



# Dynamic Gate Operations with Vehicle Detection at 4-Quadrant Gated Highway-Rail Grade Crossings

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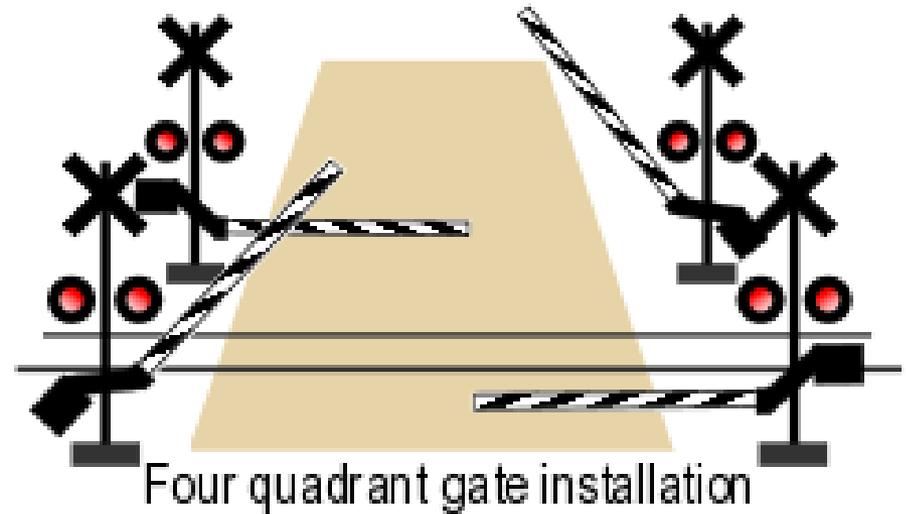
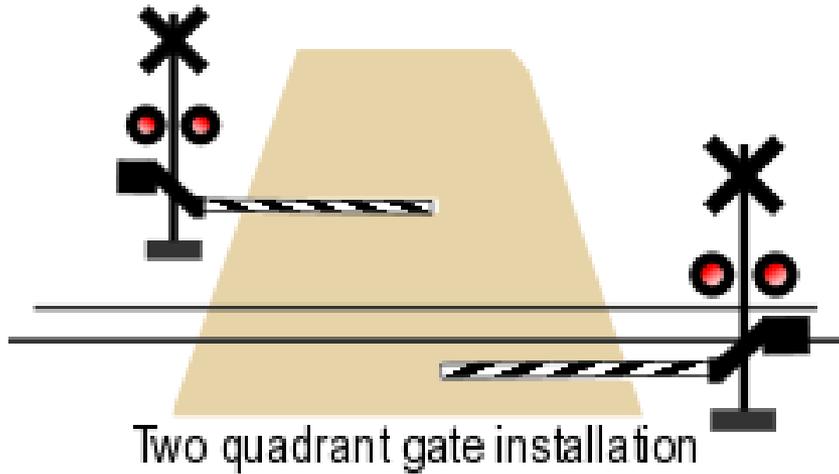
# Basic Concepts



# Three Distinct Systems

- Highway-Rail Grade Crossing System - train detection and crossing signals (gates, bells, and flashing lights).
- Traffic Signal System - traffic detection and traffic signals (pedestrian and vehicle heads).
- Radar System - traffic detection.

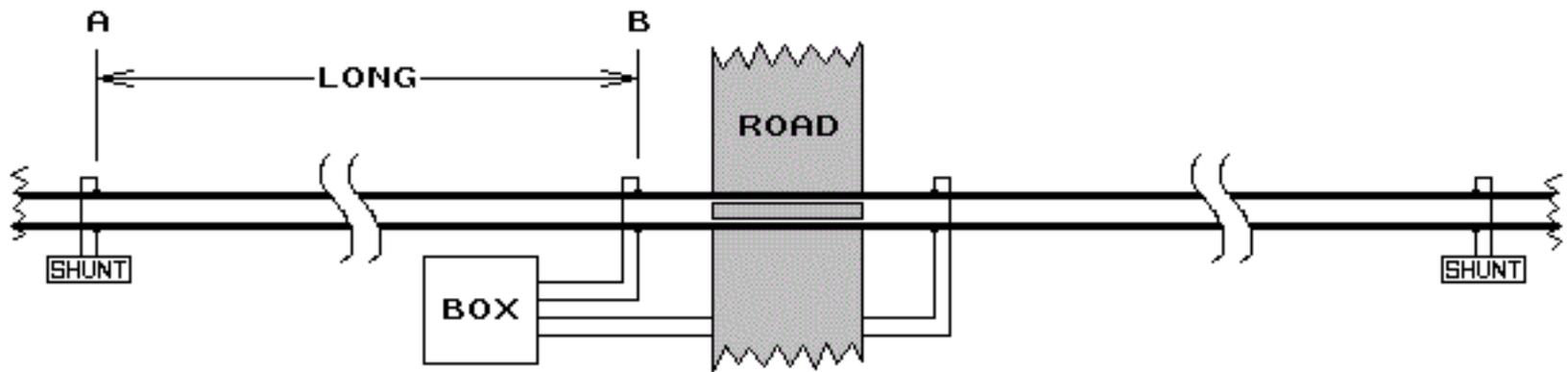
# 4-Quadrant Gated Highway-Rail Crossing



# Typical Crossing Train Detection

## Highway-Railroad At-Grade Crossing Approaches

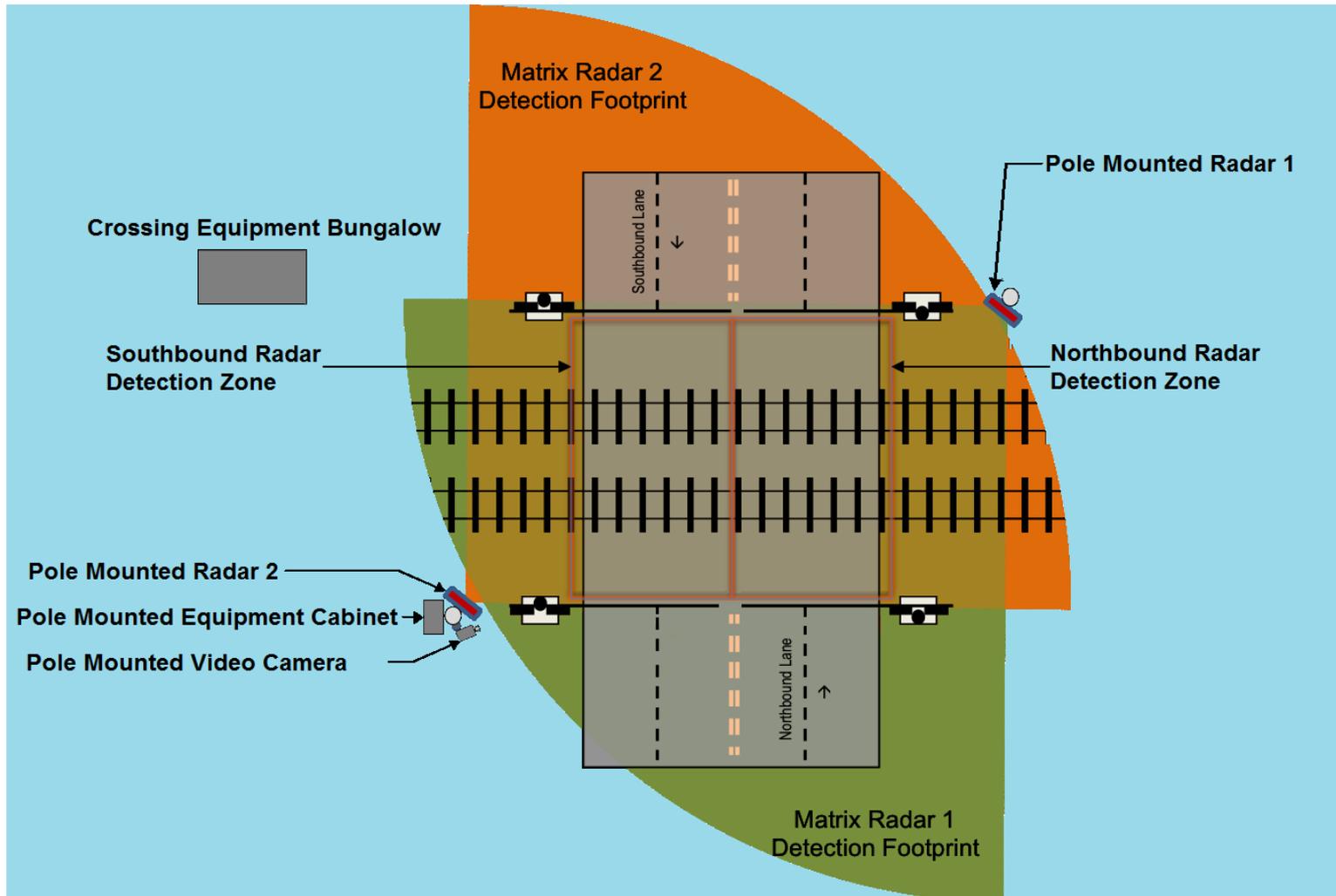
Direction of Train →



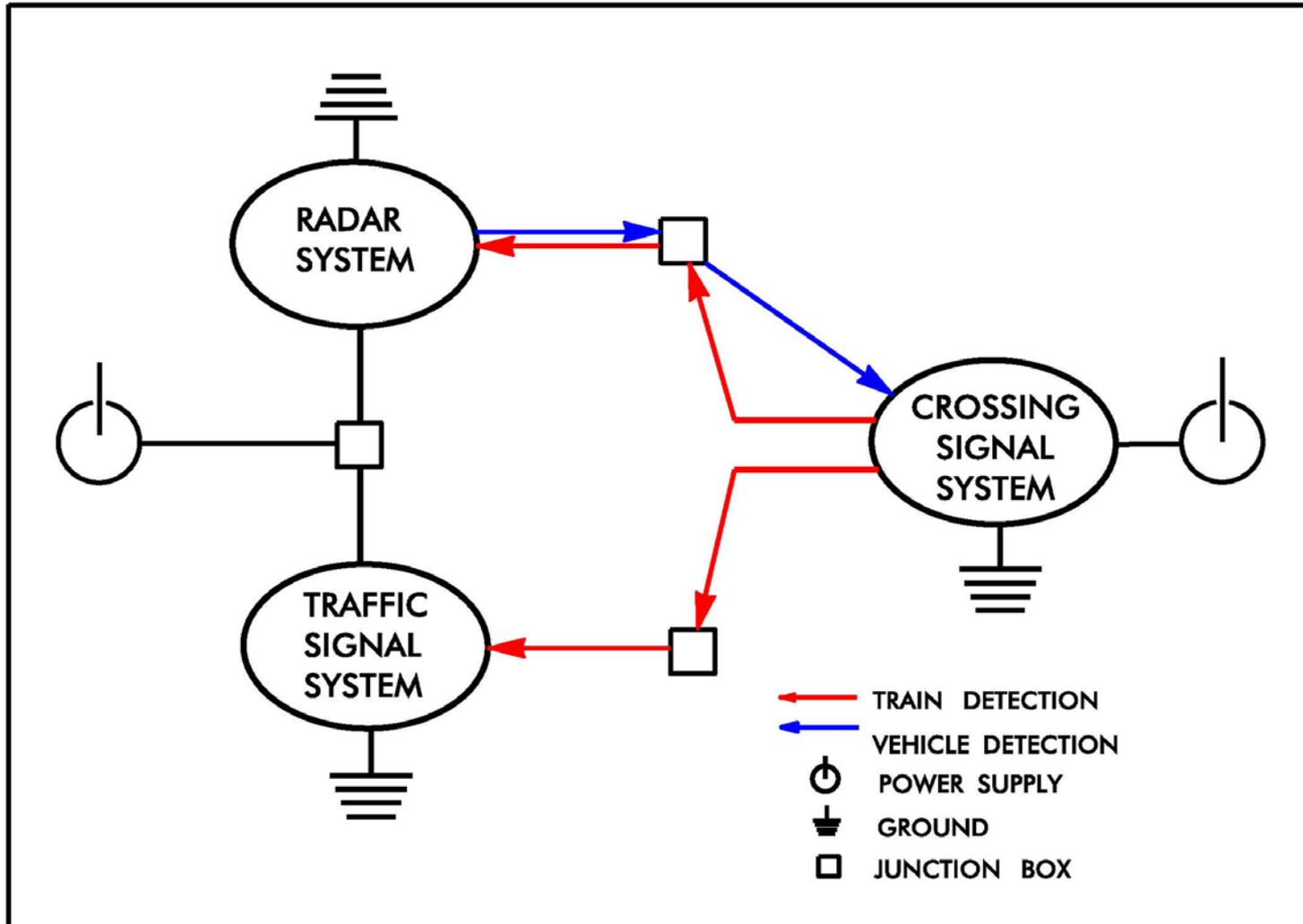
**Distance A to B - Approach distances (based on maximum allowable train speed.  
Distance B to Road - 50 Feet (island circuit).**



# Radar System



# System Communications



# Event Recording

Video cameras provide:

- Continuous real-time feed
- Train activated clips



**Example: Vehicle detected in Zone 2, and a train on the approach circuit**

# Dynamic Gate Operations with Vehicle Detection



# NCDOT Mission Statement

Connecting people and places in North Carolina – safely and efficiently, with accountability and environmental sensitivity.

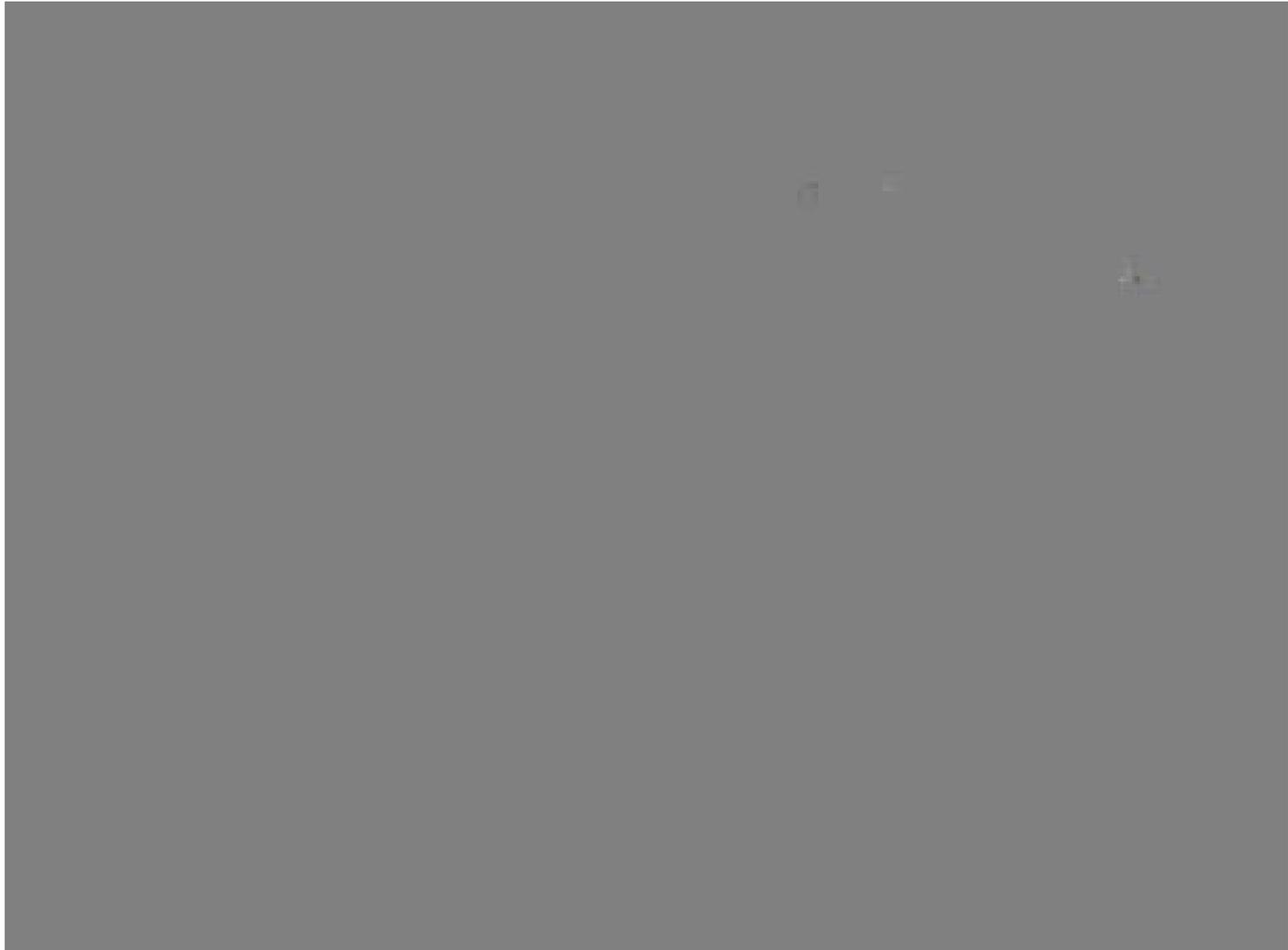
## Safely

- Near Simultaneous Gate Descent – stronger deterrent to gate running due to visual and physical impacts.
- Delay of Exit Gate Descent – gives vehicles between entry and exit gates a clearly defined optional route off the crossing.

## Efficiently

- Improved Rail Operational Speeds – Decreased potential locomotive engineer may need to slow down to let exit gate become fully deployed (as per Norfolk-Southern rules).
- Improved Vehicular Travel Time – Decreased potential of delays to motorists and communities due to vehicular-train collisions.

# Gate Violations Continue



# Project Objective

## Implement dynamic gate decent

- Currently, no vehicle detection is provided and exit gate descent is a pre-timed offset interval.
- Evaluate vehicle detection accuracy and reliability as well as operational safety enhancements.
- With vehicle detection, exit gate and entry gate will descent nearly simultaneously unless a vehicle is detected in the crossing area.
- If a vehicle is detected in the crossing area, delay descent of the exit gate to allow clear path off the crossing.
- In the event the system fails, revert to the pre-timed operation.



# Pre-timed versus Dynamic Gate Descent

Z1 Z2 Z3 Z4 XR IR H1 H2



Timed Exit Gate Operating Mode

Williamson Ave., Elon, NC DOT#722995V 226kbs 2014-05-29 11:58:37

Z1 Z2 Z3 Z4 XR IR H1 H2



Dynamic Exit Gate Operating Mode

Williamson Ave., Elon, NC DOT#722995V 199kbs 2014-05-29 17:50:24

The Z1 and Z2 zone indicators show the radar system detecting vehicles in lanes over the crossing. The H1 and H2 indicators show radar health status.



# Why Dual Matrix Radar System?

- **Provides out-of-street detection.**
  - ❑ Impact to / from track and surface work will be minimal.
  - ❑ Pavement surface quality will not impact reliability.
  - ❑ Roadway pavement shifting will not cause a failure.
- **Provides redundancy.**
  - ❑ Two radar units continuously check inputs for consistency between the units.
- **Tested technology.**
  - ❑ Eliminates potential inductive loop failures.
  - ❑ Detection is not impacted by environmental and weather conditions like video-type detection.

# Locations

## NOW OPERATIONAL

- DOT#735472D - NC119 (Fifth Street) in Mebane, Alamance County.
- DOT#722995V - SR1301 (Williamson Avenue) in Elon, Alamance County.
- DOT#735236Y – SR 1954 (Ellis Road) in Durham, Durham County.

## PROPOSED CALENDAR YEAR 2015 / 2016 BUILD

- DOT#735469V - SR 1692 (Third Street) in Mebane, Alamance County.
- DOT#722997J - SR 1323 (Oak Avenue) in Elon, Alamance County.
- DOT#724404W - SR 1706 (East 1st Street) in Kannapolis, Cabarrus County.
- DOT#724410A - SR 1530 (Elmira Street) in Burlington, Alamance County.

# Engineering and Construction



# Agreement

## **Agreement required with the operating railroad for installation of the radar systems**

- Agreement is between Norfolk-Southern Railway Company (NSRC) and the North Carolina Department of Transportation
- Agreement allows for the use of vehicle detection systems along NSRC controlled trackage in North Carolina.
- NCDOT to maintain the vehicle detection system at no expense to NSRC.
- NCDOT to repair the vehicle detection system at no expense to NSRC.
- NCDOT retains the right to remove the vehicle detection system at its discretion.
- In the event of system failure, gates to revert to pre-timed descent.

# Preliminary Engineering

- Two matrix radar units installed at each crossing.
- Each radar unit contains 16 individual radars – this is “the matrix.”
- Radars arrayed to provide 90-degree arc.
- Positioned at a height of approximately 20 feet.
- Provides redundancy with at least two radars detecting every square foot of crossing area – this is “the duality.”
- Power supplied via 15 amp circuit in traffic signal breaker box.



Radar-based vehicle detection  
at crossings

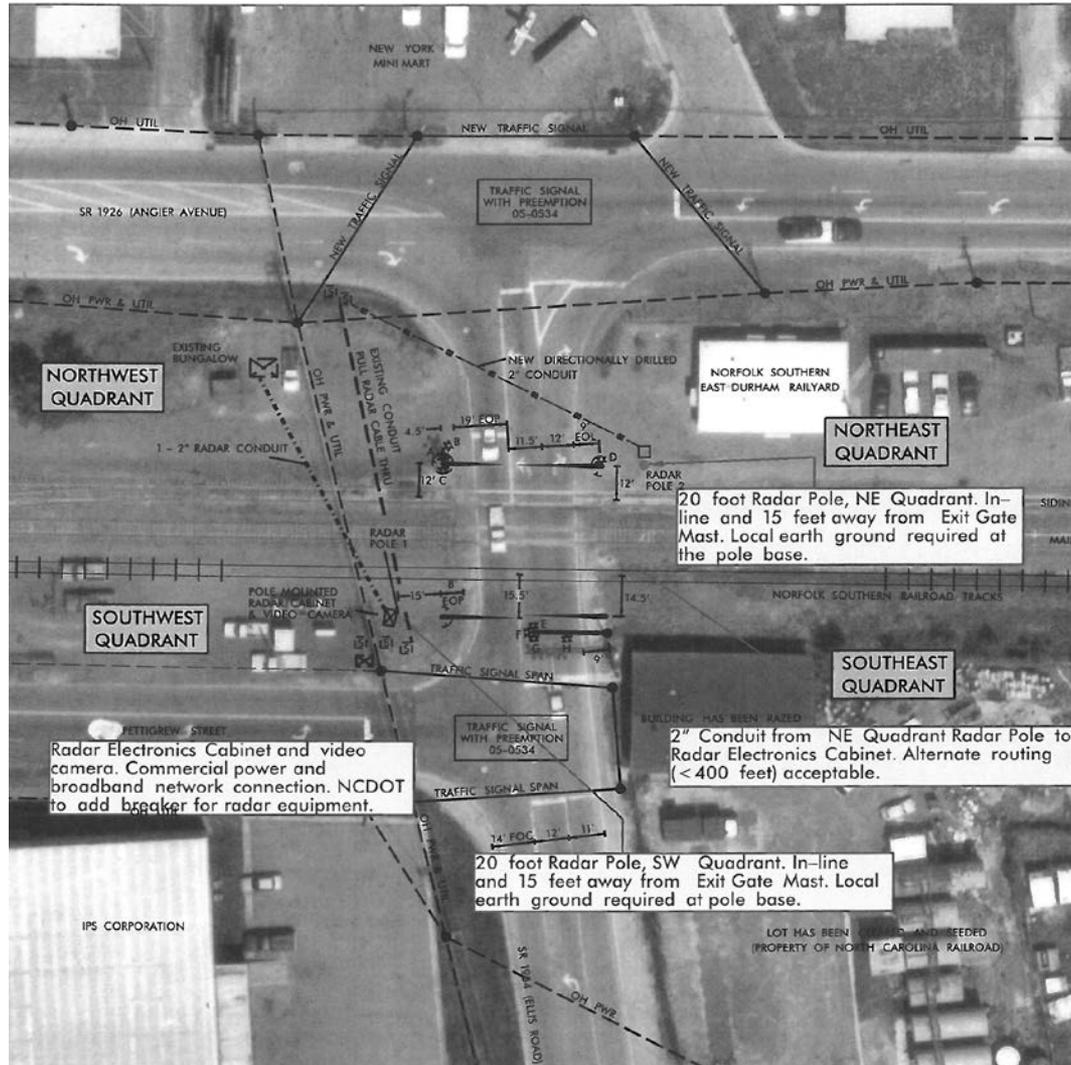
# Rail Versus Traffic Applications

- Coverage – Rail uses 16 horizontal arrayed radar elements, traffic uses 1 to 2 elements.
- Reliability – Rail uses multiple radar units for 100% redundancy
- Fail Safe State – Rail uses an open contact to trigger failsafe condition, traffic uses a closed contact.
- Detection Algorithms – Rail detects vehicles regardless of position and direction of travel, traffic filters out travel in reverse direction.
- Detection Capability – Rail detects moving and stationary vehicles, traffic detects moving vehicles.
- Radar Position Sensing (\*New Feature\*) – Internal sensor verify radar unit has not changed positions.



Radar-based vehicle detection  
at crossings

# Preliminary Engineering



# Construction



# Construction



# Implementation (Programming of Detection Zones)



# Implementation (Testing of System Operations)



# Results



# ITRE Research

- Research conducted by NCSU – ITRE (Institute for Transportation Research and Education)
- Passive Phase – Radar was operational but gate behavior remained pre-timed.
- Active Phase – Radar was operational and dynamic gate operation implemented.
- Video recordings reviewed and data collected for all train activations.
- Data collected for three months for each phase.
- Observed about 1,600 “Passive Phase” activations and about 2,600 “Active Phase” activations.



# ITRE Research (System Functionality)

Representative sample size – 477 activations.

Crossing Location	Successful Detection	Missed Detection	False Detection	Phantom Detection	Rain or Snow Detection	Adjacent Lane Detection	Critical Failures
Durham	125	0	3	0	0	0	0
Elon	166	0	1	0	1	1	0
Mebane	179	0	3	0	0	2	0
<b>Total</b>	<b>470</b>	<b>0</b>	<b>7</b>	<b>0</b>	<b>1</b>	<b>3</b>	<b>0</b>
% of Total (477)	98.5%	0.0%	1.5%	0.0%	0.2%	0.6%	0.0%

- Seven false detections (includes 1 rain / snow detection) – radar sensitivity and alignment adjusted. Issues resolved during the passive phase.
- Three adjacent lane detections – found to be due to vehicles turning and passing through both zones.

# ITRE Research (Driver Behavior)

Violation – a vehicle enters the crossing after the start down of the entrance gate.

Crossing Location	Number of Activations		Number of Violating Vehicles		Percent Violations	
	Passive	Active	Passive	Active	Passive	Active
Durham	391	363	56	40	14%	11%
Elon	555	683	114	136	21%	20%
Mebane	577	651	263	329	46%	51%
Total	1523	1697	433	505	28%	30%

- About 30% of violations observed during both, the passive and the active phases.
- However, violations during active phase were concentrated earlier in the preemption cycle.

# Conclusions



- Radar detection was found to be at least as efficient at detecting vehicles as inductive loops.
- Though no change in percentage of crossing violations between passive and active phases, violations during the active phase were concentrated earlier in the preemption cycle versus later in the cycle as the train got closer to the crossing.
- Dynamic gate descent sealed rail corridor from violations 15 to 20 seconds prior to train arrival; versus 4 to 6 seconds with pre-timed descent.
- Vehicles in the crossing during preemption have a clearly defined path and opportunity to exit the crossing.



Thank You!!

For Additional Information Concerning this  
Presentation.

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