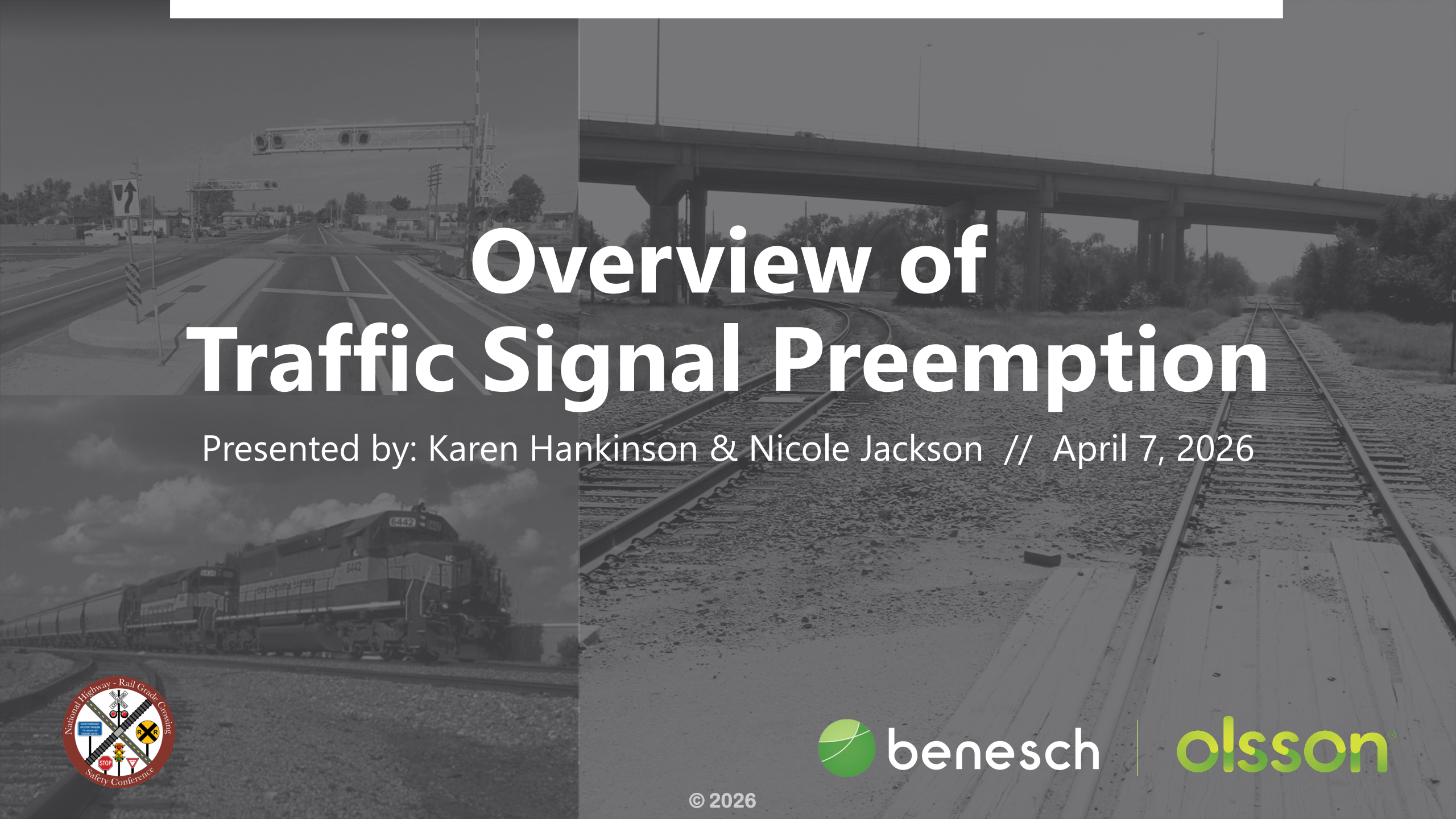


Overview of Traffic Signal Preemption

Presented by: Karen Hankinson & Nicole Jackson // April 7, 2026

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Presenters





Karen Hankinson, PE, TE

Olsson

Senior Team Leader / Rail

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Benesch

Group Manager – Grade Crossing Engineering

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Presentation Overview

- Intro
- Background
- Preemption
  - What is it?
  - When to use it?
  - Simultaneous vs. Advance Preemption
  - Preemption Time
  - 50-Second Rule
- Queue Mitigation & Prevention Techniques
  - Pre-Signals
  - Queue Cutters
- Next Steps

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Background

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Background

It’s an issue worldwide…



There is a grade crossing between the railroad and highway

There is an adjacent intersection

The adjacent intersection has a traffic signal

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Vernon, California



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Aarhus, Denmark



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Langford, British Columbia, Canada



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Background

The stage is set…

STOPPED ON THE TRACKS
AND NO PLACE TO GO

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Who Remembers?

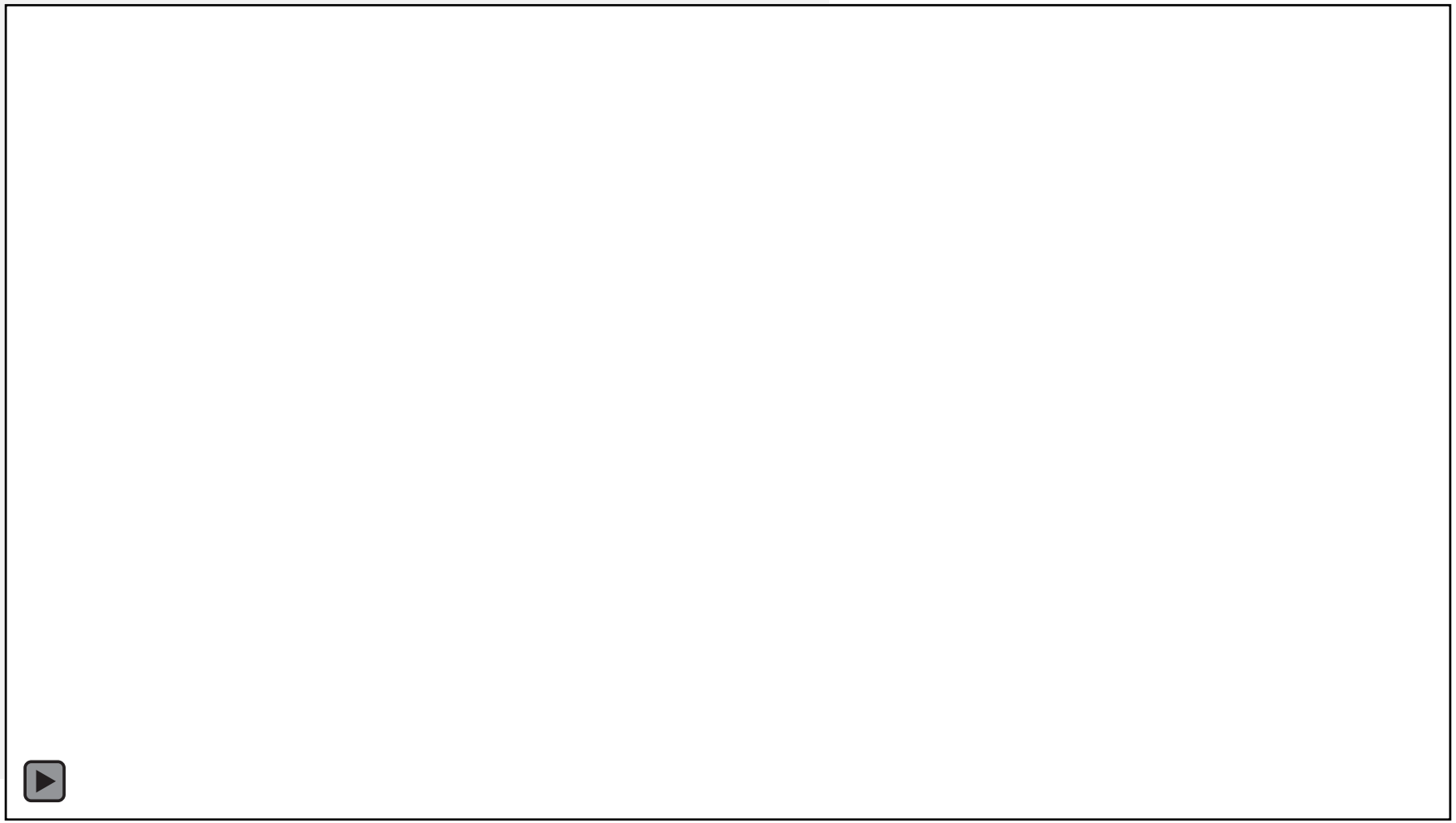
- 25 students / 1 driver on board the school bus
- 120 passengers / 3 crew on board the Metra train
- 7 deaths (all students)
- 24 injuries, many critical / life altering



Fox River Grove, IL
October 25, 1995

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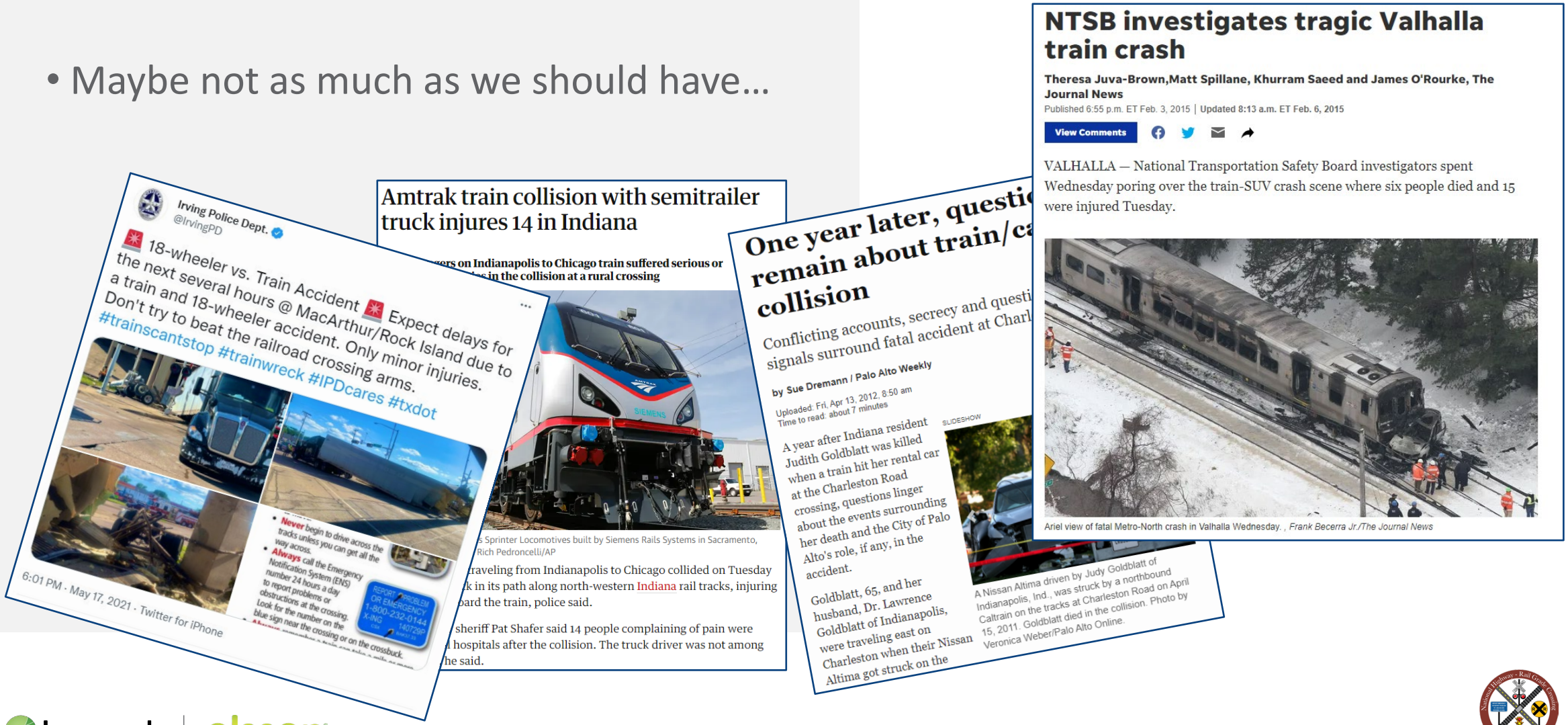
Who Remembers?



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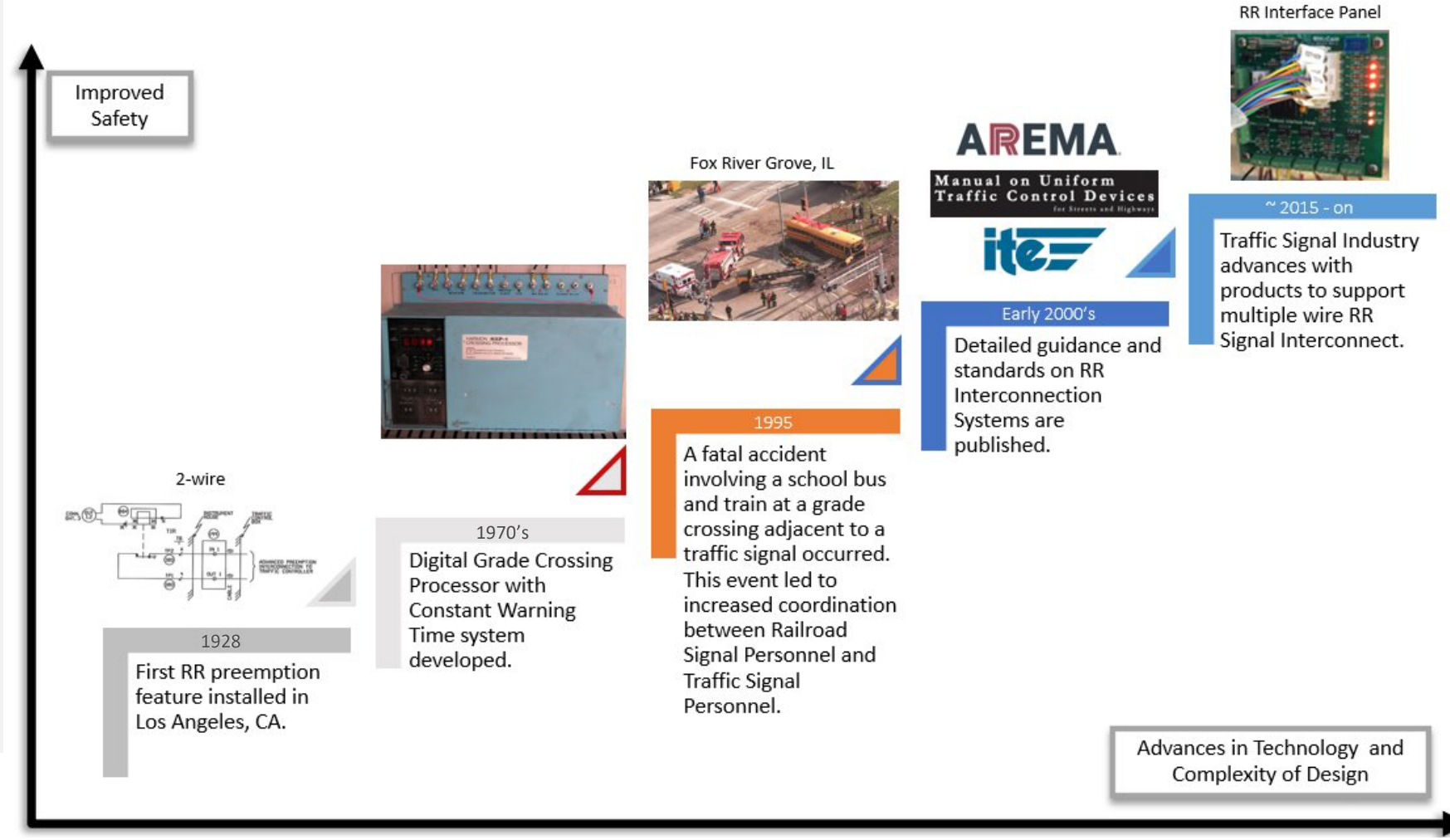
What did we learn from this tragedy?

- Maybe not as much as we should have…



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Safety Progression for Railroad Interconnection



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Background



Everyone knows not to stop on the tracks, right?

There is even a sign!

Can we design a system that provides an opportunity for motorists to clear the tracks prior to train arrival?

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Preemption

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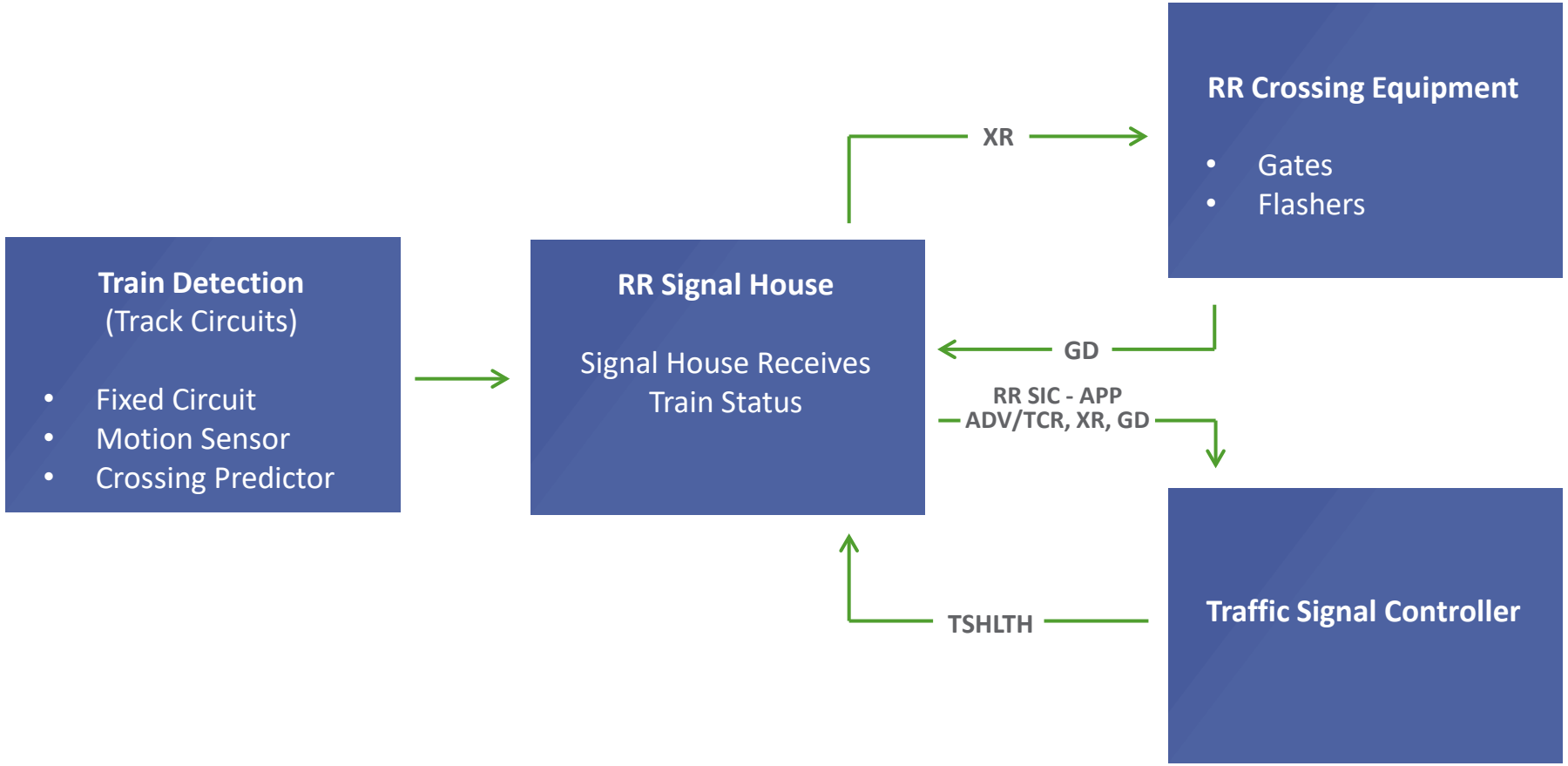
Preemption

What is it?

- Electrical connection between two systems:
  - Grade Crossing Warning System (flashing-light signals and automatic gates)
  - Adjacent Traffic Signal System
- Provides *opportunity* for motorists to clear track area before train arrives at the crossing
- Requires cooperation between the Railroad and traffic signal maintaining agency
- Not well supported by traffic signal manufacturers in controller unit software
- Overall, a general lack of understanding in its operation industrywide exists

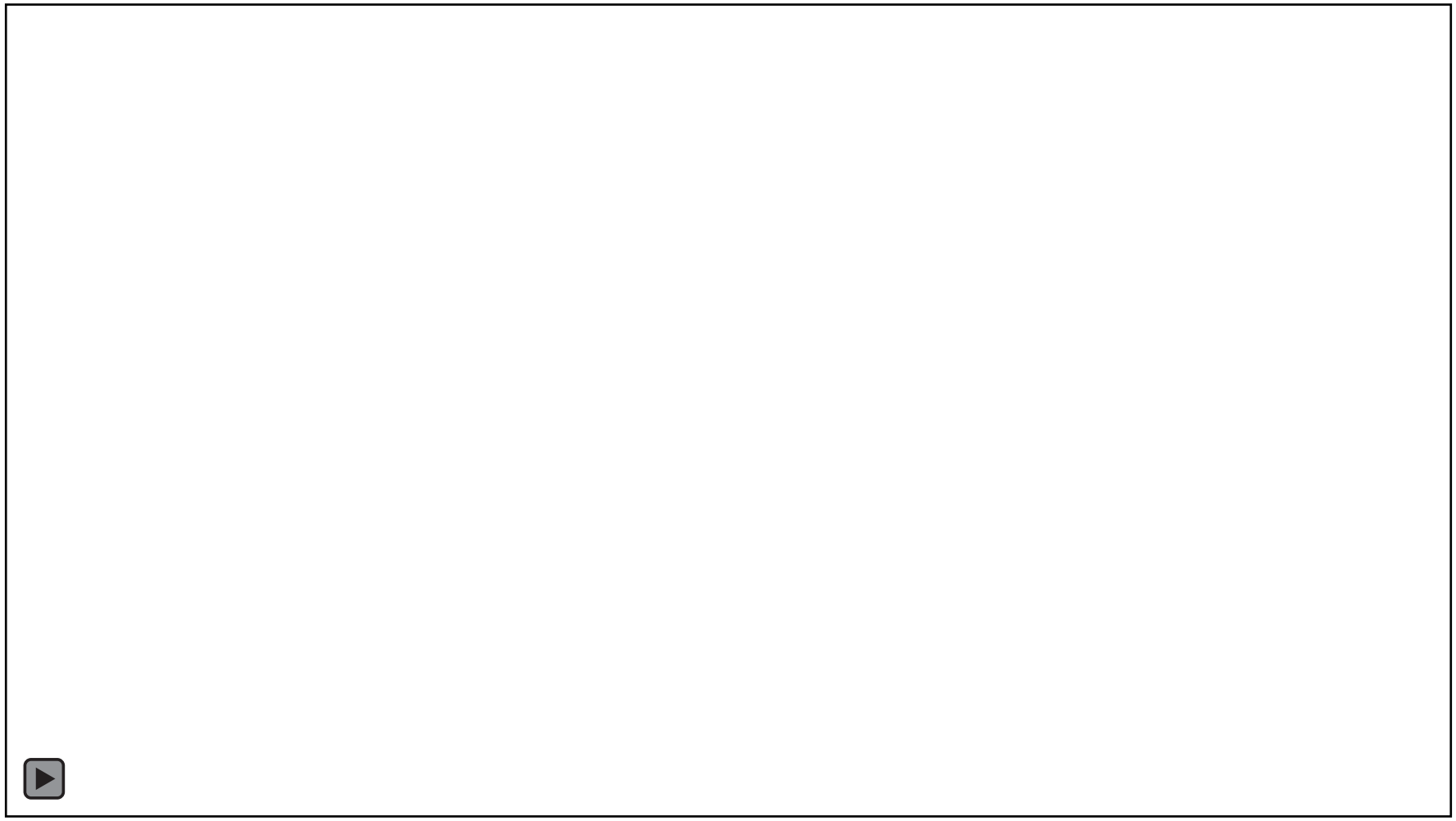
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Preemption – What is it?



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Preemption – What is it?



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Preemption

When to use it?

- Flashing-light signals located **200 feet or less** from an intersection or midblock location controlled by a traffic control signal, a pedestrian hybrid beacon, or an emergency-vehicle hybrid beacon
- **Coordination** with the flashing-light signals, such as using queue detection and queue cutter signals, blankout signs, or other alternatives, considered where a traffic control signal, a pedestrian hybrid beacon, or an emergency-vehicle hybrid beacon is **more than 200 feet** from the grade crossing
- Any highway traffic signal faces installed **within 50 feet** of any rail

- MUTCD 8D.09 -

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Preemption

When to use it?

- ITE Preemption of Traffic Signals Near Railroad Grade Crossings 2nd Edition -

Highway traffic queues are likely to extend across a grade crossing

- Crossing within 200 feet
- Over 200 feet when likelihood of queuing over the tracks exists

Traffic queues from a grade crossing are likely to interfere with a nearby highway traffic signal

- Conflicting left turning vehicles
- Blockage of adjacent intersections during train events
- Mandatory stop vehicles requiring additional time

Circular intersections

- Crossing within 200 feet
- Over 200 feet when likelihood of queuing over the tracks exists

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Preemption – Simultaneous vs. Advance

Simultaneous Preemption

Definition: The notification of approaching rail traffic is forwarded to the highway traffic signal controller unit or assembly and railroad or light rail transit active warning devices **at the same time.**

Advance Preemption

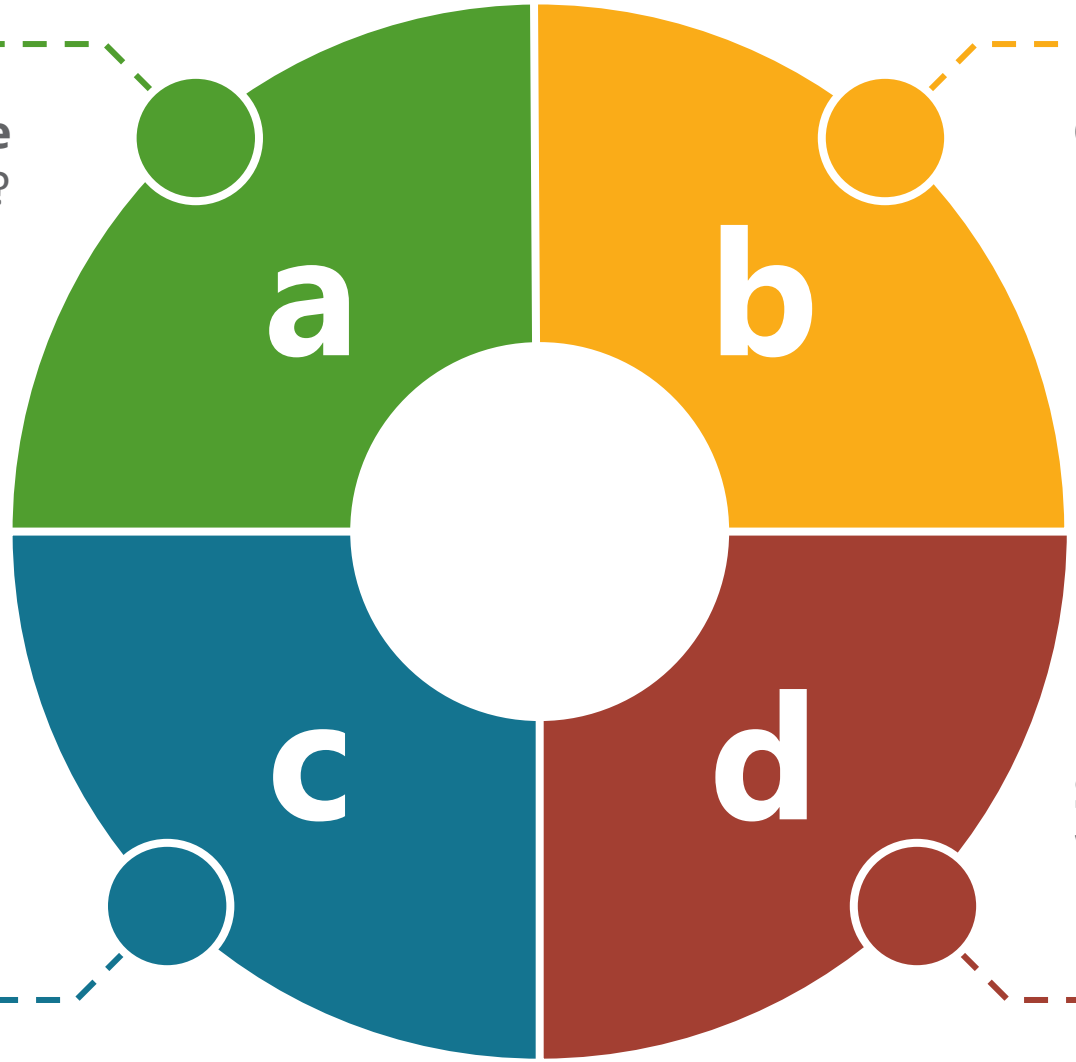
Definition: The notification of approaching rail traffic that is forwarded to the highway traffic signal controller unit or assembly by the railroad or light rail transit equipment **in advance of** the activation of the railroad or light rail transit warning devices.

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Preemption – Simultaneous vs. Advance

Time
Is there a difference in time?

Cost
Does one cost more?



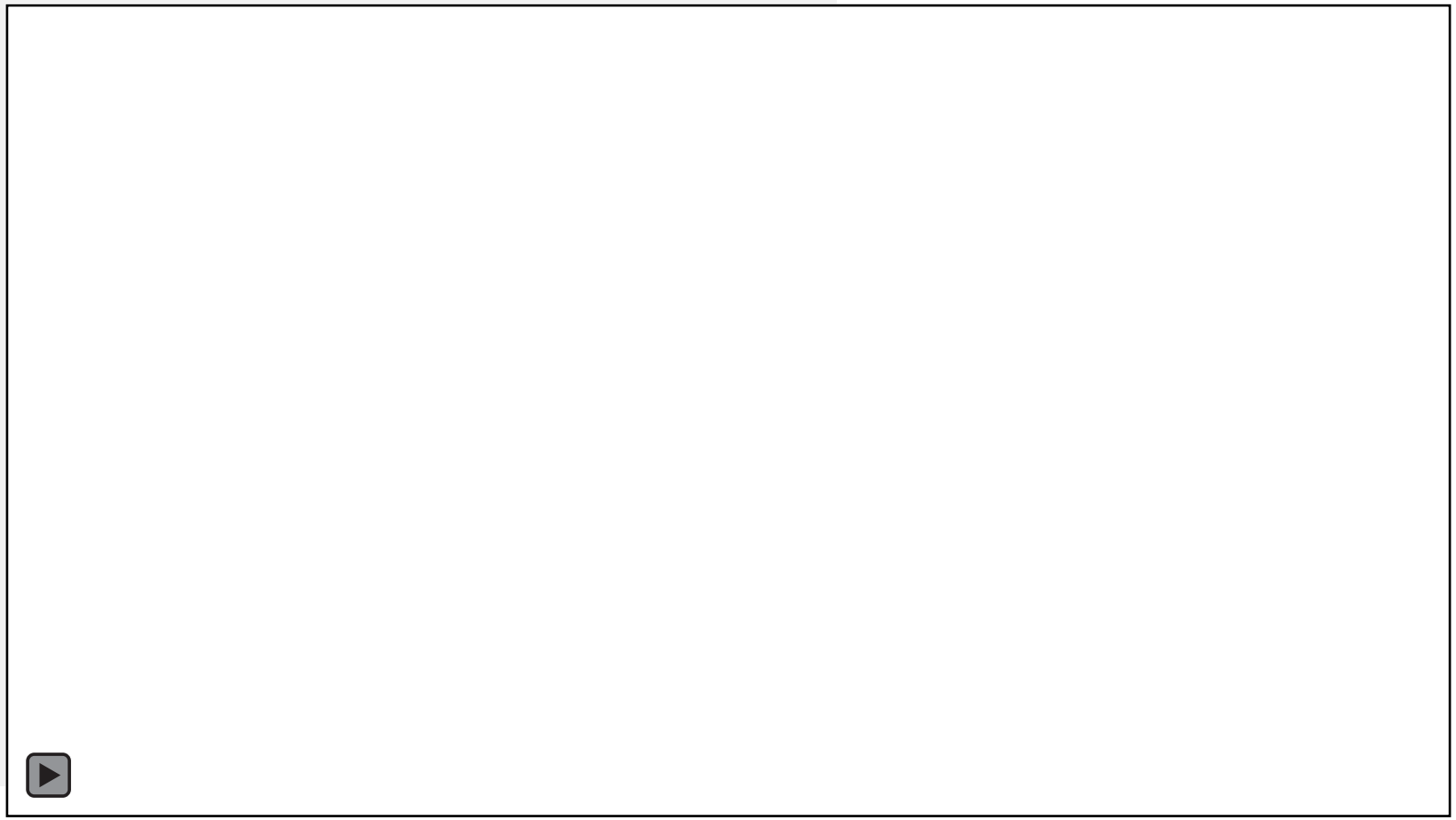
Pros/Cons
Why choose one over the other?

System Solution
What is the correct solution?

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Preemption – Simultaneous (no additional time)



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Preemption

Definition: Maximum Highway Traffic Signal Preemption Time is the maximum amount of time needed following initiation of the preemption sequence for the highway traffic signals to complete the timing of the right-of-way transfer time, queue clearance time, and separation time.

Step 1
Right-of-Way Transfer Time

Time needed to transition the traffic signal to track clearance interval

Step 2
Queue Clearance Time

Amount of time needed for design vehicle to start up and clear through the tracks

Step 3
Separation Time

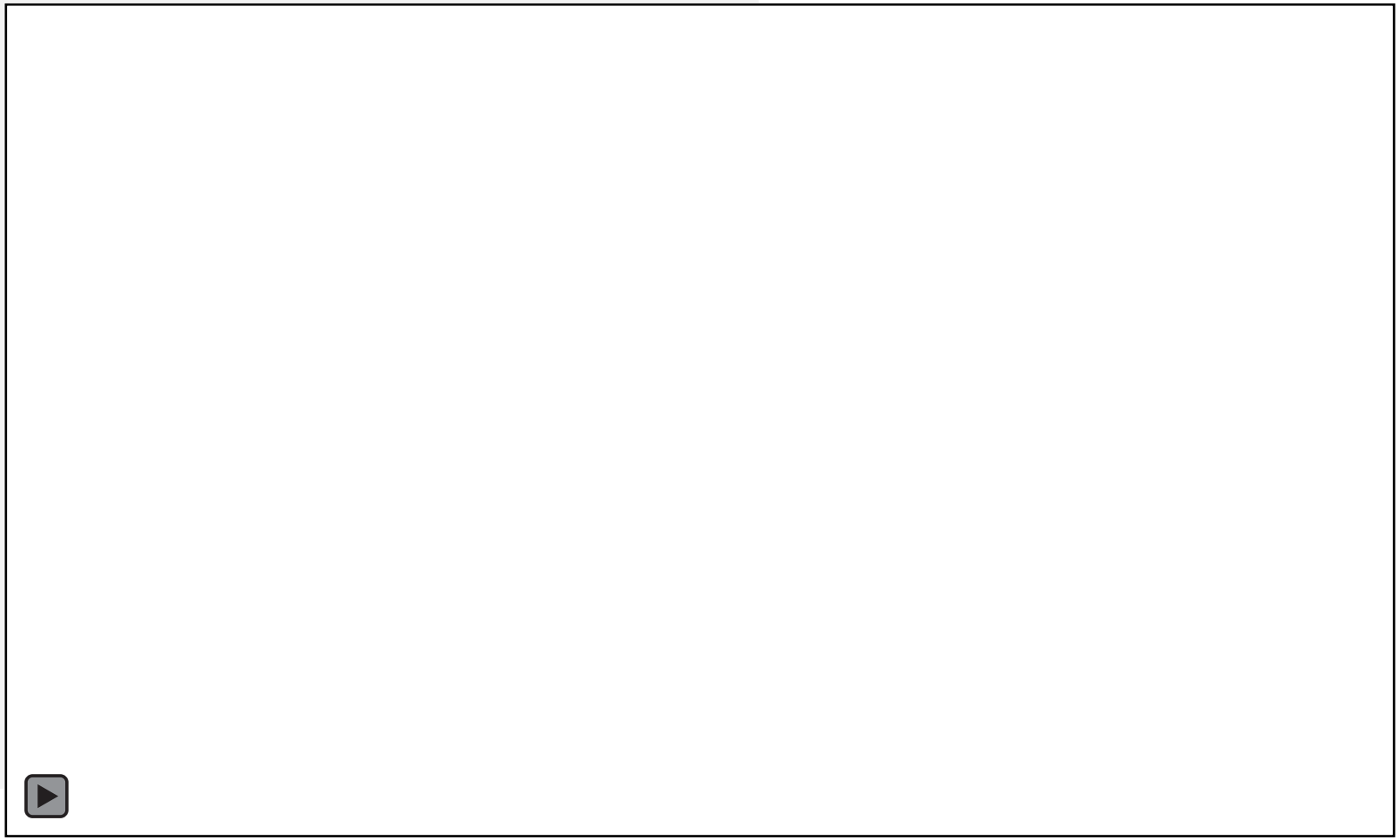
Amount of safety time after the track is clear until train arrival

There are three parameters that must be addressed!

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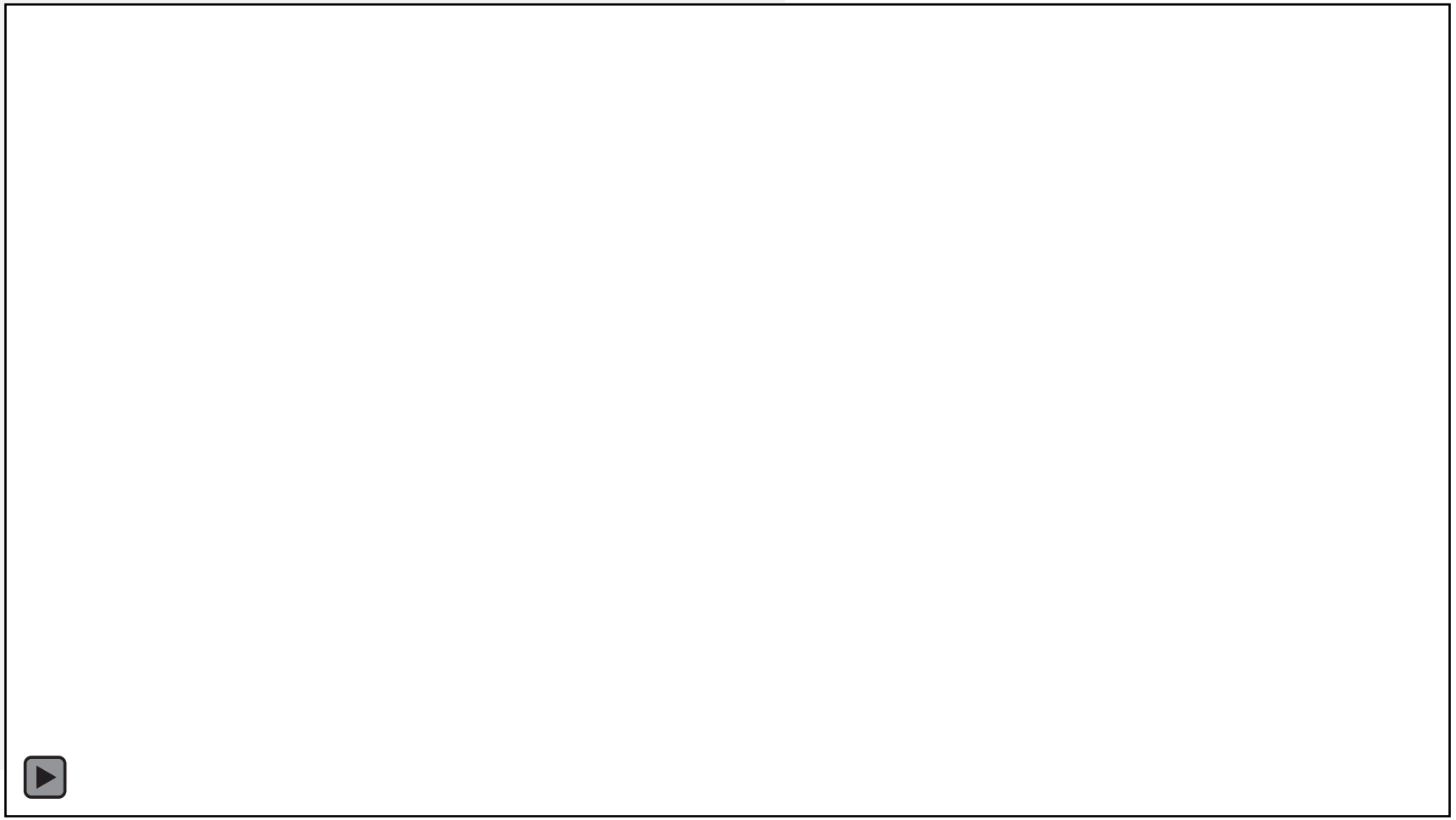
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Preemption – Simultaneous (Proper additional time)



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Preemption – Advance (Proper additional time)



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Preemption

THE TOTAL TIME *REQUIRED* FROM THE RAILROAD IS THE SAME!

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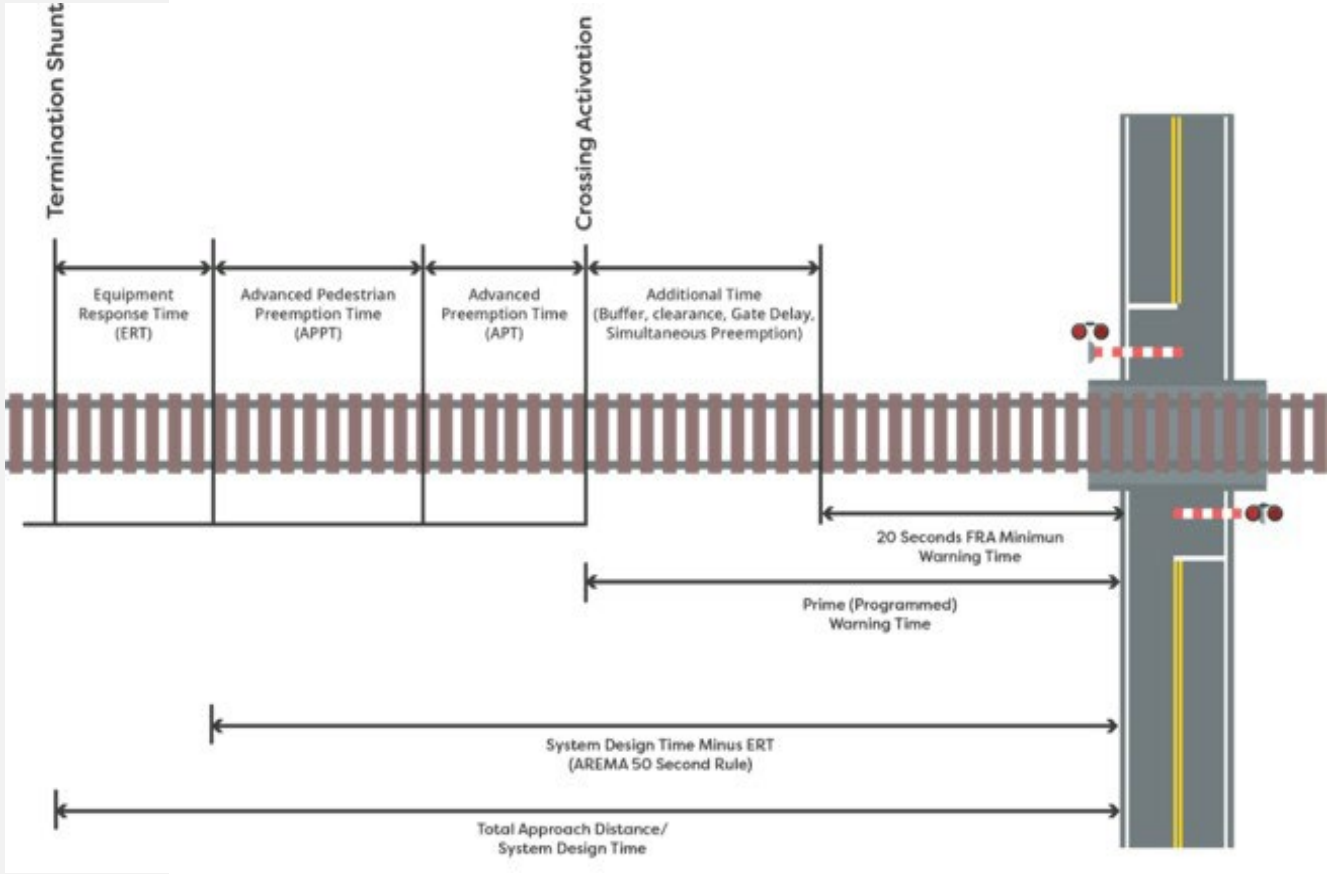
AREMA 50-Second

The “What”

“For grade crossing warning systems interconnected with highway traffic signals, System Design Time minus Equipment Response Time shall not exceed 50 seconds.”

- AREMA C&S Manual Part 3.1.10 Section C -

Most Class 1 Railroads have adopted the AREMA 50 Recommendation as their standard.



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Railroad Equipment Limitations

The “What”



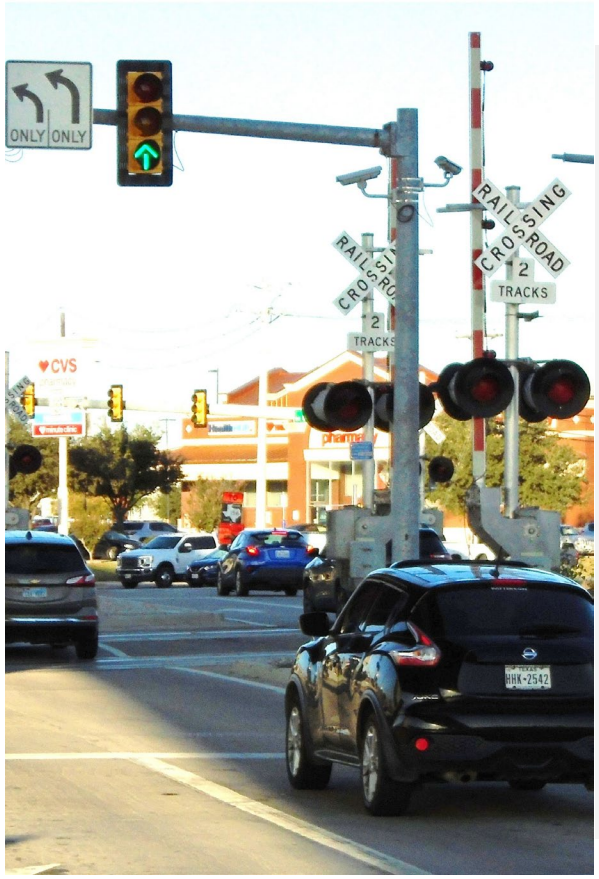
- Per the equipment manufacturers, for time beyond 50 seconds, the constant warning system **does not reliably predict train speed, resulting in longer activation times.**

- Adherence is considered best practice to avoid unnecessary increase in user delays and to ensure the **credibility of the traffic control devices** for users.

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AREMA 50-Second

The “Why”



- Beyond 50 seconds the constant warning system **does not reliably predict train speed resulting in longer activation times**
- Long railroad approaches create **complexities and variabilities** in the railroad warning system
- Adherence is considered best practice to avoid unnecessary increase in user delays and to ensure the **credibility of the traffic control devices** for users
- If site geometrics prevent compliance with the AREMA 50 Second Industry Recommendation, the designer should **notify the diagnostic team to further discuss alternatives to reduce the time request.**

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Queue Mitigation & Prevention

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Queue Mitigation + Prevention Strategies

Queue Prevention	Queue Mitigation
Pre-signal Traffic Signal	DO NOT STOP ON TRACKS (R8-8) Signs
Queue Cutter Traffic Signal	Traffic Signal Progression Along a Corridor
Hybrid Queue Cutter/Pre-signals	KEEP CLEAR Pavement Markings
	Vehicle Detection to Downstream Intersections (PTZ cameras, Loop Detectors, Video/Radar)
	Reducing Cycle Lengths at Downstream Intersections



Queue-Cutter at Chapman Ave (SCRRA), Orange, CA



KEEP CLEAR Pavement Markings at North Street (UPRR), Hollister, CA

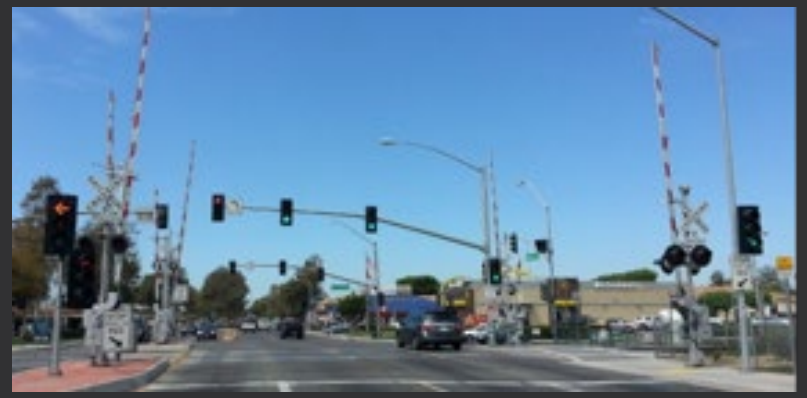
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Queue Prevention Based on CSD

CSD Measurement	Recommended Queue Prevention Strategy	Key Operational Characteristics
< 50/75 ft*	Relocate Stop Line w/ or w/o Pre-Signal	•Relocate stop line to upstream of tracks •At the upper end of distance range, consider providing a pre-signal •Intersection signal timing plan should clear CSD as well as the MTCD
50/75 ft to 200/250 ft*	Pre-Signal	•Pre-Signal operates continuously in coordination with downstream traffic signal; green extension for downstream signal •Timing plan provides queue clearance time sufficient to clear the MTCD by vehicles may remain in CSD
200/250 ft to 450/500 ft*	Hybrid Pre-Signal/ Queue-Cutter	•Hybrid pre-signal operates continuously in coordination with downstream traffic signal; green extension for downstream signal •Timing plan provides queue clearance time sufficient to clear the MTCD but vehicles may remain in CSD •Hybrid pre-signal should have queue detection to extend the duration of the red interval until an adequate downstream gap exists •Queue-cutter signal generally operates independently of downstream traffic signal for queue prevention on crossing in off-peak periods to reduce unnecessary signal cycling
> 450/500 ft*	Queue-Cutter	•Queue-cutter operates when required to prevent queuing in MTCD •Activation and timing plan designed to prevent vehicles from queuing in the MTCD but vehicles may queue in CSD •May eliminate need for preemption of downstream signal
Variable	Coordinated Traffic Signals	•Provided there is adequate CSD and traffic signals are appropriately spaced, signals may be interconnected and operated as a system to move vehicles through grade crossing in manageable platoons such that queuing in the MTCD is avoided; vehicles may queue in CSD
*Based upon length of vehicle used as the basis for design		

- ITE Preemption of Traffic Signals Near Railroad Grade Crossings (2021) -



17th St @ Lincoln Ave, Santa Ana, CA



Queue-Cutter @ Chapman Ave(SCRRA), Orange, CA

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Pre-Signals



17th St at Lincoln Ave, Santa Ana, CA

Definition: Pre-signals are traffic control signal faces that control traffic approaching a grade crossing in conjunction with the traffic control signal faces that control traffic approaching a highway-highway intersection beyond the tracks. Pre-signals can be used to stop vehicular traffic before the railroad crossing.

- FHWA Highway-Rail Crossing Handbook (2019) -

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Pre-Signals

When to use?

- If a grade crossing is located in close proximity to an intersection controlled by a traffic control signal and the clear storage distance is less than the design vehicle length, the use of pre-signals to control traffic approaching the grade crossing in the direction toward the intersection **should be considered**.

- If a grade crossing equipped with flashing-light signals, but without automatic gates, is located within **200 feet** of an intersection controlled by a traffic control signal, a pre-signal **should be provided**.

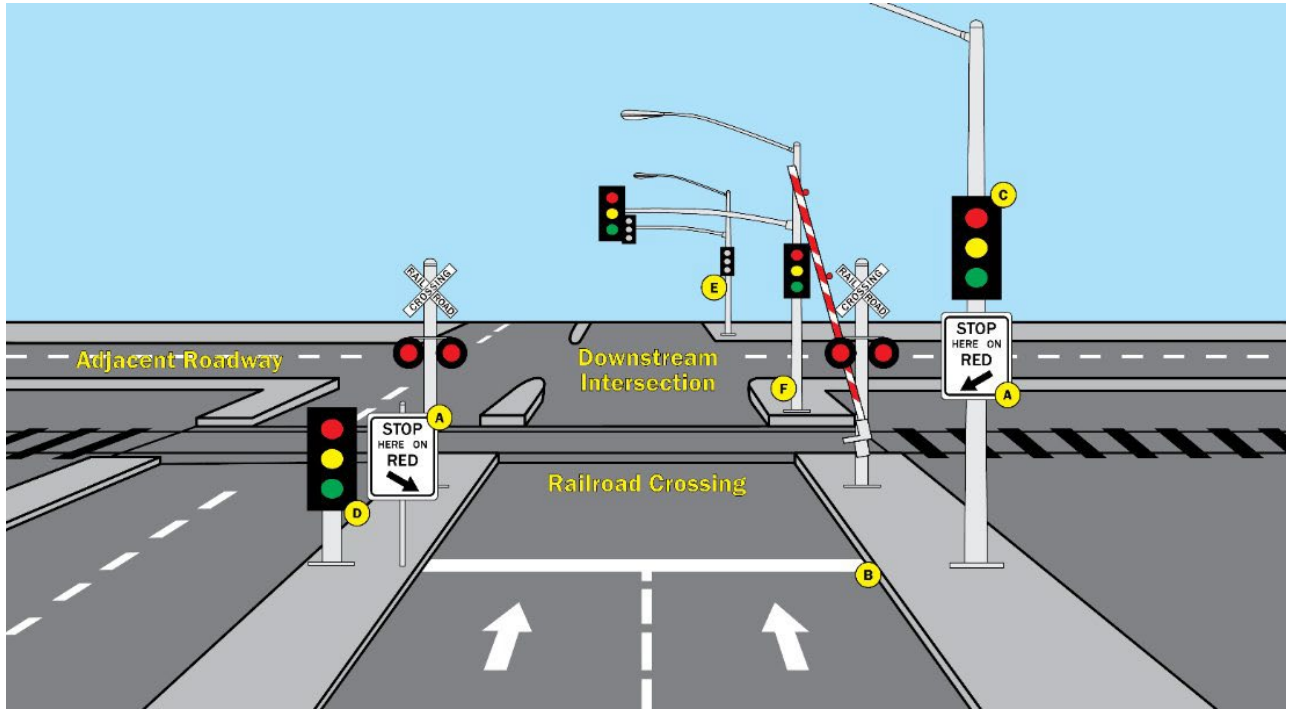
- A pre-signal is generally used **where the grade crossing is located less than 200 feet from a downstream signalized intersection.** Section 8D.12 contains information for grade crossings located 200 feet or more from a downstream signalized intersection.

- MUTCD 8D.11 -

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Pre-Signals

Downstream Placement





R10-11a



R10-11

*R10-11 or R10-11a signs **shall** also be installed at pre-signals per MUTCD 8D.11.*

Pre-Signals – Downstream Placement of Pre-Signal Mast Arm			
A	R10-6 Sign – Signage In-Line with Stop Line Details Where to Stop	D	Placement of Devices is Key for Good Motorist Visibility
B	24" RR Stop Line	E	Intersection Traffic Signal Heads should not be Visible Upstream of RR Warning Equipment
C	Traffic Signal Poles Heads and Roadside Signs need to be Placed to not Block RR Warning Equipment	F	Pre-Signal Mast Arm should be placed Downstream of the Crossing

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Pre-Signals

Upstream Placement

Pre-signal faces may be located either upstream or downstream from the grade crossing in order to provide the most effective display to road users approaching the grade crossing.

- MUTCD 8D.11 -



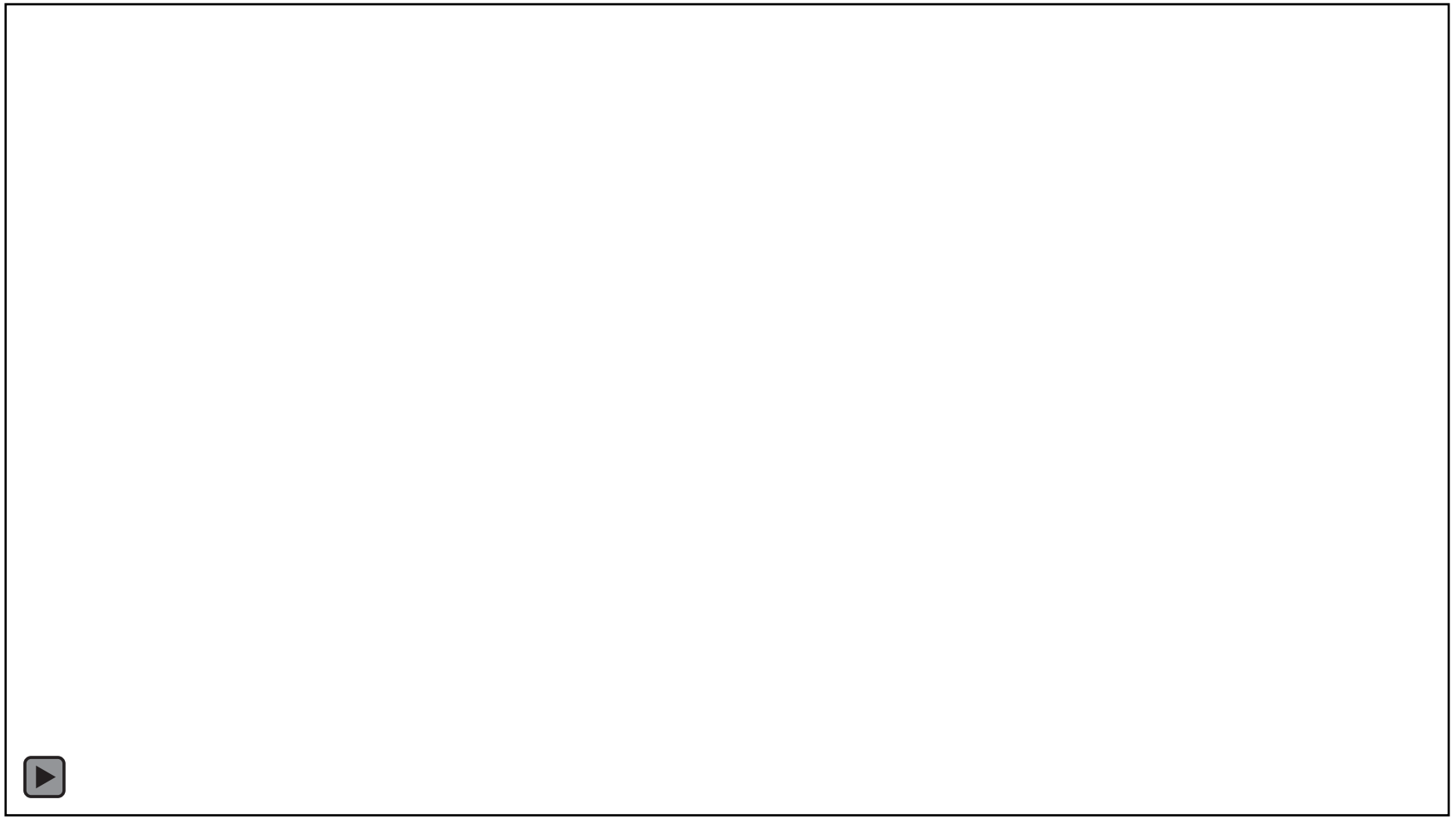
Traffic Signal Mast Arm Pole Installed Upstream of Grade Crossing

RR Stop Line is Placed Further Upstream to Accommodate Visibility of Traffic Signal Heads on Pre-Signal Pole

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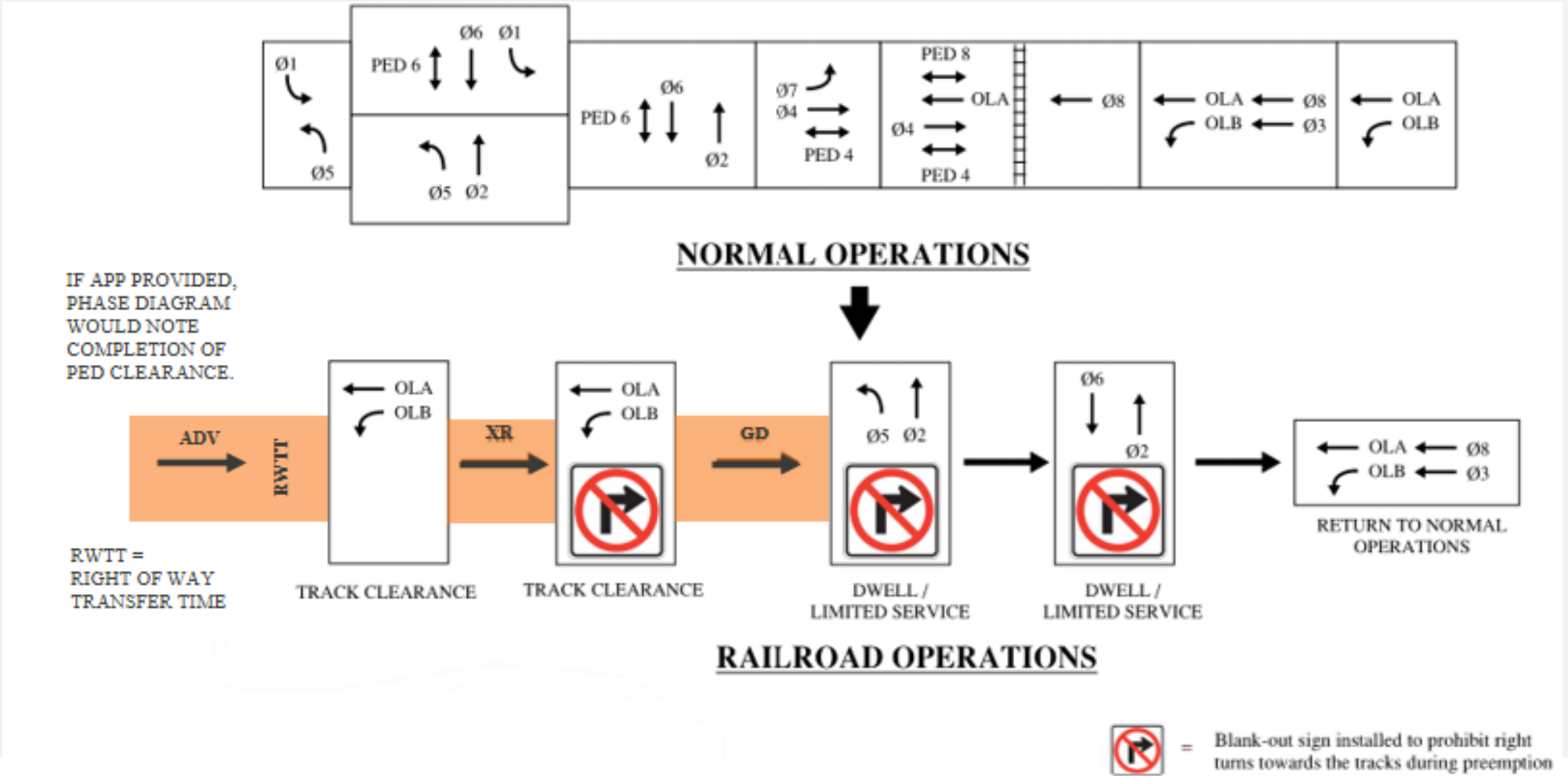
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Pre-Signals



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Pre-Signals – Typical Phasing



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Queue Cutter Signals

A queue cutter signal is a traffic control signal that controls one direction of traffic at a grade crossing to minimize the possibility of vehicles stopping within the minimum track clearance distance (see Section 8A.07). Although a queue cutter signal has a similar purpose as a pre-signal (see Section 8D.11), the difference is that a queue cutter signal is independent from the downstream signalized intersection, whereas a pre-signal is part of the downstream signal.

- MUTCD 8D.12 -



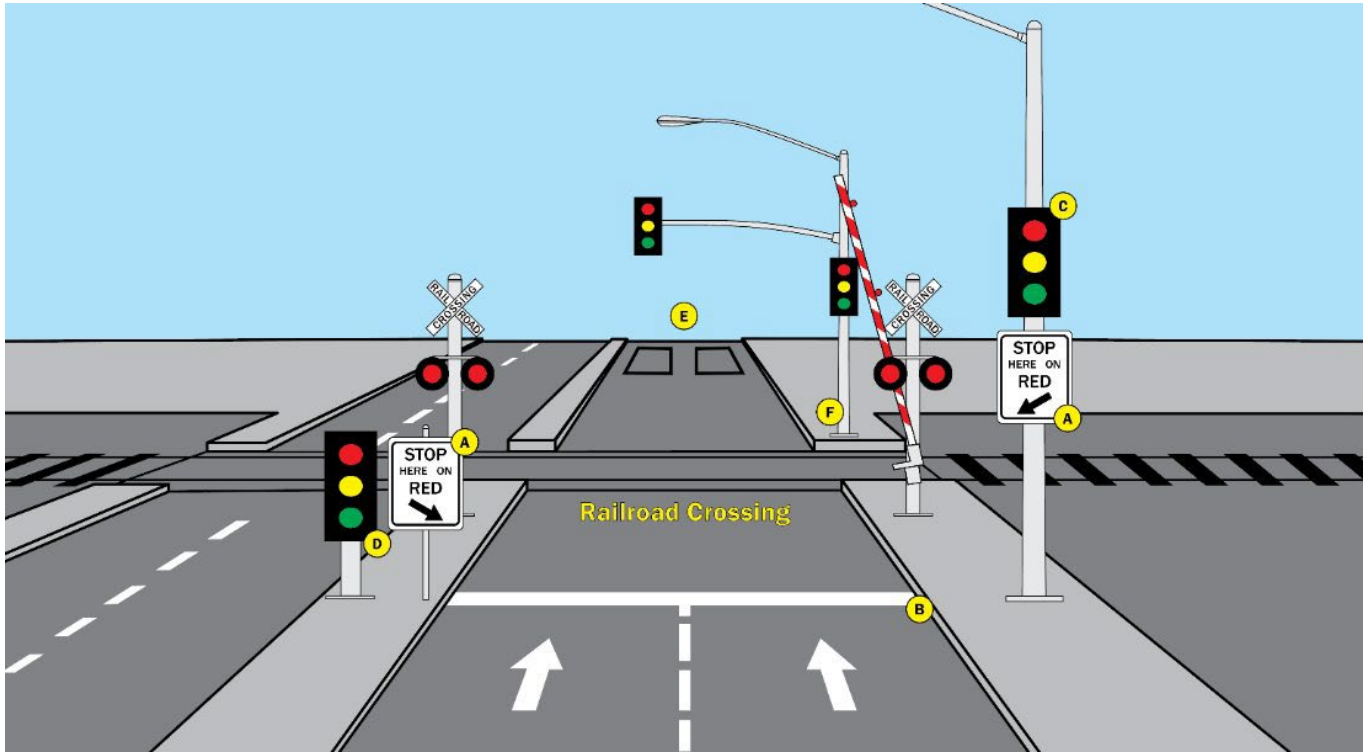
Chapman Ave, Orange, CA

Note: *Operation can be based on downstream vehicle detection, timed operations, or a combination. Downstream detection is no longer the only standard practice.*

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Queue Cutter Signals

Typical Layout

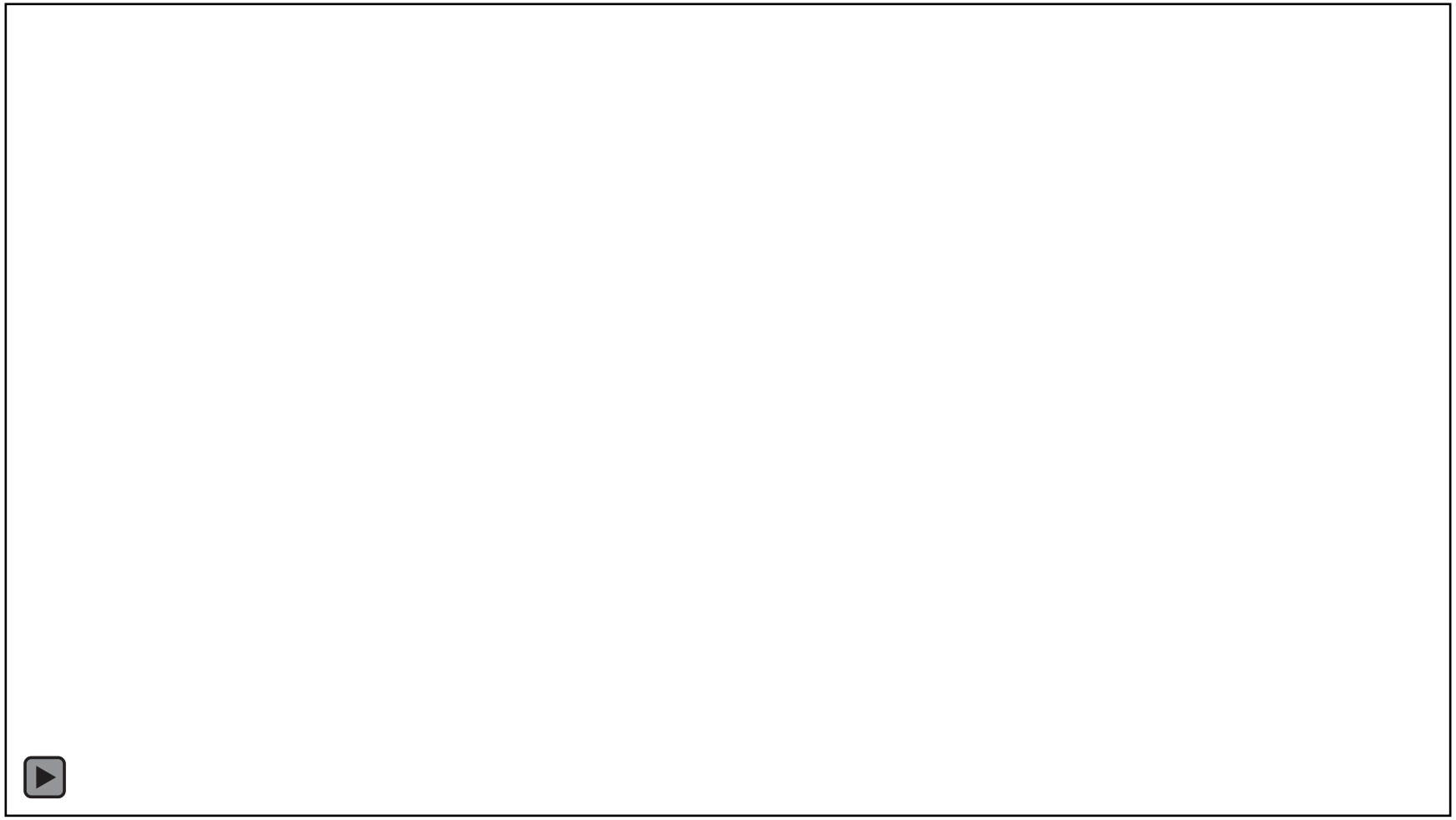


Queue Cutter – Downstream Placement of Queue Cutter Mast Arm	
A	R10-6 Sign – Signage In-Line with Stop Line Details Where to Stop
B	24” RR Stop Line
C	Traffic Signal Poles Heads and Roadside Signs need to be Placed to not Block RR Warning Equipment
D	Placement of Devices is Key for Good Motorist Visibility
E	Downstream Detection Zone
F	Queue Cutter Traffic Signal Mast Arm should be placed Downstream of the Crossing

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Queue Cutter Signals



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Queue Cutter Signals – Typical Phasing

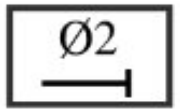
PHASING DIAGRAM

NORMAL OPERATIONS



1. QUEUE CUTTER SIGNAL TO REST IN GREEN UNLESS STOPPED VEHICLES ARE DETECTED AT DOWNSTREAM QUEUE LOOP DETECTORS (Ø2).

RAILROAD OPERATIONS



1. WHEN A RAILROAD PREEMPTION CALL IS RECEIVED, TRANSITION TO ALL-RED.

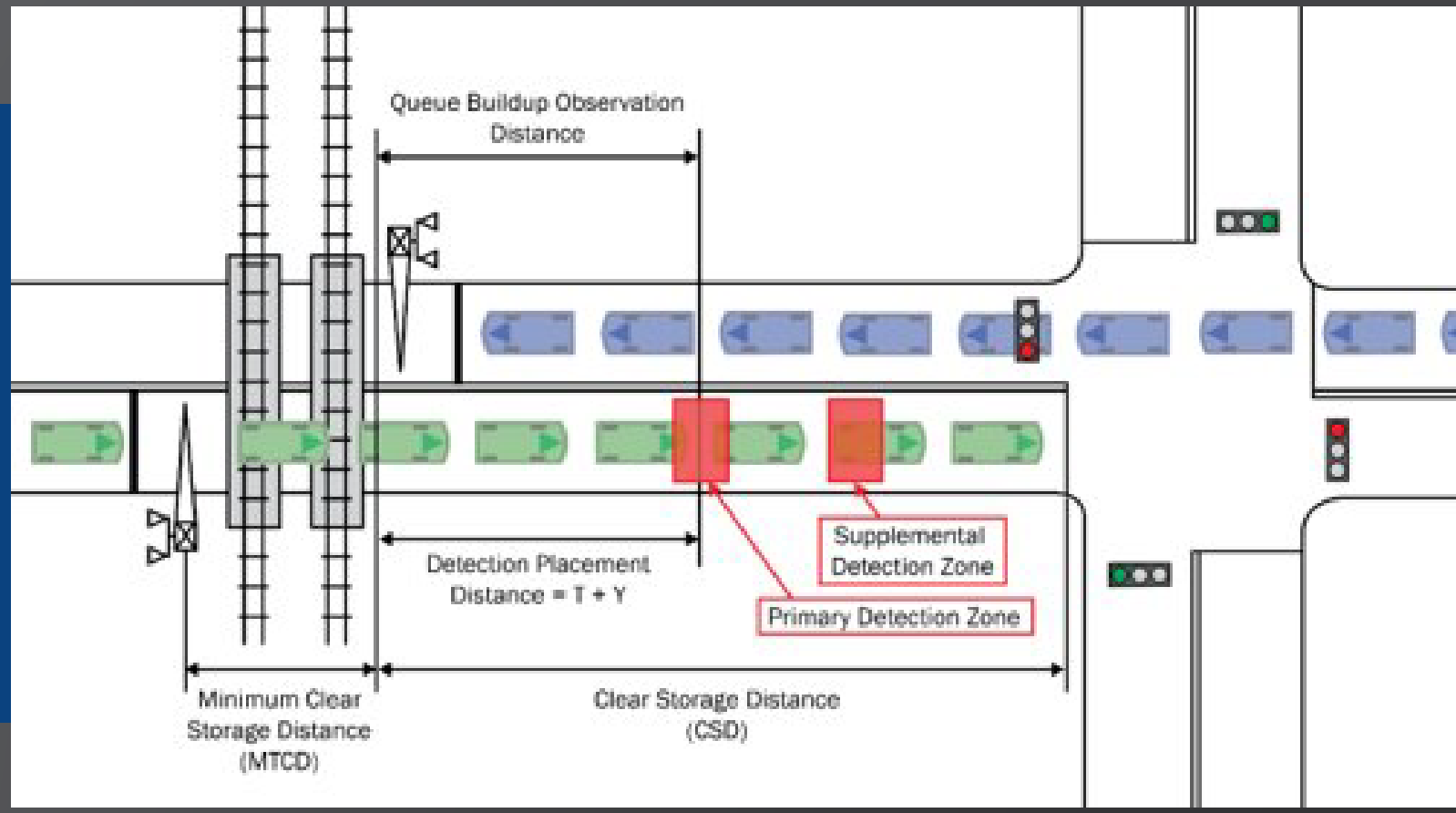
2. RETURN TO NORMAL OPERATIONS AFTER RAILROAD PREEMPTION ENDS.

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Queue Cutter Signals – Detector Placement

Placement of downstream detection is key to effective operation of a queue cutter and is an iterative process.

Placement is based on a distance equal to the time to detect stopped vehicles (T), plus the yellow change interval (Y), based on the 85th percentile speed.



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Next Steps

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Next Steps

Where do we go from here?

Step 1

There is no one, fail-safe answer from any company, organization or agency to stem the tide of train crashes; **everyone owns the problem, and collaboration is the key** to successfully finding and implementing effective, life-saving solutions.

Step 2

Promoting and regulating proper preemption operation and maintenance among state and local road authorities, while no small challenge, is an essential first step in **advancing safety** at railroad crossings.

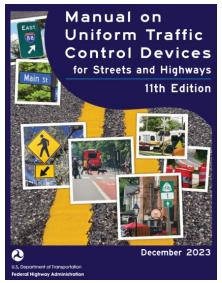
Step 3

Securing broad-based buy-in of the proven effectiveness of **preemption** technology is critical; while preemption is a minute percentage of what takes place in the operation of a traffic signal, **it has the greatest chance of preventing injuries and loss of life when a train approaches**.

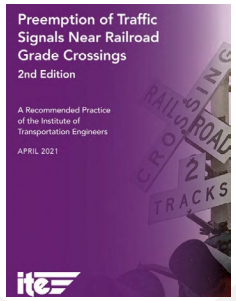
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Want More?!

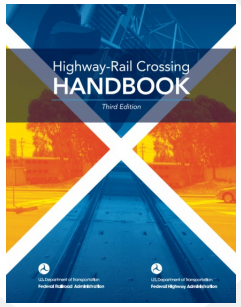
Interconnected Grade Crossings Information Sources



MUTCD
11th Edition
Part 8



ITE Recommended Practice: Preemption of Traffic Signals Near Railroad Grade Crossings



FHWA Highway Rail Grade Crossing Handbook

AREMA
MANUAL FOR RAILWAY ENGINEERING

AREMA Communications and Signals Manual

ite
A Community of Transportation Professionals

ITE Grade Crossing Committee - Webinars, Quick Bites, Website

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Want More?!

ITE Webinar: Traffic Signal Maintenance at Interconnected Grade Crossings

When: May 12, 2026 | 2:00 -- 3:00 PM ET

This webinar is led by the ITE *Railroad Grade Crossing Committee*.

Webinar Description:

Traffic signals that are interconnected with railroad signal systems require careful design, coordination, and ongoing maintenance to ensure safe and reliable operation for both roadway users and rail traffic. This webinar will provide an overview of railroad (RR) interconnections and highlight the critical role that proper traffic signal maintenance plays at these locations.

Participants will explore real-world case studies and learn design best practices for implementing and maintaining these complex systems. The session will also cover key operational considerations, including recommended monthly maintenance activities, annual joint testing with railroads, and the impacts of traffic signal timing, controller, and software changes on railroad interconnections. Attendees will gain practical insights to help ensure continued safety, compliance, and effective coordination between roadway and rail signal systems.

Learning Objectives:

- Interpret the critical nature of maintaining and testing an interconnected traffic signal as part of a larger system.
- Define when proposed modifications to traffic signal systems need to be coordinated with railroads and why.
- Describe what elements need to be included in design plans to insure a healthy combined system for years to come.

Fees:

ITE Members: Free

Non-Members: $79.00

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Thank you

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QUESTIONS?

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