

Bus Maintenance and Bus Testing Program Peer-to-Peer Exchange *Summary Report*

APRIL 2020

FTA Report No. 0160
Federal Transit Administration

PREPARED BY
SK Solutions LLC



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Federal Transit Administration
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1200 New Jersey Avenue, SE
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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liter	L
ft³	cubic feet	0.028	cubic meters	m ³
yd³	cubic yards	0.765	cubic meters	m ³
NOTE: volumes greater than 1000 L shall be shown in m ³				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C

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ABSTRACT

Significant shifts in the types of transit buses being procured (e.g., from traditional buses to alternative fuel/low- and no-emission buses) require new and different types of frontline worker training. Responding to requests from the public transit industry, the Federal Transit Administration (FTA) hosted a peer exchange to share knowledge about bus maintenance worker training and to discuss best practices for developing the next generation of highly-skilled bus technicians. This report presents a summary of the exchange and provides recommendations from industry representatives.

EXECUTIVE SUMMARY

On October 10, 2019, the Federal Transit Administration (FTA) hosted a peer exchange to share knowledge about bus maintenance worker training and to discuss best practices for developing the next generation of highly-skilled bus technicians. Participants in the peer exchange included transit agencies, original equipment manufacturers (OEMs) of buses and bus parts, trainers, academics, and employee representatives.

Today's frontline maintenance workers must be familiar with computer diagnostic systems, advanced electrical systems, video and audio technology, and other highly-technical equipment. Effective training for workers who maintain transit buses is essential to ensure that buses operate safely and efficiently and reach their expected useful life. Inadequate training can lead to wasted time and money and even transit service disruptions, as workers take longer to identify and fix problems.

However, effective training is difficult to achieve due to (1) limited training budgets, (2) limited staff time, and (3) difficulty retaining trained workers. Recruitment of new technicians is also difficult due to lower pay scales and slower advancement at transit agencies than in the private sector, as well as a general orientation of younger workers toward non-mechanical opportunities.

The panelists at the peer exchange highlighted the following recommendations for future action:

- Transit agency leadership needs better information about the value of frontline maintenance worker training; to accurately weigh its benefits against its costs. Better data collection would help address this information gap.
- Training could be accomplished more efficiently through greater use of standardized curricula, sharing training facilities and instructors, and more interactive online learning tools.
- The transit industry should identify where its needs overlap with the goals of younger workers (e.g., environmentally-friendly work, high-tech opportunities) and should market to high school and community college students as well as non-traditional groups such as women.
- Training should be considered part of the transaction cost of adopting new technology rather than a separate line-item, which could leave it subject to budget cuts.
- Effective recruitment and training require partnerships among transit agencies, educational institutions, worker education programs, and OEMs, as well as a mix of training methods including online and instructor-led programs.
- FTA and the American Public Transportation Association (APTA) should provide support in the form of workshops and guidance for training frontline workers, and FTA should assist grantees in understanding what program funds can be used for training.

Background

Significant shifts in the types of transit buses being procured (e.g., from traditional buses to alternative fuel/low- and no-emission buses) require new and different types of frontline worker training. Responding to requests from the public transit industry, the Federal Transit Administration (FTA) hosted a peer exchange to share knowledge about bus maintenance worker training and to discuss best practices for developing the next generation of highly-skilled bus technicians. Participants in the peer exchange included transit agencies, original equipment manufacturers (OEMs) of buses and bus parts, trainers, academics, and employee representatives.

Bus technology has evolved considerably over time. According to the American Public Transportation Association (APTA) *2019 Factbook*, 76% of buses now have automated stop announcements, 81% have security cameras, 91% have exterior bike racks, and 99% of buses serving fixed routes are Americans with Disabilities Act (ADA) accessible.

Although these features, along with changes in propulsion and other technology, have improved service quality, they have also changed the nature of bus maintenance. Today's frontline maintenance workers must be familiar with computer diagnostic systems, advanced electrical systems, video and audio technology, and other highly-technical equipment. Effective training for workers who maintain transit buses is essential to ensure that buses operate safely and efficiently and reach their expected useful life. Inadequate training can lead to wasted time and money as workers take longer to identify and fix problems.

Moreover, the goals and needs of younger workers have changed from those of prior generations, requiring new recruitment techniques and strategies. Jane Williams, FTA Acting Administrator, spoke on the topic of recruitment and encouraged transit agencies to look beyond typical recruitment paths. She emphasized the critical link between maintenance and safety and the need to refocus training efforts on high-tech know-how as well as traditional skills and highlighted partnerships with community colleges as a promising pathway for recruitment and training, encouraged transit agencies to recruit mid-career workers as well as younger ones, and suggested developing industry-recognized credentialing programs. She noted that FTA has invested more than \$20 million

"No buses, no maintenance
of those buses
—no bus service."

*Vincent Valdes,
Associate Administrator, Office
of Research, Demonstration,
and Innovation, FTA*

over the last six years to help transit agencies create workforce development programs.

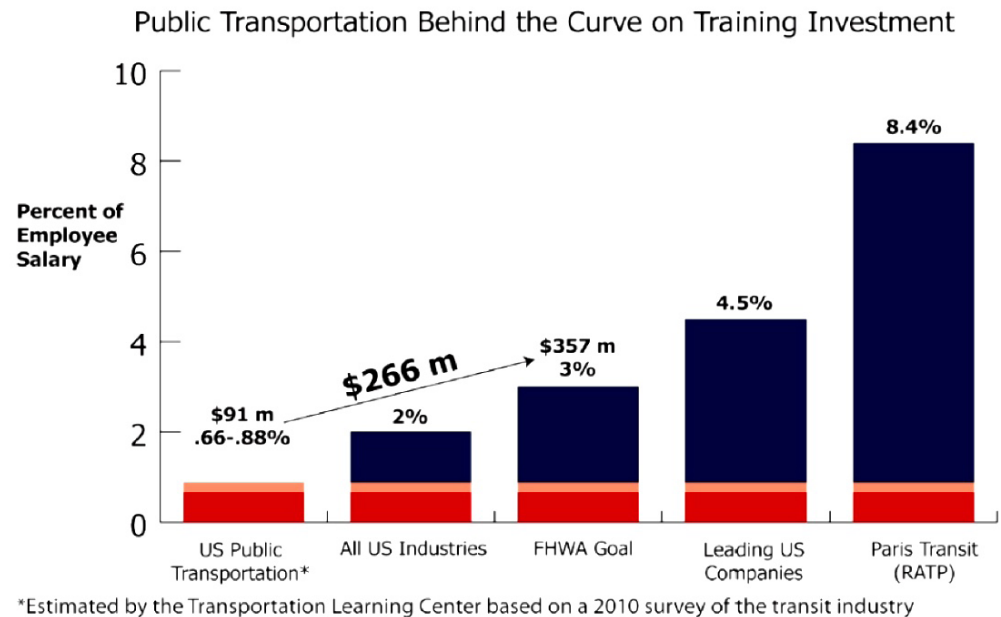
John Schiavone, Program Director–Technical Training at the Transportation Learning Center in Washington, DC, provided an overview of the current landscape of bus maintenance training and identified the following challenges with regard to recruitment and training:

- Although large transit agencies tend to have in-house instructors, training facilities, and an adequate training budget, most agencies do not. Without a formal in-house program, they rely on vendors or more-experienced technicians to train their maintenance staff, or they make do with inadequate training.
- Inadequate training leads to inefficient use of time and money, as maintenance workers identify problems through trial and error, sometimes incorrectly replacing working parts.
- The frontline maintenance workforce is growing older, and recruitment has not kept pace. Unlike prior generations who grew up with mechanical toys, recent high school graduates grew up with computers and have been discouraged from manual labor as a career.
- Although buses have become more complex technologically, some managers think computer diagnostics make training less important. In reality, the opposite is true.
- Transit leaders tend not to be fully aware of the costs of inadequate training, and the training budget is often cut when cost-savings are needed.
- Transit does not have a profit motive, so the need to satisfy customers is less than in the private sector; thus, transit can “get away with” limited training.

Although lack of standardized data makes it impossible to conduct a formal cost-benefit analysis, Schiavone estimates that the money saved from more efficient maintenance and operations would more than cover the cost of additional training. Relative to other industries, transit spends a small amount on training (Figure I-1). He recommends that the industry work on better data collection (e.g., repeat failures) in a standardized format to help transit agency leaders better understand the value of training.

Figure 1-1

Public transportation
training investment



Schiavone noted that some transit agencies do have excellent training programs, including those in Oakland, San Jose, Utah, Seattle, Philadelphia, Dallas, Los Angeles, and Washington, DC, with instructors, training facilities, labs, and established curricula, as well as strong management support and budget for training. Recognizing that most agencies lack these resources, he recommended the following strategies:

- Online or distance-based learning can be helpful in reaching more workers who do not have time to travel for training, but care should be taken to ensure that online training is still engaging and effective.
- Standardized courses on emerging technologies such as battery-electric buses would help smaller agencies provide training for their workforce.
- Using retired technicians to train current ones and sharing training among agencies in the same geographic area can be cost-effective solutions. Washington Metropolitan Area Transit Authority (WMATA), Southeastern Pennsylvania Transportation Authority (SEPTA), New Jersey Transit (NJT), and the Southern California Regional Training Consortium are already leaders in this area.
- Transit agencies should use data to identify training needs.

Schiavone also believes a national effort to recruit frontline maintenance workers is needed, and that the relatively low pay scale for technicians at most transit agencies is an issue that will need to be addressed to recruit the necessary numbers.

Transit Agency Perspectives

Attendees at the peer exchange heard from transit industry representatives, who explained that in just a few years, the industry has moved from fleets that were primarily diesel to fleets that include a mix of diesel, compressed natural gas (CNG), hybrid, and all-electric buses. As a result, technicians must be familiar with a variety of different fueling systems and engine types. Although more advanced skills are required to maintain modern buses, basic skills such as changing tires are also needed. The result is that workers need a wider variety of technical and non-technical skills than were needed just a few decades ago, and transit agencies are still working to find the best ways to provide that training.

Industry Representative Comments

- **Dinero Washington, CEO, SporTran (Shreveport, LA)**
 - When the Shreveport Area Transit System (SporTran) purchased its first CNG buses in 2010, management did not plan ahead for training, and technicians who had worked only with diesel buses were reluctant to work on CNG buses.
 - In 2017, when the agency introduced battery electric buses (BEBs), leadership spent a year working with staff ahead of time to develop training, leading to a smoother process for integrating the new buses into the fleet.
 - SporTran is working with the local community college to train students on CNG and BEBs.
- **Connie Raya, Director of Maintenance, OMNITRANS (San Bernardino, CA)**
 - The State of California requires all new bus purchases to be zero emission by 2029, with the entire fleet required to be zero emission by 2040. OMNITRANS buses are currently CNG, so it will be converting its fleet in the coming years.
 - OMNITRANS is working with the Southern California Regional Training Consortium and local community colleges to develop training on BEBs to supplement the training that will be provided by the bus OEMs. Most will be on-the-job training.
 - OMNITRANS is currently assessing infrastructure needs related to BEBs with a consultant and the local power company.

- **Henry Lukasik, Director of Maintenance, Pinellas Suncoast Transit Authority (PSTA), (St. Petersburg, FL)**
 - PSTA has 210 buses, about half of which are hybrid-electric. It also has two all-electric buses and plans to purchase more.
 - PSTA works with small groups of technicians at a time, through a combination of OEM trainers and in-house staff, to elevate their skills through hands-on training. Once a group is trained, the next group is selected. In this way, it is developing a skilled workforce that can effectively maintain both current buses and those that will be coming in the future.
- **Jerry Gauracino, Deputy Chief Engineering Officer, SEPTA (Philadelphia, PA), and Chair, APTA Bus Technical Maintenance Committee and Brake and Chassis Committee**
 - In 2000, SEPTA began buying hybrids; by 2021, 96% of the fleet will be hybrids. It also has 25 fully electric buses.
 - SEPTA includes training as part of its bus procurements. Frontline workers are asked what their needs and preferences are, and those desires are communicated to the OEMs who are developing the training.
 - Today's workers prefer to use a web-based interface (which was not the case 20 years ago), so SEPTA develops webinars and makes them available to other local transit agencies as well.

Discussion

Training

The panel emphasized the importance of partnerships in effective training and encouraged transit agencies to maintain strong relationships with bus and subcomponent OEMs, from leadership to training and parts staff. They also highlighted the value of community colleges and local high schools as training partners. In some areas, local or regional training programs exist, such as the Southern California Regional Training Consortium, whereas in other areas, larger transit agencies may open their training to smaller agencies, which can help offset the costs for everyone. Also, the APTA puts its standards, webinars, and other resources online, and the National Transit Institute (NTI) offers two Transit Maintenance Leader workshops annually at which best practices in training can be shared. The Community Transportation Association of America (CTAA) and state associations also have online resources upon which transit agencies can draw.

Transit agencies have found it invaluable to engage frontline workers in developing training protocols. When the technicians were provided with advance notice of new bus purchases and an opportunity to help shape the necessary training. In addition, engaging with frontline workers helps managers develop training programs that are better matched to their employees' needs.

This is particularly important with regard to electric fleets, as high-voltage training becomes an essential safety feature.

Not every bus technician learns the same way, so transit agencies use multiple training avenues, each with pros and cons:

- Classroom learning
 - Pro – being out of the workplace can help employees focus on learning.
 - Con – not engaging all employees requires time away from work.
- On-the-job
 - Pro – hands-on learning is effective for many people, does not require time away from work.
 - Con – workers being trained might get pulled away by supervisors for other needs.
- Distance-based (online)
 - Pro – can be done as schedules allow.
 - Con – may be less engaging than an in-person instructor, can be difficult to tell if employees are getting anything out of it.

There are some Federal resources for training. The Fixing America's Surface Transportation (FAST) Act added 0.5% to the existing 0.5% that could be used for NTI training. Training can also be included as part of a Low-No Emission Vehicle grant application.

Recruitment

Transit agencies face competition for trained technicians from school bus companies, trucking companies, and other private sector entities. In general, the pay scale at these companies is more favorable to younger workers, who can move up to higher wages faster than in a union environment such as transit. Given that today's workers typically do not expect to stay more than 4–5 years at a particular job, they do not see the benefit of entering a career at a transit agency where significant pay and benefits are available only to those who have been there for many years. PSTA responded to this issue by shortening the timeframe for progressing to the top technician classification.

Transit agencies are broadening their recruitment efforts to include not just high schools, trade schools, and community colleges, but also other sectors with employees with relevant skills. Some potential employees need more than just technical training to be ready for a transit career, such as how to write a resume or handle a job interview. The younger generation of workers needs to be engaged and informed about opportunities in transit. In addition, they are looking for flexibility in the workplace, which transit agencies historically have not provided.

Procurement

The decision about what technology to purchase should not be taken lightly; it has many ramifications, not just for employees but also for facilities, infrastructure, costs, and service. Some agencies used a third-party consultant or reached out to peer agencies for help in deciding among the various bus types. Jerry Gauracino of SEPTA recommended working with utility providers to conduct an assessment of power and infrastructure needs when considering converting to electric buses.

The transit representatives noted that as soon as an agency starts considering a new bus technology, training should be a consideration. SEPTA includes training in the procurement itself; Gauracino recommended that agencies view training as a part of the transaction cost of converting to a new technology rather than trying to add it to the agency budget after the fact.

Trainer Perspectives

Trainers can come from a variety of entities. In this section of the exchange, participants heard from an in-house trainer within a transit agency and trainers from a regional training consortium and a national association. (OEMs, who also provide a significant amount of training, participated in the next panel.)

Trainer Comments

- **Obed Mejia, Senior Bus Equipment Maintenance Instructor, Los Angeles County Transportation Authority (LA Metro) (Los Angeles, CA)**
 - Mejia leads a group of 11 instructors who provide both new employee training and refresher training. With 140 electric buses coming next year, he is working on adding high-voltage training. LA Metro has contracted with its OEMs for training and offers that training to other transit agencies.
 - Half of LA Metro’s technicians are over age 50, and the other half are younger than age 35; the younger workers respond well to online training.
 - It is difficult for management to see the benefit of training, although the cost of training is far less than the cost that results when a problem is misdiagnosed and working parts are unnecessarily replaced.
- **John McDermott, Director of Special Projects, Consortium for Worker Education (New York, NY)**
 - McDermott runs NY Atlas, a program to connect youth to long-term sustainable careers in transportation. He works with the Transport Workers Union to connect this program to jobs at New York MTA and also with an apprenticeship program that can earn participants community college credit.
 - New York City has automotive training in its high schools, with about 600 students graduating each year, but most go to private automobile companies.
 - Many youth he works with do not have a driver’s license, and to work for MTA, they have to pass New York’s Civil Service Exam, both of which cost time and money.
- **Halsey King, Master Instructor, Community Transportation Association of America (CTAA) (Washington, DC)**
 - King works primarily with paratransit buses, but he has the same goal as other trainers—to teach workers how to safely operate and maintain their vehicles.

- Federal requirements call for a systematic approach to inspection, maintenance, and repair, but there is no standardization across the country. CTAA has developed a standardized 12-module bus inspection process on which they train inspectors.
- He also gives employees training on working with people who rely on paratransit to build empathy and commitment for their work.

Discussion

Training

The trainers agreed that training should be an ongoing endeavor, not reserved for new hires. The subject of training should not be limited just to technical issues; technicians, particularly those on a career ladder, need training on asset management, records management, and personnel management as well. Halsey King of CTAA found that emphasizing the larger purpose of what the technician is doing—“building a mission into it”—can be effective for keeping people engaged. Obed Mejia of LA Metro gives workers an assessment they must pass at each stage of training to ensure they are engaged and learning.

The trainers identified several barriers to effective training. First, transit managers do not have the tools needed to quantify the benefits of training. As a result, when considering budgets and priorities, transit leaders see only the cost. Training programs would benefit from being considered an investment rather than just a cost of doing business. In Mejia’s experience, miles between road calls increase after training, but these data are not officially captured anywhere.

Limited budgets can also make it difficult to provide adequate training. One resource for training is NTI’s Transit Maintenance Leadership workshop that takes place twice a year and is intended for maintenance supervisors.

A participant asked the panel if an open shop—in which everyone does everything—is preferable to a shop in which technicians specialize. The response was that specialization is preferable, since it is difficult to know everything about buses, but agencies also need people with general skills. Obed Mejia of LA Metro offered a simple test for determining if training has been adequate—ask a mechanic what he is doing. If he can explain what he is doing, its purpose, and how it will affect the bus, he has been well-trained. LA Metro is working on more effectively using computers to assist with training so that when a work order is entered, the computer uses keywords to pull up resources related to that specific problem.

Recruitment

Most high school students graduating from technical programs are joining private automobile companies, which are seen as exciting game-changers due

to their research on autonomous vehicles, among other things. One strategy employed by the Consortium for Worker Education is to take high school students to visit a bus garage to show them first-hand that it is a high-tech workplace. It is also important to educate parents so they understand that bus maintenance is a viable career.

More outreach to non-traditional groups, including youth and women, could help address the critical shortage of mechanics the transit industry is facing. John McDermott of NY Atlas offers slots in his training programs to groups that recruit women into non-traditional careers. LA Metro started a Women and Girls Council to make recommendations for recruiting more women. They have had some success—service attendant positions, an entry-level fueling position that formerly were all male, are now 40% female.

OEM Perspectives

The third panel presented the perspectives of training and customer service managers from four bus OEMs. The OEMs provide customized training, including onsite or offsite training, instructor-led or online classes, and lesson plans designed to capture whatever a customer needs. In some cases, particularly with larger transit agencies, a detailed training program is part of bus procurement, but more often, training is developed after-the-fact.

- **Karim Derardja, Client Technical Trainer, Nova Bus-Volvo (Quebec, Canada)**
 - NovaBus trainers provide customized, onsite training based on objectives that the customer sets.
 - Training sessions accommodate a maximum of eight people and can be one day or as much as a week. NovaBus strives to have at least 50% of the training be hands-on and to avoid using too much jargon so training is useful even for participants without an engineering background.
- **Darryl Desjarlais, Technical Training Manager, New Flyer Institute (NFI) Parts, New Flyer/MCI (Winnipeg, MB)**
 - New Flyer instructors in its NFI blend classroom instruction with hands-on training provided at the transit agency, as well as some e-learning courses.
 - MCI has a Vehicle Innovation Center in Anniston, Alabama, that has classrooms, labs, and bays to facilitate learning about alternative fuels and zero emission buses.
- **Jerry Sheehan, Regional Sales Manager, Gillig LLC (York, PA)**
 - Customers can request training in a contract or purchase it at a later date. Gillig does its training on-site, where mechanics are most comfortable. If needed, it will partner with subcomponent suppliers to do the training on a particular system.
 - Gillig provides potential customers with a demo bus to explore before committing to purchase. Once procurement is initiated, Gillig holds a pre-production meeting, then a post-delivery inspection.
 - Gillig provides basic training upon delivery but waits a few months for advanced training so technicians have some experience with the buses.
- **Mike Finnern, VP Customer Service, Proterra (Greenville, SC)**
 - Proterra has trainers who travel around the country and also has videos and other resources.

- Prior to delivery, Proterra works with operators and technicians to determine their questions. Upon delivery, Proterra does basic training and more advanced training later on.

Discussion

Training

The OEMs have found it most effective to provide a general overview of their buses when they are first purchased and to wait a few months before providing detailed training. This allows technicians at the agency to have some experience with the equipment so they know what questions to ask. The OEMs meet with technicians prior to delivery to ensure that any initial questions are answered. OEMs also maintain partnerships with their suppliers, who assist them with training on particular subparts.

The OEMs prefer to use as much hands-on training as possible and to use visuals rather than text in their curricula. As other panels also discussed, the OEMs agreed that various training methods have different pros and cons:

- Access to the internet can be a barrier to online training in some bus facilities.
- Offsite training allows workers to focus on the training without distraction and gives them a stronger sense of ownership for their learning, but without buy-in from leadership, it can be difficult for technicians to get time away.
- Onsite training requires less time away and allows workers to be trained on familiar equipment, but also runs the risk that supervisors will pull technicians from training to come back to the floor.
- Train-the-trainer programs require fewer people to be trained offsite, but not all properties have the resources to train a trainer.

Another challenge faced by OEMs is designing training that meets the needs of all employees. Different workers may have different baseline understanding of bus technology but may be assigned to the same class. OEMs sometimes recommend prerequisites, but the transit agency decides who goes to the training. One strategy to address this is to use interactive software ahead of the class to bring everyone up to the same baseline of knowledge. State organizations or associations also may offer training that can help provide workers with a common baseline; for example, Pennsylvania Transportation Resource and Information Network (PennTRAIN) provides training throughout the year that is subsidized by the State.

The panel was asked about cooperating on a single national training curriculum for common bus features. Examples of standardized training providers include:

- Transportation Cooperative Research Program (TCRP)
- University Transportation Centers (UTCs) such as the Center for Urban Transportation Research (CUTR) and University Center–Irvine
- APTA
- NTI
- PennTRAIN
- Southern California Regional Training Consortium
- West Coast Center of Excellence for zero-emission buses
- SAE (for charging systems)

The advantage of a standardized approach is that training would be more readily-available and could more easily bring people to the same level of competence, perhaps with a certification similar to the “Factory-Certified Technician” label used by car companies. It was also noted that some training provided for support vehicles could be relevant for basic bus features. Participants requested that OEMs assist transit agencies in finding appropriate courses to serve as prerequisites for the OEM training.

Recruitment

Proterra is partnering with organizations that work with minorities, women, veterans, and people coming out of the corrections systems, a strategy that could work for transit agencies as well. Mike Finnern noted that transit has selling points that should be marketed to the younger generation:

- Transit is a high-tech career.
- Transit is a green, environmentally-friendly career.
- Transit provides a public service.

Procurement

The OEMs encouraged transit agencies to engage early and often with OEMs when considering a new purchase and to get their maintenance and operations staff involved. APTA’s bus maintenance committee worked on a standard training spec to include in bus procurements, but it was not widely circulated in the industry.

Another issue raised in the discussion was the need to update preventive maintenance schedules for new bus types. For example, the current targets of 6,000 and 12,000 miles for rehabilitation and replacement stem from older bus models’ oil change schedules, which do not necessarily apply to modern vehicles.

SECTION

5

Case Study: SunLine Transit Agency

Lauren Skiver, General Manager & CEO of SunLine Transit Agency in Thousand Palms, CA, provided a case study of how a small transit agency can effectively incorporate multiple bus types into its fleet. California's Innovative Clean Transportation Regulation (ICT) encouraged SunLine to be an early adopter of fuel cell technology (fuel cell acts as a range extender for the bus battery), and the agency is now testing all-electric drive.

SunLine currently operates eight types of buses. Skiver sees the proliferation of bus types as positive for the transit industry because it increases competition and choice, and she encouraged all agencies to be more open to mixed fleets. She also encouraged the industry to be more entrepreneurial and less risk-averse. SunLine has invested in a CNG facility and makes more than \$1 million per year selling CNG to other entities. The agency is currently planning a hydrogen facility large enough to produce excess hydrogen that could also be sold.

Although SunLine is a relatively small agency, with just 350 employees, Skiver ensures that her staff is trained on the technology rather than relying exclusively on OEMs or third-party consultants. She believes that staff needs to understand the technology and its trade-offs to decide which type of propulsion and fueling system is right for their agency. SunLine offers a course on factors to consider when deciding on a new bus procurement and runs a transit provider membership group—the Zero Emission Bus Resource Alliance—which provides resources, training, and workshops related to zero-emission bus deployment.

Skiver noted that training is essential; operators and technicians who are improperly trained on regenerative braking and proper charging can ruin batteries. However, many agencies fail to incentivize their staff to take responsibility for proper maintenance; instead, they rely on OEMs or have older workers train newer ones. She believes that investing in technicians is a powerful tool for transit agencies, and whenever possible, technicians should be sent offsite to be trained and given incentives to solve problems—both are ways to emphasize to frontline workers that their role is important. She has also found it helpful when deploying new bus types for the workforce to develop a mission statement or tag line to create ownership throughout the agency; SunLine's is "Today's Transit for Tomorrow's World."

With support from FTA and the State, SunLine is building the West Coast Center of Excellence for zero emissions technology. The Center will provide hands-on training to maintenance and operations staff, including hydrogen safety training and a high-voltage training

certification, and is working with Rio Hondo College to develop. (SARTA in Ohio is building a similar center to serve the eastern half of the U.S.)



In its training programs, SunLine relies heavily on tools with which technicians are familiar, such as checklists. Skiver believes that training programs should teach technicians to look for the least complex solution first, not the most complex. She has found that most bus problems are related to common bus features, not the most advanced features. Still, better performance data would help trainers focus on the areas of most need and would also help agencies make more informed decisions about different bus technologies.

Going forward, Skiver encouraged the transit industry to be open to zero-emission technology and to take advantage of incentive programs to purchase it. She noted that the cost of fuel cell buses is coming down and, in her experience, maintenance costs are lower for fuel cell buses because they have fewer moving parts. She expects more agencies will need to adopt this technology as more states pass laws like California's. That being said, she also encouraged individual transit agencies to decide for themselves on the right mix of fuels for their needs rather than just responding to pitches from OEMs.

Lowering Maintenance Costs with Bus Testing

Marcel Belanger, Bus Testing Program Manager for FTA, provided an overview of FTA's Bus Testing Program and how it can be used to lower bus maintenance costs. A report for each of the 482 (now more) bus models tested since the program began in 1990 is available online at www.altoonabustest.org. These reports include information on elements such as:

- General characteristics of bus and component systems
- Configuration and seating
- Dimensions, length, and overall and axle weights
- Overall performance
- Fuel economy
- Maintainability
- Safety and maneuverability
- Durability
- Accessibility of key components
- Failures of components or structure

Since October 2016, FTA has used a pass/fail system, as required by Congress. If a bus model fails, FTA funds cannot be used to purchase it, thereby making it risky for a transit agency to purchase a bus that has not completed testing. As of the date of the exchange, there have been no failing reports issued, as manufacturers are permitted to withdraw a bus model from testing for any reason, such as if it is not on track to pass.

Bus Testing reports are intended to help transit agencies understand the strengths and weaknesses of the bus models they are considering. Buses are allowed up to 125 hours of unscheduled maintenance during a test; if unscheduled maintenance exceeds that threshold, the bus will not pass. Most buses have 10–20 failures during testing, but some have had zero, and some have had dozens, and the severity of the failures varies. Failures are grouped into four categories by severity, and each report lists the number of failures in each category and the time it took to address them.

Testing attempts to validate claims made by manufacturers, such as how far an electric vehicle can travel on one charge. However, the results may differ from the manufacturer's claims because the driving conditions in the test cycles may not match the conditions in the manufacturer's test. The testing reports also note manufacturers' recommendations for how often parts should be serviced and how long it takes to remove and replace key components.

Transit agencies are encouraged to share the reports with their procurement and maintenance staff. Agencies can use the information in these reports to reduce maintenance costs by:

- Selecting a bus model that meets the agency's reliability requirements.
- Accurately projecting and budgeting for the time and cost of repairs.
- Keeping spare parts on hand for components more likely to fail.
- Negotiating with manufacturers for extended warranties or other accommodations for parts more likely to fail.
- Targeting preventive maintenance toward less reliable parts.
- Leasing rather than buying.

Figure 6-1

Examples of testing failures by class

Failure Class	Examples
Class 1 – Physical Safety Hazard (Potential for serious injury or severe crash)	Brakes fail; steering fails; wheel falls off; fire.
Class 2 – Road Call (Bus inoperable causing interruption in revenue service)	Engine won't run, transmission won't engage, blown suspension airbag, flat tire, major structural failure, rapid fluid loss, low/no air pressure.
Class 3 – Bus Change (Bus is operational but must be removed from service until repaired)	Moderate fluid leaks, door failure, soft tire, ADA lift or ramp inop.
Class 4 – Degraded operation (Degrades operation, may be repaired during next scheduled service interval)	Slight fluid leaks or seepage, trim loose, interior lights not working.

Belanger relayed an example of an agency successfully using the information in the bus testing report to reduce maintenance costs. Two transit agencies in a similar geographic area both acquired the same bus model; one experienced recurring problems with shock absorber mounts, and the other had no such problems, because they had seen in the Bus Testing Report that those parts were problematic and had replaced all of them as part of their preventive maintenance program.

Belanger noted that failure rates during bus testing have declined since 2006 compared to rates prior to 2006, meaning buses have been getting more reliable over time, perhaps in part due to manufacturers getting buses in better shape before they are submitted for testing. Bus testing has a very small cost (about \$3 million per year) compared to the approximately \$1.4 billion that FTA distributes annually in bus grants, which makes it a good investment in helping agencies procure cost-effective, reliable vehicles that will make it through to the end of their service life.

Responding to questions, Belanger noted that if a CNG conversion is done prior to the sale of the bus, it would be included as part of the bus model's test, but if it is done after sale, it is not. He acknowledged that no electric shuttle-bus vehicles (cutaways) had completed testing but said that those reports would be coming out "soon." Finally, he explained that the Bus Testing Program is intended to be non-destructive, so they do not perform rollover or crashworthiness tests.

Industry Feedback

Mary Leary, Deputy Associate Administrator of the Office of Research, Demonstration and Innovation at FTA, closed the peer exchange by asking attendees to share their top takeaways from the day. She also noted that FTA would issue a survey to attendees following the event to solicit more detailed feedback. She observed that the transit industry is in a time of both disruption and innovation, and FTA's goal is to work with all of its partners and customers to help them develop the workforce they need for today and for tomorrow. Participants broke into four groups, whose top takeaways were as follows:

- **Group #1**
 - Agencies should use artificial intelligence and telematics to predict failures before they happen.
 - Building key performance indicators and other analytics into preventive maintenance programs will help transit agencies get ahead on maintenance.
- **Group #2:**
 - The frontline workforce needs training now and will continue to need it in the future.
 - The industry needs to recruit replacements for workers who are going to retire in the next 10 years, as they will take decades of institutional knowledge with them. Addressing this issue requires money, both to provide respectable compensation to bring new people into the industry and to provide needed training.
 - The industry should unite in a national effort to recruit talent.
 - FTA can help by showing the industry where training money exists and how agencies can access it.
- **Group #3:**
 - It is important to connect all resources and expertise at FTA to the field. FTA could provide not just technical expertise, but also communications and customer service approaches.
 - There was a sense of urgency about maintenance needs throughout the exchange, but different entities have different approaches and even different language (mechanics vs. technicians). The industry needs to determine how to fast-track the process to get to a uniform understanding of needs and solutions.
- **Group #4:**
 - FTA should require a certain percentage of funds be used for training; without that, no one will establish long-term training programs. When FTA provides money for buses, there should be a training requirement to ensure that technicians receive training over the full 12-year life of the buses.

- Maintenance standards should be revised to reflect extended life of newer parts. If the amount of scheduled maintenance can be reduced, agencies would need fewer technicians and could pay them more.
- It would be useful to have a 1–2-page summary of the bus testing reports with a dashboard that shows, at a glance, all failures during testing.

Recommendations for the Future

Today's frontline maintenance workers must be familiar with computer diagnostic systems, advanced electrical systems, video and audio technology, and other highly-technical equipment. Effective training for workers who maintain transit buses is essential to ensure that buses operate safely and efficiently and reach their expected useful life. Inadequate training can lead to wasted time and money as workers take longer to identify and fix problems.

However, effective training is difficult to achieve due to limited training budgets, limited staff time, and difficulty retaining trained workers. Recruitment of new technicians is also difficult due to lower pay scales and slower advancement at transit agencies than in the private sector, as well as a general orientation of younger workers toward non-mechanical opportunities.

Exchange panelists highlighted the following recommendations for future action:

- Transit agency leadership needs better information about the value of frontline maintenance worker training to accurately weigh its benefits against its costs. Better data collection would help address this information gap.
- Training could be accomplished more efficiently through greater use of standardized curricula, sharing training facilities and instructors, and more interactive online learning tools.
- The transit industry should identify where its needs overlap with the goals of younger workers (e.g., environmentally-friendly work, high-tech opportunities) and should market to high school and community college students as well as non-traditional groups such as women.
- Training should be considered part of the transaction cost of adopting new technology rather than a separate line-item, which could leave it subject to budget cuts.
- Effective recruitment and training require partnerships among transit agencies, educational institutions, worker education programs, and OEMs, as well as a mix of training methods including online and instructor-led programs.
- FTA and APTA should provide support in the form of workshops and guidance for training frontline workers, and FTA should assist grantees in understanding what program funds can be used for training.



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