills

A unique feature of the rail vehicle technician qualification program is its emphasis on hands-on skills demonstration as part of the learner assessment process. Hands-on assessments measure transfer that has occurred in learners' behavior and practical understanding resulting from the training. These assessments are necessary to determine whether classroom learning can be translated effectively into the realities of the world of work. Some technicians can perform well on written tests but have trouble applying that knowledge in practice—particularly if hands-on practice is not built into the training program. Conversely, some technicians, despite strong practical capabilities, do not perform well on written tests.

In developing the rail vehicle technician qualification program, hands-on assessments are built in as the second step, following written assessments, for achieving qualifications at the journeyperson level, and the only step at the master technician level. A generic hands-on scenario bank was developed by SMEs and validated at multiple pilot locations. At the request of agencies that have provided associated training and are ready to administer a hands-on assessment, the Transportation Learning Center will work with agency SMEs to customize the hands-on scenarios and task lists to accommodate agency needs.

## Portable Certificate of Qualification

Passing the required written and hands-on assessments would lead to an issuance of a certificate of qualification in that technical area. A new hire may complete training modules

and assessments at the 100 level, for example, and move on to a number of modules at the 200 level through a local apprenticeship program. Results from these assessments provide tangible proof that technicians are qualified to perform their jobs and gives technicians recognition for their abilities. Furthermore, the qualification status is portable if the qualified technician seeks employment at another agency.

## Apprenticeship

### Overview

As TCRP Project E-07 project took form, it became apparent that a review of the state of training in the industry would be necessary to ascertain what was needed to create a comprehensive training system that could produce the very best possible outcomes. Project research found that training in the industry was inconsistent in terms of both quality and quantity. Larger agencies tend to have the best training, but even in these agencies, training is not always of the highest quality. This was found to be true of all skills training not just for rail vehicle maintainers. The National Rail Vehicle Training Standards Committee and the TCRP Project E-07 panel became convinced that a critical element of any comprehensive system of training had to include a registered apprenticeship program.

Based on the training standards already developed, the National Rail Vehicle Training Standards Committee began developing a formal national apprenticeship for rail car technicians, similar to those successfully developed for elevator-escalator by the Transit Elevator-Escalator Training Consortium and for transit bus maintenance technicians by the Bus Maintenance National Training Committee. (A similar effort is currently being undertaken by the Signals Training Consortium.) The apprenticeship proposal included developing learning objectives and determining the amount of time to be devoted to each in classroom and on-the-job training. Incumbent workers will be able to take advantage of the extra training that will be available in apprenticeship programs. However, the National Rail Vehicle Training Standards Committee felt very strongly that incumbents should be "grandparented" into the system and have their pay and seniority protected as the new apprenticeship and system of qualification are introduced.

Until these recent initiatives to develop national frameworks for transit apprenticeship were registered with the U.S. Department of Labor, apprenticeships in the industry were essentially local arrangements only. Rather than enjoying the stability of apprenticeship and training programs seen in industries with national apprenticeships, local transit apprenticeships have not been widespread in the industry, with fewer than 20 transit systems identified as having any apprenticeships at all (Transportation Learning Center unpublished internal research). Moreover, strictly local transit apprenticeships, in important cases, have proven to be fragile.

### Modern Apprenticeship Development

Apprenticeship and standards-based qualification programs are a time-tested, high-quality solution to the challenge of developing and maintaining a well-qualified technical work force in the United States and other countries that place a high priority on developing their blue-collar workforce skills. Formalized apprenticeship and qualification programs present a means by which transit agencies can grow the skills of incumbent workers and make transit jobs more attractive to a new generation of technical employees. Registered apprenticeship programs can lead to college credits for quality, work-based learning, helping with recruiting. Students and parents who see college as the only way to succeed may be convinced that a highly compensated trade with upward mobility is a fine alternative to the pursuit of academics in today's work world.

Apprenticeship offers an appealing means of producing skilled maintenance workers to cope with technological changes, looming retirements, and the maintenance demands brought by growing ridership and system expansion. The unique nature of the work performed in transit maintenance often prevents agencies from finding employees from other industries or graduates of technical education programs who have the technical skills or knowledge required for such work. This has led transit agencies to seek more effective ways of developing their own training. The attractiveness of apprenticeship for transit lies in its long-term commitment to progressive skill acquisition through a combination of practical on-the-job training and classroom instruction. Apprenticeships offer advantages over shorter-term training in that apprenticeships are able to produce highly skilled, versatile workers with solid theoretical and practical knowledge. Developing workers with such characteristics is particularly important in transit maintenance, where the work can be varied and often unpredictable. There are exceptions to this generalization at some large agencies where technicians specialize and perform the same duties every day.

Several features make apprenticeship attractive to employers and workers alike. For employers, apprenticeship can offer a guaranteed supply of "home grown" (upgrading the skills of incumbent workers) skilled workers. This is especially important in work that is unique and best learned through a combination of classroom instruction and on-the-job training. Apprenticeship provides an organized process through which older experienced workers can pass along their knowledge and skills to a new generation of workers (Glover et al. 2007). Finally, in a world where state or federal certification is increasingly required for safety-critical technical workers, registered apprenticeship is the gold standard of skill certification for many skilled blue-collar occupations.

## Rail Car Registered Apprenticeship Now Available

In June 2013, the Rail Car Maintenance Technician Apprenticeship was approved by and registered with the U.S. Department of Labor's Office of Apprenticeship (See Appendix G of the contractor's final report. Appendix G can be found by searching for *TCRP Report 170* on the TRB website). The apprenticeship program, from the development of national training standards to curriculum outline, was designed by the National Rail Vehicle Training Standards Committee with guidance from TCRP Project E-07. The Transportation Learning Center is currently aware of approximately six public transportation agencies planning to implement or already implementing an apprenticeship program based on the one designed by the National Rail Vehicle Training Standards Committee.

## Apprenticeship Benefits Employers and Workers

Apprenticeship is an effective approach that benefits both workers and employers. Workers are given a valuable set of skills that put them on a career ladder throughout their work life. Mentors strengthen their own skills and work processes by instructing apprentices. Employers find that the savings on parts and labor and reduced turnover contribute directly to their bottom line, as does the increased satisfaction of customers from clean, reliable equipment.

### *Employers*

Apprenticeship is an attractive way to develop a highly skilled and productive workforce**.** Apprentices are trained in the skills that are fundamental to their position in an agency. A steady flow of apprentices will help agencies maintain a higher level of workforce knowledge and higher level of maintenance efficiency and effectiveness. Employers are dependent on the job market for skilled workers and with in-house certified training programs, they become more attractive to job seekers. Traditional sources of skilled workers are shrinking rapidly, which is why in-house registered apprenticeship training programs are an important part of maintaining an efficient technical workforce and subsequently a state-of-good-repair.

Many studies have been published about the return on investment (ROI) to those employers that initiate apprenticeship programs. There is a general consensus on tangible benefits (Mathmatica Policy Research 2012). The most common beneficial elements cited are the following:

- Improved quality
- Improved productivity
- Improved customer satisfaction
- Reduced supervisory and administrative costs
- Higher employee satisfaction and retention

These benefits all lead to sharpening a firm's competitive edge and recognized position as an employer of choice and responsible steward of publicly invested funds. While transit agencies do not compete with one another, they do compete for scarce government dollars. The better an agency looks to the public, the better taxpayers and legislators feel about funding the transit agency. Transit authorities also compete for customers. Their product must be attractive enough to move commuters from their cars to trains and buses. A well-trained workforce ensures that a transit system has reliable, safe, and mechanically sound vehicles—all attributes of an attractive modal alternative. Finally, employers compete with one another to attract and retain a capable workforce, and a commitment to quality technical training and formal qualification helps on both fronts. In short, apprenticeship is a smart business decision and an investment in the future success of a business.

### *Workers*

Apprentices are given the opportunity to earn while they learn. They gain confidence in their skills and reasoning abilities, while obtaining a clear path to job growth. If they have the ambition to learn and strive for more, it can lead to a management position and a whole new career ladder. Increasingly, in some programs, apprentices are able to translate registered apprenticeship training into college credits. The skills learned in an apprenticeship program are retained for a lifetime, and a certificate acknowledging apprentices' accomplishments proves their qualifications.

## The Advantages to Registering an Apprenticeship

Apprenticeship and certification/qualification programs are registered with either the U.S. Department of Labor or a state apprenticeship oversight organization. Registering an apprenticeship program through the national or state department of labor apprenticeship office validates its completeness and provides legitimacy. It also gives the worker a certificate of completion that is recognized nationwide and thus enhances the worker's job mobility.

## How Is an Apprenticeship Structured?

Industries like transit, with a relatively high degree of union representation of their frontline workforce, typically establish their national apprenticeship committee structures based on agreements between the industry and the union representing

workers in a particular occupation. There are several common structural elements among apprenticeship/qualification programs that have successfully maintained quality training over a long period of time (See Appendix B of the contractor's final report. Appendix B: Building Capacity for Transit Training: International and Domestic Comparisons can be found by searching for *TCRP Report 170* on the TRB website). Formal apprenticeship programs in the United States that have met the test of time (many existing for more than 50 years) all have jointly administered national committees made up of equal numbers of labor and management representatives. The Joint Apprenticeship and Training Committee (JATC) structure offers several advantages to unilaterally run programs. Several studies have shown that joint apprenticeship programs have higher completion rates and a generally better track record than unilaterally run apprenticeships.

The JATC structure

- Increases the quality and quantity of training while reducing costs
- Increases the visibility and influence of training within the industry
- Offers greater durability of training efforts
- Enhances employee relations by developing a collaborative commitment to quality and skill
- Increases worker engagement
- Improves worker recognition and morale
- Strengthens the industry's ability to work with key external parties to improve training

Typically, a national apprenticeship and training partnership is formed between a single national union and the national industry association. This partnership then forms a national JATC to oversee and administer the work. Because transit workers are represented by a variety of unions in the United States, the Transportation Learning Center's board of directors currently serves in this capacity; presidents of several national labor organizations serve on the Transportation Learning Center's board along with the presidents of APTA and the Community Transportation Association of America (CTAA) and chief executive officers of several major transit systems.

The transit industry's emerging system of qualification for rail car technicians (and for other technical occupations) is already carrying out many of the responsibilities of the various levels of oversight in a public transportation joint apprenticeship/certification partnership such as the following:

- Analyze tasks and develop national standards
- Provide guidance to local JATCs for national standards
- Use national standards to develop skill certifications for individuals
- Develop national standards and program certification for local committees
- Develop common courseware for local programs to use
- Train local instructors on course content and teaching techniques
- Monitor technological changes and incorporate them into the courses
- Negotiate with local and national educational institutions for college credit
- Promote sharing of best practices
- Coordinate with equipment manufacturers and OEM training programs
- Measure results and local committee effectiveness
- Apply lessons to next round of training and certification standards promulgated by the NJATC

Local training partnerships at individual training agencies function as local JATCs and carry out the following:

- Negotiate local agreement including funding
- Pick local JATC members
- Oversee training process and logistics
- Develop process for picking apprentices

CHAPTER 3

# Qualification System Design, Program Rules, and Management of Training and Qualification Information

## Progression of Rail Vehicle Technician Qualifications

The National Rail Vehicle Technician Qualification Program contains three levels of qualifications, built on the foundation of the transit industry's national training standards as well as the Rail Vehicle Technician Apprenticeship as approved by the U.S. Department of Labor:

- 100 level leading to Qualified Rail Vehicle Apprentice Technician
- 200 level leading to Qualified Rail Vehicle Journeyperson Technician
- 300 level leading to Qualified Rail Vehicle Master Technician

The qualification flowchart (see Figure 12) illustrates the progression through the comprehensive national system of qualification. See a detailed flowchart containing all training and assessment modules in Appendix H of the contractor's final report. (Appendix H can be found by searching for *TCRP Report 170* on the TRB website.)

The system of qualification is fundamentally a comprehensive system of standards-based training. It includes all the elements identified—from national training standards and joint training committees to curriculum and courseware, training of instructors, coordination of classroom and on-the-job learning with the support of trained mentors, and a national framework of apprenticeship training. To validate that the learning has been successful, jointly developed assessments have been designed for each stage of the learning process.

### Training Comes Before Assessment

A fundamental principle of the national program, universally endorsed by the members of the TCRP Project E-07 panel and the National Rail Vehicle Training Standards Committee, is that quality employee training is a prerequisite before employees can be tested.

#### *Training*

To become eligible for the national rail vehicle qualification assessments, technicians should complete associated classroom and on-the-job learning as recommended in the U.S. Department of Labor's rail vehicle apprenticeship guidelines for the selected module(s) as well as any locally determined additional training and work experience requirements. (Refer to Appendix I of the contractor's final report. Appendix I: Rail Vehicle Technician Apprenticeship: Definitions of Levels of Qualification can be found by searching for *TCRP Report 170* on the TRB website.) Eligibility will be verified by management and labor training coordinators at each location and kept on file at local agencies.

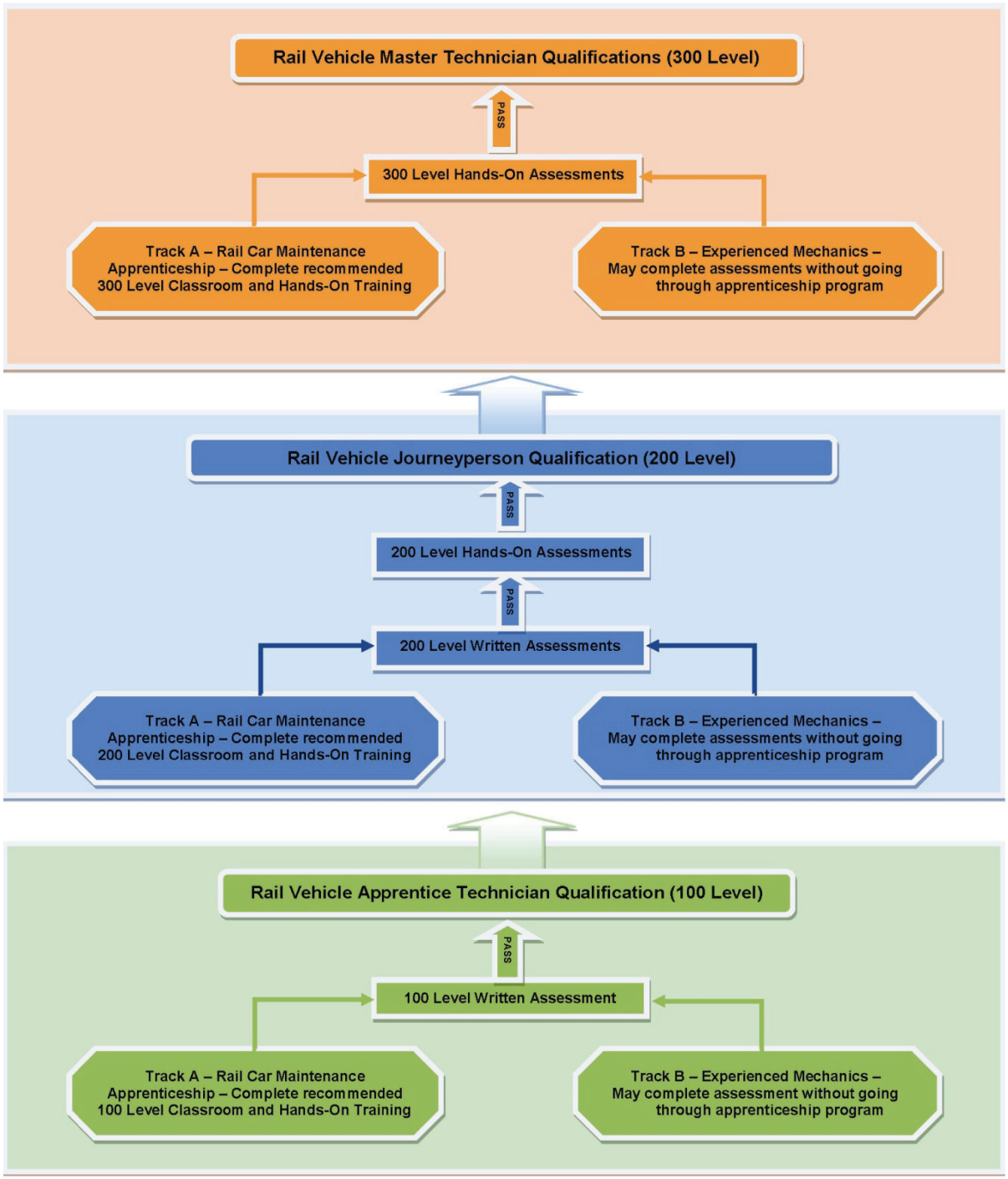
After the required training and work experience requirements are met, local training coordinators may email a spreadsheet containing the names, employee IDs, and requested assessment modules to the Transportation Learning Center staff to schedule assessments.

#### *Work Experience*

Workers are able to "test out" of training. A certain number of years of previous work experience may be required. The specific requirements for "testing out" are to be determined and verified locally.

## Grandparenting

The National Rail Vehicle Training Standards Committee has recommended that incumbents in the relevant job titles be "grandparented" in their existing jobs at their existing pay rates, with no additional assessment requirements. There can




Note: Craft titles used are for the national qualification program only. Actual local craft titles will be determined by local collective bargaining agreements.

***Figure 12. Qualification progression flowchart.***

**Table 7. 200-level modules with separate written and hands-on assessments.**

| | |
|---|---|
| 201 | Couplers—Introduction and Preventive Maintenance |
| 202 | Trucks and Axles—Introduction and Preventive Maintenance |
| 203 | Propulsion and Dynamic Braking—Introduction and Preventive Maintenance (2 tracks: AC or DC) |
| 204 | Auxiliary Inverters and Batteries—Introduction and Preventive Maintenance |
| 205 | Friction Brakes—Introduction and Preventive Maintenance |
| 206 | HVAC—Introduction and Preventive Maintenance |
| 207 | Current Collection and Distribution—Introduction and Preventive Maintenance (2 tracks: Third Rail or Pantograph) |
| 208 | Car Body—Introduction and Preventive Maintenance |
| 209 | Doors—Introduction and Preventive Maintenance |

be no question of demoting or otherwise penalizing incumbent workers who have been performing in their jobs for failure to reach new standards of formal qualification through assessments. Details of grandparenting will be decided at the local level.

On the other hand, it is appropriate to assign incumbents to take training in areas where their skills are not up to par. They should be encouraged and supported in taking qualification assessments to try to achieve formal qualification status. To obtain a portable credential in the case of moving to a new employer, a grandparented technician may want to complete the same assessment requirements laid out for new hires in the occupation.

## Local Training Structure

Each rail transit location will designate one management and one union (for locations with union representation) coordinator to oversee the qualification program at the local level. At locations where a union does not exist, a frontline worker should be assigned to oversee the program. The Transportation Learning Center will collaborate with training coordinators to address local training and assessment needs. (See Appendix J of the contractor's final report for a list of processes and materials required from the national program. Appendix J: Written and Hands-on Assessment Process Checklist can be found by searching for *TCRP Report 170* on the TRB website.)

## Assessment Modules

### 100 Level

A single comprehensive written assessment will be required at the 100 level. Some applicants may have already had sufficient training on 100-level subjects in school or in another job, either within or outside the transit industry. The assessment covers the following topics:

- Safety
- General electrical and electronics
- Pneumatics
- Hydraulics
- Mechanical

Candidates who successfully complete the written assessment at the 100 level will be granted status as a Qualified Rail Vehicle Apprentice Technician.

### 200 Level

At the 200 level, separate written and hands-on assessments will be provided for nine modules (see Table 7). For Current Collection and Distribution, a single bank of questions has been developed, but different distributions of topics will be offered based on whether the local transit agency uses third rail or overhead power. The same arrangement applies to Module 203—Propulsion and Dynamic Braking, where technicians can be assessed based on the type of propulsion system used by their agencies.

Three (3) additional modules are provided in non-standard formats (see Table 8):

It was determined that in two areas, Communication Systems and CBTC, there was not enough content in the training standards to support a stand-alone written assessment. In these areas, a small number of orally asked questions will be integrated with the hands-on assessments. For Monitoring, Diagnosis, and Troubleshooting Overview, questions are integrated in several other modules, so a stand-alone written or hands-on assessment is not necessary.

The national program does not administer assessments for the 250-level Overhaul and Rebuild of Rail Vehicle

**Table 8. 200-level modules with non-standard formats.**

| | |
|---|---|
| 210 | Communication Systems—Introduction and Preventive Maintenance |
| 211 | CBTC (ATP - ATO)—Introduction and Preventive Maintenance |
| 212 | Monitoring, Diagnosing, and Troubleshooting Overview |

Components since training and assessments in this area tend to be agency specific.

Candidates who successfully complete the pair of written and hands-on assessments for a topic will be granted status as a Qualified Rail Vehicle Technician in that area, for example, Qualified Rail Vehicle Technician in Couplers. Technicians may choose to pursue single or multiple qualification tracks based on their work specialization. Technicians who obtain all 11 qualifications at the 200 level will be granted status as a Qualified Rail Vehicle Journeyperson.

### 300 Level

No written assessments will be provided at the 300 level. Instead, 11 advanced hands-on assessments will be provided to evaluate candidate skills in each of the 11 modules (see Table 9). Again, Advanced Methods of Monitoring, Diagnosis, and Troubleshooting learning objectives are integrated in several other modules, so a stand-alone, hands-on assessment is not necessary.

Candidates who successfully complete one hands-on assessment at the 300 level will be granted status as a Qualified Rail Vehicle Master Technician in that area, for example, Qualified Rail Vehicle Master Technician in HVAC. Technicians may choose to pursue single or multiple qualification tracks based on their work specialization. Technicians who obtain all 11 qualifications at the 300 level will be granted status as a Qualified Rail Vehicle Master Technician.

Although the structure of apprenticeship or formal training programs at transit agencies may require candidates to advance from 100-level to 300-level qualifications sequentially or to obtain a certain group of qualifications at the 200 or 300 level to be fully qualified for their jobs, the national program allows the flexibility of any single or combination of qualifications to be completed separate from the remaining levels or modules.

For more information on qualification assessments, see Appendix K of the contractor's final report. (Appendix K: Qualification Assessment FAQs can be found by searching for *TCRP Report 170* on the TRB website.)

## Assessment Design and Program Rules

### Written Assessment Questions and Maintenance

In most cases, written assessments will consist of 30 multiple-choice questions, 25 of which will be scored and 5 of which will be pilot questions. The Internet-based testing (IBT) system allows for the selected questions to be presented in a random order and where appropriate for the answer choices to appear in random order for a given question. Questions that are "bad pairs," either because they are versions of the same question or one reveals an answer to the other, are identified and will not appear together in any given offering of an assessment. Questions within a module are assigned to subcategories based on the training standards, and there will be a consistent distribution across these topics each time the assessment is given. Scores by subcategory can be provided to help identify program gaps to improve training and learning outcomes.

The total size of the question banks varies, but there are at least 30 questions (and up to 87) written for each module. In all but two modules, at least 25 questions have been validated for scoring through paper-and-pencil and IBT testing of the questions at several agencies over the past 3 years. For Module 207 (Current Collection and Distribution) and Module 209 (Doors), there are fewer than 25 questions validated at this time. If sufficient data are not gathered before launching the program, these modules can be offered, but they will be scored retroactively, once the set of 25 valid questions has been determined.

As more data are gathered, additional questions will be validated and included in the rotation of questions. Other questions may be determined invalid and removed from the question banks. On some regular basis, perhaps every 2 years, SMEs will need to review the question bank as a whole and develop new questions where needed. All questions and the subtopic breakdown will also be reviewed any time the associated training standard for a module is updated.

**Table 9. 300-level hands-on assessments.**

| | |
|---|---|
| 301 | Couplers—Advanced Theory of Operation and Troubleshooting |
| 302 | Trucks and Axles—Advanced Theory of Operation and Troubleshooting |
| 303 | Propulsion and Dynamic Braking—Advanced Theory of Operation and Troubleshooting |
| 304 | Auxiliary Inverters and Batteries—Advanced Theory of Operation and Troubleshooting |
| 305 | Friction Brakes—Advanced Theory of Operation and Troubleshooting |
| 306 | HVAC—Advanced Theory of Operation and Troubleshooting |
| 307 | Current Collection and Distribution—Advanced Theory of Operation and Troubleshooting |
| 308 | Car Body—Advanced Theory of Operation and Troubleshooting |
| 309 | Doors—Advanced Theory of System Operation and Troubleshooting |
| 310 | Communication Systems—Advanced Theory of Operation and Troubleshooting |
| 312 | CBTC (ATP - ATO)—Advanced Theory of Operation and Troubleshooting |

### *Question Format*

The written assessment questions are all in multiple-choice format with a single correct answer and three distracters. In the context of the required knowledge and skills for the different maintenance subject areas, the questions seek to test different types of cognitive behavior, including applying a rule or principle, showing understanding of cause and effect, or identifying reasoning behind a particular action. Efforts were made to avoid any questions that were a simple recall of a memorized fact. The goal was to develop questions that required an applied understanding of the vehicle system and maintenance requirements.

The question stems were written to

- Be meaningful and provide a clearly defined problem
- Include as much of the full question as possible
- Be stated simply and not contain irrelevant information

Question alternatives were written to

- Fit the stem grammatically
- Fit the stem in number (singular/plural—does/do; single/multiple—cause/causes)
- Be approximately the same length
- Be as brief as possible
- Be presented in logical order
- Include only one correct or clearly best answer

Following these best practices for the questions has contributed to the reliability and validity of the questions.

### *Special-Format Questions*

There are a few special-format questions in use under the general four-answer, multiple-choice umbrella. One example is the Technician A/Technician B format. In these questions, two statements are made. The statements are usually related to the same problem, condition, or vehicle system, and the question asks if statements made by Technician A only, Technician B only, both technicians, or neither technician are correct. This acts as a "nested true-false" question in the multiple-choice format. Other examples of special formats include the phrase "Which of the following is NOT" or "All of the following EXCEPT."

These questions are structured to avoid use of "all of the above" or "none of the above" as answer choices. Whenever these formats were used, the negative wording was emphasized through capitalization and underlining of key words in the stem to avoid confusion among the test takers.

## Hands-On Assessments

Hands-on assessments will be administered at the premises of local transit agencies as needed. Hands-on assessments are based on a series of generic tasks developed by the National Rail Vehicle Training Standards Committee. Several tasks have been developed for each subject area (e.g., friction brakes, couplers, etc.). Prior to administering the hands-on assessments, the labor-management team from the transit agency works with Transportation Learning Center staff to adapt the generic task selected to the agency's particular equipment, terminology, and work procedures. The joint labor-management team decides on the exact wording of the task to be read to the candidates, the level of performance that candidates must meet in carrying out each task, and the point structure for each task. The Transportation Learning Center's role is to make certain that the intent of the original assessment remains intact and the degree of task difficulty and the point structure for tasks are consistent across all agencies.

Detailed hands-on assessment instructions can be found in these appendices from the contractor's final report:

- Appendix L: National Rail Car Hands-On Skills Assessment Tutorial,
- Appendix M: Hands-On Assessment—Task Application Form,
- Appendix N: Hands-On Assessment—Evaluators' Worksheet, and
- Appendix O: Hands-On Assessment—Candidate Version.

(Appendices L through O can be found by searching for *TCRP Report 170* on the TRB website.)

## On-Demand Delivery

Both the written and hands-on assessments will be provided when needed at the request of local training programs rather than on a predetermined national schedule.

## Flexible Written Assessment Delivery Methods

With appropriate proctoring by local labor and management proctors, written assessments can be taken by workers using either an online mechanism on local computers or a paper-and-pencil version, printed by the Transportation Learning Center and sent to each assessment location. IBT is the preferred method of delivery for the written assessments under the National Rail Vehicle Technician Qualification Program. See Appendix P from the contractor's final report for more information on the paper-and-pencil written assessment.

(Appendix P: Sample Written Assessment Tutorials can be found by searching for *TCRP Report 170* on the TRB website.)

The 100-level written assessment may not be taken with any 200-level assessments. Candidates may choose to schedule and complete more than one 200-level written assessment per sitting.

One hour is allotted for each written module.

### *IBT Option*

Written assessments are generally delivered via an IBT system. This system has minimal requirements for local setup, and the assessment process is intuitive even for technicians with limited computer literacy. Scoring is done by the automated IBT system and verified by the Transportation Learning Center as requested.

### *Paper-and-Pencil Option*

Agencies with limited information technology infrastructure to deliver IBT may contact the Transportation Learning Center to arrange paper-and-pencil written assessments. Completed paper-and-pencil assessments will be sent to the Transportation Learning Center for scoring.

## Timeframe

For each 200-level module, candidates must pass the written assessment before the hands-on assessment may be scheduled. The passing result of a written assessment expires in 5 years. If the hands-on assessment is not completed within the 5-year period, the written assessment will need to be retaken.

The written and hands-on assessment retake window and the number of retakes allowed will be determined by local labor and management training committees or structure, rather than defined through the national program rules.

## Proctoring

Proctoring of written and hands-on assessments will be conducted by certified proctors from local transit agencies. In most cases, these proctors are local management and labor training coordinators or instructors who are familiar with the training program and the national qualification system. To become certified, these proctors will go through orientation training provided by Transportation Learning Center staff and maintain a signed, valid, non-disclosure agreement on the national program file, to be renewed every 2 years.

Transportation Learning Center staff will provide technical assistance and real-time troubleshooting to proctors during assessment sessions. On-site technical assistance may also be offered for hands-on assessments.

## Assessment Fees

The assessment fee schedule is as follows. For Internet-based written assessments:

- 100-level written assessment is $50 per assessment
- 200-level written assessment is $50 per assessment

For paper-and-pencil written assessments:

- 100-level written assessment is $80 per assessment
- 200-level written assessment is $80 per assessment

For multiple written modules, there is a discount on Internet-based assessments only. Candidates taking multiple 200-level written assessments during one sitting will receive a 50 percent discount for each module after the first one. For instance, a candidate taking 200-level assessments for Couplers, Trucks and Axles, and Friction Braking (three modules total) will incur a total fee of $100 ($50 + $25 + $25) for the session.

For hands-on assessments:

- 200- or 300-level hands-on assessment is $100 per assessment (Additional costs may be incurred if Transportation Learning Center staff is requested to provide on-site technical assistance during hands-on delivery.)

Fees are the same for initial assessments or retakes. Fees will be collected from participating agencies prior to scheduling assessments. The ultimate responsibility for assessment fees will be determined at the local level.

## Rescheduling, Cancellations, and Withdrawals

Should a candidate be unable to sit for the scheduled assessment, the Transportation Learning Center must receive notification in writing no later than 7 business days prior to the assessment date. The assessment fees will be held until the agency reschedules. An additional $25 rescheduling fee will be collected from the agency for each candidate.

Agencies with candidates who withdraw or cancel after the deadline or do not sit for the assessment will receive a credit in the amount paid less the cancellation fees of $25 per person for each written assessment and $50 for each hands-on assessment. These credits may be applied to scheduling of future assessments. (See Table 10 for a tabular version of the assessment fee schedule.)

**Table 10. Assessment fee schedule.**

| Type | Level | Fees |
|---|---|---|
| **Written (IBT)** | 100 Level | $50 |
| **Written (IBT)** | 200 Level | $50 (50% discount after 1st) |
| | | |
| **Written (Paper & Pencil)** | 100 Level | $80 |
| **Written (Paper & Pencil)** | 200 Level | $80 |
| | | |
| **Hands-on** | 200 Level | $100 |
| **Hands-on** | 300 Level | $100 |
| | | |
| **Rescheduling** | Any | $25 |
| **Cancellation – Written** | Any | $25 |
| **Cancellation – Hands-on** | Any | $50 |

## Scoring

Based on the pilot experience and other considerations, in particular the emphasis on demonstration of hands-on skills, the National Rail Vehicle Training Standards Committee established a passing score of 75 percent for 100- and 200-level written assessments and 85 percent for 200-level, hands-on assessments. For 300-level hands-on assessments, more difficult scenarios or additional check points will be used with the same passing score of 85 percent. (See Table 11 for a tabular listing of passing scores.)

## Americans with Disabilities Act Accommodations

Arrangements for persons with disabilities will be provided upon request, in conformance with the Americans with Disabilities Act (ADA). Professional documentation in support of a request for accommodation must be submitted to the Transportation Learning Center no later than 4 weeks prior to the scheduled assessment date.

## Recognition of Qualification

Once the required written and hands-on assessments are successfully completed by a technician, he/she will be awarded a certificate of qualification for that assessment area by the national program (see Figure 13). Qualified technicians will receive a certificate at no cost when they complete the required assessment(s). Additional merchandise for qualified technicians may be made available for purchase.

With the consent of newly qualified technicians, their names will be listed in a national directory of qualified rail technicians in the public section of the national program website. At the request of qualified technicians, official transcripts and proof of qualifications can be sent to an authorized party at a cost. Interim credentials are encouraged by the U.S. Department of Labor Office of Apprenticeship.

## Refresher Training

The National Rail Vehicle Technician Qualification Program does not mandate an official requalification process or administer requalification assessments. Once earned, the qualified status never expires. However, in recognition of rapidly changing technologies and the need for periodic training to ensure that technicians are kept current, the program strongly recommends that transit agencies provide refresher courses to qualified technicians every 3 to 5 years, or as needed.

## Credential Management System

Partnering with a credential management system, the Transportation Learning Center has developed a comprehensive, web-based, database-driven system for tracking local training course enrollment, course completion, completion

**Table 11. Assessment passing score.**

| Type | Level | Passing Score |
|---|---|---|
| **Written** | 100 Level | 75% |
| **Written** | 200 Level | 75% |
| | | |
| **Hands-on** | 200 Level | 85% |
| **Hands-on** | 300 Level | 85% |


*Figure 13. Sample certificate of qualification.*

of standardized national assessments, and achievement of national qualification status by rail vehicle technicians. This credential management system is accessible by Transportation Learning Center staff, local training coordinators, and technicians with different permission levels and interfaces. The underlying database enables Transportation Learning Center staff to produce customized reports on training, assessments, and qualification statistics.

The credential management system consists of the following modules:

- Candidate profiles
- Local training course directory (provider module)
- Candidate training history
- Assessment completion status
- Qualification status
- National qualification statistics

## Candidate Profile

Rail technicians who wish to participate in the national qualification program may create an online profile using an online registration form. Candidates will be prompted to update their profile every 180 days. See Figure 14 for a Candidate Profile/Personal Information screenshot.

Information collected includes the following:

- Demographic information
- Contact information
- Agency and union affiliations
- Current job title, job group, and years of work experience
- Highest level of education completed

## Local Training Course Directory (Provider Module)

Providers are the local transit rail agencies or joint apprenticeship programs that provide training classes to their rail vehicle technicians, prior to sending them to qualification assessments. Each provider will be given a unique provider ID and have one designated contact person, most likely the local management coordinator.

Using the provider portal, agencies may log course names, offering dates, duration, validation status against national training standards, course type (classroom, lab, on the job, web based instructor led, web based self-paced, etc.), course standing (active/in good standing, inactive, etc.), domains (e.g., 200-level Overview of Car Body), and contact information for course registration. The populated course catalog will be searchable and viewable by any user in credential manager (see Figures 15 and 16 for screenshots).

## Candidate Training History

Although candidates' eligibility for assessments is not determined in the system by the number of training hours, and there are no retraining requirements for candidates to maintain their qualification status once earned, the industry considers it beneficial to construct a centralized database for

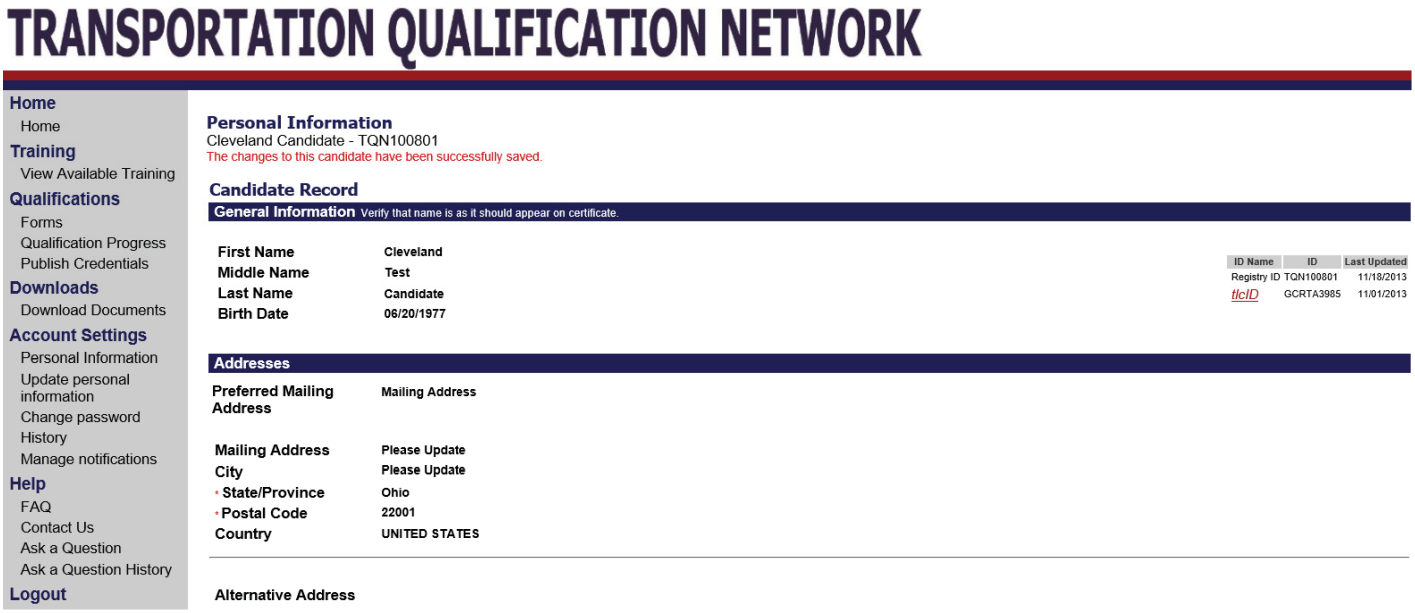



*Figure 14. Screenshot of credential manager—candidate profile/personal information.*

individual candidate training records. Candidates will be able to view local training course offerings at their employer agencies. They can also submit credits for courses taken.

## Assessment Completion Status

Once an assessment is completed, results are transmitted to the credential management system in batches. Candidates may view their assessment results online and be reminded of the next steps in their qualification process (see Figures 17 and 18 for screenshots).

## Qualification Status

Once the required written exams and hands-on exams are successfully completed by a technician, he/she will receive the qualification status in that exam area (see Figure 19). Qualification packets will be sent. Qualification status will be


*Figure 15. Screenshot of credential manager—local training course directory search.*


***Figure 16. Screenshot of credential manager—local training course directory.***

viewable online using the secure access. With the consent of newly qualified mechanics, their names may be listed in a national directory of qualified rail technicians in the public section of the national program website.

## National Qualification Statistics

This section is reserved for Transportation Learning Center staff involved in national program administration only. Queries and reports are designed to enable staff to use statistics generated by the credential management system to provide individual scoring feedback to participants, aggregated agency results to local training coordinators, and aggregated national results to the national program. Credential-management-system data will allow for better evaluation of testing validity and reliability and protection against legal liabilities. Credential-management-system data may also be used for initial assessment of new hires, job placement or assignments, identification of departmental training needs and creation of professional development plans for individual employees.


***Figure 17. Screenshot of credential manager—assessment results.***

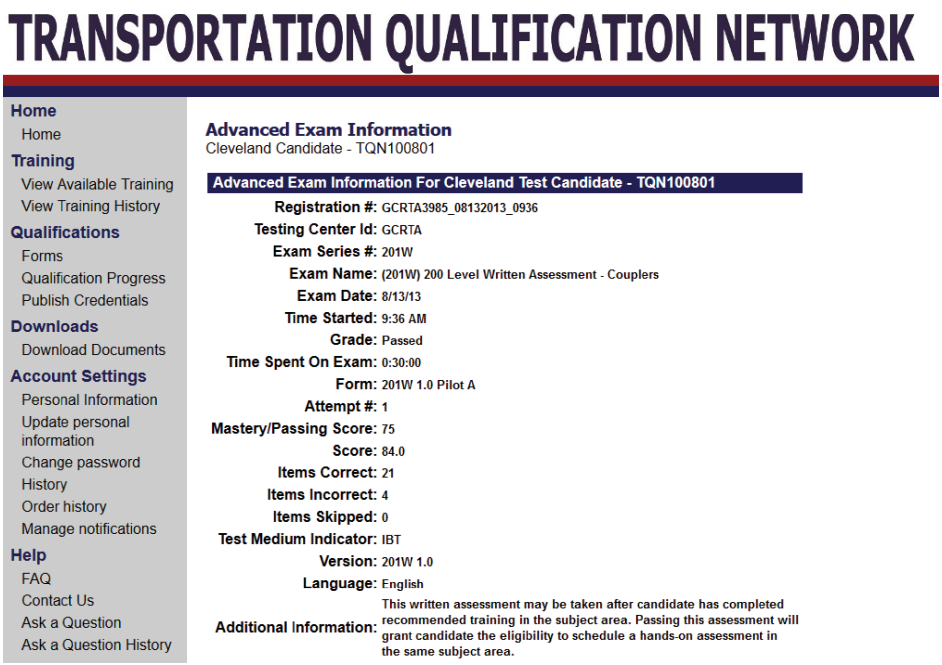



*Figure 18. Screenshot of credential manager—detailed assessment results.*

## Analyzing the Numbers: The Economics of a National System of Assessment

To provide a fiscally sound framework for the development of a national system for assessments after required training or experience, the Transportation Learning Center performed two rounds of economic analyses on the various elements of assessment within a system of transit training, first in Year 1 of the project and second in Year 5 as details of the national program were determined.

Tables 12 and 13 below provide a 10-year overview of the assessment participation rate, assessment fees, and costs associated with assessment development, delivery and maintenance. The Year 1 survey estimates that the number of technical rail maintenance employees in the entire North American transit industry is around 9,156, with 6,280 in the more skilled mechanic ranks and the rest in job titles of cleaner, helper, and

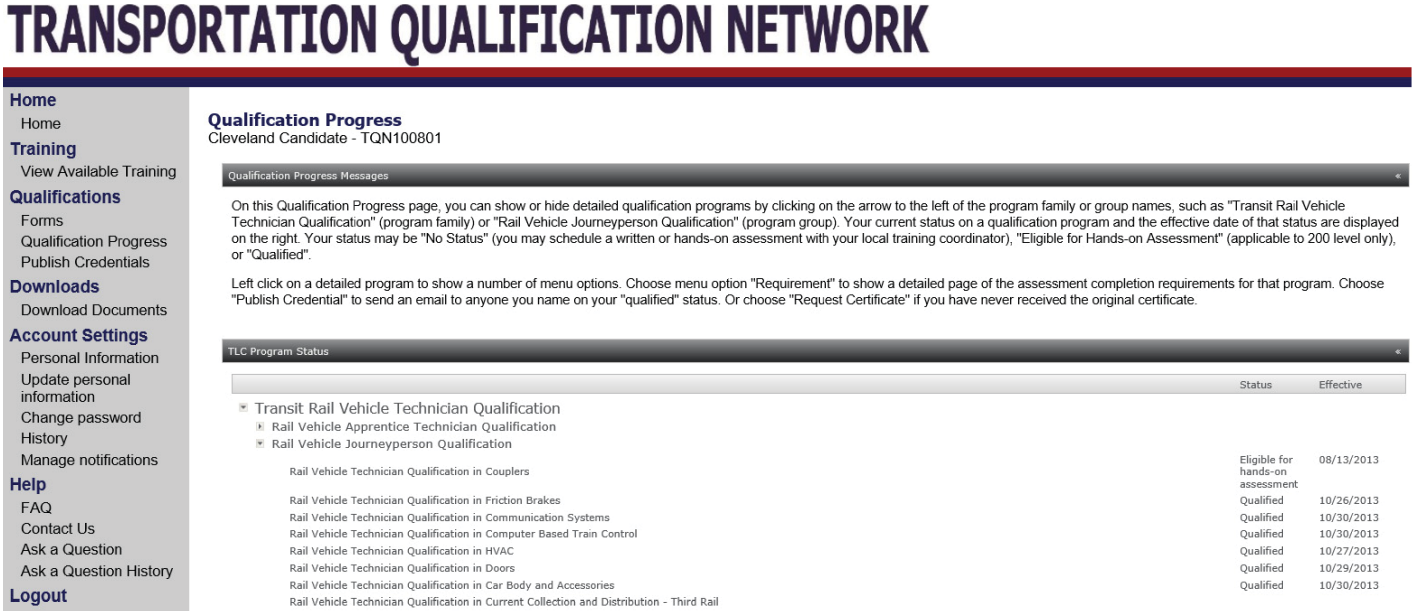



*Figure 19. Screenshot of credential manager—qualification requirements.*

## Table 12. Economic analysis of rail vehicle technician qualification program—low-participation estimate.

| | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Transit Railcar Mechanic Count*** | | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 |
| **Participating Mechanics** | **Existing Mechanics Participating - as % of Population**** | **3%** | **3%** | **3%** | **3%** | **3%** | **3%** | **3%** | **3%** | **3%** | **3%** |
| | **# of Existing Mechanics Participating** | **188** | **188** | **188** | **188** | **188** | **188** | **188** | **188** | **188** | **188** |
| | **New Hires - as % of Population (5% Replacement of Exiters, 3.8% Net Growth)***** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** | **8.8%** |
| | **# of New Hires Participating (50% of all)** | **276** | **276** | **276** | **276** | **276** | **276** | **276** | **276** | **276** | **276** |
| | # of 100 Written Assessments Taken (1 assessment/yr, New Hires only)****** | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 |
| | # of 200 Written Assessments Taken (2 assessments/yr)******* | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 |
| | # of 200 or 300 Hands-on Assessments Taken (2 assessment/technician/yr) | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 | 929 |
| **Total # of Assessments Taken** | **Written Assessments** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** | **1,206** |
| | **Hands-on Assessments** | **929** | **929** | **929** | **929** | **929** | **929** | **929** | **929** | **929** | **929** |
| | **Fees/Income (Constant $ in Thousands)** | | | | | | | | | | |
| **Fees/Income** | Written Assessment Fees ($50/assessment) | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 | 60.3 |
| | Hands-on Assessment Fees ($100/assessment) | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 | 92.9 |
| | Study Guide Fees ($0/assessment - download) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Fees/Income** | | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** | **153.2** |
| | **Costs (Constant $ in Thousands)** Note: Initial development includes task analysis, training standards approval, training materials approval, written assessment question development and validation, study guide development, Internet-based assessment system initiation, hands-on assessment scenario development and validation, proctoring system development, credential management initiation, and national committee meeting and travel associated with the above tasks. | | | | | | | | | | |
| **Fixed Costs (Overall)** | Updates for Task Analysis, Written & Hands-on Question and Study Guide (ongoing and major update every 5 yrs, incl. SME travel) | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| | Public Website Maintenance | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | Legal Costs (incl. insurance) | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| | Credential Management System License and Admin | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| | Internet-based Assessment System Maintenance | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | Orientation Training and Technical Assistance for Local Proctors | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| **Total Fixed Costs** | | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** | **80.0** |
| **Variable Costs** | Facility/Equipment/Proctoring for Written Assessment (Local Cost) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Written Assessment Setup, Support and Record-keeping ($25/assessment) | 30.1 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 |
| | Hands-on Assessment Setup, Support and Record-keeping ($50/assessment) | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 | 46.5 |
| | Recognition (Patches, certificates, etc.) ($5/person) | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 | 10.7 |
| | Study Guide Printing ($0/assessment) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Variable Costs** | | **87.3** | **63.2** | **63.2** | **63.2** | **63.2** | **63.2** | **63.2** | **63.2** | **63.2** | **63.2** |
| **Total Costs** | | **167.3** | **143.2** | **143.2** | **143.2** | **143.2** | **143.2** | **143.2** | **143.2** | **143.2** | **143.2** |
| **Annual Cost Excess/Shortage** | | **-14.1** | **10.1** | **10.1** | **10.1** | **10.1** | **10.1** | **10.1** | **10.1** | **10.1** | **10.1** |
| **Cumulative Reserve/Loss** | | **-14.1** | **-4.0** | **6.1** | **16.1** | **26.2** | **36.2** | **46.3** | **56.3** | **66.4** | **76.4** |

*Total Rail Mechanic population is estimated from the Center's survey data.

** Experienced mechanics are grandparented into the qualification program. However, they may choose to take assessments for portable credentials. This Low Participation Estimate builds in only 3 percent of the existing mechanics participating in the program. It is further assumed that each participating mechanic will complete two (2) written and two (2) hands-on modules annually.

*** 5% annual growth and 3.8% annual replacement rates are estimated using US DOT and DOL data. See Figure 1.

**** Assuming half of the new hires will participate in the program and take one (1) 100 level written assessment, two (2) 200 level written and two (2) hands-on assessments annually.

***** Assuming existing mechanics will take two (2) 200 level written and hands-on assessments annually.

## Table 13. Economic analysis of rail vehicle technician qualification program—high-participation estimate.

| | | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Transit Railcar Mechanic Count*** | | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 | 6,280 |
| **Participating Mechanics** | **Existing Mechanics Participating - as % of Population**** | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% | 5% |
| | **# of Existing Mechanics Participating** | 314 | 314 | 314 | 314 | 314 | 314 | 314 | 314 | 314 | 314 |
| | **New Hires - as % of Population (5% Replacement of Exiters, 3.8% Net Growth)***** | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% | 8.8% |
| | **# of New Hires Participating (50% of all)** | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 |
| | | | | | | | | | | | |
| | # of 100 Written assessments Taken (1 assessment/yr, New Hires only)****** | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 | 276 |
| | # of 200 Written assessments Taken (2 assessment/yr)******* | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 |
| | # of 200 or 300 Hands-on assessments Taken (2 assessment/technician/yr) | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 |
| | | | | | | | | | | | |
| **Total # of Assessments Taken** | **Written Assessments** | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 | 1,457 |
| | **Hands-on Assessments** | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 | 1,181 |
| | | | | | | | | | | | |
| | **Fees/Income (Constant $ in Thousands)** | | | | | | | | | | |
| **Fees/Income** | Written Assessment Fees ($50/assessment) | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 | 72.8 |
| | Hands-on Assessment Fees ($100/assessment) | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 | 118.1 |
| | Study Guide Fees ($0/assessment - download) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Fees/Income** | | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 | 190.9 |
| | | | | | | | | | | | |
| | **Costs (Constant $ in Thousands)** Note: Initial development includes task analysis, training standards approval, training materials approval, written assessment question development and validation, study guide development, Internet-based assessment system initiation, hands-on assessment scenario development and validation, proctoring system development, credential management initiation, and national committee meeting and travel associated with the above tasks. | | | | | | | | | | |
| **Fixed Costs (Overall)** | Updates for Task Analysis, Written & Hands-on Question and Study Guide (ongoing and major update every 5 yrs, incl. SME travel) | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| | Public Website Maintenance | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | Legal Costs (incl. insurance) | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| | Credential Management System License and Admin | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| | Internet-based Assessment System Maintenance | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| | Orientation Training and Technical Assistance for Local Proctors | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| **Total Fixed Costs** | | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| | | | | | | | | | | | |
| **Variable Costs** | Facility/Equipment/Proctoring for Written assessment (Local Cost) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Written Assessment Setup, Support and Record-keeping ($25/assessment) | 36.4 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 |
| | Hands-on Assessment Setup, Support and Record-keeping ($50/assessment) | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 | 59.0 |
| | Recognition (Patches, certificates, etc.) ($5/person) | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 | 13.2 |
| | Study Guide Printing ($0/assessment) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Variable Costs** | | 108.6 | 79.5 | 79.5 | 79.5 | 79.5 | 79.5 | 79.5 | 79.5 | 79.5 | 79.5 |
| | | | | | | | | | | | |
| **Total Costs** | | 188.6 | 159.5 | 159.5 | 159.5 | 159.5 | 159.5 | 159.5 | 159.5 | 159.5 | 159.5 |
| | | | | | | | | | | | |
| **Annual Cost Excess/Shortage** | | 2.3 | 31.4 | 31.4 | 31.4 | 31.4 | 31.4 | 31.4 | 31.4 | 31.4 | 31.4 |
| **Cumulative Reserve/Loss** | | 2.3 | 33.7 | 65.1 | 96.5 | 127.9 | 159.3 | 190.7 | 222.1 | 253.5 | 284.9 |

*Total Rail Mechanic population is estimated from the Center's survey data.

** Experienced mechanics are grandparented into the qualification program. However, they may choose to take assessments for portable credentials. This High Participation Estimate builds in 5 percent of the existing mechanics participating in the program. It is further assumed that each participating mechanic will complete two (2) written and two (2) hands-on modules annually.

*** 5% annual growth and 3.8% annual replacement rates are estimated using US DOT and DOL data. See Figure 1.

**** Assuming half of the new hires will participate in the program and take one (1) 100 level written assessment, two (2) 200 level written and two (2) hands-on assessments annually.

***** Assuming existing mechanics will take two (2) 200 level written and hands-on assessments annually.

maintenance apprentice. Table 12 represents a low-participation estimate for existing mechanics at 3 percent of current population of 6,280 and Table 13 represents high participation at 5 percent.

On the cost side, general fixed costs cover updates to the task analysis, IBT system licensing and maintenance, credential management system licensing and maintenance, qualification public website maintenance, and legal fees. To keep up with the new developments in technology, written assessments will need to be updated and revalidated and study guides revised on an ongoing basis. For hands-on assessments, the assessment task list and scenarios will also need to be updated regularly. Orientation training will be provided to proctors to ensure competency and consistency in written and hands-on assessment administration. Variable costs such as assessment scheduling and registration, scoring, transfer of assessment results, individual and aggregated feedback report generation, and certificate generation will be dependent upon the number of assessment takers. Initial development of the qualification system was funded by TCRP through TCRP Project E-07; those costs are not reflected in the tables.

For the scenarios presented in Tables 12 and 13, the following assumptions were made:

- Experienced mechanics are grandparented into the qualification program. However, they may choose to take assessments for portable credentials. The low-participation estimate in Table 12 builds in only 3 percent of the existing mechanics participating at the 200 or 300 level annually. The high-participation estimate in Table 13 assumes that 5 percent of the existing mechanics will participate in the program. It is further assumed that each participating mechanic will complete two written and two hands-on modules annually.
- Based on estimates from the U.S. Department of Labor and U.S. DOT (see Figure 1 in Chapter 1), the transit rail industry will bring in new hires at an annual rate of 8.8 percent (88 percent in the next 10 years).
- Half of these new hires will participate in the program and take one 100-level written assessment and two written assessments and two hands-on assessments at the 200 level annually.
- 100- and 200-level written assessments will be delivered primarily on local transit agency computers via the Internet and proctored by local labor and management representatives.
- Internet-based written assessment delivery costs $50 per assessment per person.
- 200- and 300-level, hands-on assessment delivery costs $100 per assessment per person with local labor and management proctoring. Additional costs may be incurred if third-party proctoring is requested.
- Study guides will be provided to assessment takers for free in a downloadable and printable format.

Given the above assumptions, the number of total written assessments taken is estimated to be between 1,206 and 1,457 annually, and hands-on assessments are estimated to be between 929 and 1,181.

In the low-participation scenario, the national qualification system will bear a net loss of $14,100 in the first year after launch and start accumulating reserves in Year 2, reaching a cumulative $76,400 by the end of Year 10. In the high-participation scenario, the national system will generate an excess of $2,300 in Year 1, reaching a cumulative $284,900 by Year 10.

CHAPTER 4

# Current Local Practices in Rail Car Training and Qualification and National Program Piloting Experience

## Limitations of Current Local Practices in Rail Car Training and Qualification

Training systems for rail vehicle technicians throughout the public transportation industry vary both in quality and quantity. The results of training at local entities are also inconsistent and often do not meet the expectations of frontline workers and managers. Numerous discussions with the National Rail Vehicle Training Standards Committee and TCRP Project E-07 panel members highlighted these shortcomings and spawned further inquiry into the causes of the problem and potential solutions.

Through these discussions, it became apparent that a comprehensive national system of qualification was needed, one in which the qualification process begins with training based on agreed-upon national training standards. At the foundation of this system of qualification is a committee structure consisting of SMEs from labor and management who jointly develop the training standards and define the quality and level of technical training needed to prepare technicians to pass assessments based on the standards. The joint committee also determines which training delivery and mentoring methods are most effective to impart technical skills and knowledge. The capstone of the national qualification system is an apprenticeship registered with the U.S Department of Labor and a tie to college credits, all developed through TCRP Project E-07. Because equipment and procedures vary between agencies, the national program is designed to provide flexibility for local customization. A detailed description of the national comprehensive system of qualification was provided in Chapter 1.

During the course of TCRP Project E-07 many stories about the state of rail vehicle maintenance training were shared with the project panel. Frontline workers were the most vocal about needing better and more training, and training administrators, trainers, maintenance supervisors, and other managers and union leaders echoed these sentiments—albeit less vociferously. The National Rail Vehicle Training Standards Committee discussed the limitations existing in current training systems, the need for more and better training, and the obstacles confronting achievement of these goals.

The safe performance of rail vehicle maintenance and safe operation of equipment following maintenance were of great concern to the National Rail Vehicle Training Standards Committee and the TCRP Project E-07 panel members. Neither can be achieved without quality training. Furthermore, assessing technician skills would not be fair or appropriate unless quality training was provided in advance of the assessment process. National Rail Vehicle Training Standards Committee members were polled to find out what they felt were the main obstacles to quality training and what training elements should be included in a national system of qualification. The results were not surprising. The first and most often repeated obstacles were a lack of organizational commitment to training and the lack of funds for training departments. The result of these two major stumbling blocks is that the elements of good training systems—good courseware, quality trainers, structured mentor plans, mentor training, structured on-the-job training, time off the shop floor for training, and more—were underfunded or not undertaken at all in the majority of agencies. In essence, it all comes down to a lack of funding. Decisions to not fund training or pull funds from training first in a financial crisis are inextricably intertwined with public transportation's perennially inadequate funding. This conundrum seems to be nearly universal within the industry. Including human capital within the definition of "capital" would go a long way toward resolving the training system underfunding issue.

The cost of quality training can be reduced by shared development of and local use of industrywide training resources that can be customized for local implementation. Joint industrywide development of the system of qualification is a perfect example, with cost-effective local solutions arising from national training standards and curriculum to courseware, training of

instructors and mentors, assessments, and apprenticeship. All of this dramatically reduces the cost to each agency and brings the knowledge of many SMEs to bear on developing courseware and training.

Investing in quality training actually saves money for agencies through the reduction in unnecessary repairs, parts replacement, and faulty repairs that result once technicians are properly trained. Studies undertaken by the Transportation Learning Center quantifying performance of equipment before and after training have shown that quality training for bus mechanics lessened diagnostic and repair times and increased the mean distance between failures (MDBF) in bus operations significantly. The Transportation Learning Center's *Metrics of Success* report shows that agency investments in quality training systems pay for themselves six times over within a few years and more than pay for themselves within 18 months (Transportation Learning Center 2010a).

Current systems too often rely on the old idea that a new hire can learn by osmosis, simply by standing next to an experienced technician. This approach often leads to a situation where true training does not readily occur and the experienced technician becomes the only person in the shop who may know how to do the work in a safe and proper manner. This can result in over-reliance on a single employee. An interesting finding during the Transportation Learning Center's research at one agency is that the MDBF decreases (gets worse) during the summer. After some investigation, it became apparent that this is because the "go to" people have the seniority to take vacation during the summer months, resulting in a seasonal brain-drain within the shop.

A structured approach to training as part of a comprehensive system of qualification solves the problems associated with workplace incompetence by providing technicians with the knowledge and skills they need to correctly, efficiently, and safely perform work tasks. Training tools developed nationally by a joint committee of SMEs ensure that the training content is appropriate and directly applicable to the jobs technicians are expected to perform every day on the shop floor. Training provided to all workers in a structured and effective manner makes certain that every person in the shop knows as much as experienced technicians and that all the experienced technicians working in the shop are in fact qualified to carry out their work. There is nothing more counterproductive in a shop than having the "go to" people passing along bad work habits and improper work procedures to others trying to learn their craft. Structured training, where classroom and on-the-job courseware and delivery elements are clearly defined and optimized, elevates the competence of all workers. These workers are then, collectively, in a better position to improve the quality of maintenance and repair work, improve shop safety, and pass along their insights in a more meaningful, productive, and correct manner.

Key to the national process are provisions that support customized local implementation. This is based on the understanding that each agency needs a training system that matches its own specific fleet equipment, job classifications, and promotion systems. With qualification frameworks and resources developed nationally by SME committees for each occupation, each transit agency can access quality materials and training delivery methods and customize them for their specific operations. Each location is no longer left on its own to develop a quality training program, simply hoping that it will be effective.

## OEM Training Quality Found to Be Inconsistent

OEM-provided training that comes packaged with new capital equipment is an important source of training, but it can fall short of the training needs of agencies for this new equipment. In a 2012 survey conducted by the Transportation Learning Center, SMEs on the National Rail Vehicle Training Standards Committee identified 50 distinct training areas on which OEMs provide training materials. The named OEMs include leading vendors in the industry. In 35 (70 percent) of these areas, the SMEs rated OEM training materials as poor or fair (see Figure 20). Among the topics covered by the OEM training materials, rail vehicle troubleshooting and communications were found to be the most problematic. Not one subject area had an average score that put it in the "Very Good" Category across all vendors (see Figure 21).

## System of Qualification—Local Implementation and Pilot Experience

Throughout TCRP Project E-07, elements of the structured system of qualification identified through the national work were put into action at a number of National Rail Vehicle

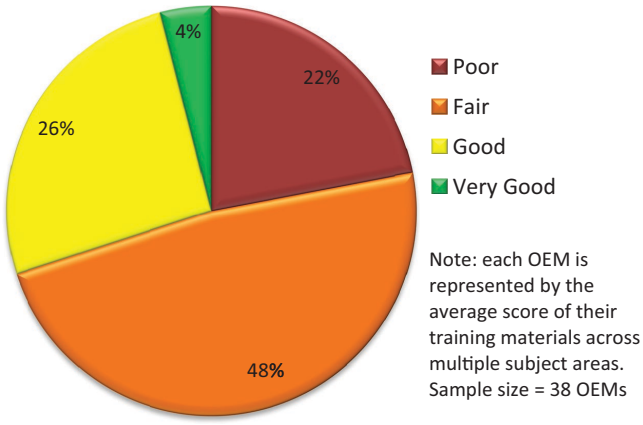
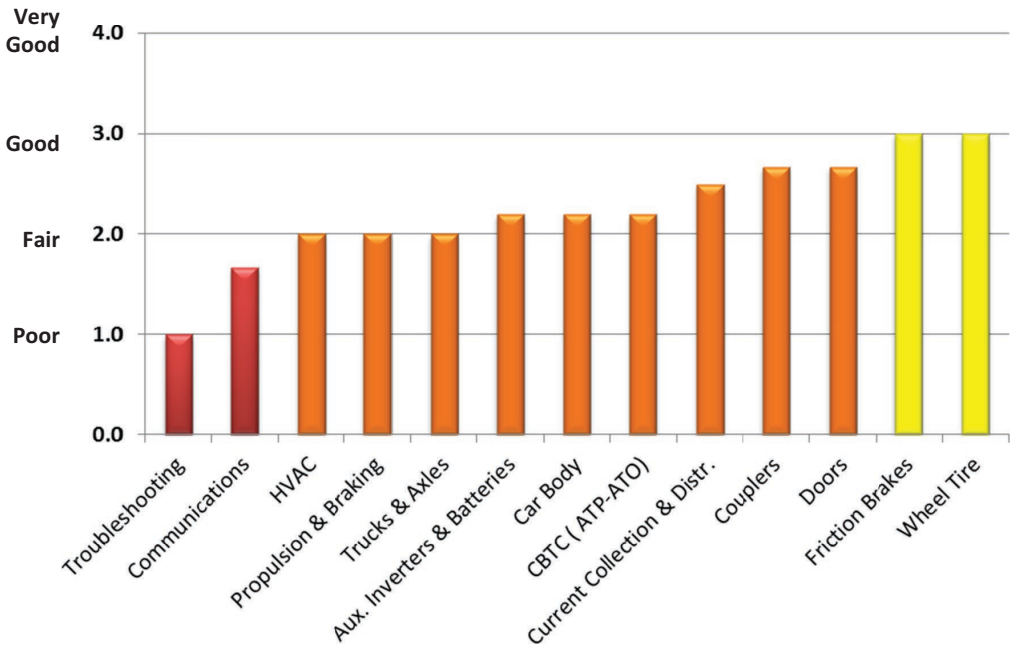



***Figure 20. Ranking of OEM training materials.***




Note: each subject area is represented by the average score of the training materials provided by relevant OEMs.

***Figure 21. Ranking of OEM training materials by subject area.***

Training Standards Committee member locations. These elements include the application of training standards, validated courseware, proven training delivery methods, apprenticeship programs, structured on-the-job mentoring, and customization provisions to suit specific agency needs.

In addition to the local implementation of these training elements, pilot locations were enlisted to administer written and hands-on assessments locally to identify and remedy potential weaknesses before rollout in the national qualification program. Doing so in advance of actual program launch allowed the assessment process to be tested and modified through National Rail Vehicle Training Standards Committee input to make it more efficient, user-friendly and fair to all participating agencies. The assessment pilot took place at six agencies: Sacramento SacRT, Santa Clara Valley Transportation Authority (VTA) San Jose, LACMTA, Massachusetts Bay Transportation Authority (MBTA) Boston, GRTA, and Port Authority of Allegheny County in Pittsburgh, PA.

## Structured Training

Application of structured training elements as identified through TCRP Project E-07 produced favorable results at many participating agencies. At UTA, national training standards developed jointly by SMEs from both labor and management were fully adopted into the agency's training program. The standards were also used to validate courseware to ensure that materials used for training complied with learning objectives contained within the standards. In areas where courseware was deficient, UTA used resources provided by the Transportation Learning Center to locate missing elements. According to the maintenance training administrator at UTA, "We plan to adopt all training standards recommended by the National Rail Vehicle Training Standards Committee, including the assessments. By using this national framework, we've been able to achieve a clear focus, and we're moving forward efficiently."

In early 2013, the GCRTA and its ATU Local 268 began the process of building a new rail car apprenticeship program. Labor and management collectively realized that the agency needed to do much more to prepare the next generation of rail car technicians. Rail vehicles and associated onboard equipment have grown in complexity, especially with regard to sophisticated electronic applications. The agency recognized that existing training methods would not be sufficient to educate the number of new hires needed to replace the many incumbent technicians about to retire. In response to this training need, the agency set out to develop an entirely new rail car apprenticeship program utilizing the structured training elements and resources of TCRP Project E-07. Management and the union agreed to work together to build an apprenticeship based on the new national system of qualification, realizing it was the most effective path they could follow.

As a result of a skill gap analysis conducted by New York City Transit (NYCT), which pointed to skill deficiencies among its rail car technician workforce, the agency stepped up to add additional training in fiber optics, HVAC, and brazing and

welding. Training provided to enhance deficient skills was based on the national training standards. An additional skill gap analysis of rail car inspector apprentices is underway to improve training in that work area.

Transportation Learning Center staff was also involved with the partnership team at NYCT to discuss potential improvements to its apprentice training based on TCRP Project E-07 activities, including a more systematic review of on-the-job training practices. The framework for examining the usefulness of on-the-job learning and its relationship to apprenticeship is also based on the national training standards. Flagging and safety have also been identified as critical training needs at NYCT. Classes conforming to training elements identified through TCRP Project E-07 have been put into place as a result of the needs analysis.

Although SacRT will most likely never have a full apprenticeship program because of its small size, the joint labor-management training partnership there has made every effort to streamline their training and bring it in line with the national standards. The light rail vehicle (LRV) maintenance trainer at SacRT credits participation in the National Rail Vehicle Training Standards Committee work and personal relationships forged there for development of a better understanding of the materials available for training rail car technicians and the best training practices available for replication. These concepts were a direct result of participation in TCRP Project E-07 and the National Rail Vehicle Training Standards Committee process. Development of standards also gave SacRT a foundation for developing hands-on training and assessments.

Participation by SEPTA allowed the agency to use much of the courseware identified through TCRP Project E-07. Additionally, National Rail Vehicle Training Standards Committee participation has helped the agency exchange ideas with other locations.

Working with the National Rail Vehicle Training Standards Committee and TCRP Project E-07 has helped MBTA shape and improve many of its training programs by incorporating national standards into its courses. Input from National Rail Vehicle Training Standards Committee members on the labor side helped management think through ways to make sure that the agency was fair in the way it offered training and promotion opportunities. Participation in TCRP Project E-07 also allowed them to ask questions during meetings and exchange ideas to help improve training. Activities are also underway at MBTA to expand its current training program to include hands-on learning and mentoring as a result of materials provided through TCRP Project E-07.

## Pilot Qualification Assessments

Pilot test delivery was conducted at six transit agencies to validate the hands-on and written assessments and confirm that rail car technicians could effectively demonstrate proficiencies resulting from training. For the pilot written assessments, all participating locations but one, MBTA, had technicians take the written assessments electronically via the Internet, allowing the research team to evaluate computer-based as well as pen-and-paper methods for test administration. MBTA had to use the pen-and-paper method because it does not have computer stations with web access on the property.

Written assessments were administered prior to the hands-on assessments per qualification procedures. Labor and management proctors at each agency first participated in a tutorial with Transportation Learning Center staff to become thoroughly familiar with the process.

### *Written Assessments*

A total of 65 validated written assessments were administered across all of the pilot locations. Another 5 were administered in Current Collection, but there were not enough validated questions in this module to score the results. Of the 65 validated written assessments, 46 received a passing score, for a success rate of 71 percent. See Figure 22 for a summary of modules taken and mean scores (see table column labeled "percentage") from all pilot locations. Assessment topics included Couplers, Trucks & Axles, Propulsion & Dynamic Braking, Friction Braking, and HVAC.

Candidates taking the written assessments did so confidentially and were given a score sheet that showed their strengths and weaknesses in specific areas (see Figure 23 and 24 for example individual feedback reports). Those who passed the assessments were informed on their score sheet that the results would be kept in the Transportation Learning Center's database and would be used toward the official rail vehicle technician qualification program.

Aggregated feedback reports were provided to the local management and union team. They gave each agency a specific indication of the areas where their training program needed to be enhanced without compromising the confidentiality of individual assessment results (see Figure 25 for an example agency feedback report). For example, if score results show that several technicians at a particular agency did poorly in certain areas (e.g., suspension, doors, etc.), agency staff could then enhance that part of their training program to supply technicians with the needed knowledge. The courseware validation tool developed under TCRP Project E-07 could also be used to make sure that certain training materials effectively address learning objectives contained in each of the national standards. In addition to determining whether technicians have the required aptitude, written assessments provide agencies with an indication of how well their training program measures up to national standards and where to redirect their training efforts.

| Written Assessment Module | All | Number of Candidates Assessed | 65 |
|---|---|---|---|

| Subject Areas | Percentage | # of Candidates | Strong >=75% | Adequate <75% and >=50% | Needs Improvement <50% | N/A |
|---|---|---|---|---|---|---|
| Module 201 - Couplers | 82% | 16 | | | | |
| Module 202 - Trucks & Axles | 74% | 5 | | | | |
| Module 203 - Propulsion & Dynamic Braking | 76% | 26 | | | | |
| Module 205 - Friction Braking | 78% | 9 | | | | |
| Module 206 - HVAC | 79% | 9 | | | | |

*Figure 22. Pilot location average—written assessment modules.*

# Module 206 - HVAC Pilot Written Assessment Feedback

| Employee | John Doe | Date of Assessment | January 31, 2013 |
|---|---|---|---|
| Agency Name | Agency A | Overall Percentage | 84% |
| Written Assessment Module | 206 - HVAC | Pass/Fail Status | Pass |

| Subject Areas | Percentage | # of Questions | Strong >=75% | Adequate <75% and >=50% | Needs Improvement <50% | N/A |
|---|---|---|---|---|---|---|
| Background Knowledge | 77% | 7 | | | | |
| Evaporators and Condensers | 80% | 5 | | | | |
| Refrigeration Components | 100% | 3 | | | | |
| Tools | 100% | 6 | | | | |
| Compressor/Motors | 100% | 2 | | | | |
| HVAC Controls | 100% | 2 | | | | |

**Comments:** Congratulations, you passed this module! Your assessment result will be kept in our confidential database and may be used towards the official Rail Vehicle Technician Qualification Program once it is launched. Thank you for your participation in this pilot!

Note: Overall percentage = the # of correct answers/ # of incorrect answers for the entire module.

*Figure 23. Example individual feedback report for passing assessment.*

## Module 206 - HVAC Pilot Written Assessment Feedback

| | | | |
|---|---|---|---|
| **Employee** | John Doe | **Date of Assessment** | January 31, 2013 |
| **Agency Name** | Agency A | **Overall Percentage** | 64% |
| **Written Assessment Module** | 206 - HVAC | **Pass/Fail Status** | **Fail** |

| Subject Areas | Percentage | # of Questions | Strong >=75% | Adequate <75% and >=50% | Needs Improvement <50% | N/A |
|---|---|---|---|---|---|---|
| Background Knowledge | 54% | 12 | | | | |
| Evaporators and Condensers | 100% | 3 | | | | |
| Refrigeration Components | 100% | 4 | | | | |
| Tools | 60% | 3 | | | | |
| Compressor/Motors | 100% | 1 | | | | |
| HVAC Controls | 50% | 2 | | | | |

**Comments:** Sorry, you did not pass this module. Your assessment result will be kept confidential. You will have the opportunity to retake this module once the official Rail Vehicle Technician Qualification Program is launched. Thank you for your participation in this pilot!

Note: Overall percentage = the # of correct answers/ # of incorrect answers for the entire module.

***Figure 24. Example individual feedback report for failing assessment.***

## Module 206 - HVAC Pilot Written Assessment Feedback

| | | | |
|---|---|---|---|
| **Agency Name** | Agency A | **Date of Assessment** | January 31, 2013 |
| **Written Assessment Module** | 206 - HVAC | **Average Percentage** | 73% |
| **Number of Candidates Assessed** | 7 | | |

| Subject Areas | Percentage | Strong >=75% | Adequate <75% and >=50% | Needs Improvement <50% | N/A |
|---|---|---|---|---|---|
| Background Knowledge | 85% | | | | |
| Evaporators and Condensers | 75% | | | | |
| Refrigeration Components | 95% | | | | |
| Tools | 80% | | | | |
| Compressor/Motors | N/A | | | | |
| HVAC Controls | 30% | | | | |

***Figure 25. Sample agency aggregated feedback report.***

### *Hands-On Assessments*

Pilot hands-on assessments followed the written assessments. Hands-on assessments are an important element of the qualification program because they provide technicians who may not do well on written assessments an opportunity to display their abilities in an actual work environment. Transportation Learning Center staff worked with the labor-management team at each agency location to take the generic hands-on tasks developed by the National Rail Vehicle Training Standards Committee and customize them to suit each agency's equipment, work procedures, and terminology. The process confirmed that one fixed set of hands-on assessments would not be appropriate for all agencies to follow because of the differences across agencies in equipment, practices, and so forth. Transportation Learning Center staff worked with local labor-management teams to develop a series of hands-on assessment scenarios and scoring structures that remained consistent with the National Rail Vehicle Training Standards Committee's generic procedures yet conformed to each agency's equipment and practices.

The pilot hands-on assessments resulted in some minor modifications to the assessment procedures, as reflected in the final versions of three documents:

- National Rail Car Hands-On Skills Assessment Part 1: Task Application Form
- National Rail Car Hands-On Skills Assessment Part 2: Evaluator's Worksheet
- Candidate Assessment Form

Modifications made to these documents as a result of the pilot testing were aimed at clarifying communication with the candidates, making certain they fully understood what was expected of them prior to and during the assessments.

Part 1 of the National Rail Car Hands-On Skills Assessment consists of the form that agencies will use to apply for a hands-on assessment. It begins the process of working with the Transportation Learning Center to tailor tasks to each agency location. Part 2 is the evaluator's worksheet to be used by the joint labor-management team to conduct the assessments, assess each candidate's performance, and arrive at a final score. A third document, the Candidate Assessment Form, provides rail technicians planning to take the assessments with essential background information about the process to make them feel more comfortable about the assessments. The Candidate Assessment Form was a direct outcome of the piloting process because it became evident that technicians needed more up-front information. Final piloting confirmed that the material contained in all three documents, following some minor revisions, is now ready for large-scale implementation.

## Feedback on Pilot Experiences

Pilot experiences and feedback received from each agency proved useful to fine-tuning the hands-on process.

### *SacRT and IBEW Local 1245—Sacramento, California*

A management evaluator and labor evaluator made up the labor-management team at SacRT. Hands-on assessments for friction brake inspection were administered to four technicians. All four had recently completed training in which conducting a brake inspection was included. Candidates were asked to conduct a brake inspection per agency procedures, verbalize those procedures, and identify planted defects. They achieved scores ranging from 60 to 100. It is noteworthy that during one of the TCRP Project E-07 pilot hands-on assessments a major fault identified by a technician resulted in the agency issuing a fleet defect directive, resulting in modifications being made to the entire fleet to avoid serious electrical consequences.

Comments from the four SacRT technicians indicated that they found the hands-on assessment exercise very helpful in identifying possible problems during brake inspections. Given the opportunity, several indicated that they would participate in future exercises. Knowing that San Jose VTA would be conducting assessments next, the joint labor-management team from that agency traveled to Sacramento to witness the pilot process, which put them in a better position to conduct their own assessments.

### *VTA and ATU Local 265—San Jose, California*

A management evaluator and labor evaluator administered the hands-on assessment to five technicians in the area of Current Collection, Pantograph Inspection with scores ranging from 85 to 100. Students had also recently completed training in the topic, and the assessments provided a way for the agency to gauge learning and its training program. Witnessing the hands-on assessments at SacRT in advance allowed VTA to conduct their own assessments without on-site assistance from the Transportation Learning Center. Transportation Learning Center staff worked with the labor-management team over the telephone and through emails in advance to develop the assessment tasks, a process that will be used once the program becomes operational on a national level.

Comments from those taking the hands-on assessments were again generally positive:

- "I enjoyed the test. It helped me to figure out what I did not understand about certain problems. [We] need more frequent training."

- "Test was performed well and explained well." This comment reveals that the steps taken by the labor-management team to more fully explain the assessment process, steps that were taken as a result of the Sacramento piloting, were successful.
- "Good test procedures. Good to find out what I didn't know or wasn't shown when getting taught in the beginning." This comment highlights the assessments as a way for students to gauge their learning; allowing them to apply their training to real-world job tasks reveals any learning gaps.
- "A very good assessment process to improve mechanics' skills for younger generation." The comment implies that younger mechanics appreciate learn-by-doing methods.

The management evaluator added the following:

> Through the pilot, we were not only able to evaluate our current training, but also received some great ideas and feedback from the candidates that will be used to improve future training. We felt that this pilot program was extremely successful, and we are pleased to have participated in it. We are confident that this national program will continue to be a valuable tool for us to boost training of our technicians.

### *LACMTA and ATU Local 1277—Los Angeles, California*

Hands-on assessments were administered to two Los Angeles rail car technicians by a management evaluator and labor evaluator. The pilot assessments consisted of performing an HVAC system inspection. Both technicians had strong scores—85 percent or higher. Comments from the two candidates included the following:

- "Hands-on training helped me pass this test."
- "Degree of difficulty OK for me because I work much on AC, but would be more difficult for others with limited experience." Both comments reveal that training and experience are required to pass the assessments, an indication that they were not too easy.

The management evaluator, speaking about the overall project said:

> This committee has given me a great experience and valuable resource for any future issue that may arise. I concur with everyone that this committee has done a great job!

### *MBTA and ATU Local 589—Boston, Massachusetts*

Hands-on assessments were administered to eight technicians by the labor evaluator and management evaluator. As part of the assessment, technicians were asked to perform coupler inspections according to local agency procedures, verbalize what they were doing, identify planted defects, and describe procedures to correct the defects. All eight had recently completed coupler training where they performed coupler inspections as part of the training. All but one achieved a perfect score of 100. The other pilot candidate, who scored 60 percent, had not completed all elements of the training due to personal reasons. The perfect score achieved by the others is an indication that the training as delivered by MBTA is effective.

### *GCRTA and ATU Local 268—Cleveland, Ohio*

Hands-on assessments were given to three Greater Cleveland RTA technicians on conducting inspections of propulsion and dynamic braking systems. The assessments were administered by two labor evaluators and two management evaluators. Unlike technicians at the other agencies, these technicians were not provided with recent training on the subject. Two of the pilot subjects who had not had recent training scored 60 and 70 percent. This points to the need for additional refresher training.

Greater Cleveland RTA uses an agency-developed version of hands-on assessment to validate their training and welcomed the opportunity to pilot a nationally developed process that they helped create. The agency will change their locally developed hands-on assessment process to conform to the national format.

### *Port Authority of Allegheny County and ATU Local 85—Pittsburgh, Pennsylvania*

A labor-management project team was formed to work on the piloting initiative. The project team reviewed and updated hands-on and written assessment documents concerning propulsion system inspections. Assessments were administered by labor and management evaluators. Six employees (including three Rail Tech As and three Rail Tech Bs) participated in both written and hands-on assessments.

Written assessment results showed that the Rail Techs' knowledge was strong in three of the four subject areas. Test data suggested that training in one subject area, AC propulsion components, needed improvement. The assessment feedback offered valuable data analysis to identify the training needs of the workforce. The participants' comments concerning the assessment focused on terminology issues. The technical jargon found in the assessment at times was not consistent with the terminology used on the shop floor.

Technicians participating in the hands-on assessment verified that years of training and experience are beneficial to developing a skilled workforce. All six rail technicians scored 100 percent on the hands-on assessment. As a result of the interaction between the assessment participants and the

labor-management evaluators during the hands-on assessments, the project team realized the need to update the agency's standard operating procedure concerning propulsion system inspections.

## Lessons Learned and Conclusions

The pilot training and assessments allowed various elements of a structured national system of qualification to be implemented at several agency locations. Although not at the scale needed by the rail industry, these pilot implementations did begin the process of locally identifying the need for and benefits associated with a structured training program, one based on national training standards. The pilot implementations also provided a trial run of the written and hands-on assessment processes developed through National Rail Vehicle Training Standards Committee involvement. With the important prerequisite that training be given in advance of testing, the hands-on assessments allowed technicians to demonstrate their ability to carry out work tasks in accordance with nationally recognized standards in a way that might not be realized through written testing alone. Hands-on assessments fully achieve what written assessments cannot—confirming that as a result of their training technicians can in fact properly and safely perform job tasks that they will be responsible for on a daily basis. Whereas written tests evaluate a technician's knowledge, hands-on assessments prove that technicians can convert that knowledge into useful workplace skills. The pilot implementations demonstrated that incorporating both written and hands-on assessments following training are essential to a national qualification program.

As revealed by many of the comments provided, labor and management representatives were generally pleased with the implementation process. For labor and management evaluators, many of whom served on the National Rail Vehicle Training Standards Committee to develop the process, the pilot implementations provided an opportunity to witness just how effective the qualification process could be, and how labor-management relations are strengthened as a result of that process. Having labor represented as an equal partner in the process provided assurances to union technicians that the training and assessment process was developed in a fair and impartial manner. Assessing technicians following recent training on a particular subject allowed the joint labor-management teams to determine just how effective the training was at matching nationally established standards.

The pilot implementations also revealed that conducting hands-on assessments, while a worthwhile program element, does take additional time and effort. Equipment needs to be secured and made available during the assessments, and evaluators need to plant defects and return the equipment to normal operating condition following each assessment. Unlike written assessments, which can be scheduled as a group activity within a relatively short period of time, hands-on assessments need to be scheduled over a longer time period because candidates participate one at a time.

Additionally, the pilot implementations once again confirmed the importance of training in the qualification process. As mentioned regarding MBTA, all candidates, except for one who did not take training because of personal reasons, achieved a perfect score. These results illustrate that training is essential to achieving the skills needed to become qualified. Other interesting findings are that some technicians without formal training scored well because of their extensive experience, which supports a provision in the program that allows technicians to opt out of the training prerequisite requirement if they feel they have sufficient training. If the assessments show that this is not the case (i.e., they do not pass), they can take targeted training to acquire the knowledge and skills needed to become qualified.

All pilot assessment results are kept confidential, with individual results and feedback provided to each participating technician and aggregate results and analysis provided to the joint labor-management teams at each agency. Those technicians who passed the assessments will be given credits for their scores when the program is officially launched.

CHAPTER 5

# Moving Forward—Implementing Systems of Qualification

The completion of TCRP Project E-07 is not the end of, but rather an important milestone along, the transit industry's road to an effective system of qualification for rail vehicle maintenance technicians. This opportunity comes at a time of great need for skills development in the transit industry—to backfill positions after pending retirements and to develop new positions with the continuing expansion of transit rail. As part of an interrelated suite of ongoing national training initiatives in the transit industry, the results of this project will serve as a pathfinder for the emerging system of frontline technical qualification that cuts across many transit occupations with urgent training requirements.

The road forward involves interactive initiatives for (1) implementing the framework of qualification that is now available at the local level and (2) developing additional components of the system of qualification at the national level. These two sets of activities are designed to be mutually reinforcing.

## Local Implementation of the New Framework for Qualification

Local implementation of the new national training resources within transit systems across the country is based on customizing the national resources created by TCRP Project E-07 and related initiatives. To be useful locally, the framework of new national resources has to be customized to create a good fit with local conditions—the baseline of previously existing training practices and resources, instructor development, mentoring, and coordination of classroom and on-the-job training. Figure 26 (previously presented as Figure 7 in Chapter 1) shows the critical national resources for the system of qualification for rail vehicle technicians in the left column and their local implementation in the right column.

The recognition of this entire structure of qualification by the U.S. Department of Labor in June 2013 as a new registered national apprenticeship is raising awareness of the new qualification system within the transit industry. The combination of components in this approved apprenticeship is one of the most comprehensive within the American framework of technicians' apprenticeship. The rail car apprenticeship combines national training standards and curriculum; a national training committee; in-depth tools for building effective mentoring and on-the-job training; a CMS for tracking the qualification experience of technicians across the industry; and a jointly developed set of assessments, both written and hands-on, to confirm that technicians have developed the necessary knowledge and skills. This entire framework and its components form the basis of the national apprenticeship now recognized by the U.S. Department of Labor. All of this significantly advances standards-based, partnership-centered, quality training for frontline transit technicians in general. Recognition by the U.S. Department of Labor drives home the idea that there is a coherent system of training that transit agencies need to implement.

With these resources now available, individual transit systems can move forward in making this system the new norm in the industry. As detailed in Chapter 4, a number of agencies represented on the TCRP Project E-07 panel and the National Rail Vehicle Training Standards Committee have already begun local implementation of key parts of the qualification system. The experience at the locations piloting the framework and conducting pilot hands-on and written assessments highlighted the gaps between their current practice and the potential of the qualification system. As agencies expand and upgrade their training systems, they will find that the jointly developed hands-on and written assessments can help them evaluate the effectiveness of their training programs and identify areas that need further improvement.

The projected need to hire and train the equivalent of 88 percent of today's total transit industry workforce over the next 10 years will continue to drive transit leaders toward more effective training solutions and more cost-effective solutions that draw on industrywide resources. The system of qualification is intended to provide high-quality, cost-effective, and

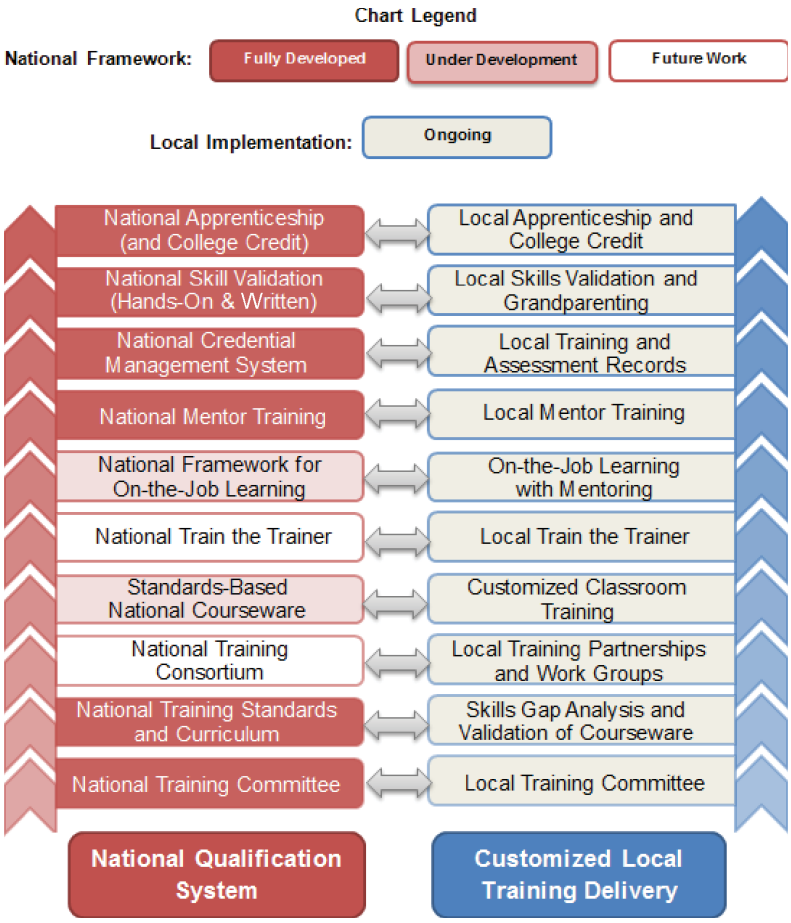



***Figure 26. Rail vehicle national and local qualification system.***

consistent solutions for meeting transit's workforce challenge over the next decade and beyond. As more new technicians are hired and need to be trained, more transit systems should recognize the benefits of this systems-based solution. It is clear that no transit agencies are prepared to hire and train the numbers of new technicians they will need over the next decade. Raising these new hires to consistently high levels of skill to produce reliable, efficient, and safe operations will require utilizing quality training systems—systems that can most effectively be created by implementing the resources of the national system of qualification.

## Registering and Expanding Apprenticeships and Standards-Based Training

An early step that the industry can take toward implementing this new system is for existing local transit rail car apprenticeships to align themselves with the new framework for apprenticeship developed by this project. Local rail car apprenticeships already exist in seven U.S. transit systems—Metropolitan Atlanta Rapid Transit Authority (MARTA), NYCT, Portland's Tri-County Metropolitan Transportation District (TriMet), Denver Regional Transportation District (RTD), LACMTA, New Jersey Transit (light rail), and Pittsburgh's Port Authority Transit system. Project panel or National Rail Vehicle Training Standards Committee members from most of these locations have expressed an interest in working to align their existing apprenticeships and register them within the new national framework, hoping to take advantage of the opportunity to improve their training systems and access potential college credit. These agencies and their unions can further strengthen their training programs by aligning them with the national apprenticeship and utilizing the resources of the new national system of qualification.

Developing altogether new rail car apprenticeships utilizing the resources of this project offers an attractive option for transit systems currently without an apprenticeship. Even before the completion of TCRP Project E-07, Greater Cleveland RTA and ATU Local 268 started the process of building a new rail car apprenticeship. Both RTA and the union recognized that they needed to do much more to prepare their next generation of rail car technicians, and they agreed that working together to build an apprenticeship based on the

new national system of qualification was the most effective path they could follow. A handful of other transit systems are considering similar upgrades to their rail car training programs, utilizing the resources of the TCRP Project E-07 system and the new framework for apprenticeship. Philadelphia's SEPTA has expressed a desire to register their existing rail car training program as an apprenticeship with Pennsylvania's state office of apprenticeship, utilizing apprenticeship language negotiated in their collective bargaining agreement several years earlier. Other agencies, such as UTA, are upgrading their rail car training programs to align more closely with the overall system of qualification, thus moving closer to the possibility of a formally registered apprenticeship.

Still other locations across the transit industry are starting to analyze the challenges of impending retirements, rail system expansion, and advancing technologies. Given the workforce realities facing them, they will have to find cost-effective ways to raise the quality of their rail car training. They can continue on transit's traditional path, where each location is forced to figure it all out for themselves, or they can approach this challenge through a comprehensive and systematic upgrade of their frontline workforce training in cooperation with the rest of the industry.

## Developing the Qualification System and Supporting Local Implementation: Proposed Rail Car Training Consortium

Beyond simple local implementation, a way to move forward is for a group of agencies and local unions to come together in a new consortium to advance the system's rail car technician qualification while also increasing their local capacity to implement quality training systems. A proposed rail car consortium now under consideration would do just that, with an initial focus on training trainers and mentors and supporting implementation of this project's system of qualification.

Fundamentally, this consortium proposal—discussed among transit leaders across the industry in late 2013 and early 2014—is a continuation of the cross-location work on rail car training undertaken in TCRP Project E-07. More broadly, the consortium would build on the precursor effort (2006–2009) to develop national training committees and national training standards for five technical occupations, with funding support from FTA and the U.S. Department of Labor. The proposed rail car training consortium is also closely related to transit's other recent industrywide joint training consortia now underway for elevator-escalator technicians and signals technicians. Both of these existing consortia are developing specialized train-the-trainer programs for their occupations, recognizing the importance of both quality training delivery and local leadership in building effective training programs. Not coincidentally, the elevator-escalator and signals consortia both adopted the mentor training framework developed for rail vehicle technicians under TCRP Project E-07 for use in their occupations.

Many transit leaders have expressed interest in a consortium aimed in the first instance at improving the capabilities of transit rail car trainers as well as frontline mentors. They see train-the-trainer programs as an area of urgent need in the transit industry, particularly for rail car trainers. Like other transit technical instructors, most rail car trainers are excellent technicians who have been promoted to training responsibilities but without any specific preparation in training systems, training design, or training delivery. These instructors' version of classroom training too often consists of reading aloud the text of PowerPoint slides projected on a screen, with no opportunity for hands-on exercises and no integration of classroom lessons with on-the-job learning. If these instructors were not exposed to mentoring as they came up years ago, they are unlikely to develop mentoring or structured on-the-job learning.

The train-the-trainer and mentor training focus in the proposed consortium will be designed to contribute broadly to quality training delivery. It will go far beyond conveying generic guidelines on effective instructional communication to put trainers and mentors in position to utilize all the resources in the comprehensive system of qualification. Thoroughly prepared trainers will understand learning systems from the classroom, the lab on-the-job experience with mentors, along with apprenticeship and credential management. Likewise, well-prepared mentors will be able to connect each segment of on-the-job learning with the material in the training standards, curriculum, and classroom training.

By aiming first at developing instructors and mentors, the proposed rail car training consortium will also be accelerating local implementation of the qualification system and its components. Knowledgeable training staff can partner with well-prepared mentors as internal advocates for quality training. Together, they can form the core of local training partnerships, providing internal leadership for implementation of the qualification system. Developing this internal training capacity will support the second major goal of the rail car consortium: to further expand local implementation of the system of qualification. Other projected activities in the consortium include broader use of the TCRP Project E-07 curriculum and progressions; sharing courseware and on-the-job resources across locations; partnering with career and technical education and training programs; expanding use of the rail vehicle assessments in a "building for success" model, to confirm current skill sets and identify training targets; and identifying priorities and opportunities for further courseware development, particularly at the 200 and 300 levels.

In a relatively new development, OEMs are emerging as natural stakeholders in these training development consortia. OEMs have a powerful interest in making sure that their equipment is properly and safely maintained in public

transportation operations. In addition, OEMs generally provide initial training when they deliver new equipment, but—as shown in Chapter 4—OEMs such as rail car manufacturers are generally not training specialists, and most of the training they deliver is perceived to be only fair or poor in effectiveness by their transit customers. The transit training consortia for elevator-escalator and signals technicians have increasingly developed the natural productive partnership among transit agencies, unions, and OEMs, setting an example that can be followed by the proposed rail car training consortium.

## Expanding Resources for Frontline Workforce Qualification

Across the timeframe of TCRP Project E-07, some transit chief executive officers have come to recognize that they have to allocate resources for meeting the training challenges facing their organizations. Local union presidents generally agree. In effect, these leaders are saying that they can't afford to wait for hypothetical future resources to become available. Given the demands facing their agencies due to retirements, expansion, and new technology, these leaders have to rearrange their budget and program priorities to ensure that their agencies can continue to provide safe, reliable service in transit rail.

For those transit leaders and their agencies, the resources developed under TCRP Project E-07, Establishing a National Transit Industry Rail Vehicle Technician Qualification Program—Building for Success, offer high-quality, low-cost solutions to help meet training and budgetary challenges.

## Postscript: Career Pathways for Tomorrow's Transit Technicians

This project has focused on qualification systems for today's incumbent transit technicians and new hires into the industry. It is important to remember, however, that the pipeline of qualified applicants for entry-level technical positions is also critically important for the industry's ability to develop a fully qualified technical workforce. Expanded career pathways from the K-12 education system and community and technical colleges are strongly connected to the presence of effective qualification systems for workers once they are hired. Particularly for young people who are not headed straight to a four-year college after high school, having a clear view and connection to an explicit system of qualification with work-based learning can greatly increase their chances of staying in school. A clear line of sight to a good job and a good career opportunity can underscore for them the value of learning to show up every day, working well with others, and mastering the fundamentals of math, science, and communications. TCRP Project E-07 directly addresses career ladder training for new hires and incumbents rather than building the career pipeline for future transit employees. Yet, there are inevitably many strong connections between effective pre-employment education, especially through career and technical education programs and the industry's ability to attract qualified young applicants for frontline technical jobs. Many agencies report that they cannot find qualified young applicants, yet they urgently need them. With accelerating retirements and the expansion of rail transit, agencies are running out of retirees they can hire from other transit systems or railroads to fill their vacancies. Conversely, 40 percent of young people who are not headed straight to a four-year college after high school drop out and don't graduate. These students are typically not successfully engaged by education programs that emphasize theory-first learning rather than hands-on learning in a quixotic effort to prepare all students for four-year colleges—something that only 30 percent of them will achieve. Partnering transit systems with schools and extending the elements of a proven system of qualification toward a viable education pathway for young people is an approach that can pay major dividends for transit agencies and the communities that they serve.

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# List of Abbreviations, Acronyms, and Initialisms

| | |
|---|---|
| AC | Alternating current |
| ADA | Americans with Disabilities Act |
| ASE | National Institute for Automotive Service Excellence |
| ATC | Automatic train control |
| ATO | Automatic train operation |
| ATP | Automatic train protection |
| ATU | Amalgamated Transit Union |
| CBTC | Computer-based train control |
| CMS | Credential management system |
| CTAA | Community Transportation Association of America |
| DC | Direct current |
| DOT | Department of transportation |
| GCRTA | Greater Cleveland Regional Transit Authority |
| JATC | Joint Apprenticeship and Training Committee |
| HVAC | Heating, ventilation, and air conditioning |
| IBT | Internet-based testing |
| IBEW | International Brotherhood of Electrical Workers |
| ISD | Instructional system design |
| LACMTA | Los Angeles County Metropolitan Transportation Authority |
| LRV | Light rail vehicle |
| MARTA | Metropolitan Atlanta Rapid Transit Authority |
| MDBF | Mean distance between failures |
| MBTA | Massachusetts Bay Transportation Authority |
| NJATC | National Joint Apprenticeship and Training Committee |
| NTI | National Transit Institute |
| NYCT | New York City Transit |
| OEM | Original equipment manufacturer |
| PPE | Personal protective equipment |
| RATP | Paris Regional Transit System |
| RTD | Denver Regional Transit District |
| ROI | Return on Investment |
| SacRT | Sacramento Regional Transit |
| SEPTA | Southeastern Pennsylvania Transportation Authority |
| SME | Subject matter expert |
| TriMet | Tri-County Metropolitan Transportation District |
| TTN | Transit Training Network |
| TWU | Transport Workers Union |
| UTA | Utah Transit Authority |
| VTA | Santa Clara Valley Transportation Authority |

*Abbreviations and acronyms used without definitions in TRB publications:*

| | |
|---|---|
| A4A | Airlines for America |
| AAAE | American Association of Airport Executives |
| AASHO | American Association of State Highway Officials |
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI–NA | Airports Council International–North America |
| ACRP | Airport Cooperative Research Program |
| ADA | Americans with Disabilities Act |
| APTA | American Public Transportation Association |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| ATA | American Trucking Associations |
| CTAA | Community Transportation Association of America |
| CTBSSP | Commercial Truck and Bus Safety Synthesis Program |
| DHS | Department of Homeland Security |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| HMCRP | Hazardous Materials Cooperative Research Program |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991 |
| ITE | Institute of Transportation Engineers |
| MAP-21 | Moving Ahead for Progress in the 21st Century Act (2012) |
| NASA | National Aeronautics and Space Administration |
| NASAO | National Association of State Aviation Officials |
| NCFRP | National Cooperative Freight Research Program |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NTSB | National Transportation Safety Board |
| PHMSA | Pipeline and Hazardous Materials Safety Administration |
| RITA | Research and Innovative Technology Administration |
| SAE | Society of Automotive Engineers |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) |
| TCRP | Transit Cooperative Research Program |
| TEA-21 | Transportation Equity Act for the 21st Century (1998) |
| TRB | Transportation Research Board |
| TSA | Transportation Security Administration |
| U.S.DOT | United States Department of Transportation |