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Operating Practices Working Group

Defensive Rail Operations

Abstract: This recommended practice provides guidance to rail transit agencies (RTAs) for the creation of programs that encourage and promote the defensive operation of trains and other rail transit vehicles. Defensive operation encompasses situational and operational awareness of the operating environment. This document identifies considerations for how an RTA may establish a policy and provide guidance to employees on situational and operational awareness and how to operate trains in a defensive manner so as to minimize the potential for being involved in different types of incidents, while simultaneously improving operational safety and efficiency.

Keywords: defensive operations, hazard analysis, operating environment, operational awareness, operations, rail transit, rule compliance, safe zone, situational awareness

Summary: This recommended practice establishes a framework for the types of programs that RTAs may enact to provide train operators with the guidance and skills that will help them to be more aware of their operating environment. It provides guidance on how RTAs may structure such programs and what content is useful for such a program. It addresses the difference between situational and operational awareness. It addresses a need for developing programs based on the mode of operation and the different designs of the right-of-way, since they all affect what the operator will encounter and must be aware of while operating the train. It introduces the concept of a safe zone—the space around a train that an operator must ensure remains clear of obstructions or people that may come in contact with the train while it is in motion. It addresses fitness for duty and its impacts on awareness, and it provides guidance to RTAs on how to communicate and provide instruction for program expectations.

Scope and purpose: The purpose of this recommended practice is to provide RTAs with structured recommendations on creating an increased situational and operational awareness of their train operators through the creation, delivery and management of a defensive operations program. The purpose of developing a defensive operations program is to increase train operator situational awareness and reduce the potential for incidents or accidents at the rail transit agency, which can be prevented through the consistent application of awareness tactics and defensive operation.

This document represents a common viewpoint of those parties concerned with its provisions, namely transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any recommended practices or guidelines contained herein is voluntary. APTA standards are mandatory to the extent incorporated by an applicable statute or regulation. In some cases, federal and/or state regulations govern portions of a transit system's operations. In cases where this is a conflict or contradiction between an applicable law or regulation and this document, consult with a legal adviser to determine which document takes precedence.

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Introduction

This document recommends that rail transit agencies develop a program that instructs and guides train operators to adopt defensive operation techniques as a means of minimizing the risk of being involved in a preventable incident. Defensive operation is grounded in situational and operational awareness, and it requires different techniques and awareness depending on the mode of rail transit, the operating environment and other factors identified in this recommended practice. RTAs may develop specific defensive operations programs or may incorporate provisions of this recommended practice into their existing train operator training programs. RTAs that have adopted practices identified in this document report that they have reduced collisions and other types of incidents as a result.

It must be noted that rail transit is not directly comparable to railroads (e.g., Amtrak, commuter, freight rail). Rail transit systems differ greatly in the types of service, vehicles and technology employed, with some systems operating fully automated trains on exclusive rights-of-way and others operating on streets mixed with traffic. Rail transit demands a unique approach to solving its problems, and the APTA Rail Transit Standards Program was enacted to accomplish this complex task.

APTA recommends the use of this document by:

- individuals or organizations that operate rail transit systems;
- individuals or organizations that contract with others for the operation of rail transit systems; and
- individuals or organizations that influence how rail transit systems are operated (including but not limited to consultants, designers and contractors).

Defensive Rail Operations

1. Use of defensive rail operations programs in rail transit

The goal of a defensive operations program is to reduce the potential for incidents or accidents through the systematic deployment of various techniques of awareness and recognition. Rail transit agencies (RTAs) should ensure that programs are kept current and are based on changes to the rail operating environment, reported hazards and unsafe conditions. Some RTAs have stand-alone defensive rail operations programs that complement their existing train operator training.

Many RTAs have developed guidance for their train operators to be aware of the environments in which they operate their train. The development of a formal defensive rail operations program ensures that consistent and comprehensive information is provided to train operators during their initial training and on a recurring basis.

2. Policy, rules and procedures

The RTA should develop a policy that establishes defensive operation instructions, measurements and guidance for train operators. The policy should provide an overview of what defensive operation for a train operator entails and how the RTA intends to communicate expectations for defensive operations and measure train operator performance.

The RTA should establish a policy for measuring the results of the defensive operation program and taking action based on those results. For example, an RTA may measure results including, but not limited to, an increase or decrease in the following:

- accidents, incidents and safety events
- injuries
- near misses
- rule compliance
- customer complaints

The RTA should determine if this program is optional or mandatory and how it will be incorporated into the existing training and supervision programs.

As appropriate, the RTA should revise and/or develop rules and/or procedures related to a defensive operations program.

3. Design and operational considerations

The RTA should develop its defensive operations program to meet the design and operational conditions of its specific rail lines. For example, heavy rail transit poses different safety and operational factors from light rail, and the RTA's defensive operation program should reflect the real-world environment of the particular mode.

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Within modes, different lines may have different operating conditions that require specialized information for each operating line. Considerations may also include the following:

- number of employees on the train and the location of employees in relation to passengers
- historic versus modern vehicles
- fully automated, semi-automated and manual operation systems
- surrounding environment
- operating environment

4. Determination of “safe zone” around train

The “safe zone” is a dynamic space that remains with the train while it is stopped or in motion and changes depending on the location and operating dynamics of the train. The safe zone will differ by mode and vehicle type and other environmental factors. The safe zone may also include the presence of other hazards that may affect safe train operation, such as a fallen tree or debris encroaching on the right-of-way.

The safe zone is a visualization the train operator should have that consists of the area where passengers, pedestrians or trespassers may stand or walk without risk of making contact with a train in motion. It is the zone in which motor vehicle movements also pose a similar risk. The safe zone includes both immediate risks and potential risks that can occur. The safe zone is not the same as the dynamic envelope of the train. The safe zone is the clearance around the rail vehicle or train that should be maintained to prevent collisions, accidents and/or contact with people and objects.

The RTA should determine what constitutes a “safe zone” around a train. Train operators would envision the space around a train in which a hazard has the potential of entering and violating the dynamic envelope of the train, which might result in contact with the train, thereby creating the potential for an unsafe event.

Train operator situational awareness of the safe zone involves monitoring the areas visible from the cab, as well as via mirrors and/or cameras to determine if any person or object is within the safe zone and could potentially be at risk of moving into the train or into the path of the train. The safe zone can extend beyond the dynamic envelope, since it factors in considerations of potential hazards beyond the envelope that are related to train movements.

The RTA should incorporate the concept of the safe zone into its defensive rail operations program and the training for this program.

5. Operating infrastructure and environment

In order to identify potential hazards and factors affecting situational awareness, the RTA should evaluate its complete operating environment in the development of its defensive operations program. The operating environment consists of the physical, operational and environmental elements and conditions through which trains operate, and where train operators must maintain awareness in order to operate safely.

The RTA should consider, but not be limited to, the following types of operating environments when developing and implementing a defensive operations program so that it may communicate necessary information to train operators as part of this program.

The RTA should evaluate its right-of-way environment for factors such as exclusivity for rail vehicle operations, interaction with non-transit vehicular traffic, interaction with pedestrian traffic, and other external factors that may or may not be within the control of the RTA. Transit-specific design elements, such as grade

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crossings, intersections, street/surface operations, entry points for maintenance vehicles, etc. should also be considered. The following factors should be considered:

Right of way (ROW)

- RTA's definition of right-of-way

Access points

- grade crossings
- station interface
- platforms (overcrowding, passenger inattentiveness, etc.)
- pedestrian crossings
- informal historic pedestrian crossings
- schools and recreation areas
- fencing and no fencing

Other modes of mobility

- motor vehicles
- pedestrians and trespassers
- strollers
- wheelchairs or other mobility devices
- bicycles, scooters, other non-motorized wheeled devices

Train operations

- operating speed
- acceleration and braking
- door operations

Environmental

- time of day/lighting
 - night-time glares, headlights, other unusual lighting
 - visual distance viewable during night or tunnel or other covered-structure operations
- weather conditions

Vehicle and wayside infrastructure

- train control systems/cab signals/computer screen on train
- cab design:
 - enclosed versus non-enclosed
 - visibility of surrounding environment
 - passenger/person interface

6. Operational and situational awareness

In rail transit operations, defensive operation is grounded in different types of awareness. For the purposes of this document, operational awareness relates to the awareness of RTA rules and procedures. Situational awareness relates to the factors traditionally considered in the formal, scientific definition of the term, which is grounded in three phases: perception, comprehension and projection. While operational awareness is focused on understanding and complying with RTA rules and procedures, situational awareness involves understanding the dynamic types of conditions for the fundamental risk elements (e.g., train operator, rail vehicle, environment and type of operation) that affect safety before, during and after the train operations.

6.1 Operational awareness

In developing the defensive operations program, the RTA should take into consideration the following aspects of operational awareness and establish its expectations including, but not limited to:

- rules/procedures
- priority
- following non-rail transit vehicles
- passing adjacent vehicles
- passing fixed infrastructure
- berthing/door opening/closing
- signals
- train traffic
- motor vehicle
- managing/operating with system defects
- different grade crossing designs along alignment
- train order/work assignment
- compliance checks/efficiency testing
- coordination with rule compliance programs
- tracking and analyzing the data to make adjustments in the program
- continuous improvement/positive safety culture
- work zones and roadway worker protection
- operation past adjacent construction
- vehicle status
- public awareness or knowledge of hazards rail operations present
- training and retraining

6.2 Situational awareness

In developing the defensive operations program, the RTA should consider the following dynamic aspects of situational awareness and provide guidance on how operators can operate defensively and be fully aware of the myriad possible conditions. The following awareness concepts may be included:

- Concept of focusing on the operating environment for dynamic hazards versus seeing a familiar environment and not being aware of subtle changes that may result in hazards.
- Concept of “safe zone” that moves with the train:
 - Is a passenger or pedestrian within the safe zone?
 - Are there any vehicles, animals or objects that are at risk of entering the safe zone?
- How does the operator observe and recognize hazards and respond appropriately in the moving environment?
 - pointing and calling technique versus just seeing the environment approaching (see Section 10 of this recommended practice)
 - scanning (at intersections/elsewhere)
 - approaching intersections (no acceleration, in coast—cut reaction time in half)
- Awareness while train is in motion:
 - awareness of speed restrictions and schedule and impacts on ability to maintain operational focus while train is in motion (e.g., speed limits and response to being behind schedule)
 - braking distance of trains at different speeds, including considerations for reaction time, environmental factors and other conditions (see Appendix A)

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- Awareness while train is stopped:
 - at station (including passengers with special needs who may require additional time before train moves)
 - at intersections or grade crossings
 - while stopped over or at a switch
 - while stopped in relation to a work zone or other wayside worker direction
 - elsewhere
- Awareness while approaching and exiting stations or platforms.
- Awareness while approaching grade crossings.
- Awareness while approaching work zones and passing roadway workers.
- Awareness that the same environment may be different depending on various factors:
 - changes communicated via train order or other RTA instruction to operator
 - time of day
 - weather/season
 - adjacent construction work on or near the ROW
 - coordination with track allocation, unplanned work (coordination with employee in charge)
- Awareness while listening to radio communications (busy radio traffic); special radio channels for emergencies/special comms, etc.
- Awareness of potential impacts on known environments during special events (crush loads, nearby traffic, crowds, etc.).
- Awareness of compliance with RTA electronic device policy requirements.
- Awareness of impacts of the following on safe operations:
 - complacency
 - task overload
 - vehicle status
 - fatigue
- Awareness of impacts of personal life situations that affect an operator's ability to focus on train operating duties. (Note: It is not the duty of the RTA to inquire about such impacts, but simply for train operators to be aware that they must be able to focus solely on train operation.)
- Awareness of impacts of train operator interactions with other RTA employees, such as individuals who give out work assignments or otherwise interact with the train operator in the course of his or her duties.

7. Defensive operation in yards and shop areas

The RTA should incorporate the defensive operations program in its yard operations. In addition to considering the factors presented elsewhere in this recommended practice, yard-specific factors may also include, but not be limited to the following:

- speed/low speed
- clearance around train on turntables, traverser tracks
- employees walking on tracks
- employees inspecting tracks, switches, power rails and/or catenary, rail vehicles
- grade crossings in yards
- entering/exiting maintenance facility buildings
- audible signal use when passing trains or fixed infrastructure
- coupling/uncoupling
- dynamic envelope of the train (e.g., open panels)
- sounding audible device or broadcast announcement prior to moving vehicle
- blue light protection (crew work)
- fouled track protection and fouling point markers

- operation of and over switches
- operation on powered and unpowered track
- use of safety stops
- signal
- work zones
- entering/exiting yard territory/main line

8. Pre-trip inspections of trains

The RTA should integrate the pre-trip inspection of trains and the defensive rail operations program to ensure that train conditions are such that they do not introduce new hazards that may affect the safe zone of the train.

9. Safety and hazard analysis

In the administration of the defensive operations program, the RTA should consider its relationship with the RTA's safety management system (SMS), including its data gathering, safety performance measures and hazard management program. With added awareness, operators and other rail operations employees may identify additional safety concerns, areas of improvement or hazards that should be further evaluated. The RTS should consider the following:

- safety management systems (SMS) for incident reporting and trend analysis
- reporting mechanism for hazards (e.g., from signal issues to visibility issues) through the safety risk management program
- near-miss reporting and analysis
- state safety oversight agency requirements
- accident/incident investigation (incorporate defensive rail operations program into investigation process to learn if operator was operating defensively, what hazards and distractions existed, and what corrective actions can be taken)
- degrees of awareness/degrees of difficulty in operation and whether/how this should be taught (e.g., a grade crossing with a higher-than-average rate of events)
- job hazard analysis

10. Techniques for defensive operations

RTAs should evaluate techniques for train operators to use that promote defensive operation. While this document does not advocate any single technique, successful approaches at some rail transit agencies and other operational organizations include, but are not limited to:

- Pointing and calling, which is a method in occupational safety for avoiding mistakes by pointing at important indicators and calling out the status. Making large gestures and speaking out the status helps with focus and attention. It requires co-action and co-reaction among the operator's brain, eyes, hands, mouth and ears.
- Defensive driving techniques such as the systems for bus drivers to regularly scan the horizon, read every sign, and take other actions that promote awareness and attention to the changing environment.
- Visual scanning of immediate and distant viewpoints.
- The art of focusing as related to the provisions of this recommended practice.
- The concept of seeing the environment for the first time every time (e.g., do not assume the signal will always be red, or always expect to react in case the designed elements are not functioning correctly).

11. Public engagement

The RTA should incorporate public engagement requirements into its defensive operations program. The RTA should identify how operator awareness techniques integrate with public safety campaigns.

The RTA should develop a public safety campaign warning the public of the hazards of the rail transit system. This could include, but is not limited to, the following:

- public safety campaigns
 - grade crossing safety
 - safety at stations and on platforms
 - trespass prevention
 - suicide prevention
 - school safety programs
 - outreach to the ADA community
- customer safety campaigns
- roles of communicating to customers over radio/PA or in person
 - from cab
 - at platform
- communicating hazards/malfunctions
- signage for vehicle identification
- wayside signage and warnings (environmental design)

12. Communications requirements

The RTA should identify any unique parameters or expectations related to communications and incorporate them into the defensive rail operations program. This would include protocols for reporting of information in real time during operations or at other times, with protocols including, but not limited to, the following:

- to/from operations employees and other RTA employees (with OCC, over the radio)
- to/from supervision and/or management (e.g., reporting of hazards, sharing of information)
- guidance in relation to nonpunitive reporting expectations (see APTA RT-RP-OP-026-20, “Roadway Worker Near Miss Reporting Requirements,” for additional information)

13. Training requirements

The RTA should determine how it will integrate defensive rail operations guidance into existing train operator training curricula. The RTA should identify any certification, recertification, qualification, requalification, refresher or other types of training requirements that will apply to this program. Elements of training for consideration may include, but are not limited to the following:

- initial and refresher training
- classroom and field instruction
- simulator use, videos and/or photos to help show the reality of the operation
- instruction post-incident
- decision-making (e.g., FAA DECIDE Model)
- simulator use in training or post-incident to recreate various types and levels of hazardous operating conditions

Please see APTA RT-OP-S-013-03, Rev. 2, “Training of Rail Operating Employees,” for more information about rail operations training requirements.

14. Fitness for duty and fatigue

Train operators' fitness for duty and fatigue may affect their ability to maintain situational awareness and operate defensively. The RTA should consider these factors in development of a defensive rail operations program. Please see APTA RT-OP-S-018-12, "Fitness for Duty Program Requirements," and APTA RT-OP-S-023-17, "Fatigue Management Program Requirements," for more information. The RTA should also consider impacts of hours of service and scheduling on a train operator's ability to operate defensively. See APTA RT-OP-S-017-08, "Hours of Service," for more guidance.

15. Coordination with outside agencies and organizations

The RTA should determine if operator reports resulting from the defensive operations program yield information that should be shared with outside agencies responsible for transportation planning, city services, emergency response or other municipal functions. The following are examples:

- coordination with cities/municipalities/DOTs
- use of MOUs/mutual agreements with municipalities or with emergency first responders
- coordination with state safety oversight agencies

16. Coordination during system design and planning

The RTA should incorporate lessons learned from the defensive operations program in the design of new vehicles, stations, platforms, alignments and other changes to the system. This may include the preliminary and operational hazard analyses.

RTAs may incorporate changes into the stations, along the alignment and elsewhere along the right-of-way. Operations department personnel should be aware of hazards that exist on and along the right-of-way and should be consulted in reviewing the designs to ensure that new hazards are not being introduced and that changes will not negatively affect the ability of the train operator to operate the train defensively. See the next section.

17. Management of change

Any change to the infrastructure, vehicles or operation of the RTA should be evaluated for potential new factors that should be incorporated into a defensive operations program. The RTA should incorporate the defensive operations program into its management-of-change processes. The RTA may use its safety risk management process or other method for identifying the potential impacts, including risks, with changes to the operating environment or infrastructure.

For example, when an RTA introduces a new technology into the cab of a rail transit vehicle, the RTA should evaluate its potential for causing a distraction to the operator in relation to existing operating practices and the needs of the RTA (e.g., excessive alerts, video screen displays).

The RTA should evaluate all new technologies that may have an effect on operations, including but not limited to operator assist systems that sound alarms or alerts about potential hazards. Please see APTA RT-OP-RP-024-19, "Crash and Fire Protected Inward and Outward Facing Audio and Image Recorders in Rail Transit Operating Compartments," and APTA RT-OP-S-022-17, "Operations Personnel Requirements in New Rail Transit Projects." Please note that any use of technology does not eliminate operator responsibilities to operate in accordance with all RTA rules and procedures.

APTA is in the process of developing a recommended practice for "Managing Short- and Long-Term Changes Affecting Rail Operations."

Related APTA standards

APTA RT-OP-S-013-03, Rev. 2, “Training of Rail Operating Employees”

APTA RT-S-OP-017-11, Rev. 1, “Electronic Device Distraction Policy Requirements”

APTA RT-OP-S-018-12, “Fitness for Duty Program Requirements”

APTA RT-OP-S-023-17, “Fatigue Management Program Requirements”

APTA RT-OP-S-022-17, “Operations Personnel Requirements in New Rail Transit Projects”

APTA RT-OP-S-024-19, “Crash and Fire Protected Inward and Outward Facing Audio and Image Recorders in Rail Transit Operating Compartments”

APTA RT-RP-OP-026-20, “Roadway Worker Near Miss Reporting Requirements”

APTA RT-RP-OP-027-20, “Platform Berthing Requirements”

References

None

Definitions

at grade, exclusive right-of-way (ROW): At-grade track that cannot be crossed or entered by any other vehicle or pedestrian.

at grade, mixed and cross-traffic: Includes alignments where rail vehicles and rubber-tire vehicles travel in the same lanes and alignments where pedestrians may freely cross the tracks at any point.

at grade, with cross-traffic: At-grade track that cannot be entered by non-rail traffic except at certain crossing points.

dynamic envelope: The maximum space that the vehicle will occupy as it moves over the track. Includes overhang on curves, lean due to the action of the vehicle suspension and track super elevation, track.

heavy rail passenger cars (HR): Rail cars that have motive capability, are driven by electric power taken from overhead lines or third rails, are configured for passenger traffic, and are usually operated on exclusive ROW.

mixed traffic operations: The operation of transit vehicles on nonexclusive rights-of-way (transit ROW category C) with non-transit vehicles.

right-of-way (ROW): An area at or above track level at a distance from the centerline of the track, as specified by the RTA.; the land on which the railroad track and associated structures (bridges, tunnels, signals, platforms, etc.) are located; all land purchased by the transit system authority for the development and operation of the system; and lands or rights used or held for track operation.

safe zone: The area around a train or rail vehicle that an operator must ensure remains clear of obstructions or people that may come in contact with the train while it is in motion, not to be confused with dynamic envelope or work zone terms such as “clear of track.”

train orders: Instructions, usually written, used to govern train operations manually.

Abbreviations and acronyms

MOU	memorandum of understanding
NATSA	North American Transportation Services Association
OCC	operations control center
PTASP	public transportation agency safety plan
ROW	right of way
RTA	rail transit agency
SMS	safety management system
SSOA	state safety oversight agency

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	May 7, 2021	July 9, 2021	August 3, 2021	Sept. 9, 2021	Sept. 28, 2021

Appendix A: Example stopping distance chart

The following is provided for example purposes only, but it shows a stopping distance chart that can be used as part of a defensive operations program. The idea is to provide train operators with practical information about the distance it takes to stop a train from different speeds, taking into account reaction time and braking distance. This is provided for example purposes only, and any RTA choosing to create such a chart would need to develop it in relation to conditions of its own individual vehicles and their operating characteristics.

FIGURE 1
Example Stopping Distance Chart

Speed	Reaction Time	+	Braking Distance	=	Stopping Distance
10 mph	11 ft	+	24.5 ft	=	35.5 ft
20 mph	22 ft	+	97.5 ft	=	119.5 ft
30 mph	33 ft	+	220 ft	=	253 ft
40 mph	44 ft	+	391.5 ft	=	435.5 ft
50 mph	55 ft	+	563.2 ft	=	618.2 ft