National Hump Crossing Database: The Latest

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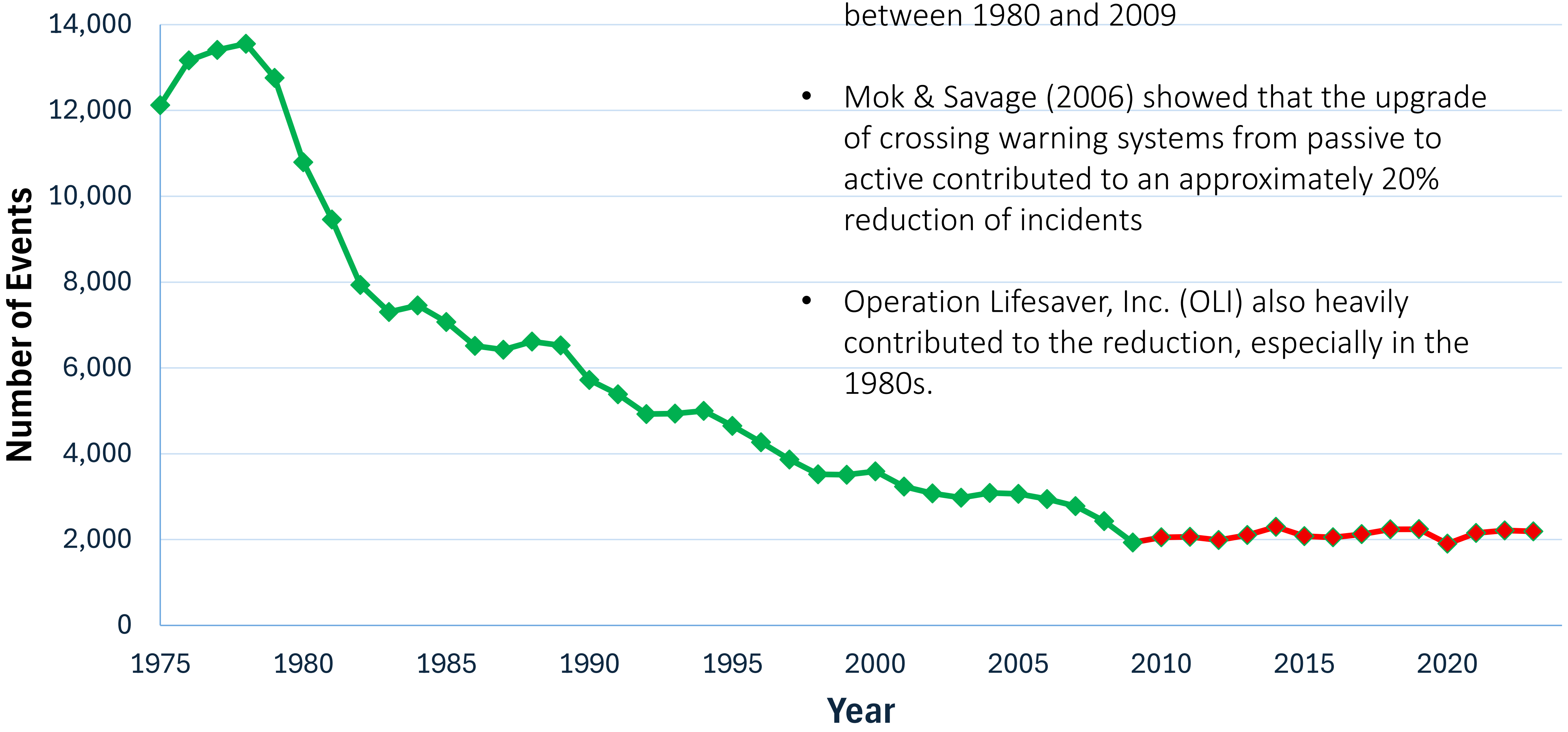
U.S. Department of Transportation
Federal Railroad Administration

Current Progress on Research

Presenter Name, Title
Program Office

After a 30-Year Decline Incidents Are Again Rising

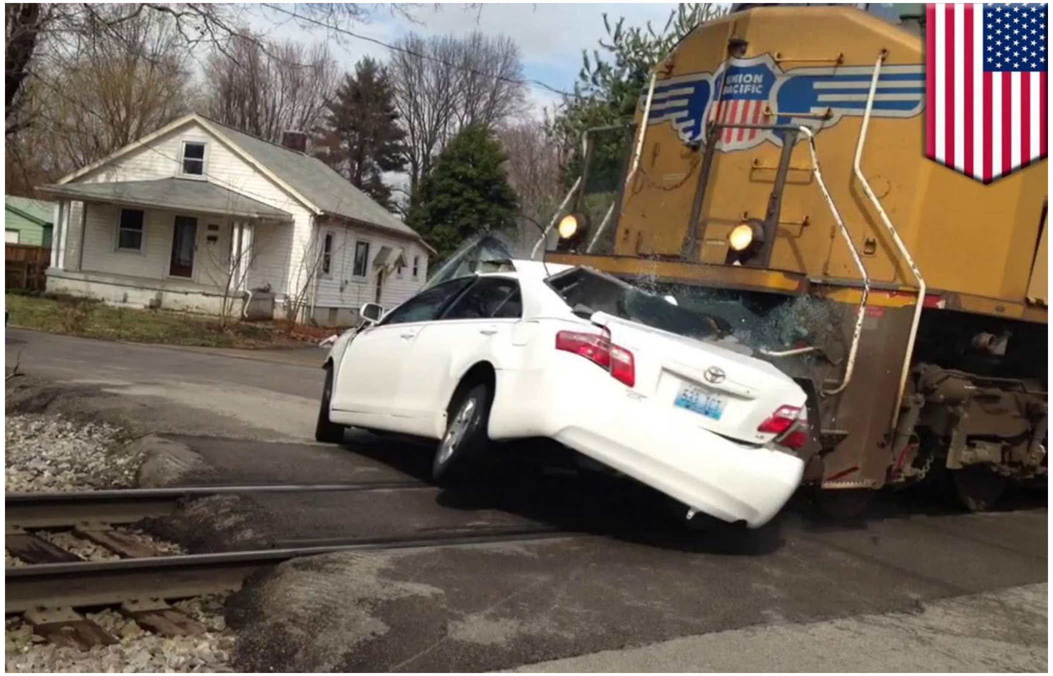


- There was a six-fold reduction in incidents between 1980 and 2009
- Mok & Savage (2006) showed that the upgrade of crossing warning systems from passive to active contributed to an approximately 20% reduction of incidents
- Operation Lifesaver, Inc. (OLI) also heavily contributed to the reduction, especially in the 1980s.

Grade Crossing Collision Types

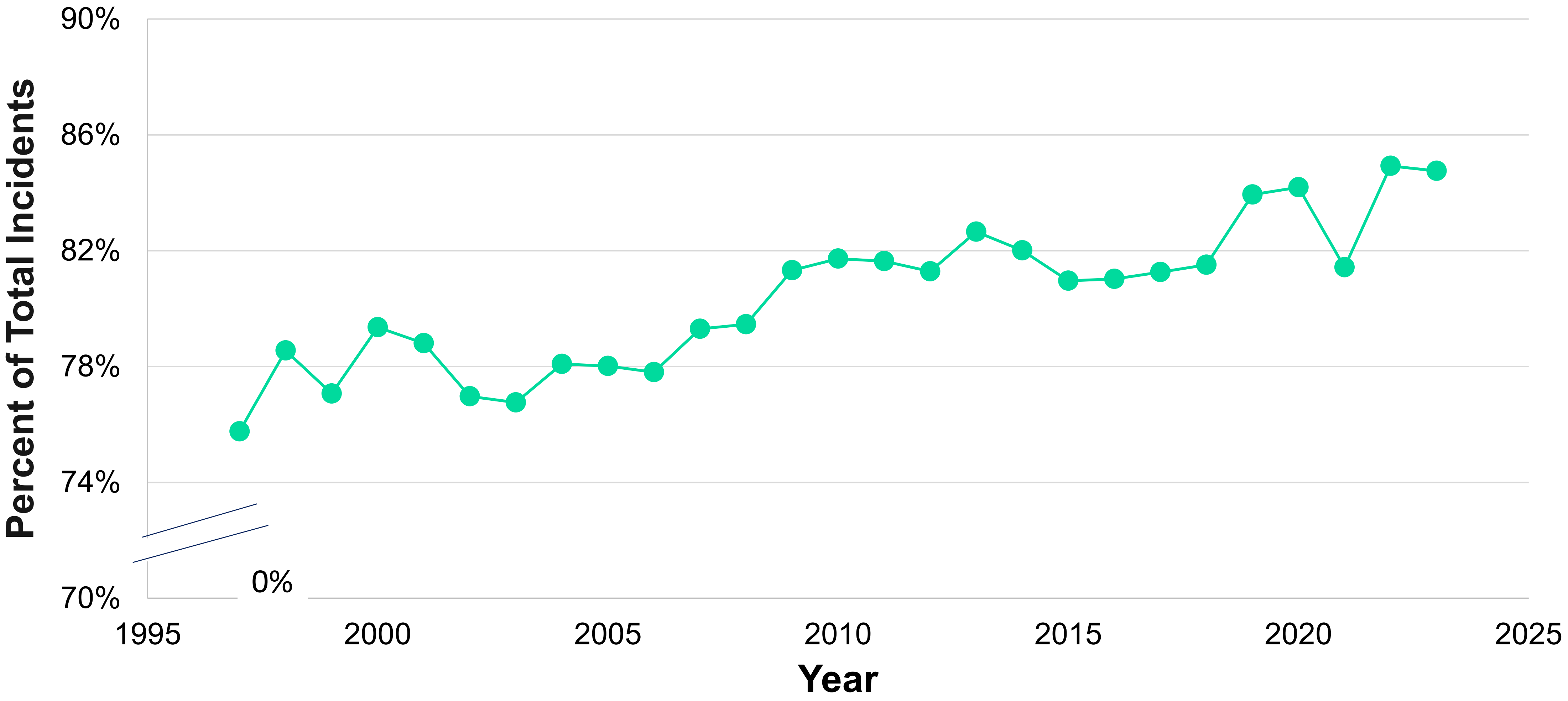
Two types of grade crossing collisions

Train strikes vehicle (TSV)



Vehicle strikes train (VST)

Percentage of TSV Incidents Increased 10% From 1995 to 2023



Research Motivations

- The percentage of TSV incidents has increased over the past two decades
- TSV incidents can occur when a vehicle's underbody comes into contact with the crossing surface causing it to become lodged and unable to continue to clear the crossing (vehicle hang-up)
- Eck et al. (1992), Sobanjo (2006), Tang (2016) and others studied the interaction between vehicle characteristics and crossing vertical profile that can result in a vehicle hang-up
- Vehicle hang-ups appear to be the cause of several grade crossing collisions each year, but the extent of this problem is not known
- Extensive research has focused on the effect of grade crossing warning systems on incident occurrence
- However, relatively little attention has been given to the effect of grade crossing physical characteristics such as the crossing's vertical profile, the probability of a vehicle hang-up, and its effect on incident occurrence

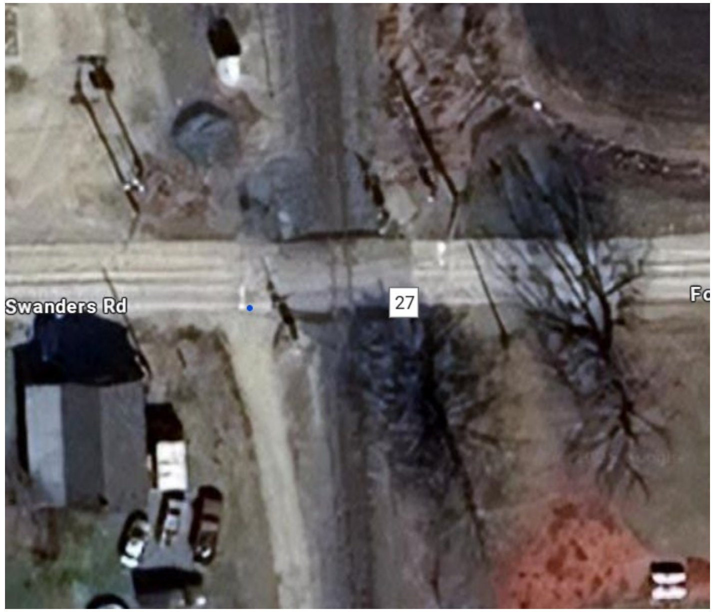
New Crossing Parameters and Data

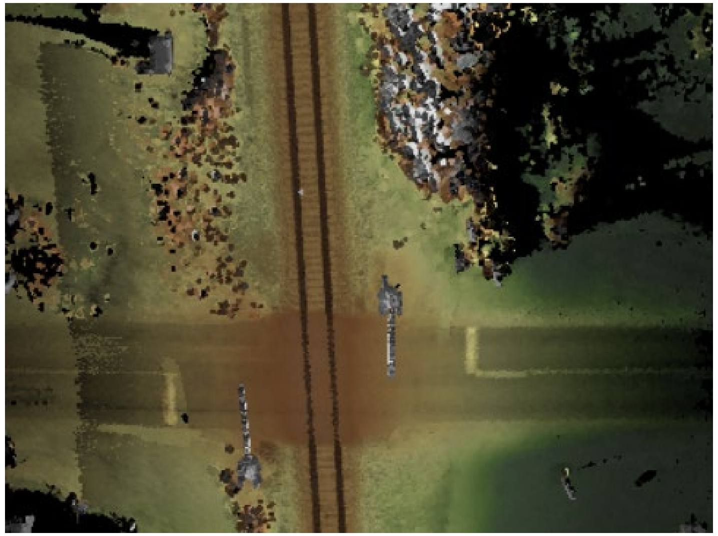
New crossing parameters have been identified using recent advancements in scanning techniques such as light detection and ranging (LiDAR) and photogrammetry

- Vertical profiles – differences in elevation on highway approaches
- Intersection angles – higher resolution direct measurement of highway/railroad crossing angle
- Potential for calculation of minimum sight distances for motor vehicle operators

A New Tool: Light Detection and Ranging (LiDAR)

- Lidar, also LIDAR, LiDAR or LADAR, an acronym of "light detection and ranging" or "laser imaging, detection, and ranging”
- Used in various fields
  - Safety, traffic management, navigation, asset management
- FRA’s Office of Research, Development and Technology began exploring the use of LiDAR in 2015 with the development of a prototype system mounted on one of its geometry cars





Automated Track Inspection Program (ATIP)

ATIP cars conduct operational surveys of the U.S. rail transportation network to determine railroads' compliance with Federal Track Safety Standards and for trend analysis and technology advancement.

ATIP car with LiDAR equipment

A LiDAR system is mounted on the geometry car, and another system is mounted on a hi-rail (bi-modal) vehicle.
It activates at crossings using the latitude and longitude coordinates of the crossing reported in the GCI.
The system is capable to scan grade crossings at speeds up to 55 mph

Grade Crossing Scans Summary

- Over 100,000 LiDAR scans
- 76,000 unique records, as of December 2025
- 60,000 crossings with at least one train per day and a nonzero difference in elevation have been included in the present analysis
- How many of these crossings meet the AASHTO guideline?

Distribution of Grade Crossings with a Recorded Difference in Elevation

What is the risk associated with the crossings that do not meet the AASHTO guideline?

Development of Grade Crossing Vertical Design Specifications Since 1910

1910

American Railway Engineering Association (AREA) developed recommended practices for crossing design with a 5% highway approach grade.

1923

Approach grade revised to be no more than 3 in. higher and 9 in. lower at 30 feet from the field side of the rail.

1953

Approach gradients were revised to be no more than 3 in. higher or 6 in. lower 30 feet from the field side of the rail.

1961

The “no more than” text was relaxed to “highly desirable”.

1990

In 1990, the American Association of State Highways and Transportation Officials (AASHTO) incorporated AREA text into their “Green Book”.

Current AASHTO design guideline

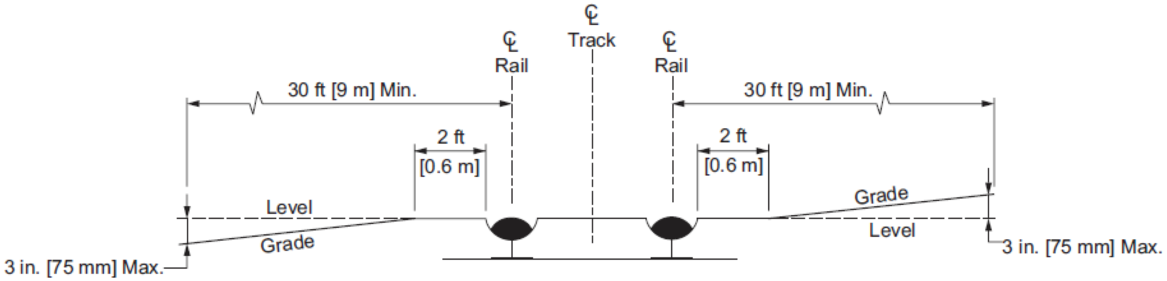


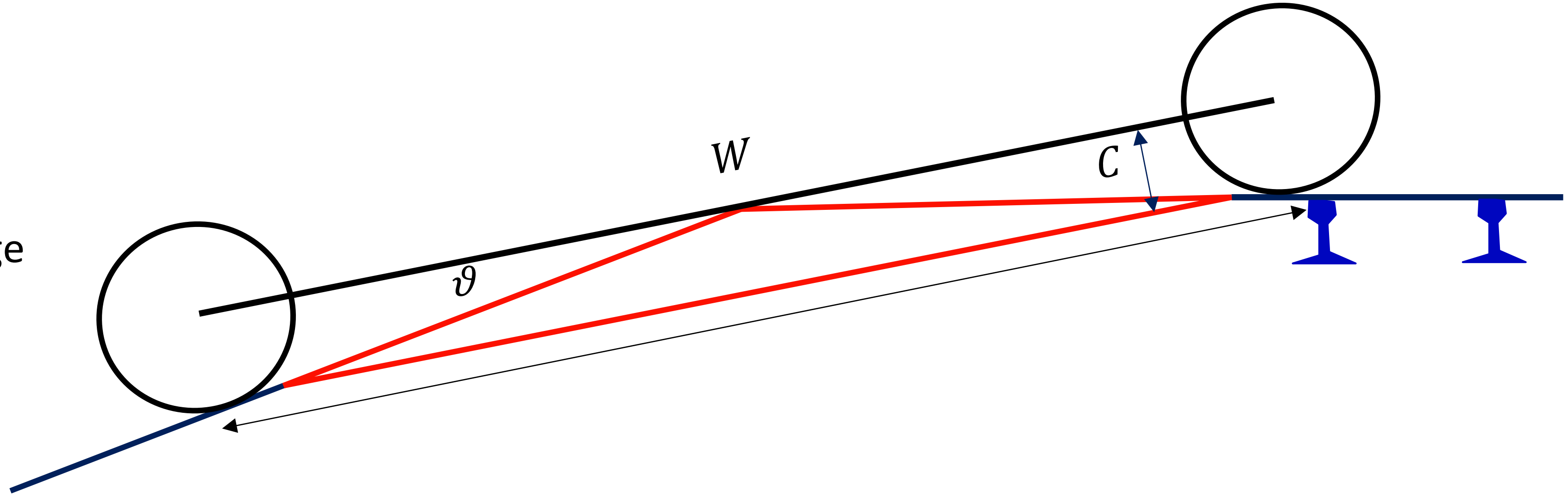
Figure 9-66. Railroad–Highway Grade Crossing

LiDAR Metadata Using AASHTO's Guidelines

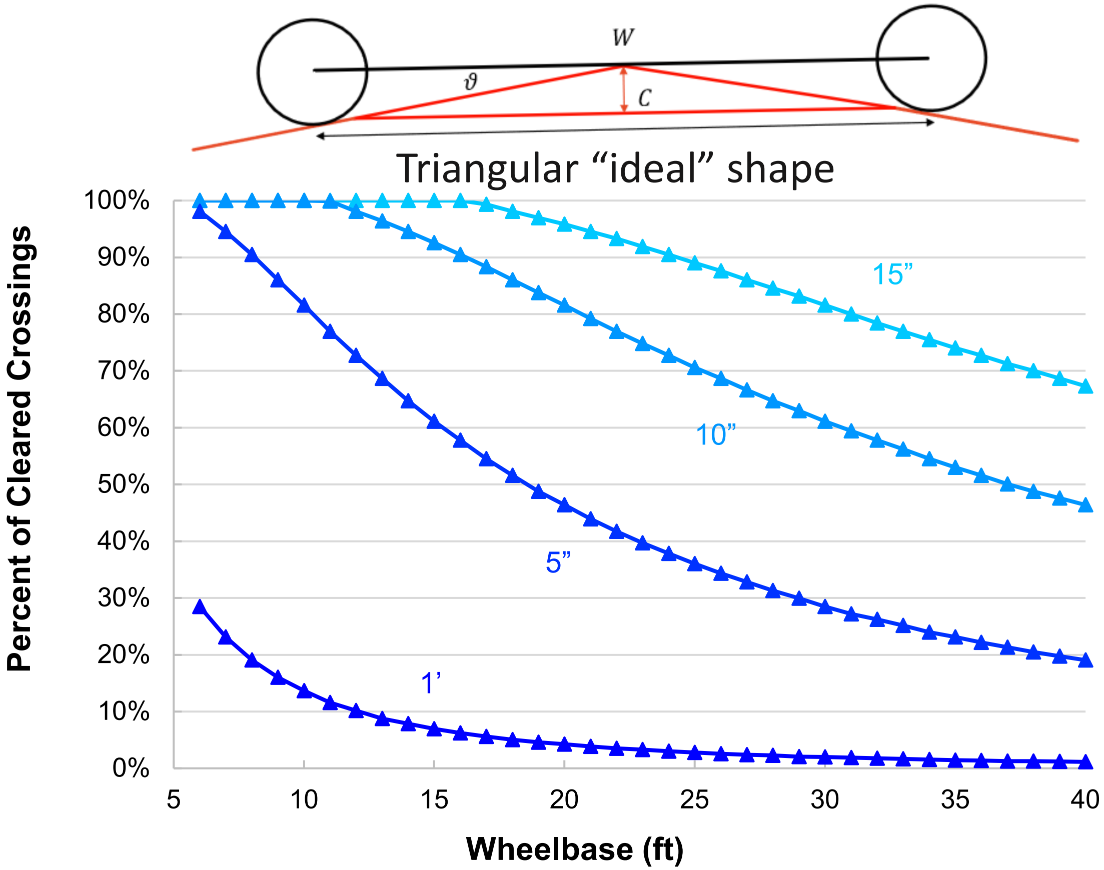
Crossing ID	Difference in Elevation (in)	Slope (%)	Slope Angle
467431J	50.5	15	8.55

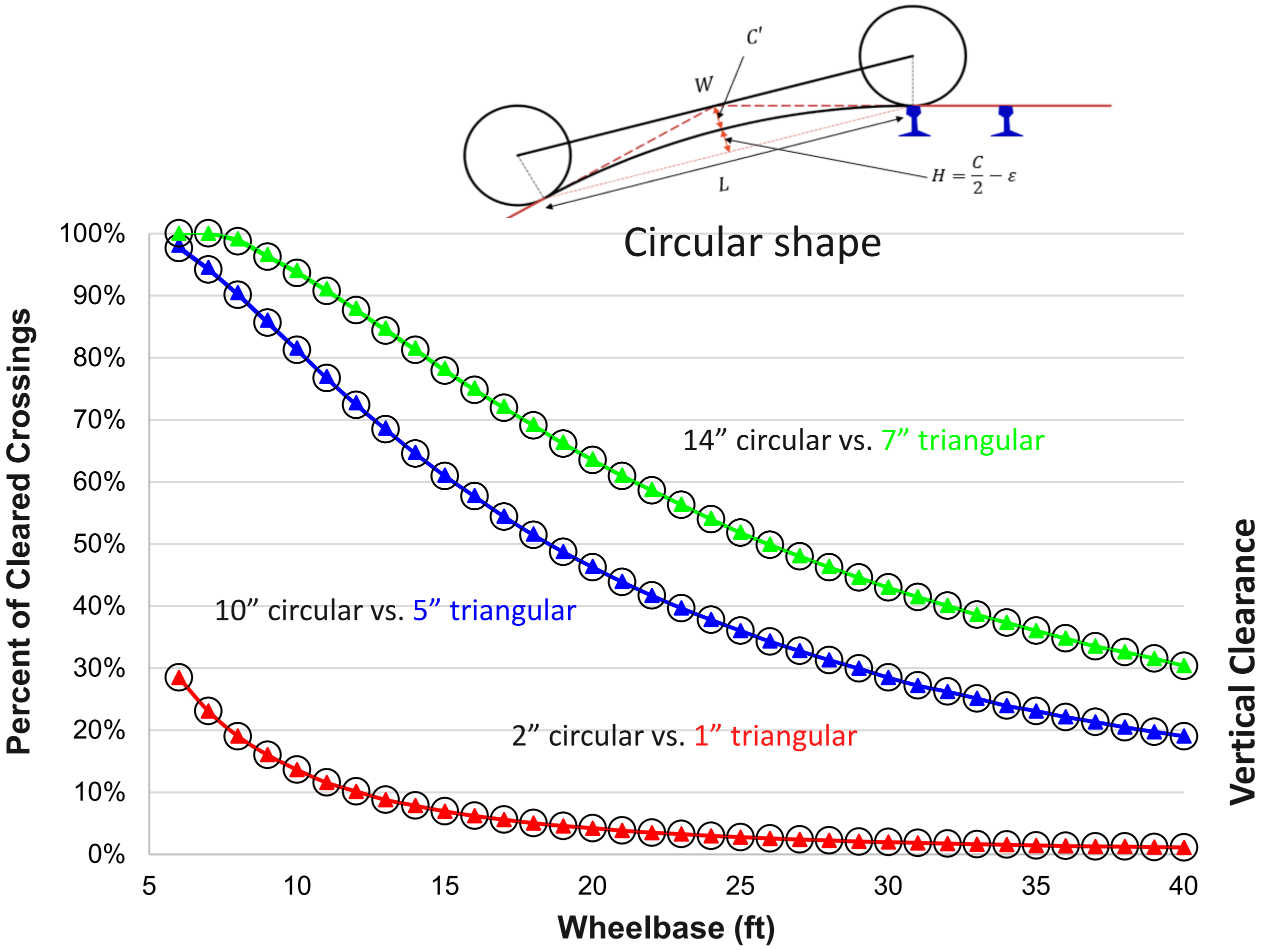
- Change in elevation determined using three coordinates
  - Two points 30' away from the either field side of the track
  - One point at the track centerline
  - Total of 65'
- Using simple geometry, one can quantify how many crossings a vehicle with a given ground clearance can cross.

C: vehicle ground clearance
W: wheelbase
$\vartheta = \arctan\left(\frac{2C}{W}\right)$
As W increases, the percentage of grade crossings that can be cleared decreases



Theoretical Relationship Wheelbase – Vertical Ground Clearance and Level Crossing Vertical Profile





Designing a level crossing profile as a compound vertical curve with circular or parabolic transitions mitigates the risk of a hang up.

Grade Crossing Research: What’s Next

- New web portal
  - 3-D scans of crossings
  - New parameters
    - Vertical profile
    - Angles
    - Sight distances
- New design standard

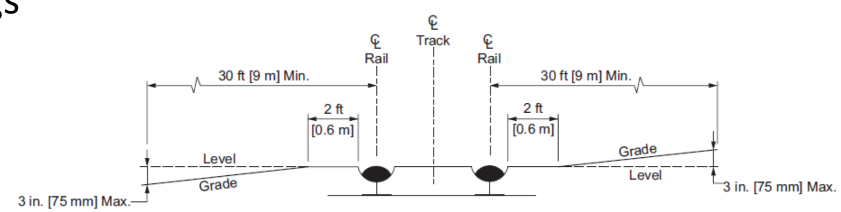
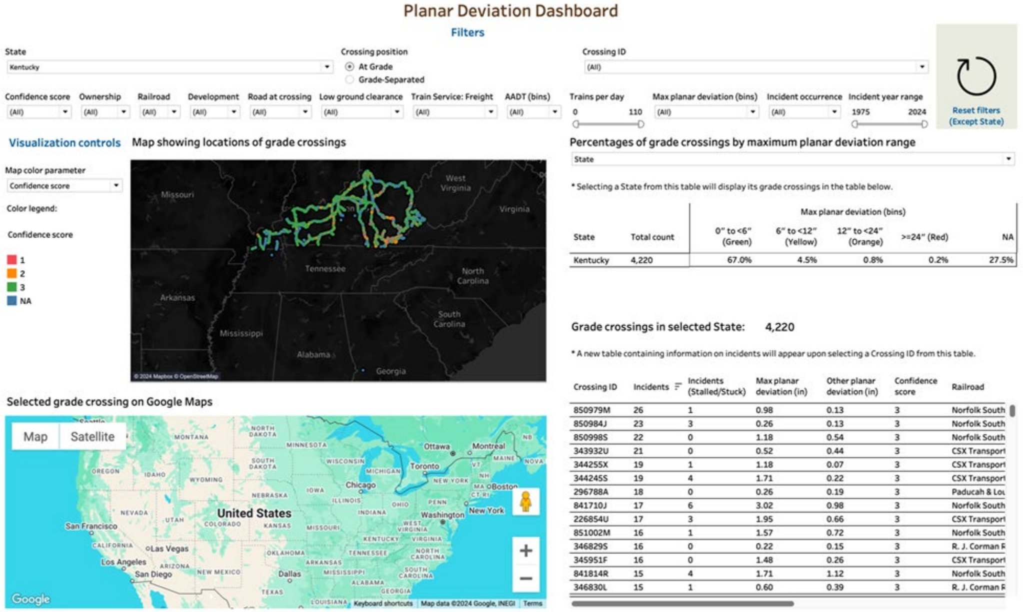
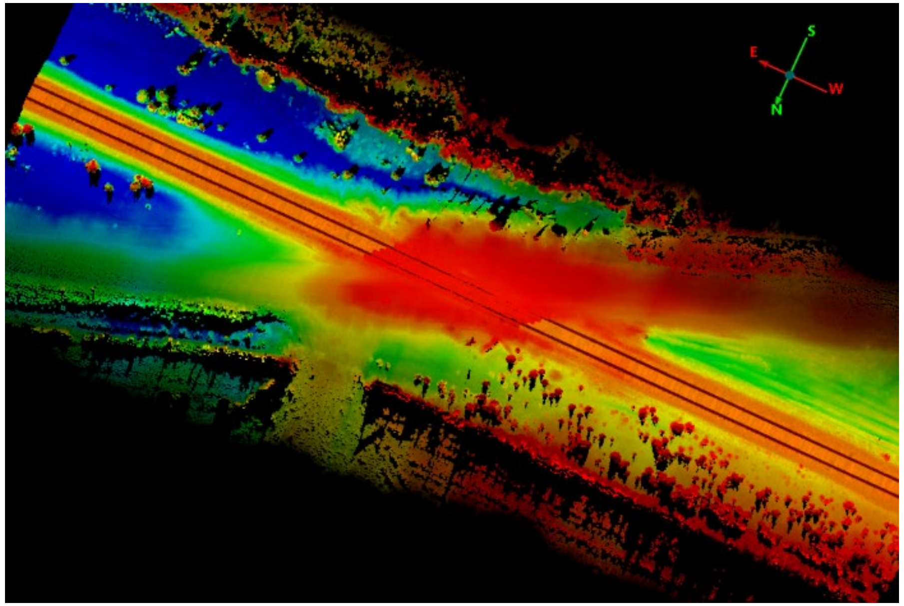


Figure 9-66. Railroad–Highway Grade Crossing

Univ. Maryland Humped Crossing Dashboard





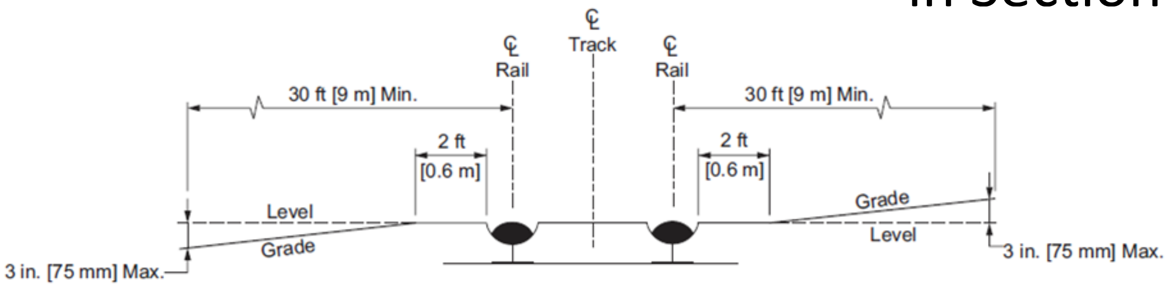
Grade Crossing Vertical Profile Working Group

WHO

- Class 1s
- AAR
- FHWA
- FRA
- AASHTO
- State DOTs

WHAT

- Revisit Section 9.12 of Green Book
- Potential new figure or figures to replace figure 9.66
- Propose to include ground clearance values to typical design vehicles (maybe as a separate table in Section 9.12 or update Table 2-4a&b) as reported in Section 2.8 of the Green Book



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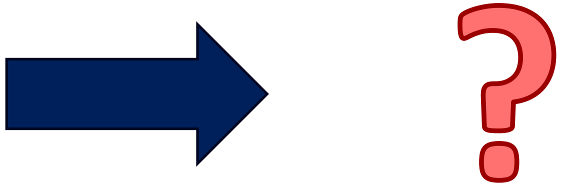

QUESTIONS?

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