Module 18:
Transit and the Automated/Connected Vehicle Environment/ Emerging Technologies, Applications, and Future Platforms

Table of Contents

Module 18 Transit and the Automated/Connected Vehicle Environment/ Emerging Technologies, Applications, and Future Platforms

2

1. Module Description

"Automated vehicles open up possibilities for saving lives, saving time, and saving fuel. Automated vehicles promise to move people and goods more efficiently than we are moving them today." "Today I am announcing that the President is proposing $3.9 billion over 10 years to fund pilot projects that help accelerate the development and adoption of safe vehicle automation." - U.S. Department of Transportation Secretary Anthony Foxx, January 14, 2016

This module is a continuation of Module 11 – Transit and the Connected Vehicle Environment/Emerging Technologies, Applications, and Future Platforms. Module 11 described the connected vehicle environment using Dedicated Short Range Communications (DSRC), relevant standards, and transit applications including those in the FTA Integrated Dynamic Transit Operations (IDTO) program.

The purpose of this module is to expand discussion on the connected vehicle environment for transit to accommodate "advancing automation" in the USDOT 2015-2019 ITS strategic plan and in the recent initiative announced by the USDOT.

2. Introduction/Purpose

Module 18 will provide transit agencies and other interested participants with an overview of developments in vehicle automation that complement vehicle connectivity for both bus and rail transit. This module will define relationships between connectivity and autonomy for transit vehicle operation. It will present examples of the state-of-the art transit vehicle automation applications including autonomous lane keeping and collision avoidance warning systems. This module also will describe how connectivity and automation are being deployed in rail transit, primarily in terms of train control systems for safety and capacity.

3. Samples/Examples

Distinguishing Automated Vehicles from Connected Vehicles

Automated or autonomous?

- **Automated** - perform a task using machinery or computers rather than humans
- **Autonomous** – having the power to control oneself, make decisions

Two types of connectivity

- Connect by using **Dedicated Short Range Communications** technology (DSRC) for Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications
- Connect vehicles as the Internet of Things (IoT) using commercial **Wi-Fi** and **cellular** technology

"Connected Vehicles" is a term used by the US Department of Transportation to describe a roadway environment in which wireless communications permit vehicles to communicate with other vehicles, (V2V) and with stationary devices such as traffic signals, (V2I.) Numerous benefits are posited for connected vehicles. However, connectivity does not necessarily imply that vehicles will be automated. V2V and V2I could present information to a human driver that would warn of an impending collision, but the driver would be required to act to avoid the collision.

Automated vehicles do not necessarily require wireless communications to function. Automated driving systems can use various types of sensors to acquire data about the driving environment, which is processed internally. Signals are sent from the automated driving system to the electronic components controlling vehicle steering, acceleration, and braking, to manage the driving task. Although GPS, which is a wireless communications technology, is widely used for navigation, other navigation systems such as inertial guidance, gyros, and compasses can provide location and direction to the automated driving system. Likewise, although local area wireless Internet communication is frequently used to upload software and data to an on-board automated driving system, other ways to exchange data may be used.

NHTSA Levels of Automation

In the Federal Automated Vehicles Policy released in September 2016, NHTSA changed its original five levels of automation (0 to 4) to correspond with the six levels of automation developed by SAE International which are similar to those developed by the German Federal Highway Research Institute. The six levels of automation are the following:

- At SAE Level 0, the human driver does everything.
- At SAE Level 1, an automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task; examples are anti-skid braking (ABS) and electronic traction control (ETC).
- At SAE Level 2, an automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task; examples are adaptive cruise control and lane-keeping assist.
- At SAE Level 3, an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests; Tesla Autopilot is an example.
- At SAE Level 4, an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions; Google and Uber retrofitted vehicles are examples
- At SAE Level 5, the automated system can perform all driving tasks, under all conditions that a human driver could perform them. Google's small two-passenger car with no steering wheel, brake and accelerator pedals is an example.
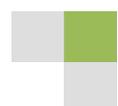
Source: Federal Automated Vehicles Policy, "Accelerating the Next Revolution In Roadway Safety," September 2016, National Highway Traffic Safety Administration (NHTSA) US Department of Transportation https://www.transportation.gov/AV

Distinguishing Full Automation from Less-Than-Full Automation

NHTSA Levels 3 and 4 require the driver to take over when the system determines it no longer can accomplish the driving task. NHTSA Level 5 is defined as performing all aspects of the driving tasks under all conditions. The only human function would be to input the destination or point to which the vehicle is to navigate. Full automation permits operation of an unoccupied vehicle.

Lane Transit District Automated Docking

Collision Avoidance, Magnitude of the Problem

Mode	Reporting Period 2002-2014			Reporting Period 2002-2013
	Collisions	Fatalities	Injuries	Total Casualty and Liability Expenses by Mode
Total Bus, Demand Responsive and Van Pool	85,391	1,340	201,382	$5.75 Billion
Total Rail	6,118	1,303	89,806	$3.17 Billion

Washington State Transit Insurance Pool Safety Pilot

Module 18 Transit and the Automated/Connected Vehicle Environment/ Emerging Technologies, Applications, and Future Platforms

7

"MOBILEYE SHIELD+" OPERATOR REFERENCE GUIDE

MOBILEYE®
Our Vision. Your Safety.™

ROSCO VISION SYSTEMS®
OFFICIAL MOBILEYE PARTNER

LEFT SIDE DISPLAY

OFF
- Left Side Pedestrian Display
- For detecting pedestrians and cyclists who are near left front corner of bus or left side of bus.

DETECTION
- Yellow illumination with no sound
- Informs the operator a pedestrian or cyclist has been detected near the left front or left side of bus.
- Operator should exercise additional caution until verifying that the danger of collision has passed.

ALERT
- Red flashing with beeping sound
- Informs the operator a pedestrian or cyclist has been detected in the left front or left side of bus and collision is imminent.
- Operator should take action to carefully stop bus to avoid collision.

CENTER DISPLAY & EYEWATCH

OFF
- Center Display
- Contains the Pedestrian Display and EyeWatch.
- The EyeWatch readouts and explanations can be found below on this document.

DETECTION
- Yellow illumination with no sound
- Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus.
- Operator should exercise additional caution until verifying that the danger of collision has passed.

ALERT
- Red flashing with beeping sound
- Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus and collision is imminent.
- Operator should take action to carefully stop bus to avoid collision.

RIGHT SIDE DISPLAY

OFF
- Right Side Pedestrian Display
- For detecting pedestrians and cyclists who are near right side of bus.

DETECTION
- Yellow illumination with no sound
- Informs the operator a pedestrian or cyclist has been detected near the right side of bus.
- Operator should exercise additional caution until verifying that the danger of collision has passed.

ALERT
- Red flash with beeping sound
- Informs the operator a pedestrian or cyclist has been detected on the right side of bus and collision is imminent.
- Operator should take action to carefully stop bus to avoid collision.

EYEWATCH READOUTS

• Solid green dot with hash marks on each side. • System is operational with bus at 0 speed.	• Solid green dot • System is operational.	• Lane Departure Warning (LDW) • Occurs when crossing the lane markers without using turn signal. • Appears as a vertical white hash line on the Eyewatch • A series of sharp warning beeps of short duration. • The hash line will be on the Eyewatch side corresponding to the lane marker crossed. • For pilots this feature is not active	• Speed Limit Indicator (SLI) • Appears when the bus is traveling at least 5 mph (adjustable) over the last posted speed limit sign. • Two vertical white hash lines on each side of the Eyewatch will appear with a white number indicating miles over the last posted speed limit • Has a chime sound. • Operator should reduce speed to keep within the speed limit.	• Headway Monitoring (HMW) • Appears as green car • Indicates detection of a vehicle in the path of the bus. • No number shown if bus is traveling a safe distance behind the vehicle in front or when bus is traveling below 19 MPH.	• Headway Monitoring (HMW) • Appears as green car and number • Indicates how far the vehicle in front of the bus is in seconds. • The 2.5 indicates the seconds until a collision could occur if the front vehicle were to come to a stop. • Operator is advised to reduce speed if time to collision falls below preset seconds and car turns red. • Has a chime sound.	• Headway Monitoring Warning (HMW) • Appears as a red car with an audible chime • Indicates the distance between bus and vehicle in front has fallen below a safe threshold. • Operator is advised to reduce speed to increase distance to a safe level.	• Forward Collision Warning (FCW) • Appears as flashing red car with a high pitched beeping sound • Indicates rear end collision is imminent • Operator must stop the bus immediately

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Enlargement of center panel

CENTER DISPLAY & EYEWATCH

OFF
- Center Display
- Contains the Pedestrian Display and EyeWatch.
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DETECTION
- Yellow illumination with no sound
- Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus.
- Operator should exercise additional caution until verifying that the danger of collision has passed.

ALERT
- Red flashing with beeping sound
- Indicates a pedestrian or cyclist is in front of the moving bus or coming towards the moving bus and collision is imminent.
- Operator should take action to carefully stop bus to avoid collision.

CItyMobil2 Demonstrations

Demo Type	Location	Start Month	End Month	Vehicle Mfr.	# Of Veh.	Route (km)	Stations Served	# of Riders
Large Scale	Lausanne, CH	4/2015	8/2015	Easymile	4	1.5	6	7,000
	La Rochelle, FR	12/2014	4/2015	Robosoft	6			14,660
	Trikala, GR	9/2015	1/2016	Robosoft	6	2.5		12,150
Small Scale	Antibes, FR	1/2016	3/2016	Easymile	4	1.0	5	4,000
	Oristano, IT	7/2014	9/2014	Robosoft	2	1.3	7	2,500
	Vantaa, FI	7/2015	8/2015	Easymile	4	1.0		19,000
	San Sebastian, ES	4/2014		Robosoft	3			3,500
Showcase	Bordeaux, FR	10/2015	10/2015	Easymile	4	1.0	2	
	Leon, ES	9/2014	9/2014	Robosoft	2			
	Warsaw, PO	4/2016						

EZ10 Vehicle Features

The EZ10 is manufactured by French light weight automobile maker Ligier. Founded in 1971 and with a background in motor racing (including 20 years in Formula 1), Ligier is the second largest European microcar provider. Ligier marketed electric vehicles since 2008.

EZ10 is an electric people mover. It can transport up to 12 people six seating positions and six standing positions) and can cater to reduced mobility passengers.

The shuttle has no steering wheel and neither dedicated front nor back. At any point on its route EZ10 can easily change its direction without needing a short turn.
Source: http://easymile.com/mobility-solution/

CityMobil2 - Easymile EZ10 Vehicle Specifications
Capacity: 12 persons (6 seating and 6 standing)
Cruising speed: 20 km/h (12 mph)
Maximum speed: 40 km/k (25 mph)
Propulsion engine: Electric asynchronous
Autonomy: up to 14 hours of operation
Battery: Lithium-ion (LiFeP04

Battery Charger: 110V – 230V 16A
Length: 3,928 m / 154.6"
Width: 1,986 m / 78.2"
Height: 2,750 m / 108.3"
Wheelbase: 2,800 m / 110.2"
Payload: 1700 kg / 771 lbs
Fully loaded: 2800 kg / 1,270 lbs

Robosoft RobuCITY Vehicle Specifications
Capacity: 10persons (6 seating and 4 standing)
Maximum speed: 32 km/h
Propulsion engine: 7.5 KW DC 72V
Range: 20-30 km
Battery: Lead acid 6 V 225Ah
Battery Charger: 110V – 230V 25A
Length: 5,000 mm/196.8"
Width: 1,986 mm/78.1"
Height: 2,670 mm/105.2"
http://www.robosoft.com/products/people-transportation/robucity.html

Click the following link to see the YouTube video of the Trikala demonstration that shows operation of low speed transit in mixed pedestrian and auto traffic at night.
https://www.youtube.com/watch?v=pLsmsTj393o

Positive Train Control

What is Positive Train Control?
 "Positive Train Control" (PTC) describes technologies designed to automatically stop a train before certain accidents caused by human error occur. Specifically, PTC as mandated by Congress must be designed to prevent:
- Train-to-train collisions
- Derailments caused by excessive speed
- Unauthorized incursions by trains onto sections of track where maintenance activities are taking place
- The movement of a train through a track switch left in the wrong position

The Rail Safety Improvement Act of 2008 (RSIA) requires passenger railroads and Class I freight railroads to install PTC by the end of 2015 on main lines used to transport passengers or toxic-by-inhalation (TIH) materials.

The PTC systems that will be installed to meet the statutory mandate are overlay systems, meaning they supplement, rather than replace existing train control systems.

4. Reference to Other Standards

ASCE Standard 21-13 Automated People Movers is a consolidation of previous four-part Automated People Mover Standards. An Automated People Mover (APM) is defined as a guided transit mode with fully automated operation, featuring vehicles that operate on guideways with exclusive right-of-way. Chapters: 1–11 cover requirements for design of an APM system, and Chapters 12–16 cover requirements for an APM in passenger operation, including chapters on security; emergency preparedness; system verification and demonstration; operations, maintenance, and training; and operational monitoring. Source: ASCE

IEEE SCC42 Transportation (IEEE Standards Coordinating Committee on Transportation)

Leads the coordination of IEEE standardization activities for technologies related to transportation, especially in the areas of connected vehicles, autonomous/automated vehicles, inter- and intra-vehicle communications, and other types of transportation electrification. These technologies include but are not limited to Mobile Apps, Sensor Networks, and Communications that allow human to vehicle, vehicle to vehicle, vehicle to infrastructure, vehicle to platform, and vehicle to everything exchange of information and data. Where standardization needs exist, the SCC will develop guides, recommended practices, standards, and common definitions of terms.

IEEE P2040 – Standard for Connected, Automated, and Intelligent Vehicles: Overview and Architecture – This standard defines an architectural framework for connected, automated and intelligent vehicles. This standard leverages existing applicable standards.

IEEE P2040.1 – Standard for Connected, Automated and Intelligent Vehicles: Taxonomy and Definitions – This standard specifies the taxonomy and definitions for connected, automated, and intelligent vehicles.

IEEE P2040.2 – Standard for Connected, Automated, and Intelligent Vehicles: Testing and Verification – This standard defines an overarching framework of testing and verification of the connectivity, automation, and intelligence aspects and their combination for connected, automated and intelligent vehicles. This standard identifies existing applicable standards for testing and verification, and defines the integration of these standards into a consistent testing environment.

ISO 19091 Intelligent Transport Systems -- Cooperative ITS -- Using V2I and I2V communications for applications related to signalized intersections
This document describes the use cases, information needs, requirements, data frames, and data elements for several applications that address safety, mobility, and ecological sustainability.

SAE J3018 Guidelines for Safe On-Road Testing of SAE Level 3, 4, and 5 Prototype Automated Driving Systems (ADS) Scope: This document provides guidelines for the safe conduct of on-road tests of vehicles equipped with prototype conditional, high, and full (levels 3-5) automated driving systems (ADSs), as defined by SAE J3016. It does not include guidance for testing production ADSs intended for sale to the general public. The scope is further limited to testing of automated

prototype vehicles on public roads. These guidelines do not address: • Testing of driver assist (Level 1) or partial (Level 2) automation systems, which rely on a human driver to monitor the environment. (See SAE J3016 for Definitions of Levels of Automated Systems.) • Closed-course testing. • Component-level testing. The precise regime of road testing for a particular prototype will depend on the intended level of automation and the targeted capabilities of the prototype (see SAE J3016 for more information). A prototype suitable for testing on public roadways is presumed to have already passed laboratory and/or closed-course testing, which are not addressed by this document.

SAE 3092 Dynamic Test Procedures for Verification & Validation of Automatic Driving Systems (ADS) This document provides dynamic test procedure information and guidelines for verification and validation (V&V) of automated driving systems (ADSs). The levels of automation addressed in this document include conditional (level 3), high (level 4), and full (level 5) as defined by SAE J3016; when activated, these ADSs do not rely on a human driver for monitoring and responding to the vehicle or traffic environment.

SAE J3131 Automated Driving Reference Architecture SAE J3131 defines an automated driving reference architecture that contains functional modules supporting future application interfaces for Levels 3 through 5 (J3016). The architecture will model scenario-driven functional and nonfunctional requirements, automated driving applications, functional decomposition of an automated driving system, and relevant functional domains (i.e., functional groupings). Domains include, but are not limited to, automated driving (i.e., automation replacing the human driver), by-wire and active safety, and those related to automated recovery from faults and system failures (e.g., system bringing the vehicle to a safe state). The architecture will address Tier 1 and Tier 2 functional groupings. The document will include one example instantiation being divides the functionality into two functionality groupings, and will detail the functional and information interface between the groups.

Federal Railroad Administrations Regulations for Positive Train Control
Subpart I—Positive Train Control Systems

Sec.
236.1001 Purpose and scope.
236.1003 Definitions.
236.1005 Requirements for Positive Train Control systems.
236.1006 Equipping locomotives operating in PTC territory.
236.1007 Additional requirements for high speed service.
236.1009 Procedural requirements.
236.1011 PTC Implementation Plan content requirements.
236.1013 PTC Development Plan and Notice of Product Intent content requirements and Type Approval.
236.1015 PTC Safety Plan content requirements and PTC System Certification.
236.1017 Independent third party Verification and Validation.
236.1019 Main line track exceptions.

236.1021 Discontinuances, material modifications, and amendments.
236.1023 Errors and malfunctions.
236.1025 [Reserved]
236.1027 PTC system exclusions.
236.1029 PTC system use and en route failures.
236.1031 Previously approved PTC systems.
236.1033 Communications and security requirements.
236.1035 Field testing requirements.
236.1037 Records retention.
236.1039 Operations and Maintenance Manual.
236.1041 Training and qualification program, general.
236.1043 Task analysis and basic requirements.
236.1045 Training specific to office control personnel.
236.1047 Training specific to locomotive engineers and other operating personnel.
236.1049 Training.

Association of American Railroads (AAR) Standards for PTC – Manual of Standards and Recommended Practices Section K

Part I – Railway Electronics System Architecture and Concepts of Operations (9000 Series)
Part II – Locomotive Electronics and Train Consist System Architecture (9100 Series)
Part III – Wayside Electronics and Mobile Worker Communications (9200 Series)
Part IV – Office Architecture and Railroad Electronics Messaging (9300 Series)
Part V – Electronics Environmental Requirements and System Management (9400 Series)
Part VI – Railway Data Management and Communications (9500 Series)

Communications Based Train Control Standards

CBTC signaling is currently standardized in accordance with IEEE 1474.1 and has become the reference technology for metro operators worldwide.

IEEE defines CBTC as a continuous automatic train control system utilizing

 • High-resolution train location determination, independent of track circuits

 • Continuous, high-capacity, two-way train-to-trackside data communications

 • Train borne and trackside processors capable of performing essential functions

1474.1-2004 IEEE Standard for Communications-Based Train Control (CBTC) Performance and Functional Requirements

1474.2-2003 IEEE Standard for User Interface Requirements in Communications-Based Train Control (CBTC) Systems

1474.3-2008 IEEE Recommended Practice for Communications-Based Train Control (CBTC) System Design and Functional Allocations

1474.4-2011 IEEE Recommended Practice for Functional Testing of a Communications-Based Train Control (CBTC) System

Source: Eric Louis-Marie and Dr. Peter Nuechter, "CBTC Connectivity Solutions White paper Edition 2011," Huber+Suhner AG

http://literature.hubersuhner.com/Marketsegments/Transportation/RailCBTCEN/

5. Case Studies

Case Studies shown in the presentation are:

- Minnesota Bus on Shoulders – Automated Guidance for Buses Operating on Narrow Freeway Shoulders

- Lane Transit District BRT Automated Docking – Using Automated Bus Guidance for BRT Operations

- Washington State Transit Insurance Pool Safety Pilot – Testing Automated Collision Avoidance Warning Systems for Buses

- CItyMobil2 Demonstrations – Testing Low-Speed Automated Road Transit in Europe

- Communications Based Train Control (CBTC) – Implementing CBTC at New York City Transit

6. Glossary

Term	Definition
Automated Vehicles (AV)	Vehicles that use computers or machinery to accomplish some portions of the driving task instead of a human driver
Autonomous Emergency Braking (AEB)	Braking that is initiated and accomplished by a computer system rather than a human driver
Bus Rapid Transit (BRT)	A bus transit system that operates on exclusive lanes or roadways
Collision Avoidance System (CAS)	Computer system that warns a driver of an impending or potential collision and can trigger an AEB system if present
Communications Based Train Control (CBTC)	A train signaling and control technology that uses a communications architecture to create a virtual separation zone around a train. That zone can be adjusted to allow for changes in speed, frequency of trains, and train length.
Connected Vehicles (CV)	A roadway environment in which wireless communications permit vehicles to communicate with

Term	Definition
	other vehicles, (V2V) and with stationary devices such as traffic signals, (V2I.)
Connected/Automated Vehicles (CAV)	Vehicles that use computers or machinery to accomplish some portions of the driving task instead of a human driver and communicate wirelessly with other vehicles and stationary devices
Platooning	A column of vehicles operating in coordination
Positive Train Control (PTC)	Railroad signaling and control technologies mandated by the US Congress designed to automatically stop a train before certain accidents caused by human error occur
Telematics	Long distance transmission of computerized information

7. References

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3. "Connected Vehicles 101" online course http://www.citeconsortium.org/course/connected-vehicles-101/

4. "Connected Vehicles 102" online course https://www.pcb.its.dot.gov/documents/Connected_Vehicles_102.pdf

5. Jim Barbaresso, Gustave Cordahi, Dominie Garcia, Christopher Hill, Alex Jendzejec, Karissa Wright, "USDOT's Intelligent Transportation Systems (ITS) ITS Strategic Plan 2015-2019," Booz Allen Hamilton, for US Department of Transportation Intelligent Transportation Systems, Joint Program Office, May 15, 2014 http://www.its.dot.gov/strategicplan/

6. "Levels of Road Vehicle Automation," SAE International http://www.sae.org/misc/pdfs/automated_driving.pd

7. National Highway Traffic Safety Administration, "Preliminary Statement of Policy Concerning Automated Vehicles," U.S. Department of Transportation, Washington, D.C., May 30, 2013,

http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development Accessed June 20, 2013

8. Federal Automated Vehicles Policy, "Accelerating the Next Revolution In Roadway Safety," September 2016, National Highway Traffic Safety Administration (NHTSA) US Department of Transportation https://www.transportation.gov/AV accessed September 24, 2016

9. Bryant Walker Smith, "SAE Levels of Driving Automation," The Center for Internet and Society, December 18, 2013, http://cyberlaw.stanford.edu/blog/2013/12/sae-levels-driving-automation. accessed July 25, 2014

10. "Intelligent Transportation Systems Vehicle-to-Infrastructure Technologies Expected to Offer Benefits, but Deployment Challenges Exist," Government Accountability Office (GAO) Report to Congressional Requesters, September 2015, http://gao.gov/products/GAO-15-775

11. Craig Shankwitz, "Minnesota Bus on Shoulder System (BoSS)," Automating Public Mass Transit in the Connected and Automated Era, Presentation at the Transportation Research Board Annual Meeting, 13 January 2015

12. Greg Larson, "Vehicle Assist and Automation (VAA) Using Bus Steering Automation Technology to Improve Safety, Costs, and Efficiency," Caltrans Division of Research, Innovation and System Information (DRISI), Power Point Presentation for CalACT Spring Conference

13. "Field Operational Tests of Vehicle Assist and Automation Technologies California-Oregon VAA Team," Ching-Yao Chan and Wei-Bin Zhang 5th National BRT Conference Las Vegas August 22, 2012

14. "Demo '97: Proving Ahs Works," Federal Highway Administration, Public Roads Vol. 61 No. 1 Date: July/August 1997, https://www.fhwa.dot.gov/publications/publicroads/97july/demo97.cfm

15. Special Investigation Report – "The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear End Crashes," National Transportation Safety Board (NTSB), May 19, 2015 http://www.ntsb.gov/safety/safety-studies/Documents/SIR1501.pdf

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24. "Positive Train Control, AAR" https://www.aar.org/search/Pages/results.aspx?k=Positive%20Train%20Control

25. "Collision of Metrolink Train 111 With Union Pacific Train LOF65-12 Chatsworth, California September 12, 2008," Accident Report, National Transportation Safety Board NTSB/RAR-10/01 PB2010-916301 Notation 8175, Adopted January 21, 2010, http://www.ntsb.gov/investigations/AccidentReports/Reports/RAR1001.pdf

26. 49 CFR Part 229, 234, 235, et. al: Positive Train Control Systems; Final Rule, Federal Railroad Administration, January 15, 2010, https://www.fra.dot.gov/eLib/details/L01347

27. Association of American Railroads, Safety and Operations, "Manual of Standards and Recommended Practices Section A, Part I," 2/26/2016

8. Study Questions

1. **In a NHTSA Level 3 automated vehicle, the driver is:**

a) expected to be available for control in certain areas
b) not expected to be available for control during the trip
c) responsible for monitoring and available to resume control
d) in complete and sole control

e) Which of the following bus pilot technologies is most reliant on connected vehicle (V2V) technology?

a) Automated Docking
b) Bus on Shoulder
c) Hybrid Propulsion
d) Bus Platooning

f) Which of the following statements is true?

a) Casualty and liability expenses for rail transit far exceed those for bus transit
b) Driver reaction time is not a factor in avoiding bus collisions
c) National Transportation Safety Board does not require forward collision warning systems on all new vehicles
d) Transit buses are currently being delivered with Autonomous Emergency Braking

g) Which of the following was not true of the Citymobil2 demonstrations?

a) The program was funded at about $19.5 million by the European Union
b) Two different contractors each built six robotic vehicles
c) The vehicles traveled at low speed and carried passengers
d) The vehicles required exclusive rights-of-way with no pedestrian or vehicular crossings

h) Which of the following statements is true?

a) Positive Train Control standards are voluntary
b) All Communications Based Train Control Systems must be interoperable
c) Communications Based Train Control Systems allow only one train in a fixed block at a time
d) Positive Train Control systems and Communications Based Train Control systems can be overlaid on existing fixed block signal systems

9. Icon Guide

The following icons are used throughout the module to visually indicate the corresponding learning concept listed out below, and/or to highlight a specific point in the training material.

1) **Background information:** General knowledge that is available elsewhere and is outside the module being presented. This will be used primarily in the beginning of slide set when reviewing information readers are expected to already know.
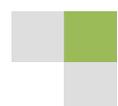
2) **Tools/Applications:** An industry-specific item a person would use to accomplish a specific task, and applying that tool to fit your need.

   Example: S*ystems engineering, specifications, test documentation, etc. A systems engineering approach to developing an ATC procurement specification.*

3) **Remember:** Used when referencing something already discussed in the module that is necessary to recount.

4) **Refer to Student Supplement:** Items or information that are further explained/detailed in the Student Supplement.