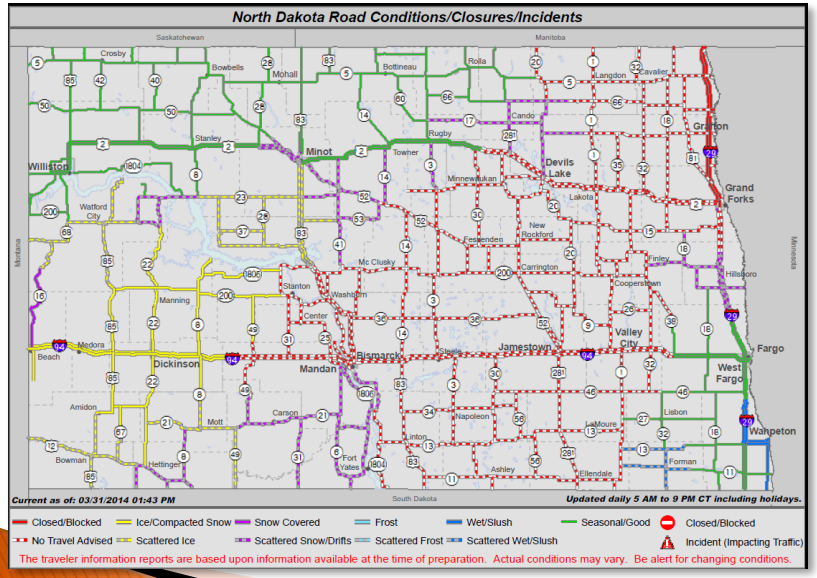
NDDOT Maintenance Operations

Snow & Ice Control and Travel Information



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North Dakota Travel Info
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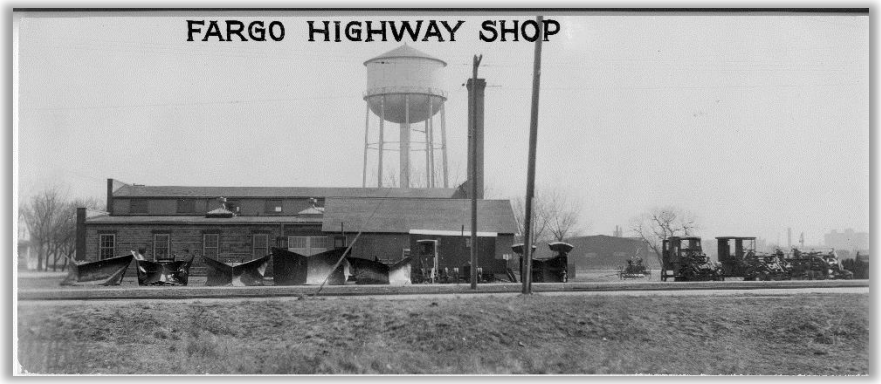
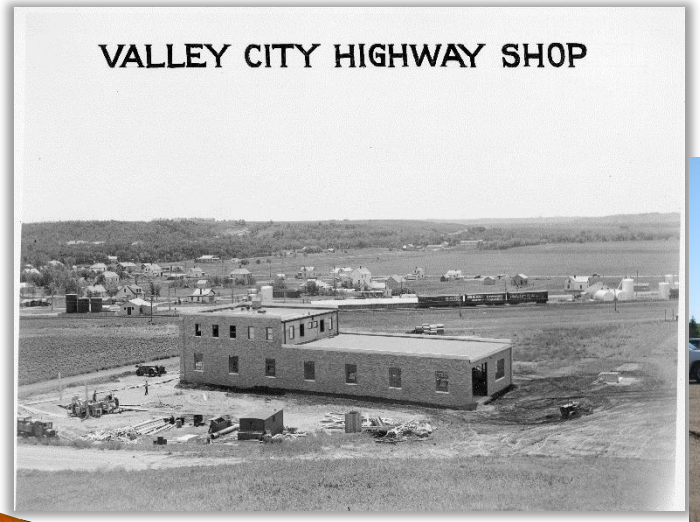
- Agenda
  - Maintenance Background
  - Materials & Uses
  - Equipment
  - Snow & Ice Control Costs
  - Travel Information

- NDDOT Mission
  - Safely move people and goods.

NDDOT Maintenance Background





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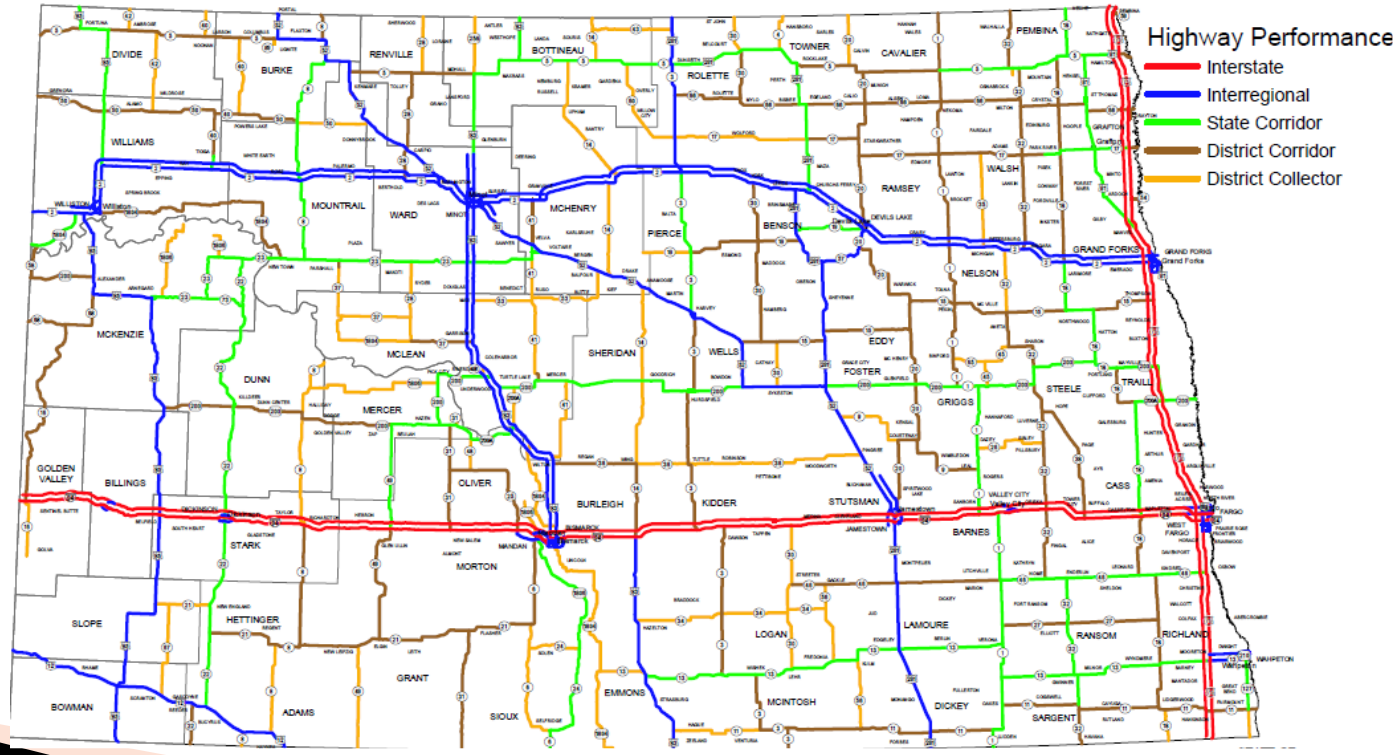
NDDOT Highway System

- State does not maintain city or county roads.
- Highest priorities: Interstate and four lane divided
- Lower priorities: Rural two lane highways



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NDDOT Hours of Operation

- 5am to 7pm
- 14 hour maximum shift length for plow operator
  - Exceptions for emergencies
- Bismarck, Minot, and Fargo have limited 24/7 operations

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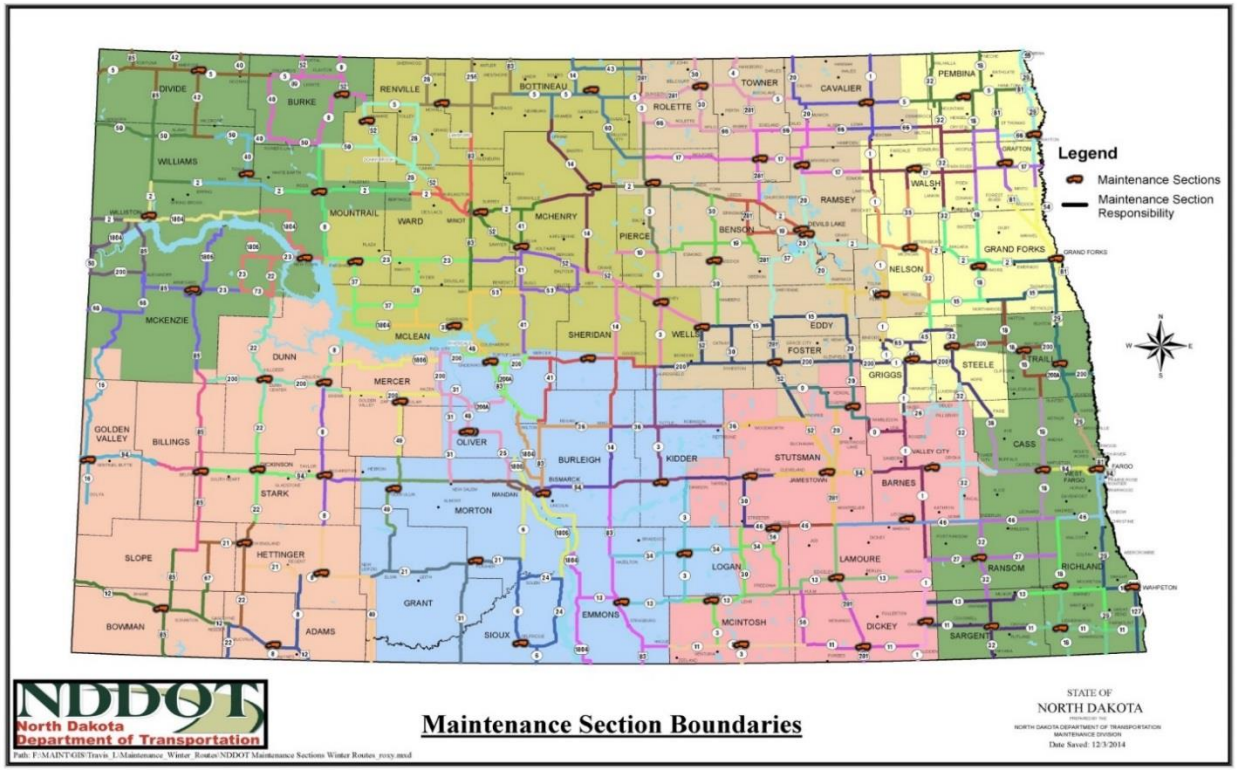
NDDOT Districts & Sections

- Central Office and Eight Districts
- 8-10 Sections in each districts
- Maintain over 17,000 lane miles



NDDOT Maintenance Operations

- De-icing
  - Application of liquid or solid chemicals to melt existing snow/ice.
- Anti-icing (pre-treating)
  - Anti-icing of the roadway before the onset of a storm creates a bond breaker between the snow/ice and the pavement.
- Sand or Grit
  - Intended to provide temporary traction.
- Salt/Salt Brine
  - Intended to melt snow/ice/frost.
- Plowing and Blowing
  - Mechanical method of removing snow/ice with a snow plow, snow blower, or motor grader.

NDDOT Materials and Uses

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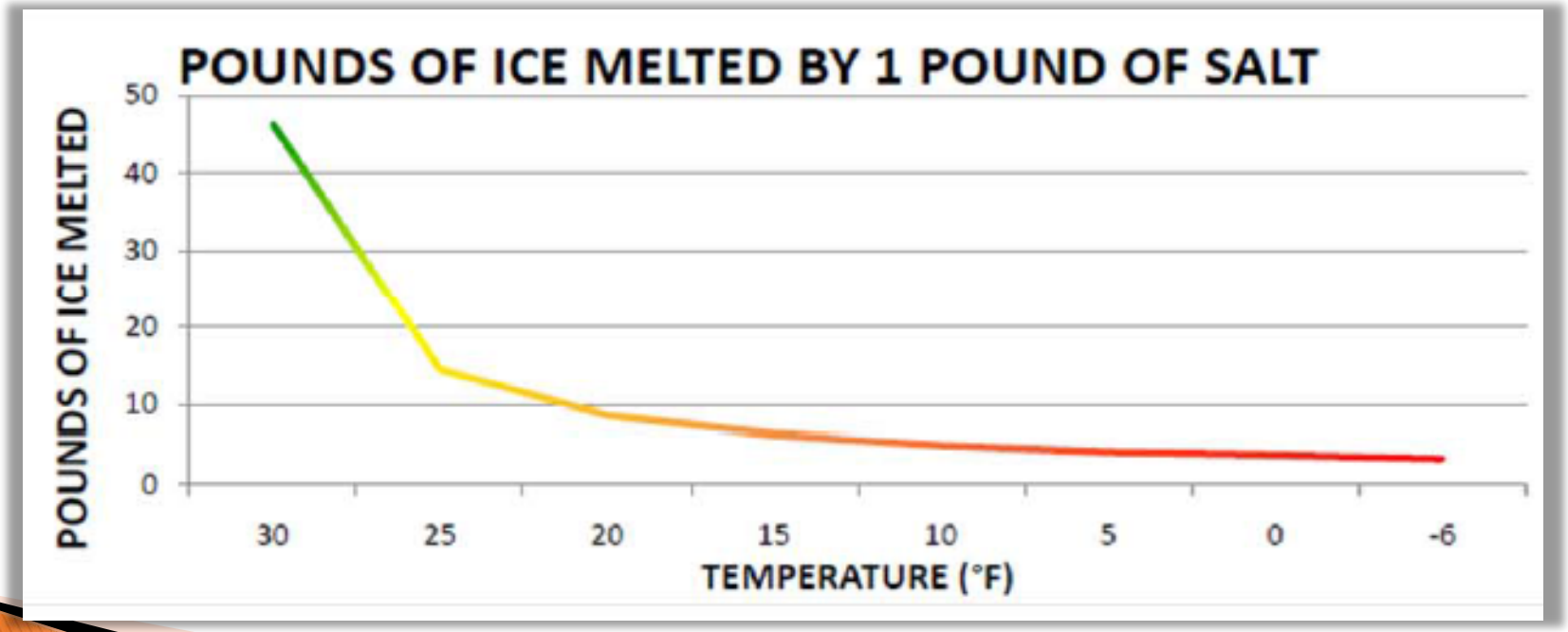
NDDOT Materials and Uses

- Salt
- Salt Brine/Geomelt
  - 80/20 mix ratio
- Salt/Sand
  - Ratios vary across the state
- Anti-Ice
  - Before a storm to prevent ice
- De-Ice
  - Melt after ice has accumulated
- Prewet
  - Jump start salt activation to melt faster

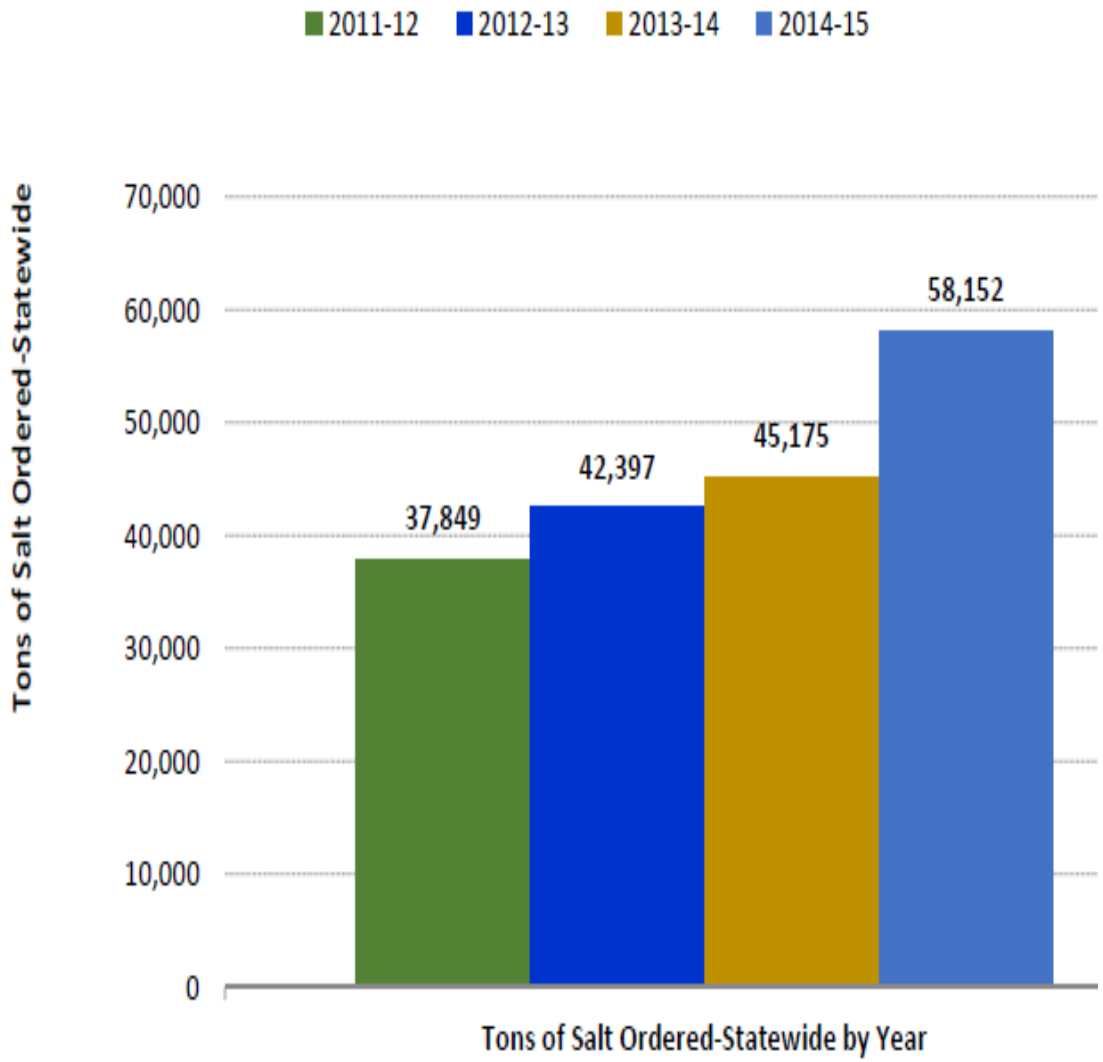
NDDOT Materials

- Salt
  - Melt snow and ice
  - Effective down to about 10º-15º F
    - Melts down to -6º F, but loses cost effectiveness



NDDOT Materials

- Salt
  - 14-15 winter
    - 44,257 tons of salt used
  - 15-16 winter
    - 30,801 tons of salt used



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- 70 salt buildings
- 91,150 tons of capacity

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NDDOT Materials

- Salt Brine/Geomelt
  - Salt brine contains 23% salt in solution
  - NDDOT mixes salt brine with sugar beet juice (Geomelt)
    - 80% salt brine
    - 20% beet juice
  - Helps prevent freezing in tanks and pumps
  - Helps melt snow and ice from roadways
  - Beet juice generated in Hillsboro or East Grand Forks
  - Biodegradable and non-toxic

- 14-15 Brine Used
  - 1,818,415 gallons

- 15-16 Brine Used (to date)
  - 1,462,085 gallons

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NDDOT Materials

- 84 salt brine tanks
- 1,465,000 gallons of capacity

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NDDOT Materials

- Sand/Salt Mixes
  - Sand provides temporary traction
  - Sand does not melt snow and ice
  - Sand mixed with salt prevents freezing in truck or stockpiles
  - Each district has different mix ratios
  - Spread on hills, curves, intersections

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NDDOT Snow & Ice Equipment

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NDDOT Snow & Ice Equipment

- Snow Plows (orange trucks)
  - 356 Snow Plows across the state
  - $210,000
  - 17 year replacement schedule

Stay Back – Stay Alive

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NDDOT Snow & Ice Equipment

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NDDOT Snow & Ice Equipment

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NDDOT Snow & Ice Equipment

- TowPLows (pull behind trailer plows)
  - 25 TowPLows across the state
  - $140,000
  - Improve efficiency of a single operator
  - Liquid tanks allow for anti-icing or decing

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NDDOT Snow & Ice Equipment

- Anti-Icing

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NDDOT Snow & Ice Equipment

- 25 Motor Graders
- 63 Snow Blowers

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Automatic Vehicle Location

- 34 AVL units across the state
  - GPS location
  - 10” touchscreen monitor
  - Cell modem
  - Plow sensors
  - Force America 5100 and 6100 integration
  - Dashboard camera
- Two-way data communication with MDSS
  - Send data and receive updated recommendations
- MDSS in the truck provides driver with current information

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Current Truck Cab

Truck Mounted Camera

- Photos taken and sent to MDSS
- Visual description of actual conditions

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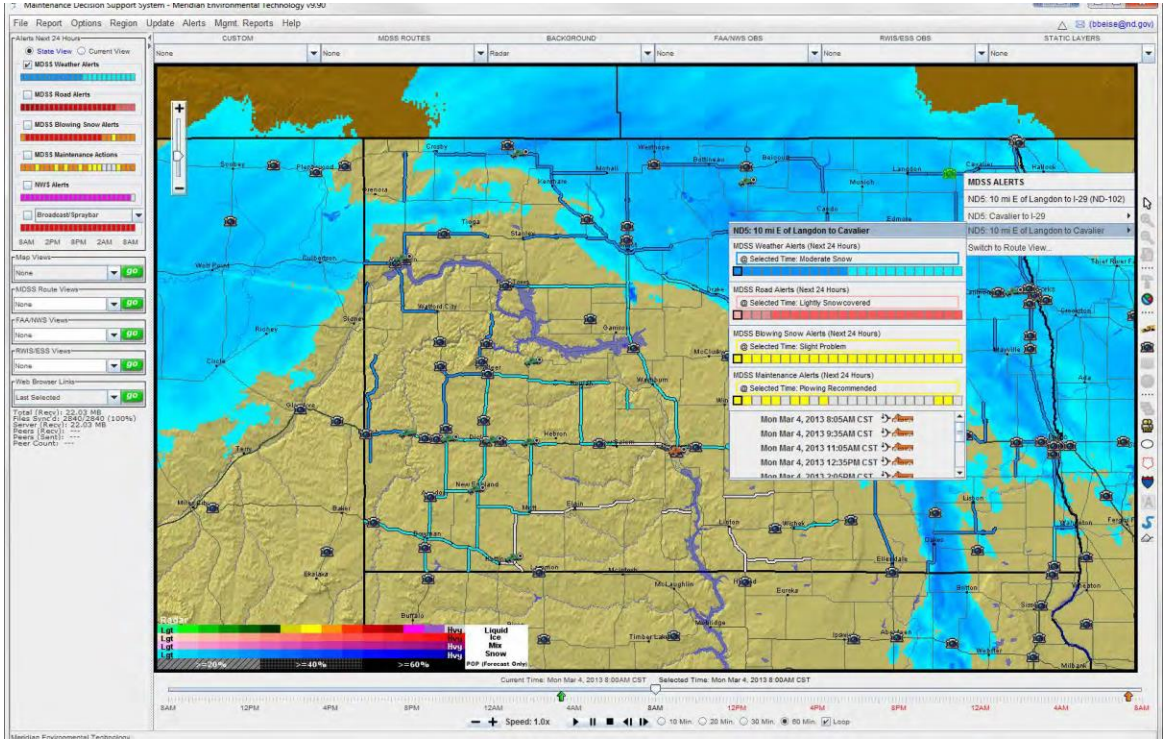
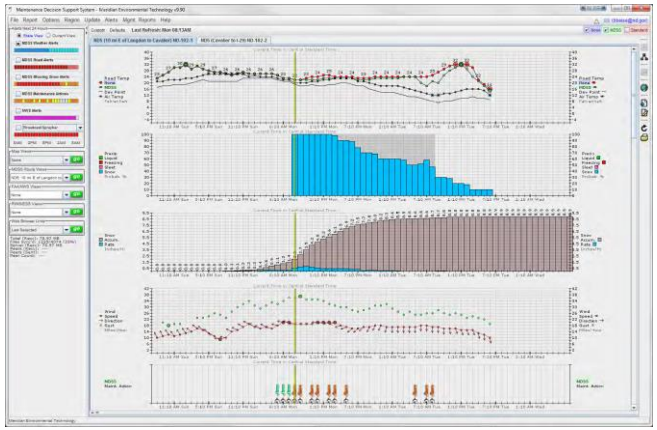
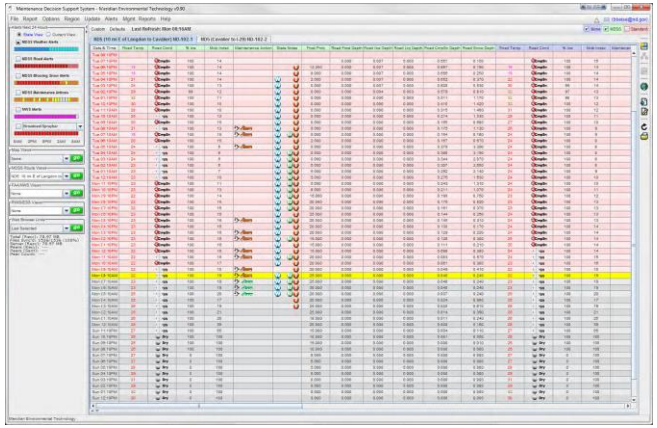
Maintenance Decision Support System (MDSS)







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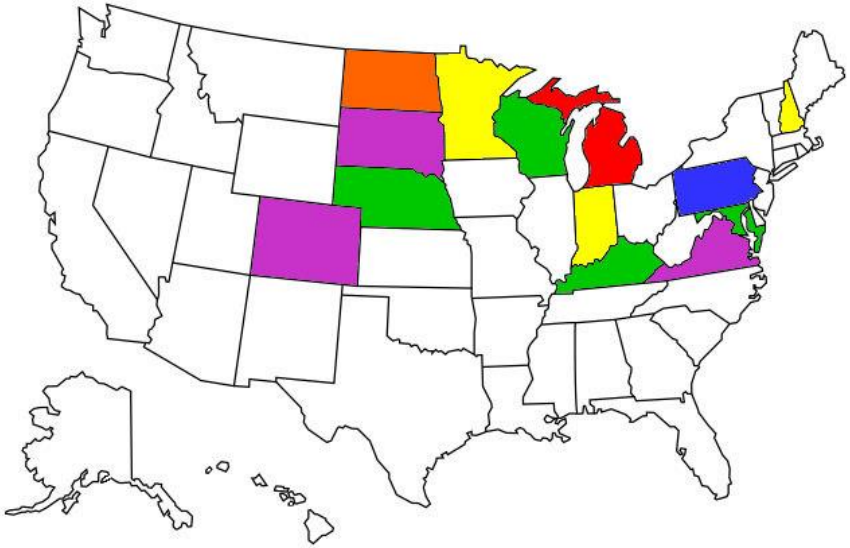
MDSS

- 13 States Involved in Pooled Fund Study
- Colorado, Kentucky, Indiana, Maryland, Michigan, Minnesota, Nebraska, New Hampshire, North Dakota, Pennsylvania, South Dakota, Virginia, and Wisconsin



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What does MDSS do?

- Assess current road and weather conditions
- Provide time- and location-specific weather forecasts that will affect transportation routes
- Predict how road conditions will change in response to maintenance treatments
- Suggest optimal maintenance strategies to maintenance personnel that can be achieved with available resources

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Benefits of MDSS

- Save $$$ on Labor, Fleet, and Materials
- Staff and material planning prior to winter events
- Increase compliance with Level of Service goals
- Improve decision making
- Less chemicals used leads to reduced impacts on infrastructure, vehicles, and the environment
- More consistent treatment among maintenance sections results in more seamless road conditions for the road user

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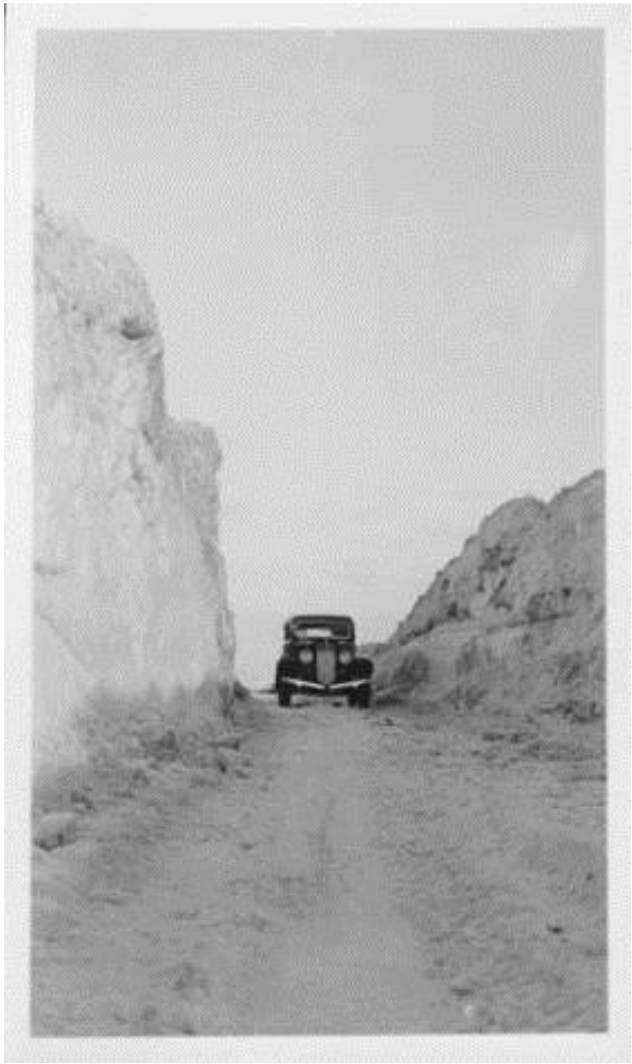
Snow & Ice Control Costs



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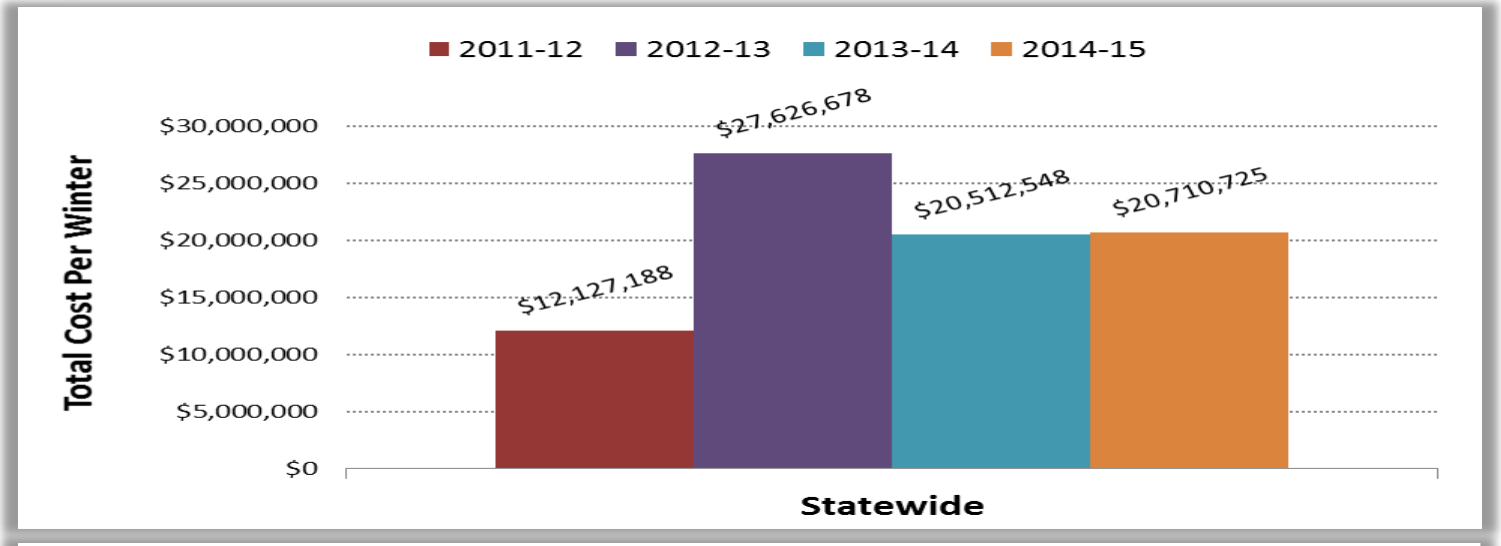
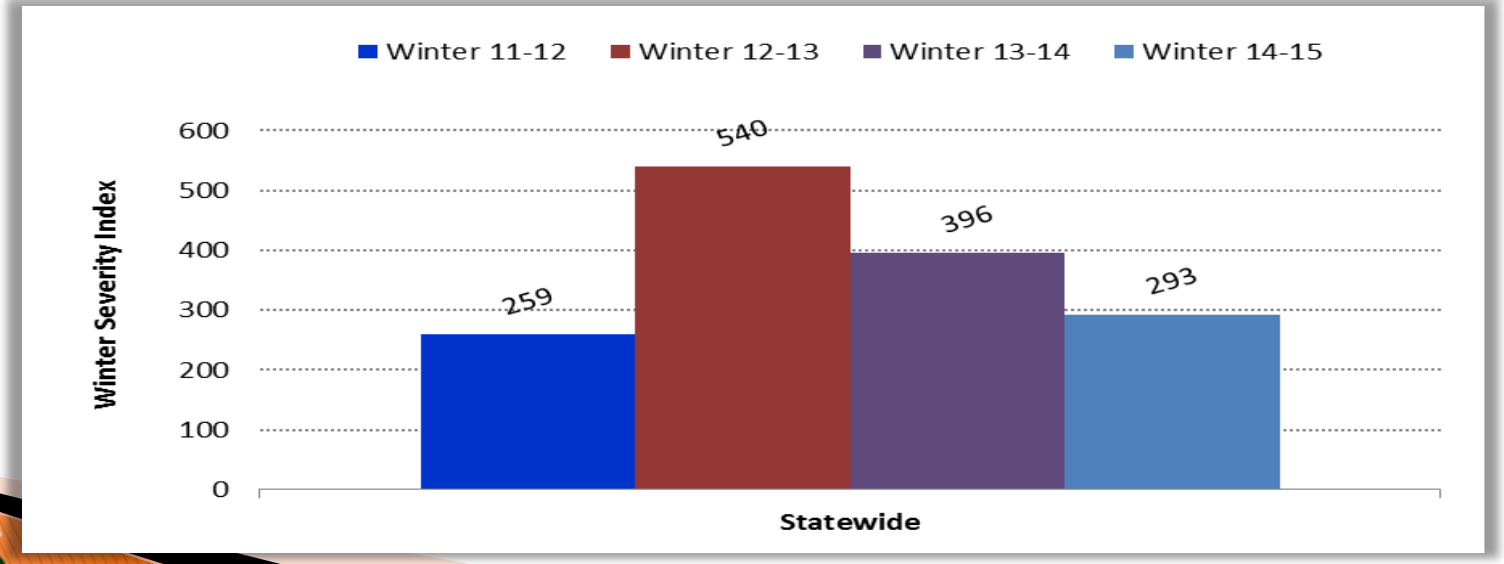
4 Year Winter Costs and Severity Index





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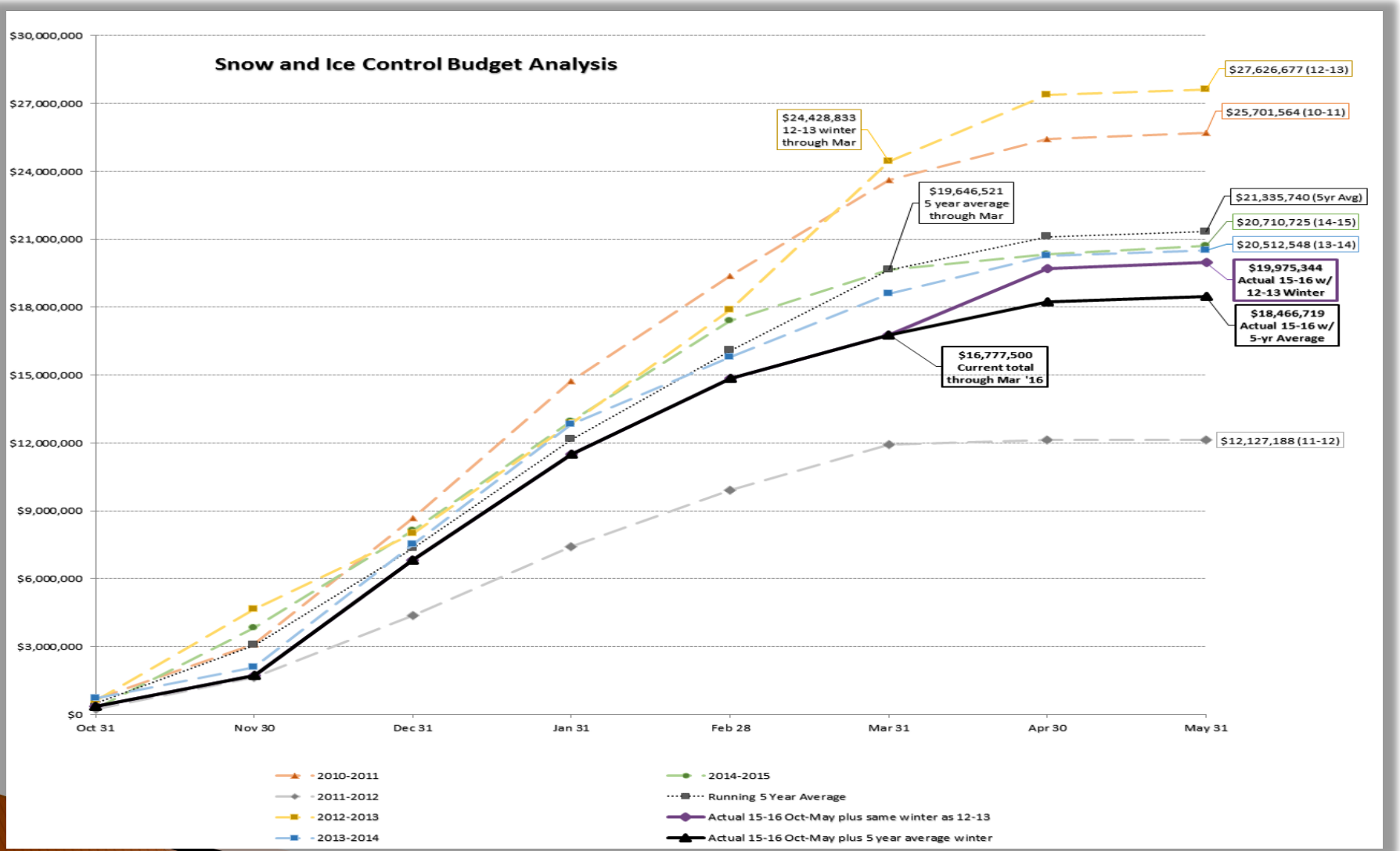
Snow & Ice Control Costs



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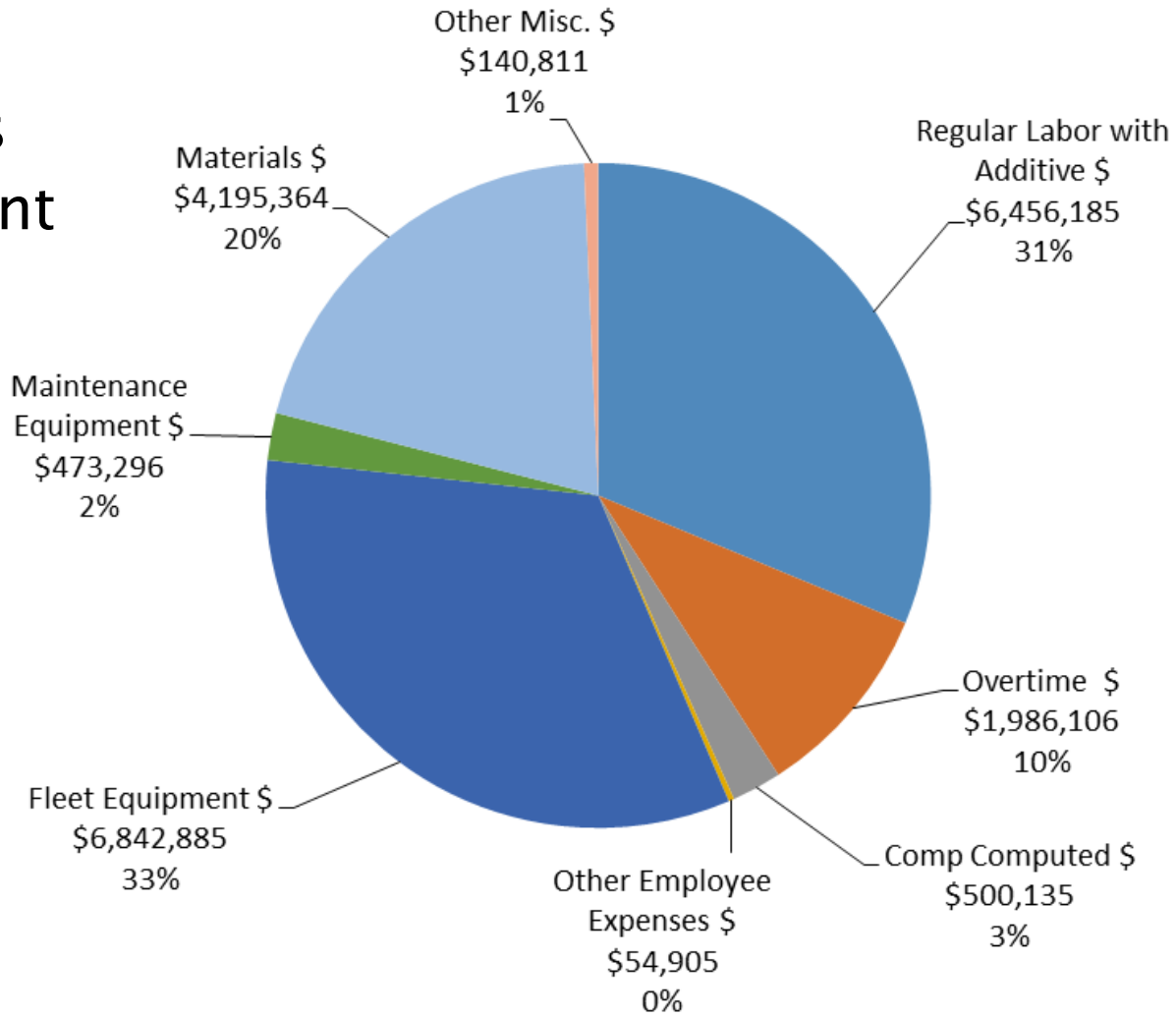
Snow & Ice Control Costs

- 2014-2015
  - 1/3 Materials
  - 1/3 Equipment
  - 1/3 Labor



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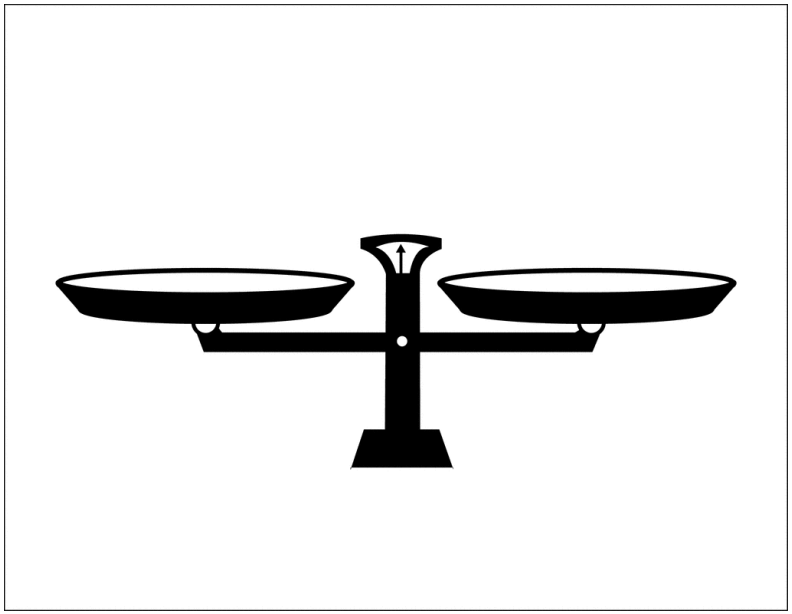
Operational Funding

- Winter Snow & Ice Control
  - Plowing
  - Anti-Icing
  - De-Icing
- Summer Pavement Preservation
  - Crack Sealing
  - Chip Seals
  - Pavement Repairs



Travel Information

https://www.dot.nd.gov/	
Travel Information Map	Travel Information Map
ND ROADS	Travel Information Mobile App
511 Travel Info	511 telephone service
SMS	Gov Delivery email/text notification

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Travel Information

Usage Last Year	
Travel Information Map	1,494,000 page views
ND ROADS	55,900 Apple users 36,800 Android users
511 Travel Info	106,201 calls
SMS	8,340 subscribers 28,411 subscriptions

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Travel Information

- https://www.dot.nd.gov/
  - Road Conditions
  - Work Zones
  - Load Restrictions
  - Road/Weather Cameras
- Know Before You Go

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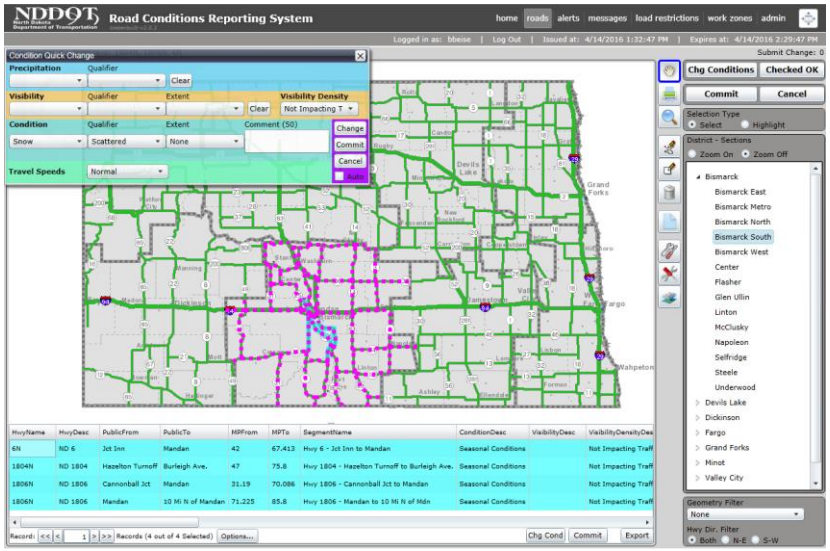
Travel Information

- Road Condition Reporting
  - Website or app or 511
  - Snow plow operators call in actual road conditions
  - Predetermined times and as conditions change
  - 4:30 AM to 10:00 PM
  - October to April, including weekends and holidays



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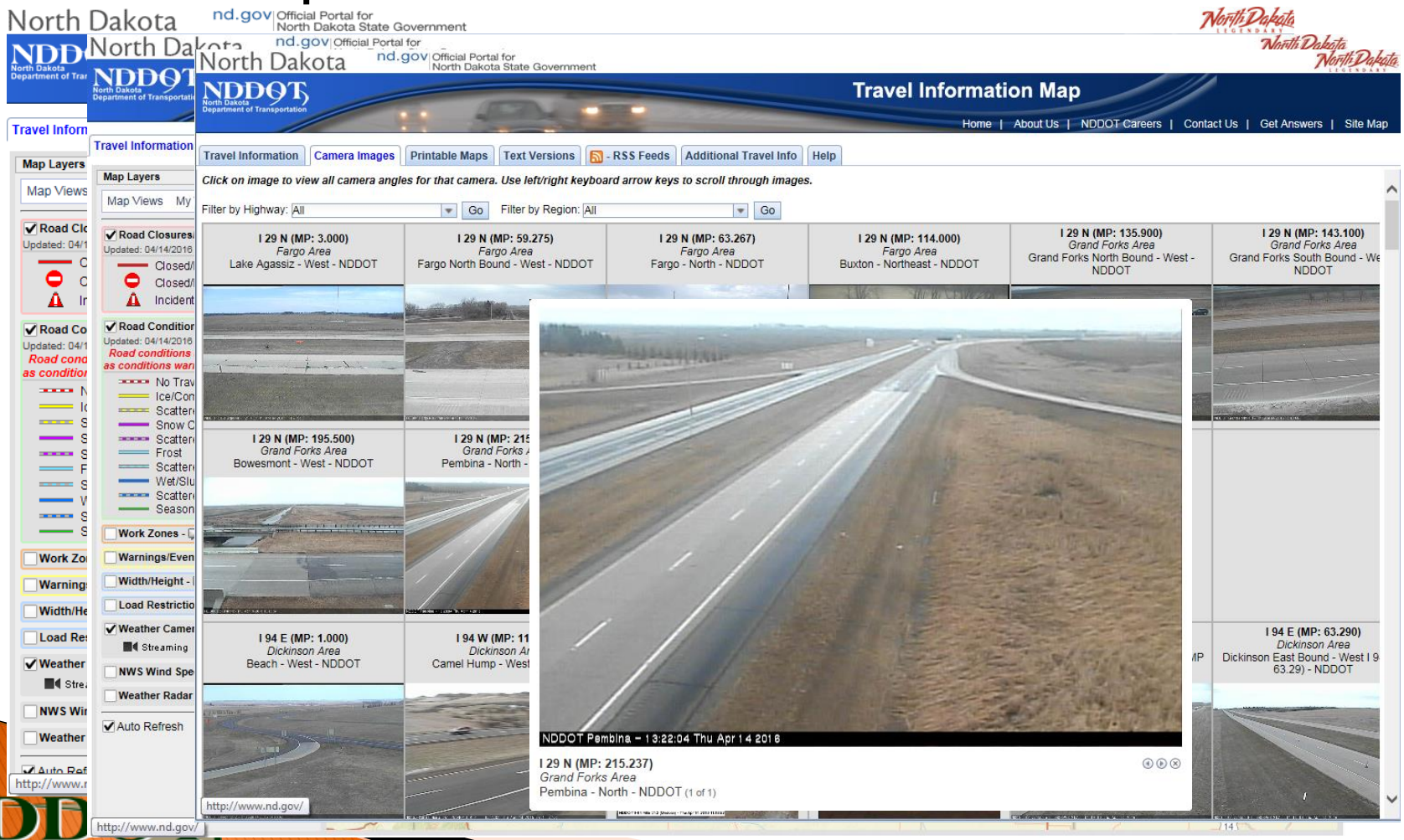
Travel Information

Travel Map



Travel Information

- Road/Weather Cameras
  - 82 cameras throughout the state
  - Images updated every 5-10 minutes
  - Most images are timestamped
  - Most have illuminators to view night images
  - Positioned at trouble spots, turnarounds, and available power

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Travel Information

- Environmental Sensor Stations
  - Tools to obtain road weather info and aid in decision making
  - Atmospheric data:
    - Air temperature
    - Humidity
    - Visibility distance
    - Wind speed and direction
    - Precipitation type and rate
  - Pavement data:
    - Pavement temperature
    - Pavement condition (Ex: wet, icy)
    - Subsurface conditions (Ex: soil temperature)

Travel Information

- Dynamic Message Signs
  - 31 DMS
  - Major corridors
  - Major cities
  - Remotely controlled

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Travel Information

- Travel Warnings
  - HP and District DOT coordinate
  - Issue travel warning
    - Travel Alert
    - No Travel Advised
    - Road Closed/Blocked
  - DOT Communications to issue news release
  - Update Travel Map and 511
  - Put messages on DMS

Travel Information

- Travel Alert
  - Motorists can still travel but may encounter areas of challenging winter weather driving conditions on roadways.
- No Travel Advised
  - Motorists should not travel due to hazardous conditions which may make it unsafe to travel.
- Road Closed/Blocked
  - Motorists are not allowed to travel on a closed road due to life threatening conditions.
  - The road might be impassable or blocked.

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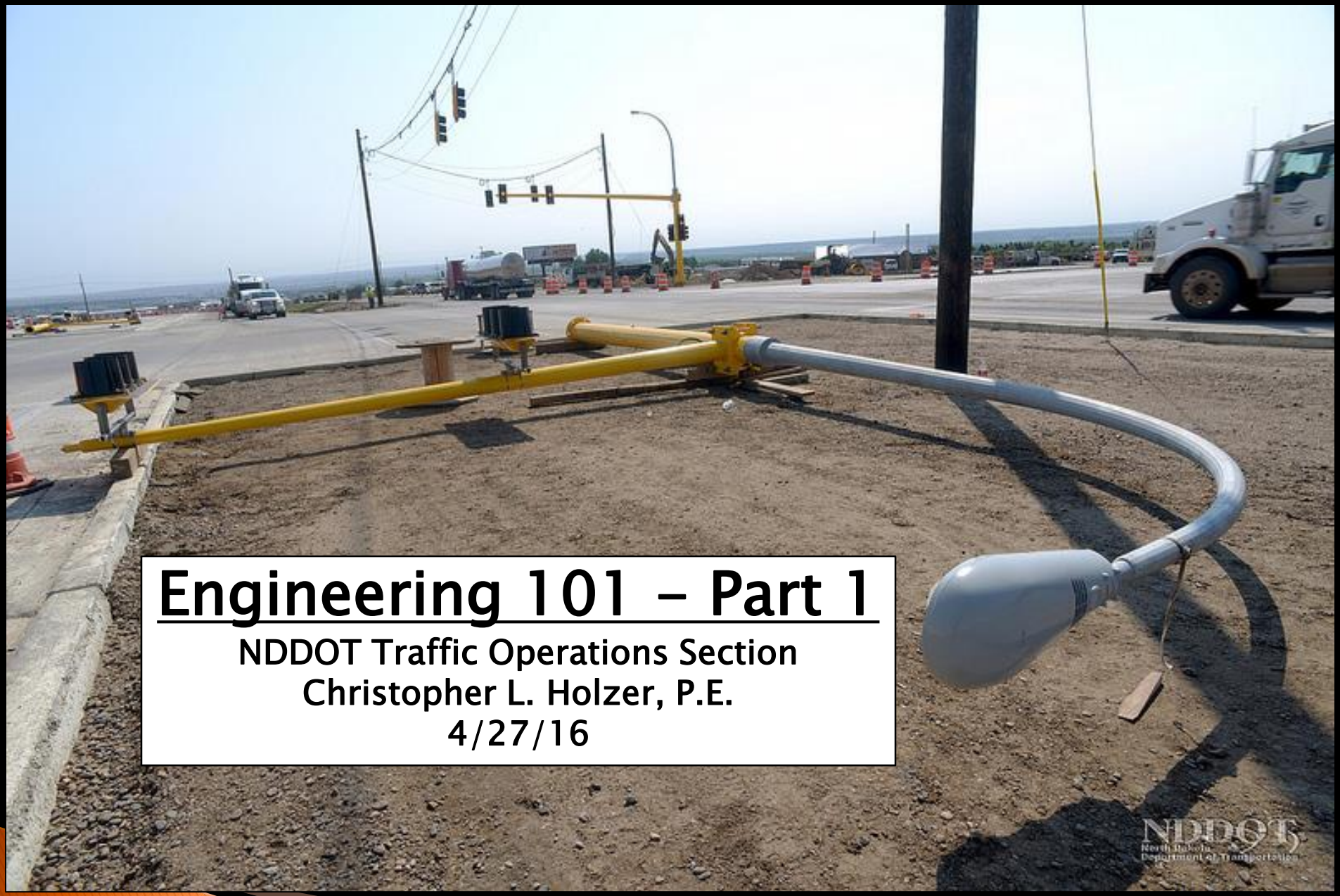

Engineering 101 – Part 1

NDDOT Traffic Operations Section
Christopher L. Holzer, P.E.
4/27/16

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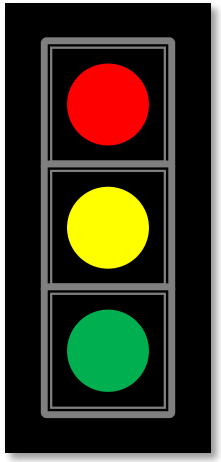
Are Intersections Safer With

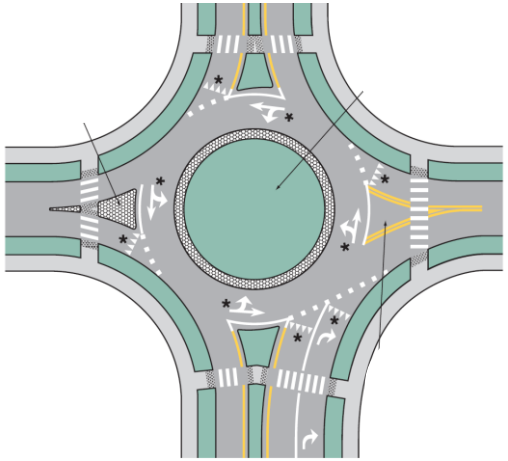
Stop signs on side streets

or



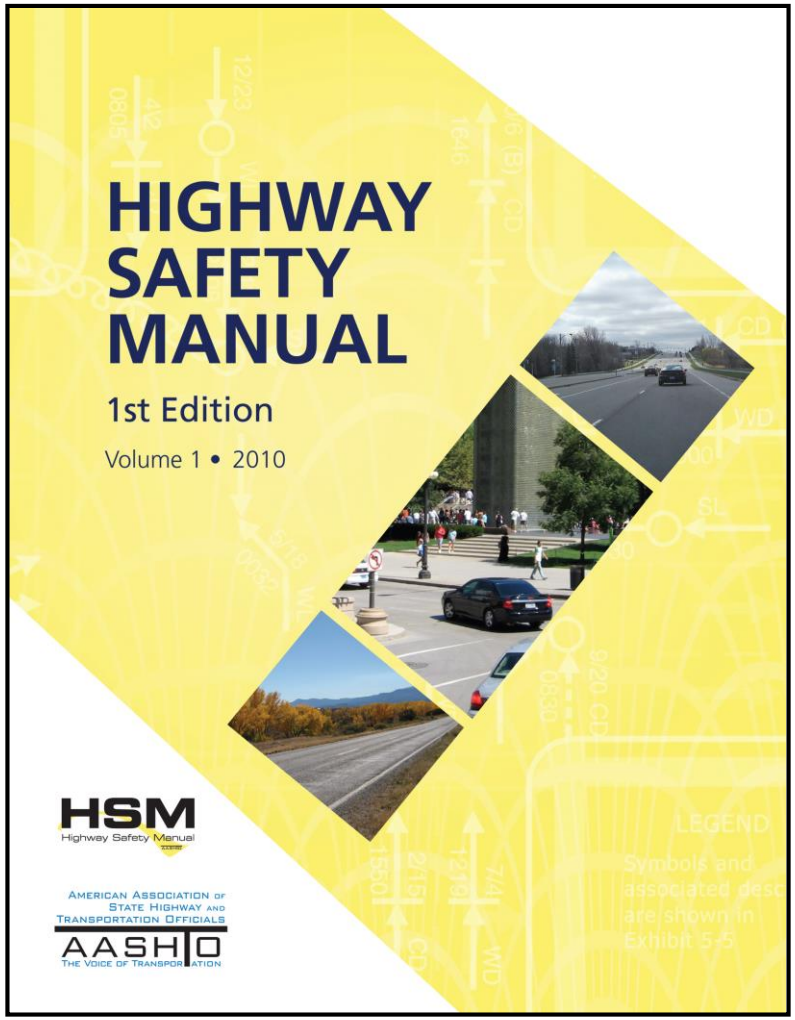
Traffic Signals

or



Modern Roundabouts

Let's Check the Highway Safety Manual



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Convert Stop Signs to Traffic Signals

	# Crashes
Total Crashes	

Data from HSM Table 14-7, Urban setting.

Statistics are only applicable if MUTCD traffic signal warrants are satisfied.

Convert Stop Signs to Traffic Signals

	# Crashes
Total Crashes	4% ⇧ to 14% ⇩

Data from HSM Table 14-7, Urban setting.

Statistics are only applicable if MUTCD traffic signal warrants are satisfied.

Convert Stop Signs to Traffic Signals

	# Crashes
Total Crashes	4% ⇧ to 14% ⇩
Right Angle Crashes	61% to 73% ⇩

Data from HSM Table 14-7, Urban setting.
Statistics are only applicable if MUTCD traffic signal warrants are satisfied.

Convert Stop Signs to Traffic Signals

	# Crashes
Total Crashes	4% ⇧ to 14% ⇩
Right Angle Crashes	61% to 73% ⇩
Rear End Crashes	**103% to 183% ⇧**

Data from HSM Table 14-7, Urban setting.
Statistics are only applicable if MUTCD traffic signal warrants are satisfied.

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Convert Stop Signs to Traffic Signals

	# Crashes
Total Crashes	4% ⇧ to 14% ⇩
Right Angle Crashes	61% to 73% ⇩
Rear End Crashes	103% to 183% ⇧

Data from HSM Table 14-7, Urban setting.

Fine Print!

Statistics are only applicable if MUTCD traffic signal warrants are satisfied.

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Convert Traffic Signals to a Roundabout

	# Crashes
Total Crashes	

Data from HSM Table 14-3, All Settings.

Convert Traffic Signals to a Roundabout

	# Crashes
Total Crashes	42% to 54% ⇩

Data from HSM Table 14-3, All Settings.

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Convert Traffic Signals to a Roundabout

	# Crashes
Total Crashes	42% to 54% ⇩
Injury Crashes	71% to 85% ⇩

Data from HSM Table 14-3, All Settings.

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Convert Traffic Signals to a Roundabout

	# Crashes
Total Crashes	42% to 54% ⇩
Injury Crashes	71% to 85% ⇩

Why do roundabouts reduce crashes so much???

Data from HSM Table 14-3, All Settings.

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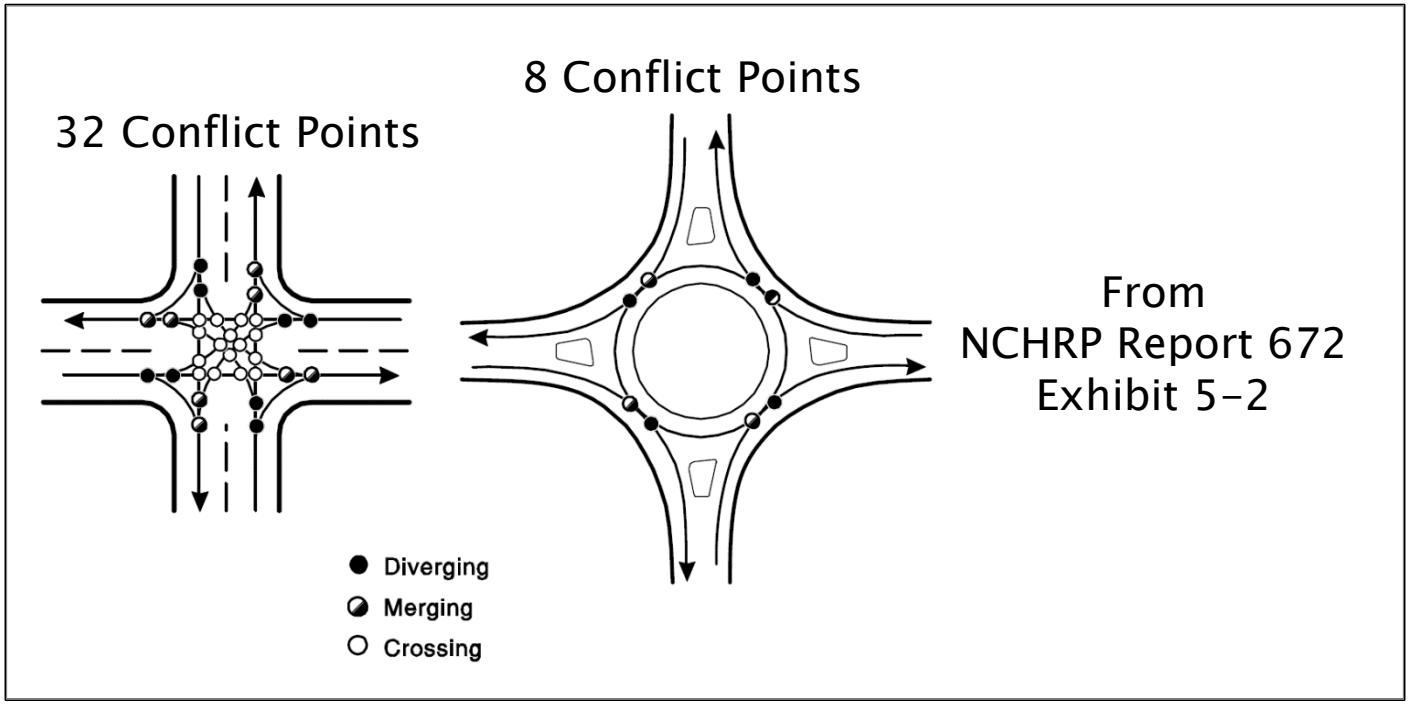
Why Do Roundabouts Reduce Crashes?

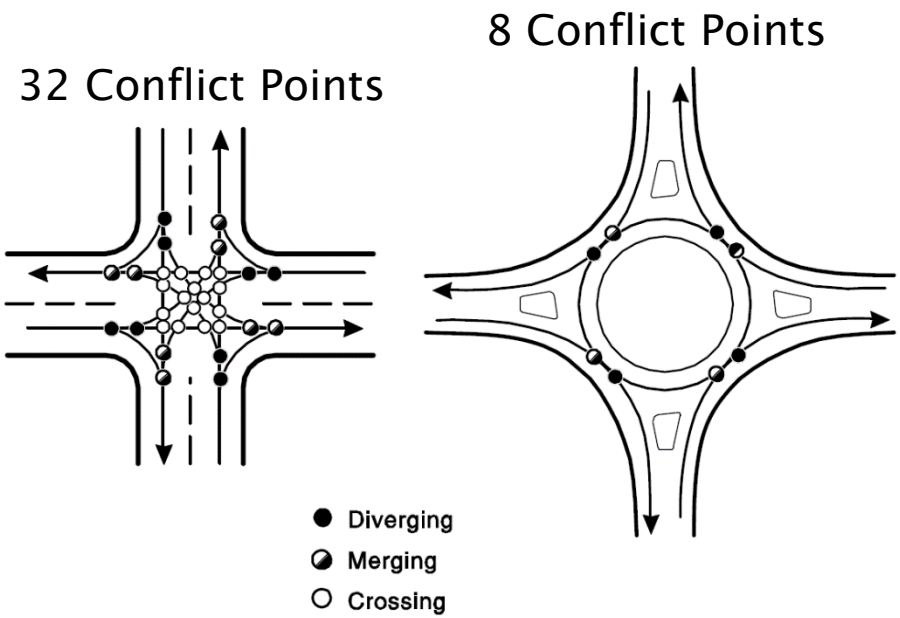
- Less conflict points. Less severe conflicts.



From
NCHRP Report 672
Exhibit 5-2

Why Do Roundabouts Reduce Crashes?

- Less conflict points. Less severe conflicts.
- Slower vehicle speeds.

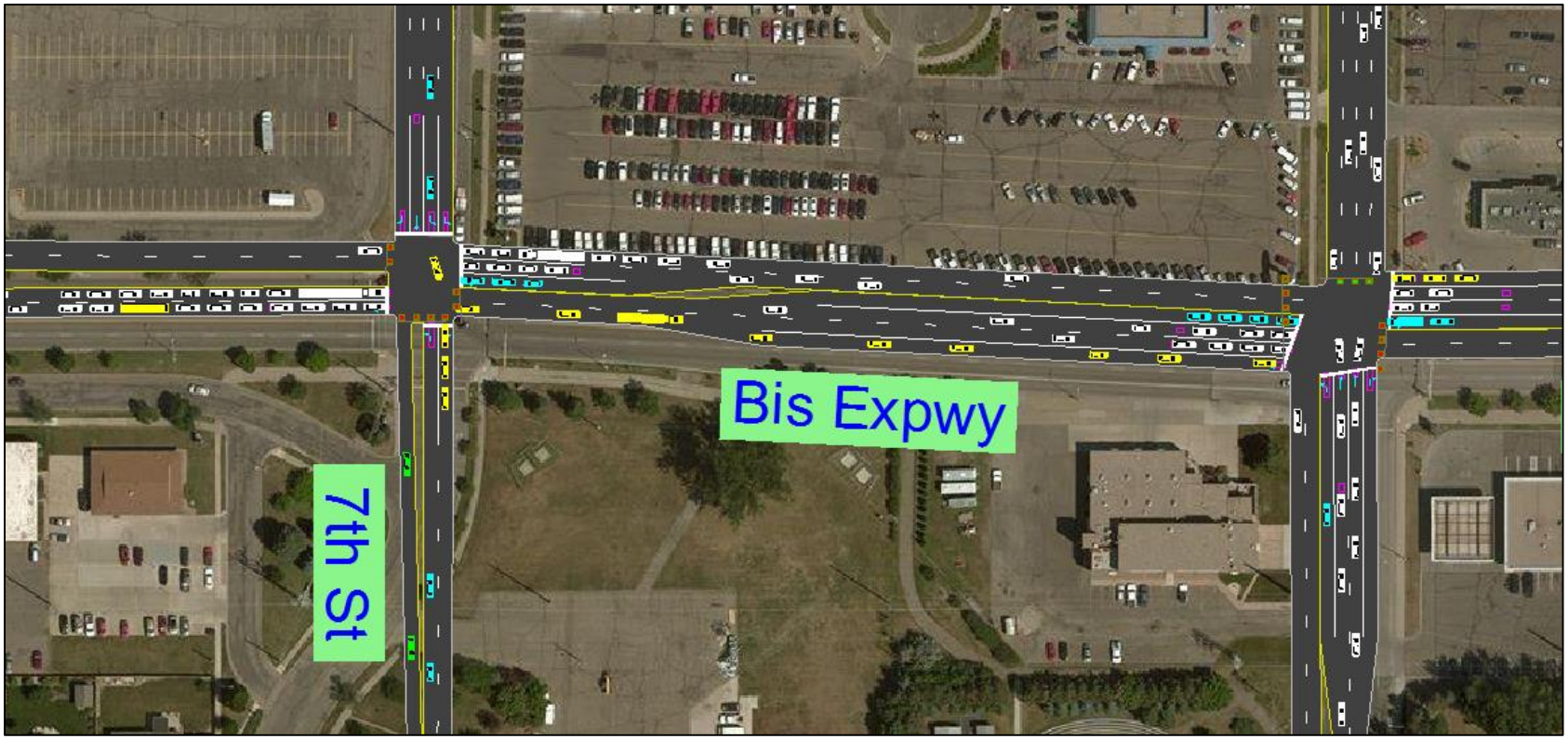


From
NCHRP Report 672
Exhibit 5-2

Capacity Analysis

Capacity Analysis Simulation

- Play the simulation video.



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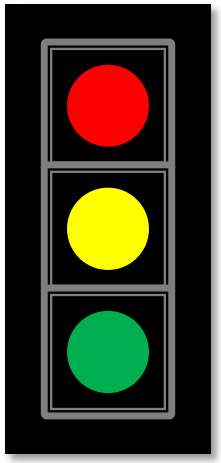
Traffic Signals 101



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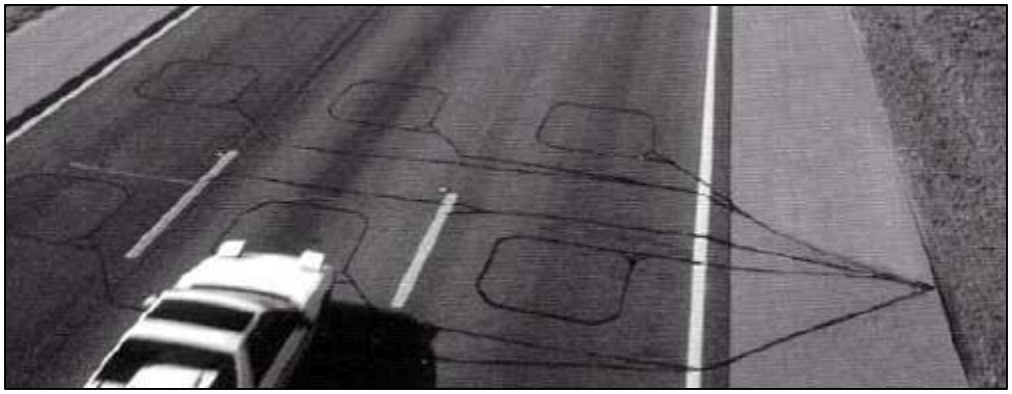
How is Traffic Detected?

How is Traffic Detected?

- No Detection (pre-timed)

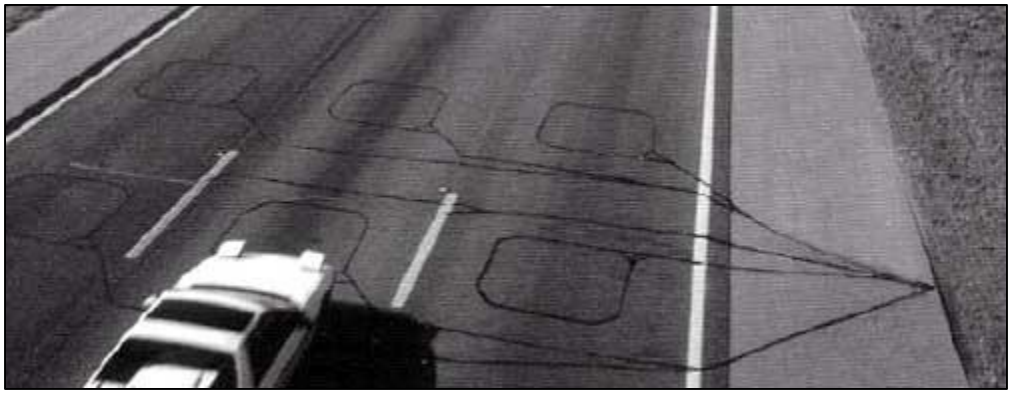
How is Traffic Detected?

- No Detection (pre-timed)
- Inductive Loops



How is Traffic Detected?

- No Detection (pre-timed)
- Inductive Loops



- Video Detection Cameras (photo on next slide)

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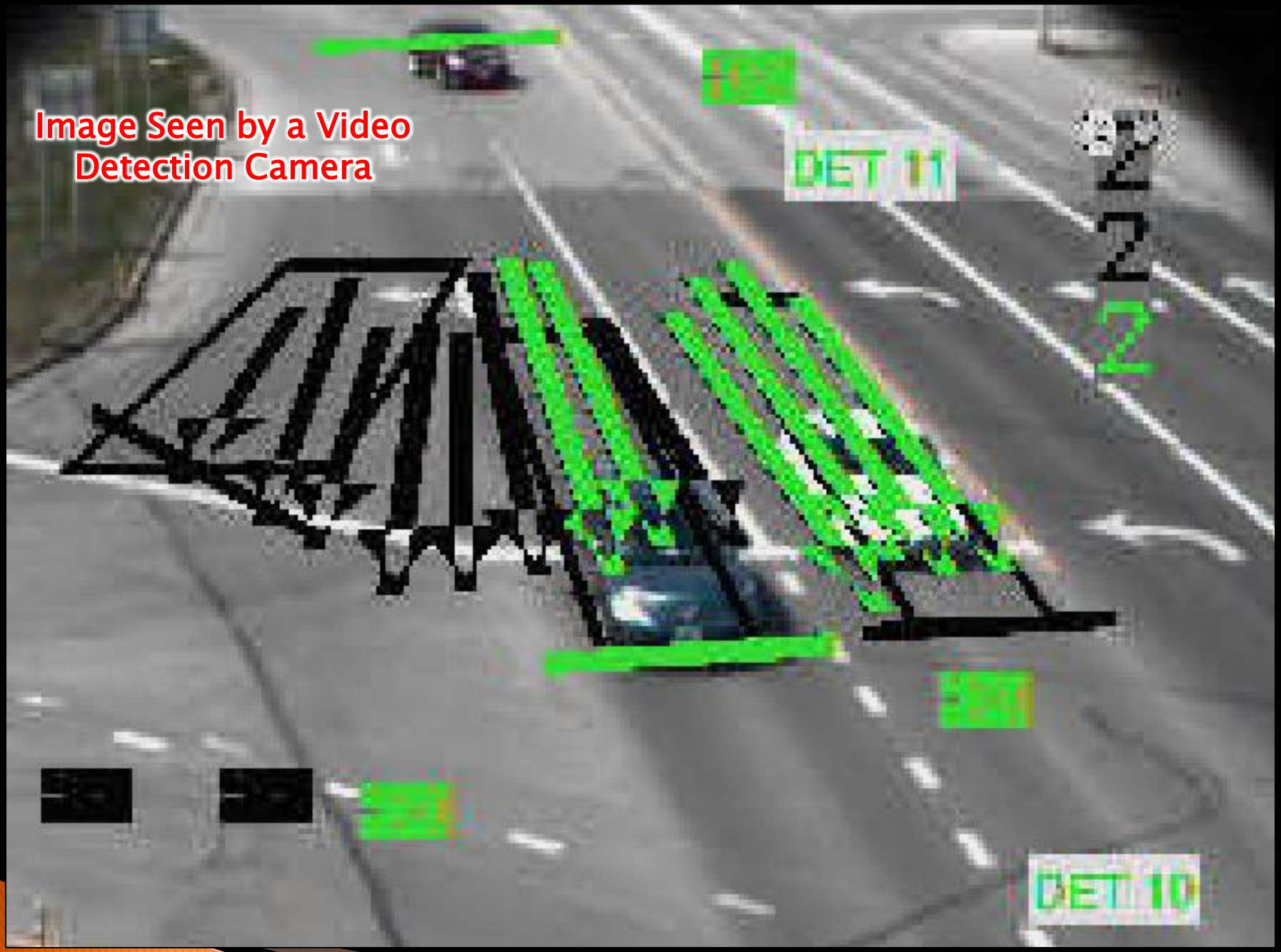

Image Seen by a Video Detection Camera

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How is Traffic Detected?

- Train Pre-Emption

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How is Traffic Detected?

- Train Pre-Emption
- Emergency Vehicle Pre-Emption

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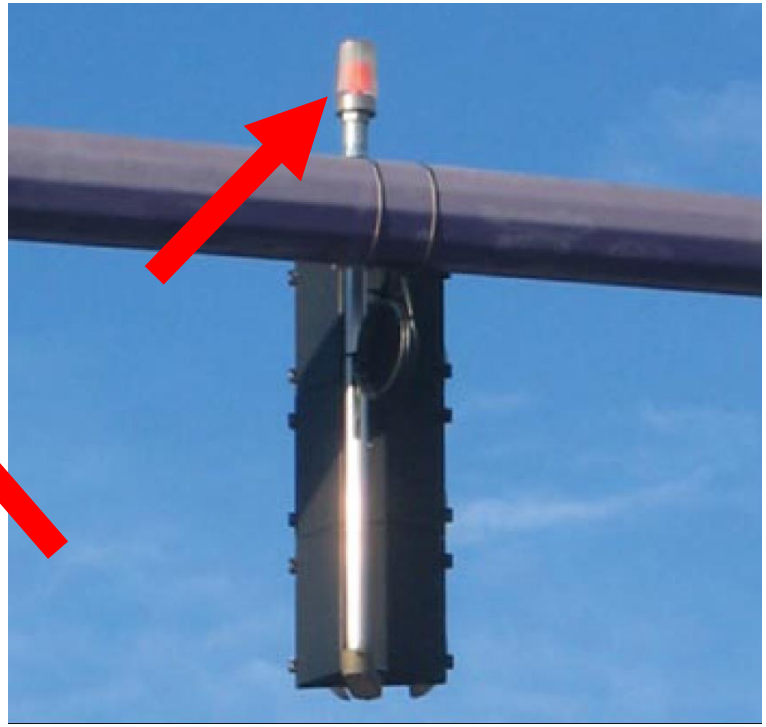
How is Traffic Detected?

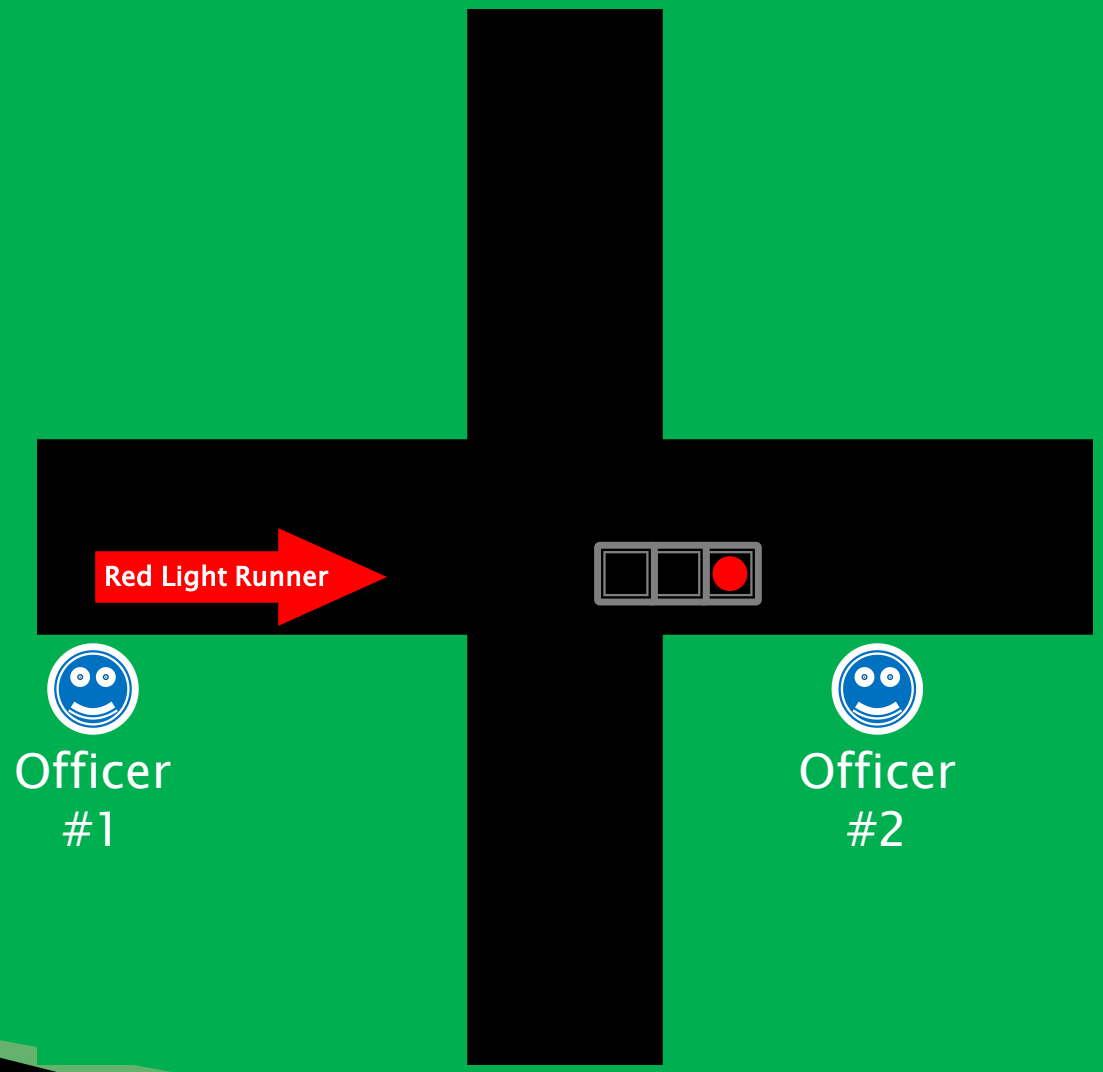
- Train Pre-Emption
- Emergency Vehicle Pre-Emption
- Pedestrian/Bike Pushbuttons

Law Enforcement Confirmation Lights

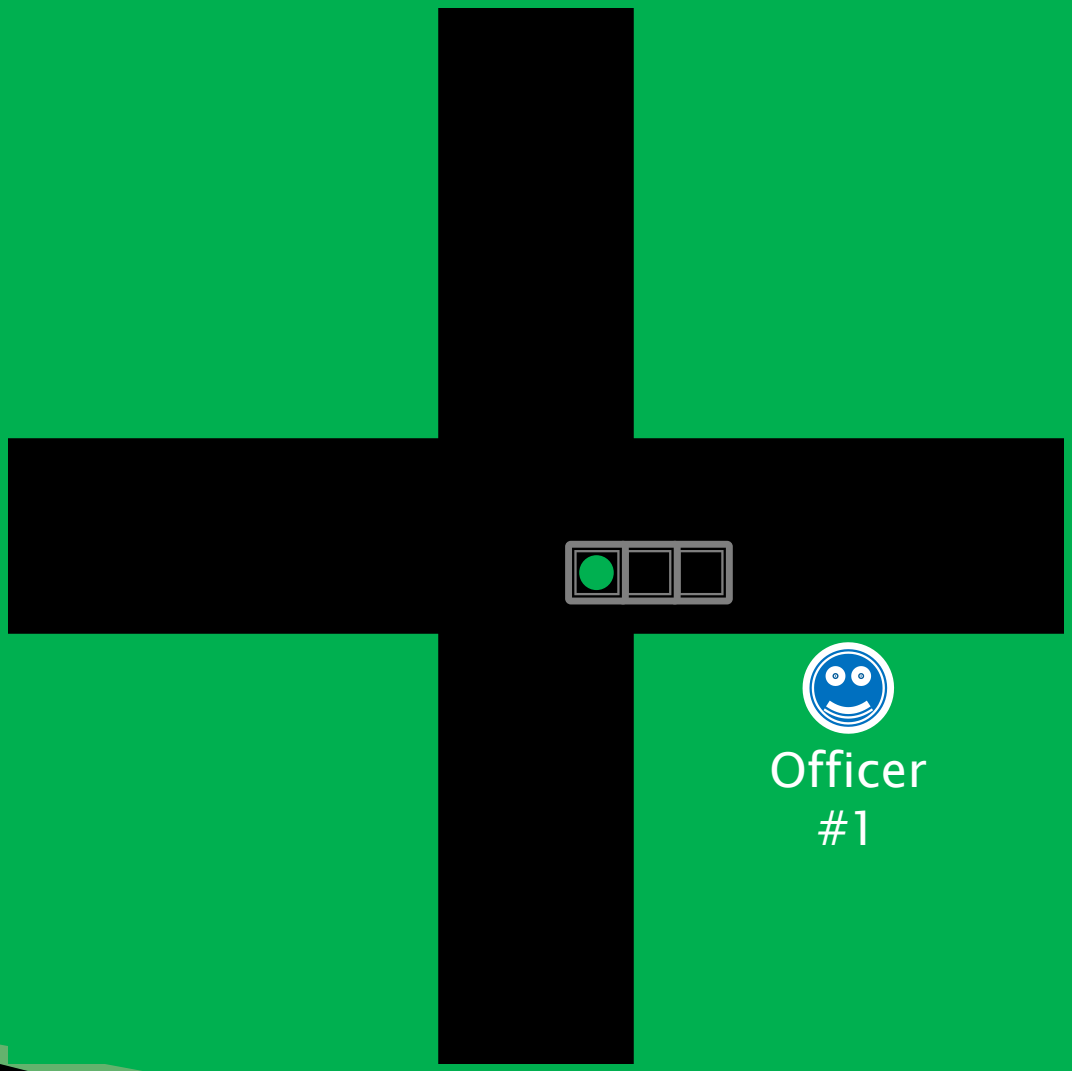
Law Enforcement Confirmation Lights



Current Practice



Using a Confirmation Light



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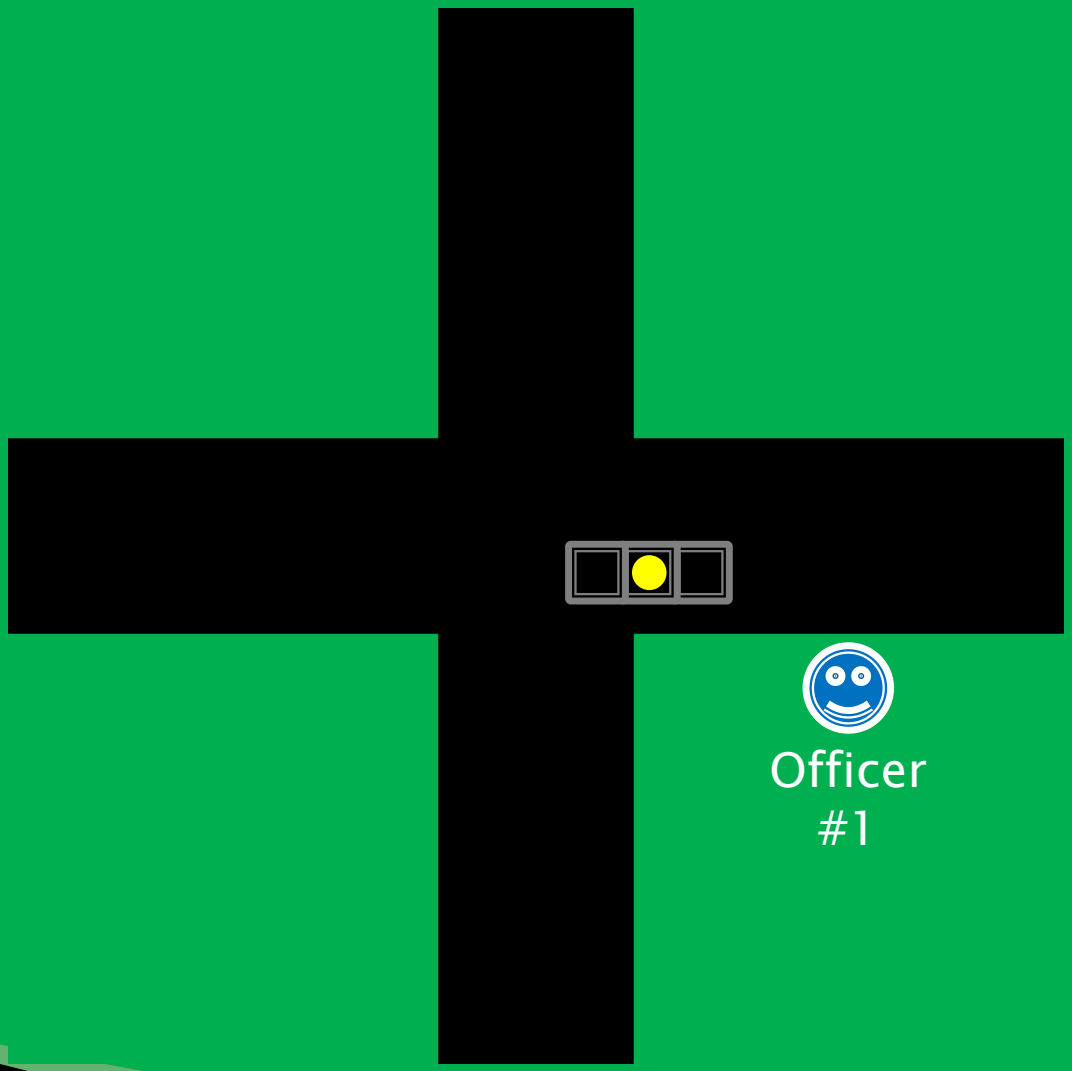

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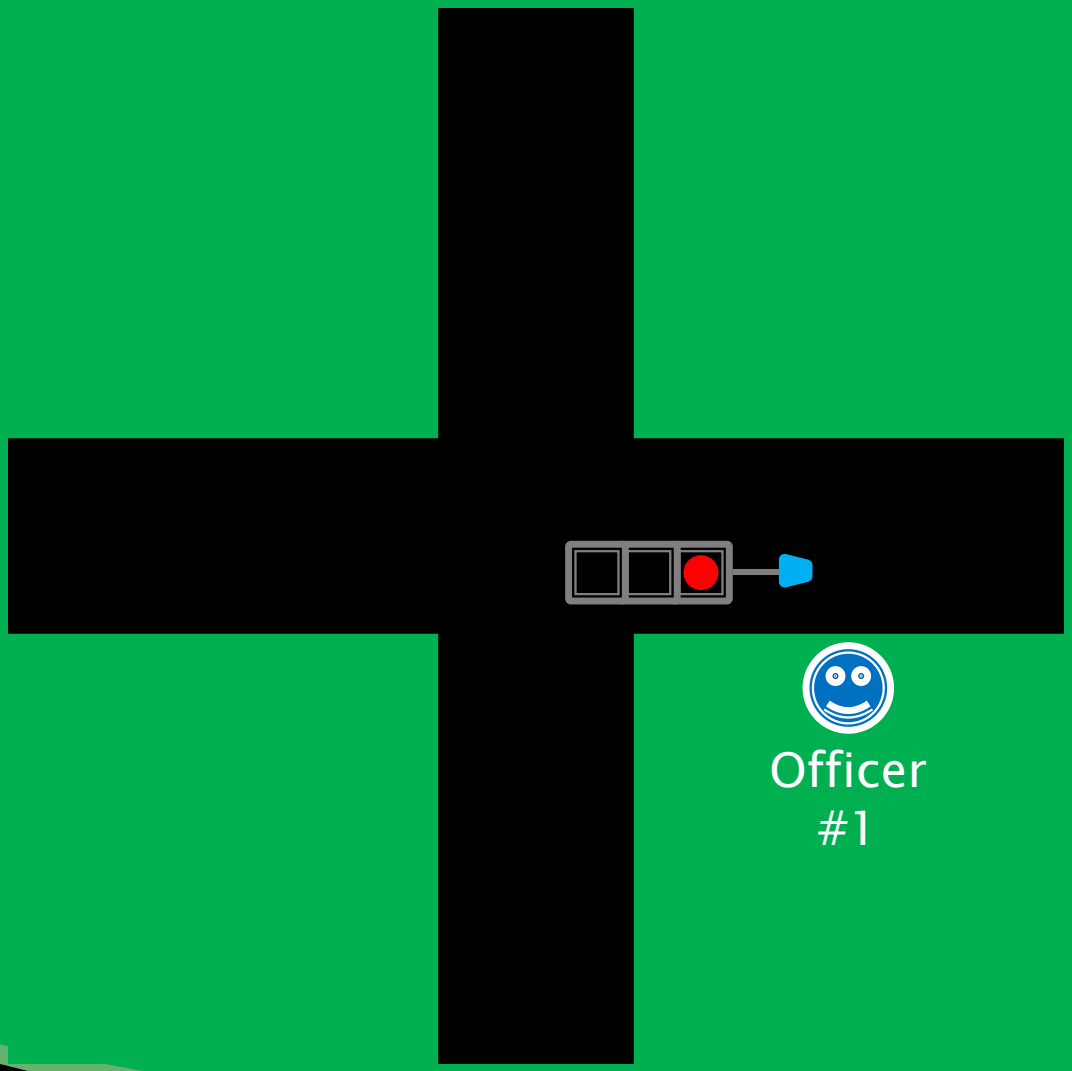
Using a Confirmation Light



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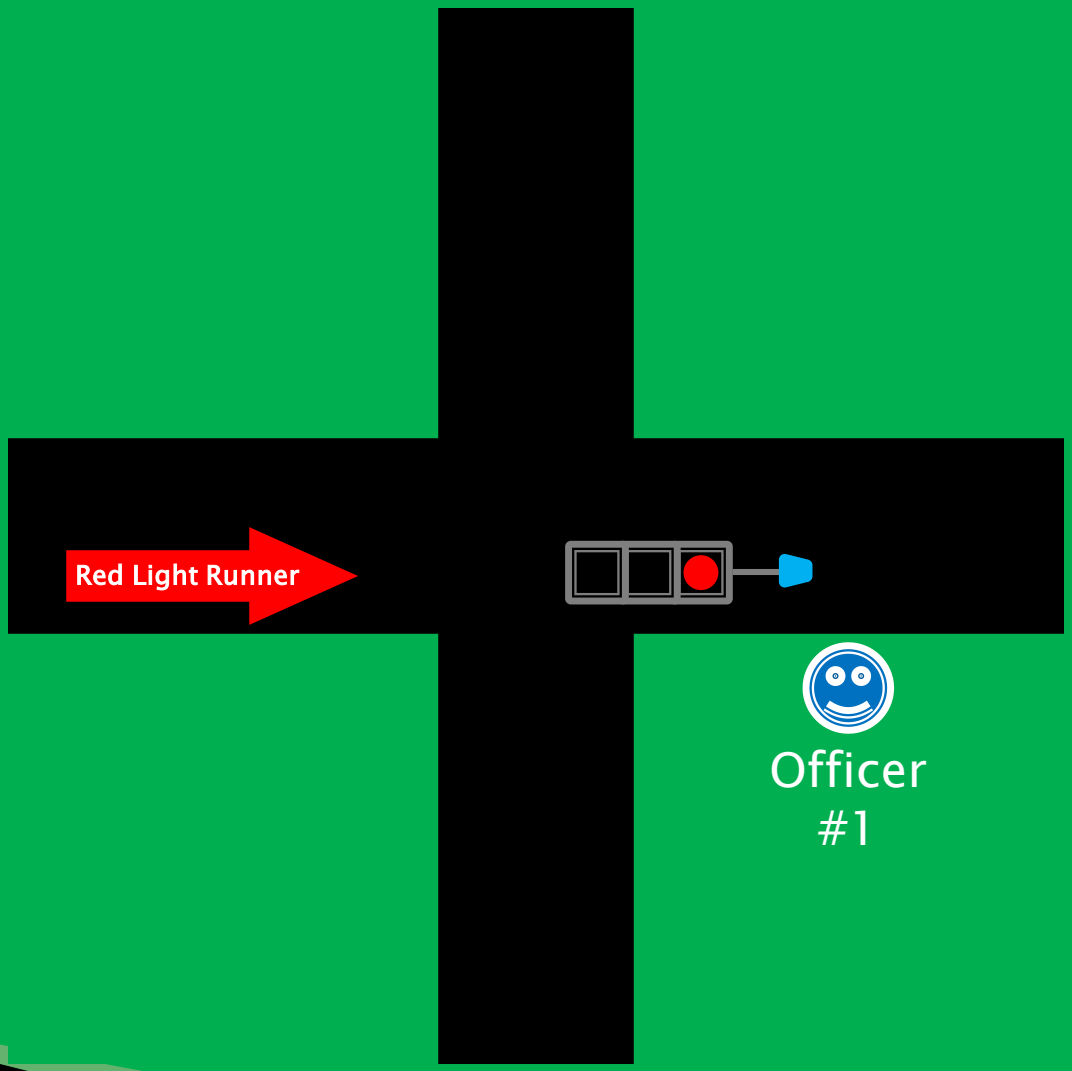

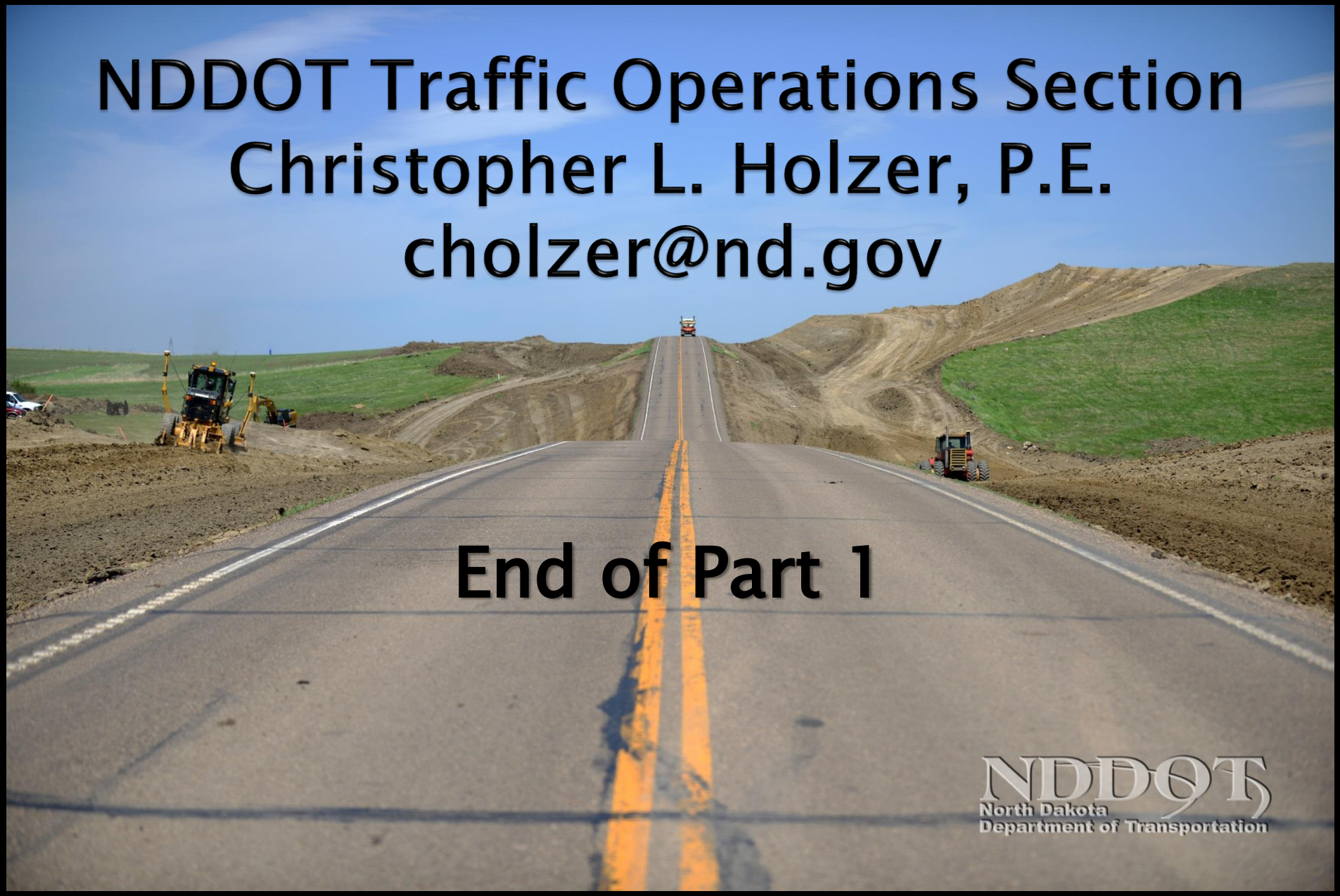
NDDOT Traffic Operations Section
Christopher L. Holzer, P.E.
cholzer@nd.gov
End of Part 1
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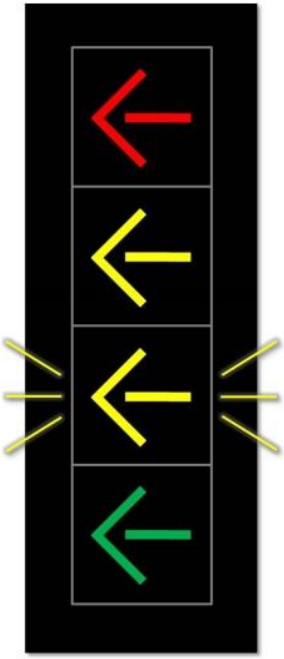
Extra Slides
(only if needed)

Flashing Yellow Arrows 101



http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

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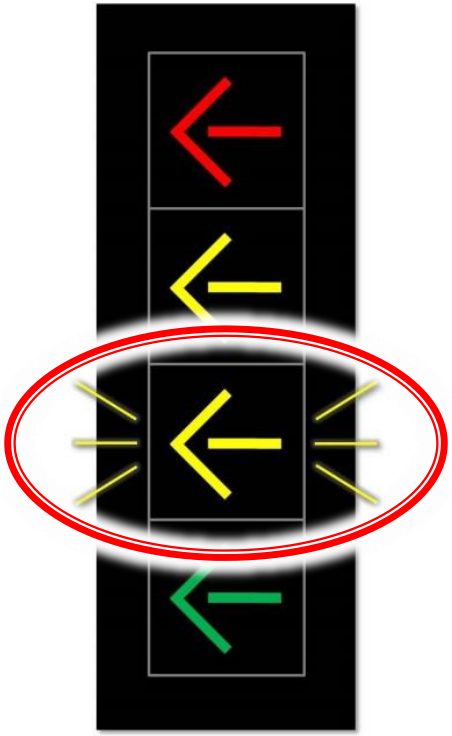
What Does a FYA Mean?



Caution. You may cautiously turn left after yielding to oncoming traffic and to pedestrians.

http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

Why Use FYA?

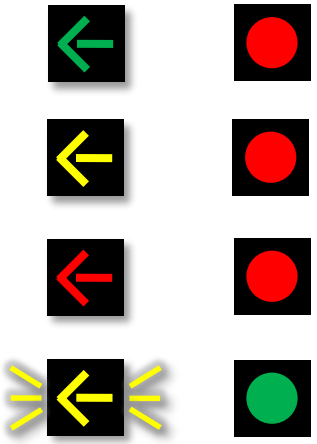
- Safer
  - A national study showed drivers made fewer mistakes with FYA indications than with green ball indications.

http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

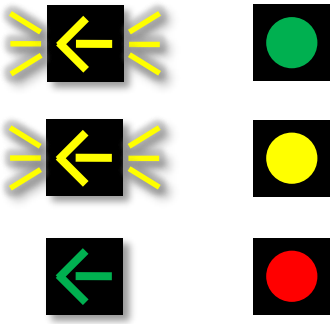
Why Use FYA?

- More Efficient
  - The green arrow can go either before or after through traffic has a green ball. This can improve progression of coordinated traffic signals.

Ex. Sequence #1
(green arrow first)



Ex. Sequence #2
(green arrow last)



http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

Why Use FYA? (continued)

- More Flexible
  - Can change operation based on time-of-day.

http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

Why Use FYA? (continued)

- More Flexible
  - Can change operation based on time-of-day.
    - Example. Rush hour = no gaps in traffic = utilize green arrow only (no FYA).
    - Example. Off-Peak = many gaps in traffic = drivers don't need a green arrow to turn = utilize FYA only.

http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

Why Use FYA? (continued)

- More Flexible
  - Can change operation based on time-of-day.
    - Example. Rush hour = no gaps in traffic = utilize green arrow only (no FYA).
    - Example. Off-Peak = many gaps in traffic = drivers don't need a green arrow to turn = utilize FYA only.
- Federal Rules (MUTCD)
  - For new traffic signals, green ball indications are no longer allowed over left turn lanes.

http://dot.nd.gov/divisions/programming/flashing-yellow-arrow.htm

How To Keep Roadway Safe From Obstructions

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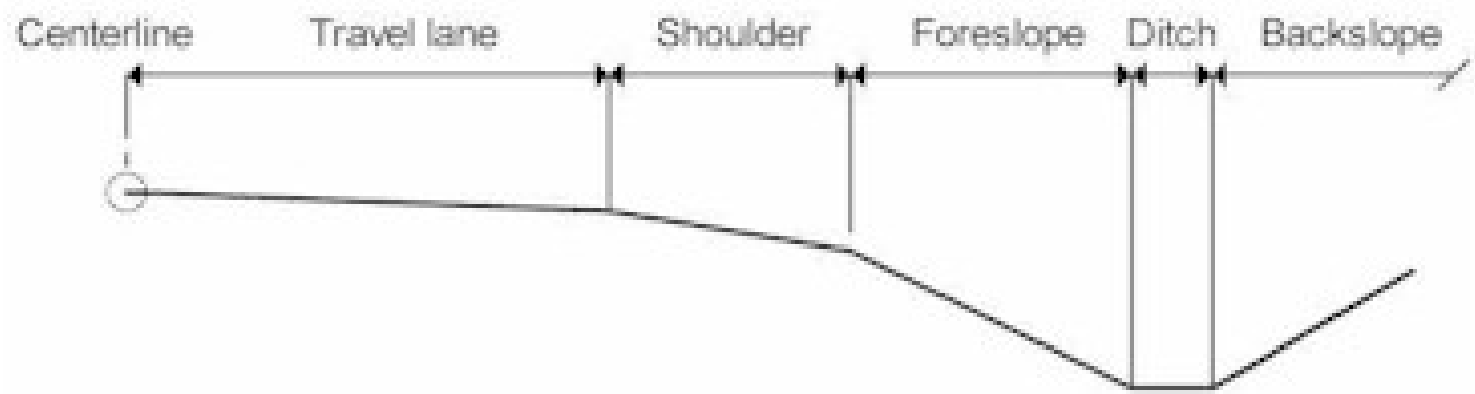
What is a roadway?



Why Roadside Safety?

- Approximately 40,000 vehicle accident fatalities per year
- 30% of these involve run off road accidents

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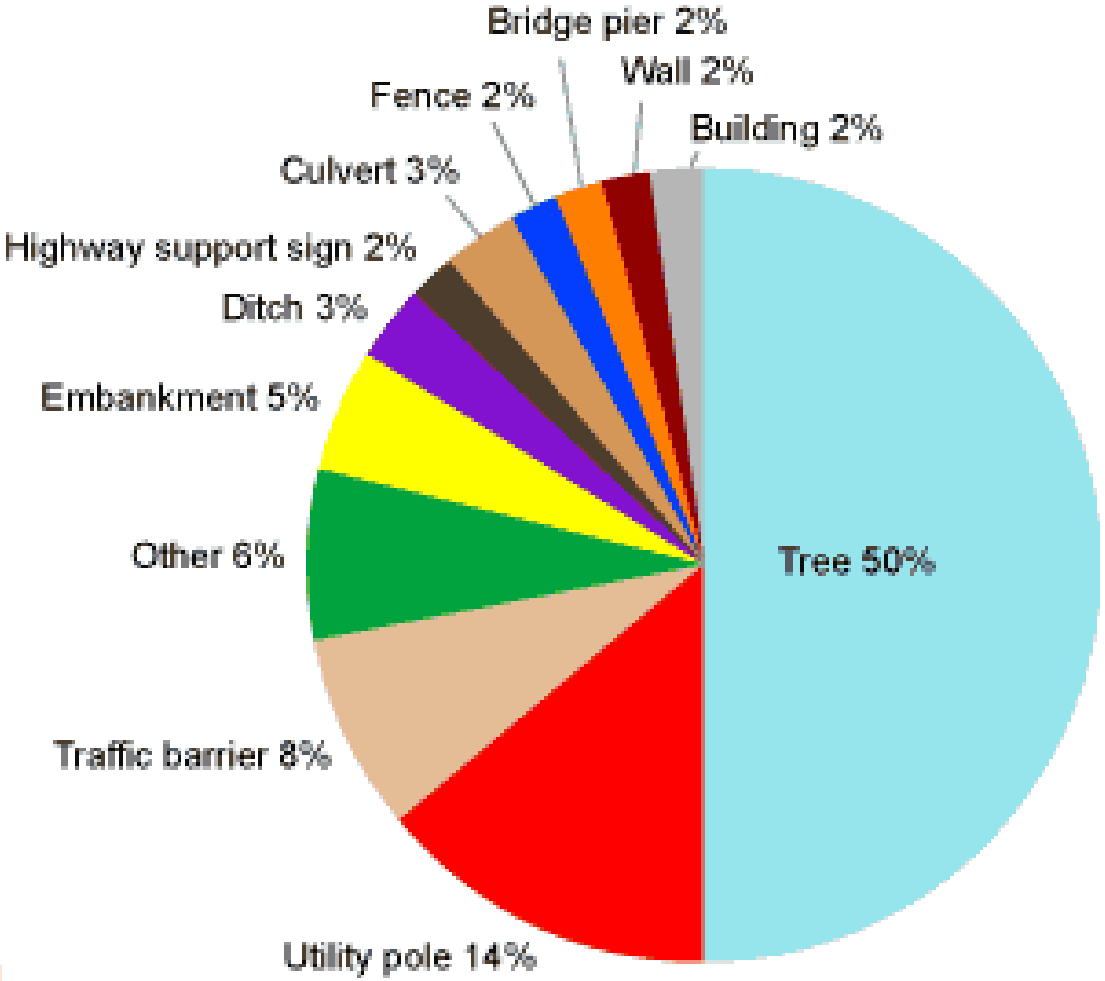
Percent of fixed object crash deaths – 2014



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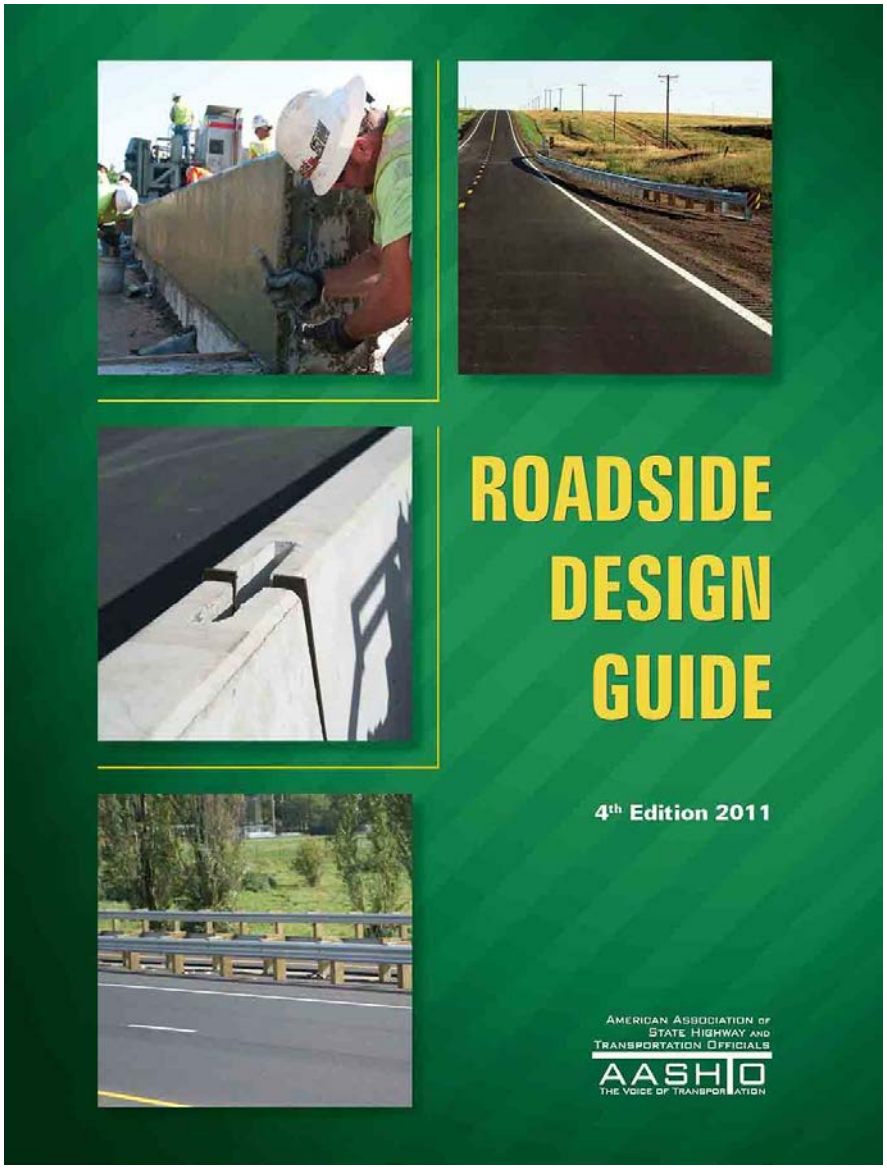
How To Deal With Fixed Obstructions

- Eliminate
- Make Crashworthy
- Shield



Types of sign supports used in North Dakota

- Perforated tube
  - Small signs (up to 4 posts)
- Round steel pipe
  - Larger signs (1 post)
- W shape
  - Large signs (2 or more posts)

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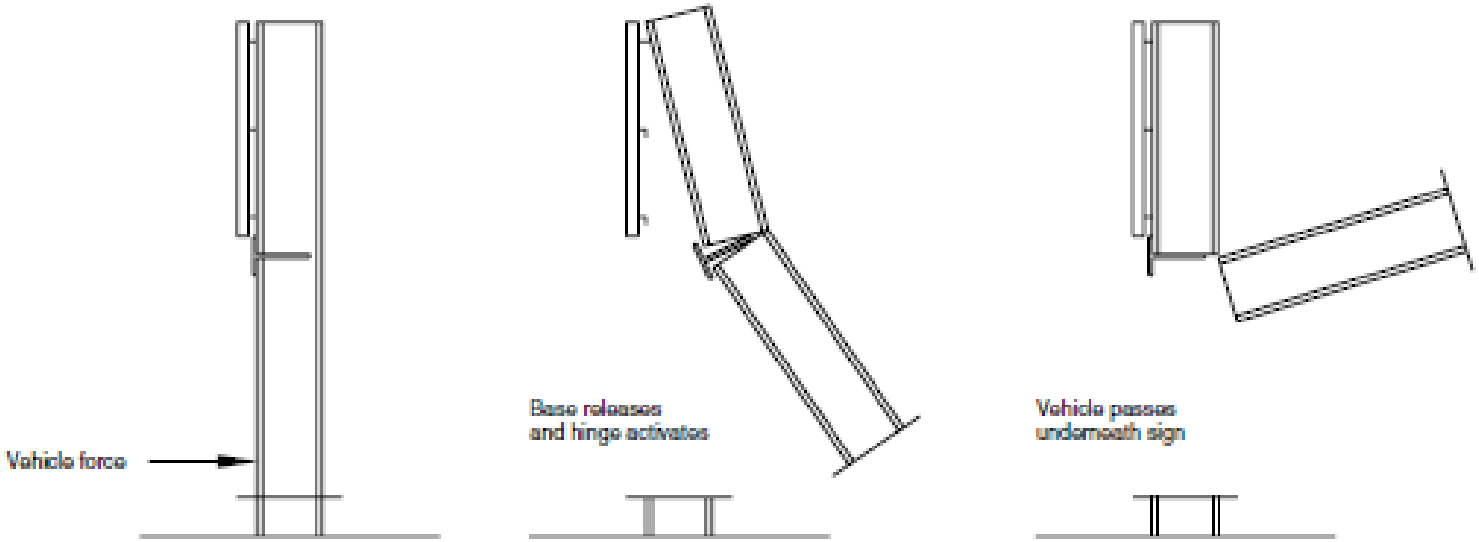
Vehicle force
Base releases
and hinge activates
Vehicle passes
underneath sign

14”
4”

3 Types of Guardrail Used in North Dakota

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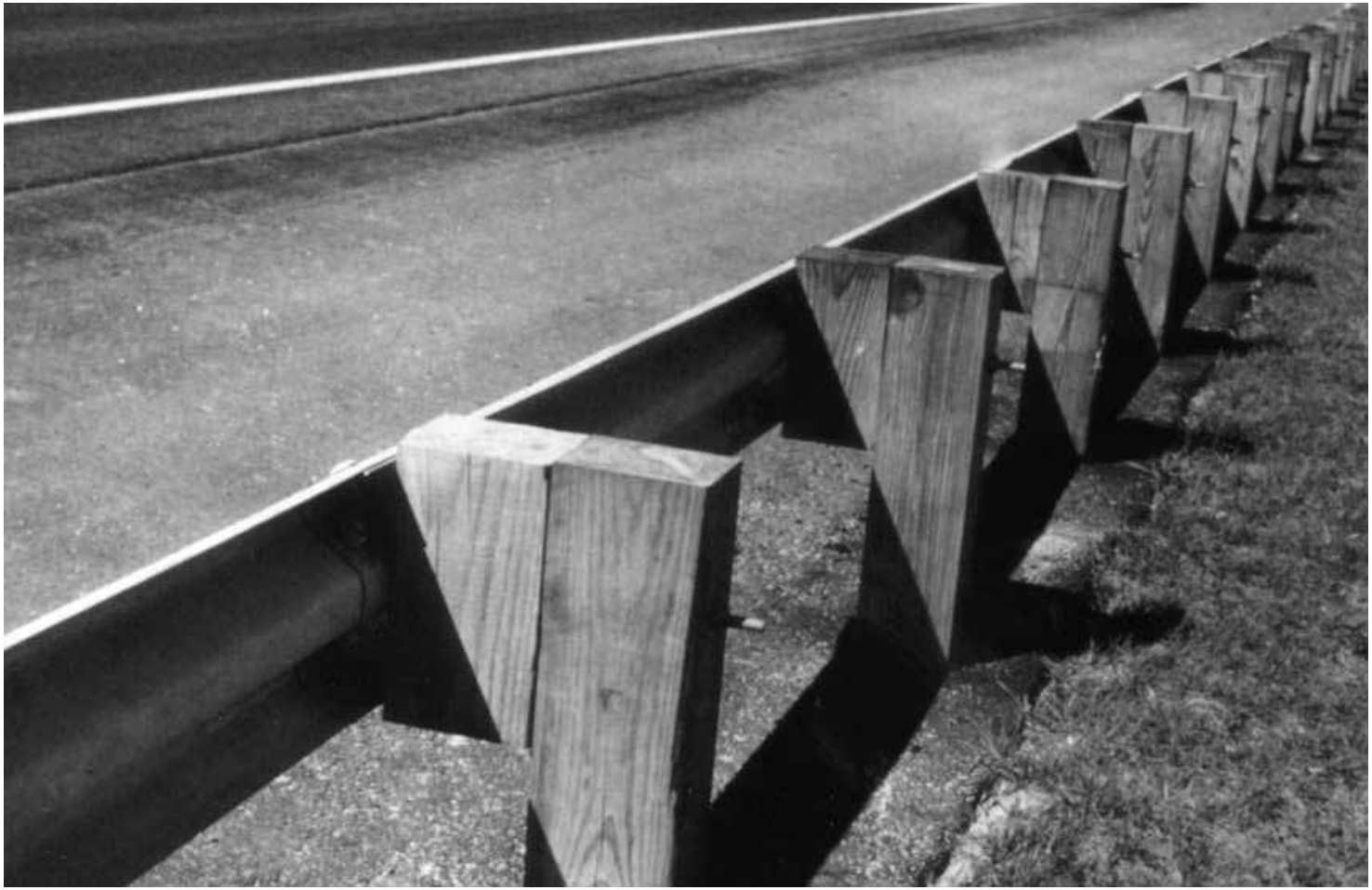
Low Tension 3 Cable

W Beam

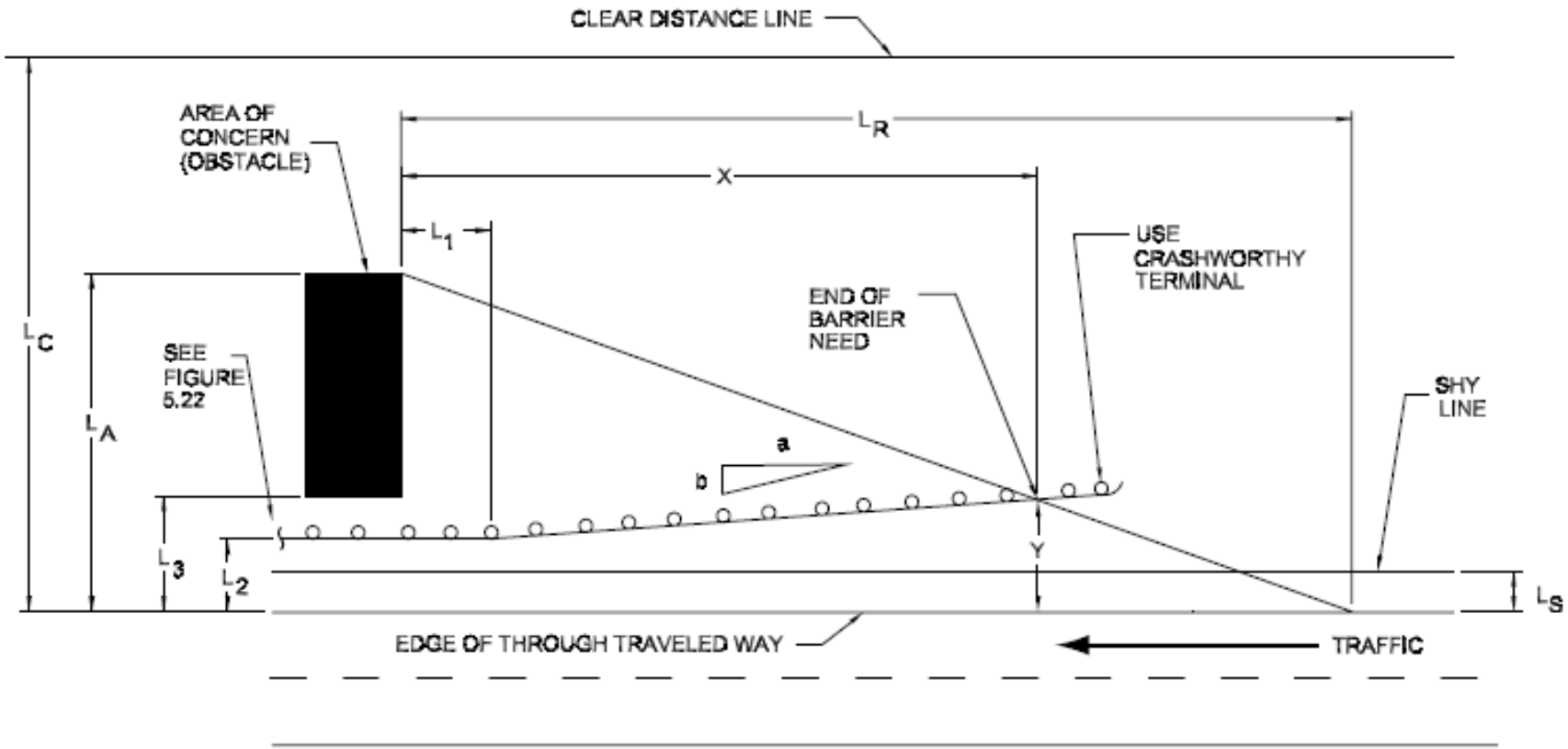


Concrete Jersey Barrier

What length of guardrail is needed?

- What is the obstruction
- Where is the obstruction from the driving lanes
- What is the speed limit of the roadway
- Is it on a curve
- Calculate Length of Need

Length of Need



Traffic Volumes (ADT)				
Design Speed (mph)	Over 6000 vpd	2000-6000 vpd	800-2000 vpd	Under 800 vpd
	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)	Runout Length L_R (ft)
75	520	485	430	395
70	475	445	395	360
65	450	425	370	345
60	425	400	345	330
55	360	345	315	280
50	330	300	260	245
45	260	245	215	200
40	230	200	180	165
30	165	165	150	130

Suggested Runout Lengths for Barrier Design

Lighting

- Breakaway
  - Higher speeds
- Non- breakaway
  - Urban areas with lower speeds
  - Pedestrian facilities near by.

LED Lighting

- Switching HPS lighting to LED lighting
  - How much light
  - How uniform or consistent the light

How are safety features crash tested?

Conclusion

- Eliminate obstructions on or near the roadway
- Make obstruction crashworthy
- Shield obstructions

Doug Schumaker

North Dakota Department of Transportation

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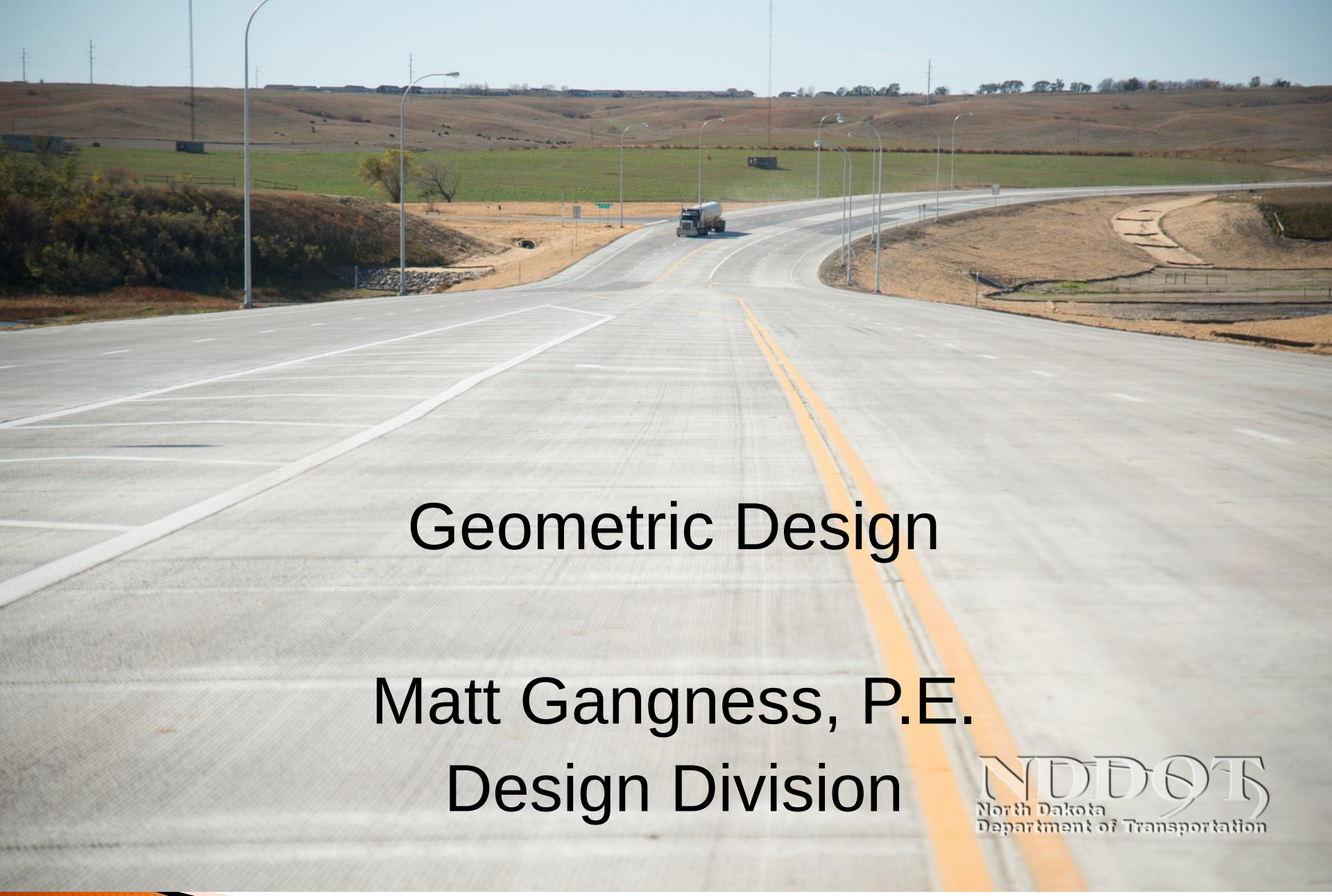

Geometric Design

Matt Gangness, P.E.
Design Division

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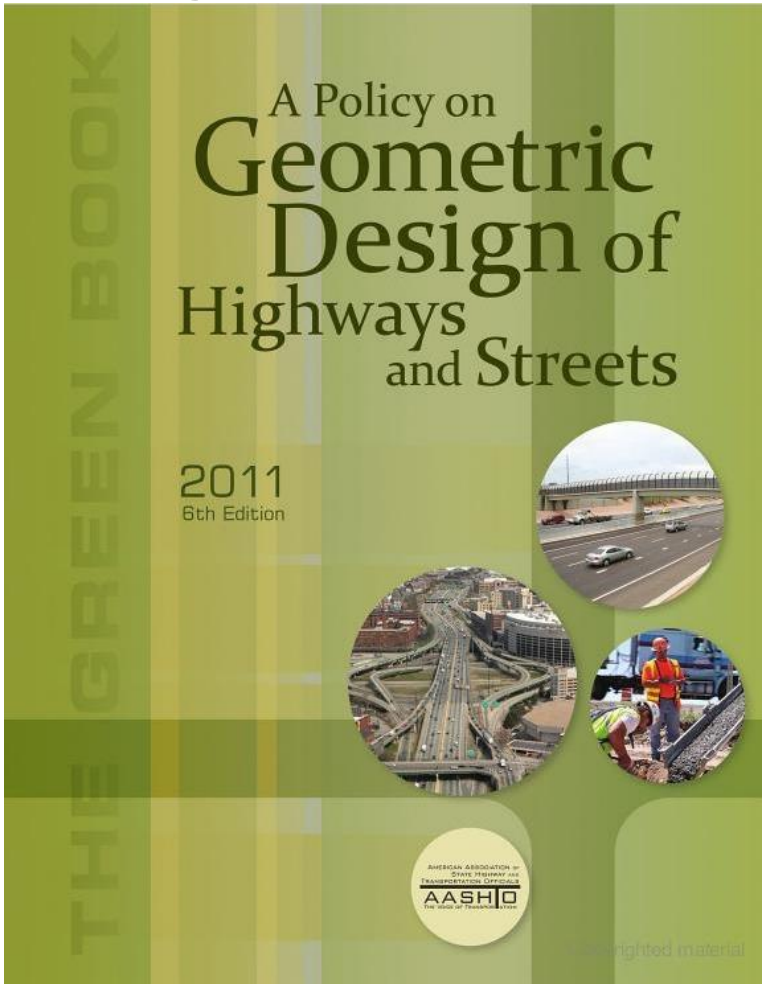
Did you know…

- The first documented auto fatality in the United States was H.H. Bliss of New York City.
- He was struck by an electric powered taxicab on September 13, 1899, while walking out of a trolley car.
- Arthur Smith, the driver of the taxicab, was arrested and charged with manslaughter, but was acquitted on the grounds that he had no malice, nor was he negligent

AASHTO Green Book

American Association of State Highway and Transportation Officials (AASHTO)



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AASHTO Green Book

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NEW MEXICO	Gabriela Contreras-Apodaca, Joe S. Garcia
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Stopping Sight Distance (SSD)

- Comprised 2 distances:
  - Reaction Time + Braking Distance = SSD
  - Reaction Time = 2.5 seconds
    - Capable for most drivers, including older drivers
    - Accounts to stop for unexpected object in roadway
  - Braking Distance uses deceleration rate = 11.2ft/s²
    - Comfortable deceleration for most drivers
    - Capable to stay in own lane and maintain steering
    - *Unexpected/emergency stop = 14.8ft/s²*

Stopping Sight Distance

- Engineers love formulas:
  - *What is Stopping Sight Distance for 55mph car?*
  - $SSD = 1.47Vt + 1.075\frac{V^2}{a}$

    Reaction Time Distance Braking Distance
  - $SSD = 1.47(55)(2.5) + 1.075\frac{55^2}{11.2}$
  - $SSD = 202 + 290$
  - $SSD = 492ft \approx$ <u>495 ft</u>

Approximate Stopping Distance

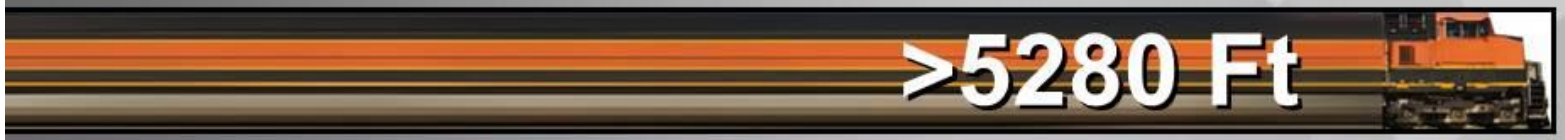
At 55 MPH

~~200 Ft~~ 495 Ft

230 Ft

300 Ft

600 Ft



>5280 Ft

OPERATION LIFESAVER®
Look, Listen & Live

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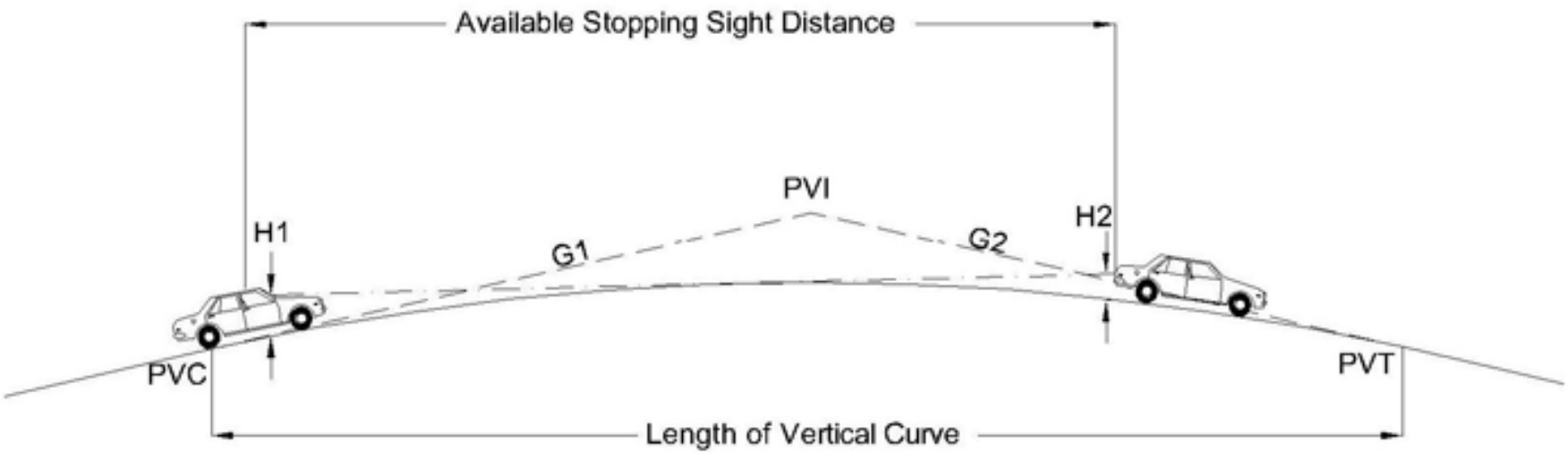
Don't kick the tires!

- The tire contact patches—the areas of the tires that actually touch the road at any given moment—cover an area of just over 100 square inches for an average family sedan.

- In other words, all of the accelerating, cornering, braking, and everything else that your four wheels do, happens on a piece of ground scarcely bigger than your own two feet!

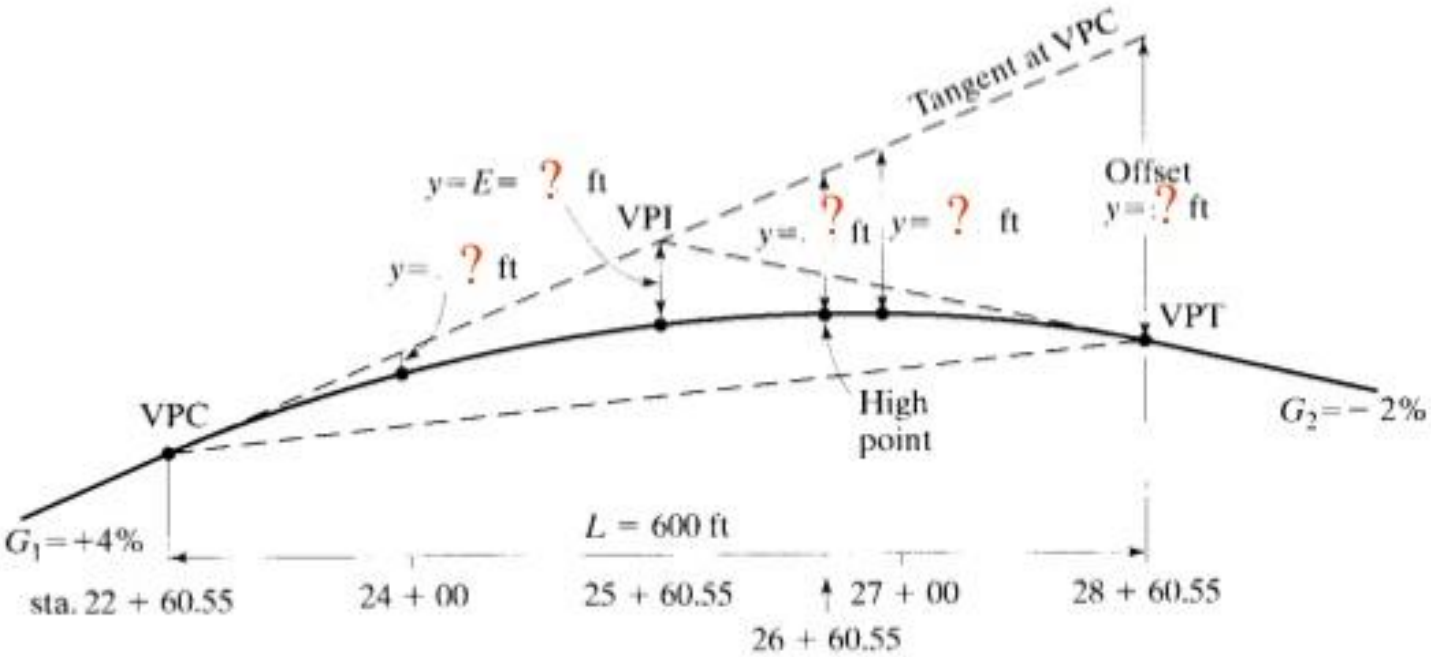
Vertical Curvature

- Crest Vertical Curve
  - Use SSD for given speed to design vertical curves
  - $L = \frac{(G1-G2)S^2}{2158}$
  - H1 = 3ft (height of eye)
  - H2 = 2ft (height of object/tail light)



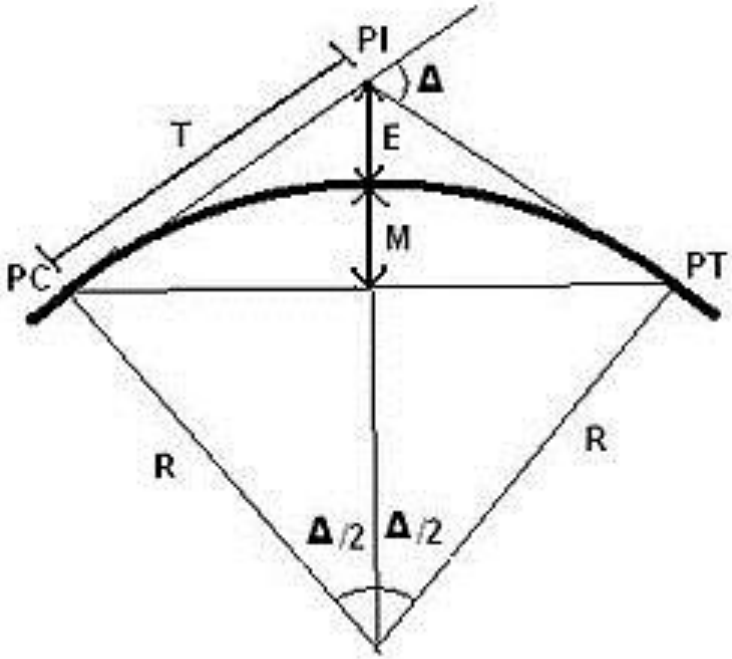
Vertical alignment example

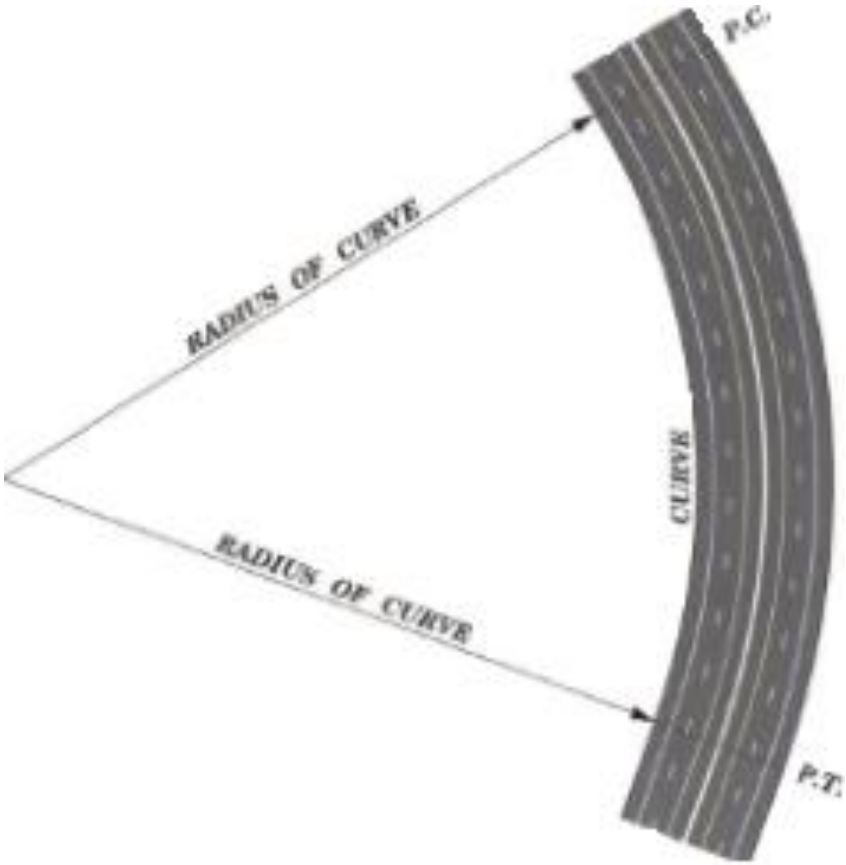
- A 600-ft curve connects a +4% grade to a –2% grade at station 25+60.55 and elevation 648.64 ft. Calculate the location and elevation of the VPC, the middle of the curve, the VPT, and the curve elevation at stations 24+00 and 27+00



Horizontal Curvature

- Simple Curve





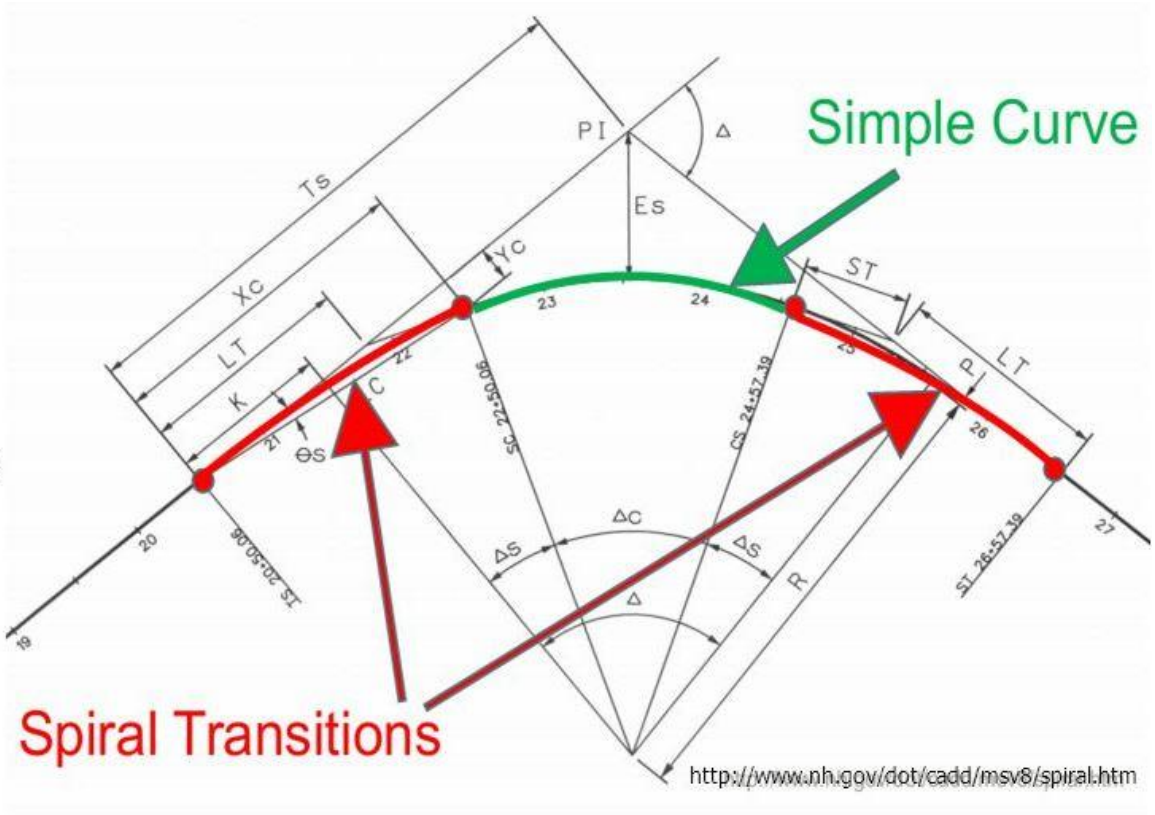
Horizontal Curvature

- Spiral Curve combination

$$k = 100\ D / L_s$$

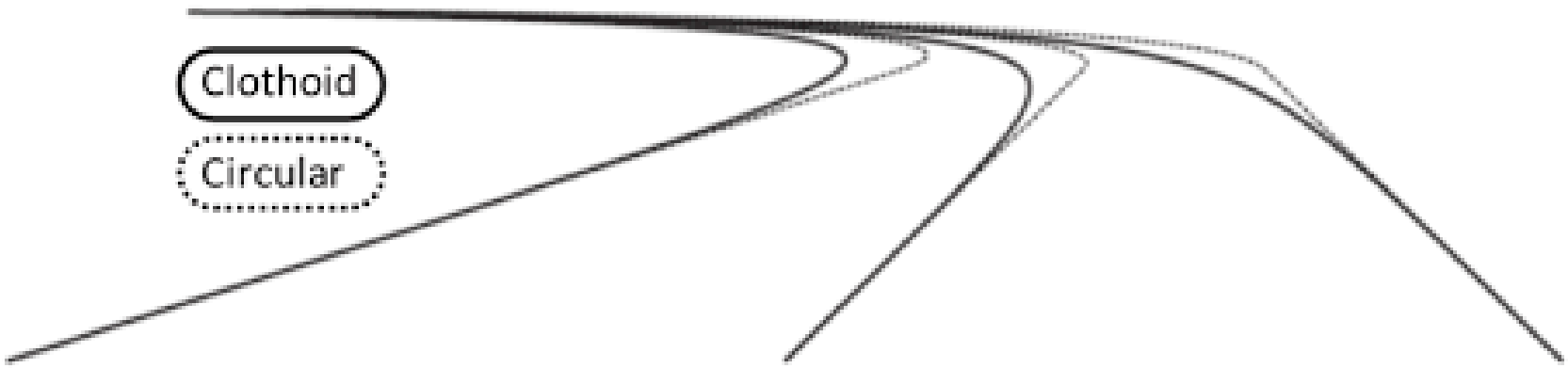
$$\Delta = \Delta_c + 2\,\Delta_s$$

$$\Delta_s = L_s\,D / 200$$



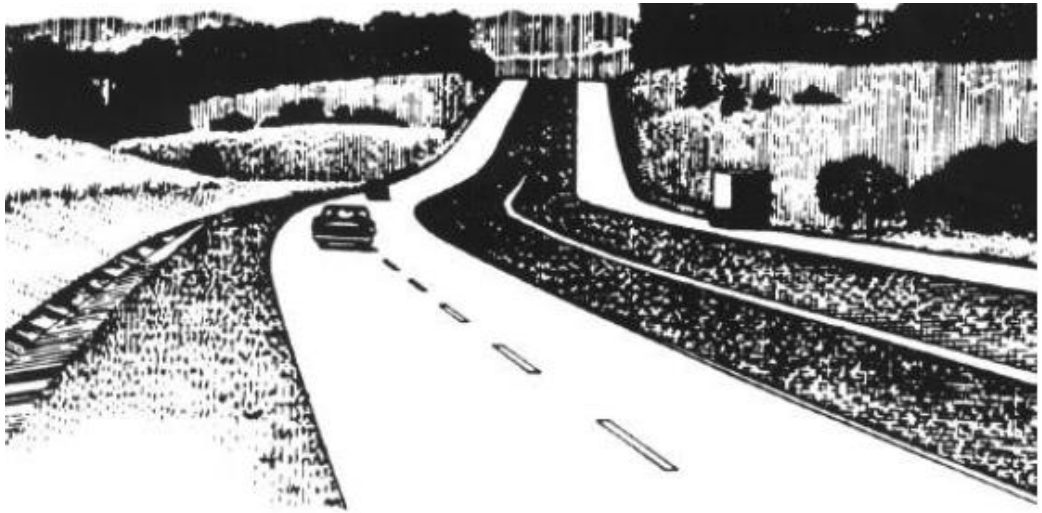
Horizontal Curvature

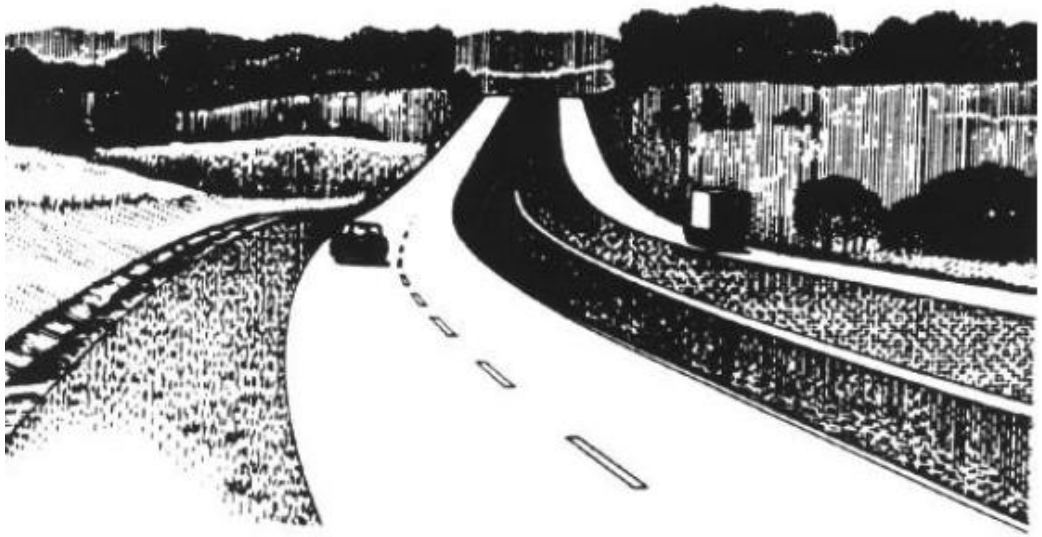
- Simple Curve vs. Spiral Curve



Horizontal Curvature

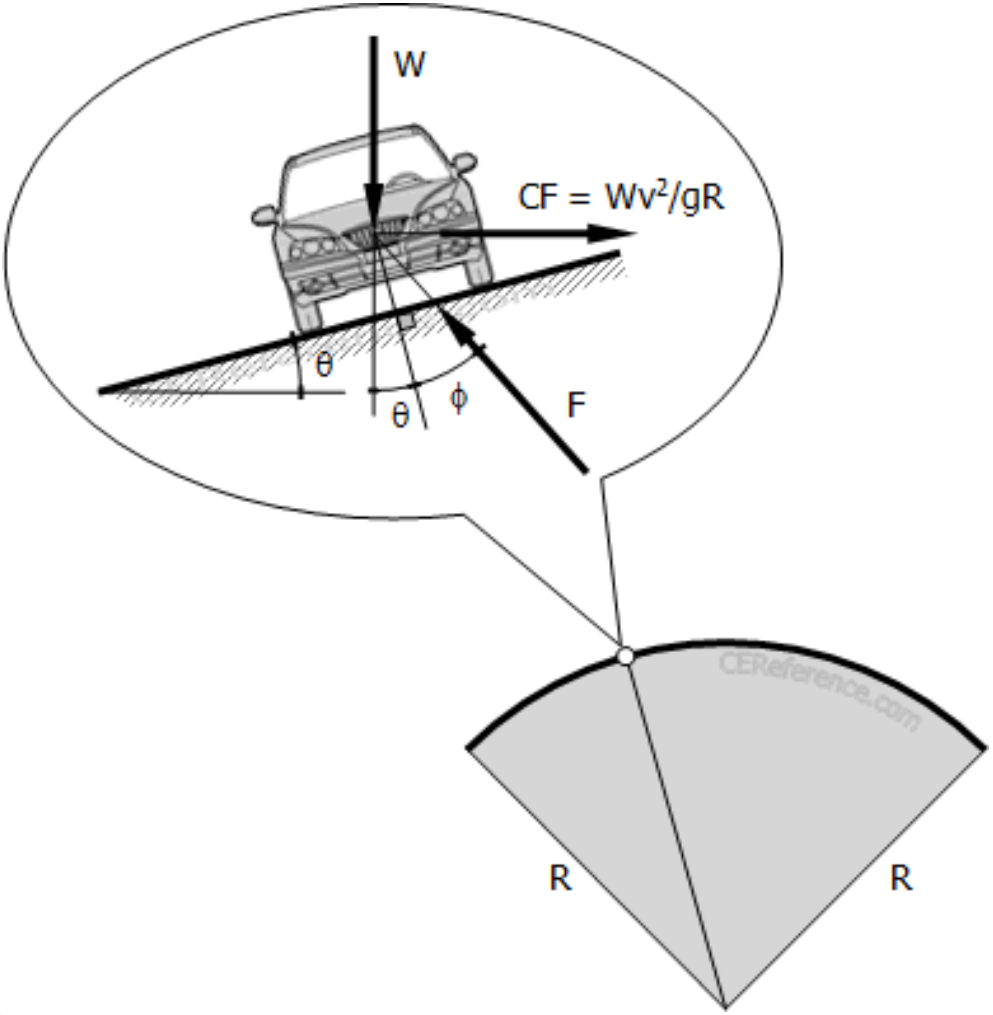
- Simple Curve vs. Spiral Curve





Horizontal Curvature

- Superelevation
  - Max 6% for NDDOT
  - Normal Cross Slope of about -2%



Horizontal Curvature

- Superelevation around the world…

Life without the Green Book

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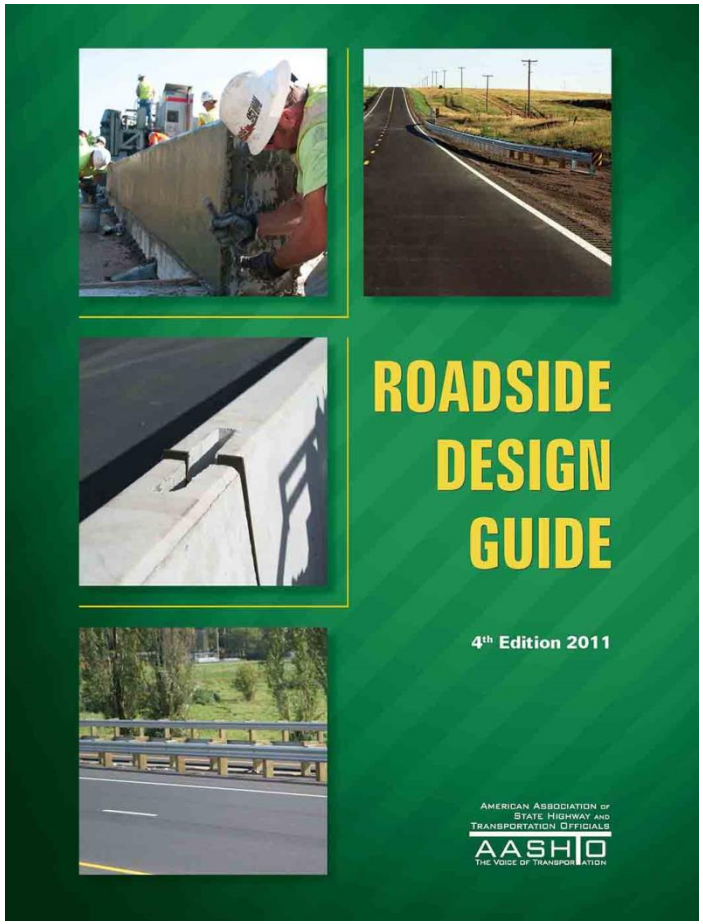
Clear Zone Concept

- AASHTO Roadside Design Guide
  - “the other green book”



Clear Zone Concept

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Region 4 Idaho South Dakota Texas California	Damon Allen Bernie Clocksin Aurora (Rory) Meza Kevin Herritt

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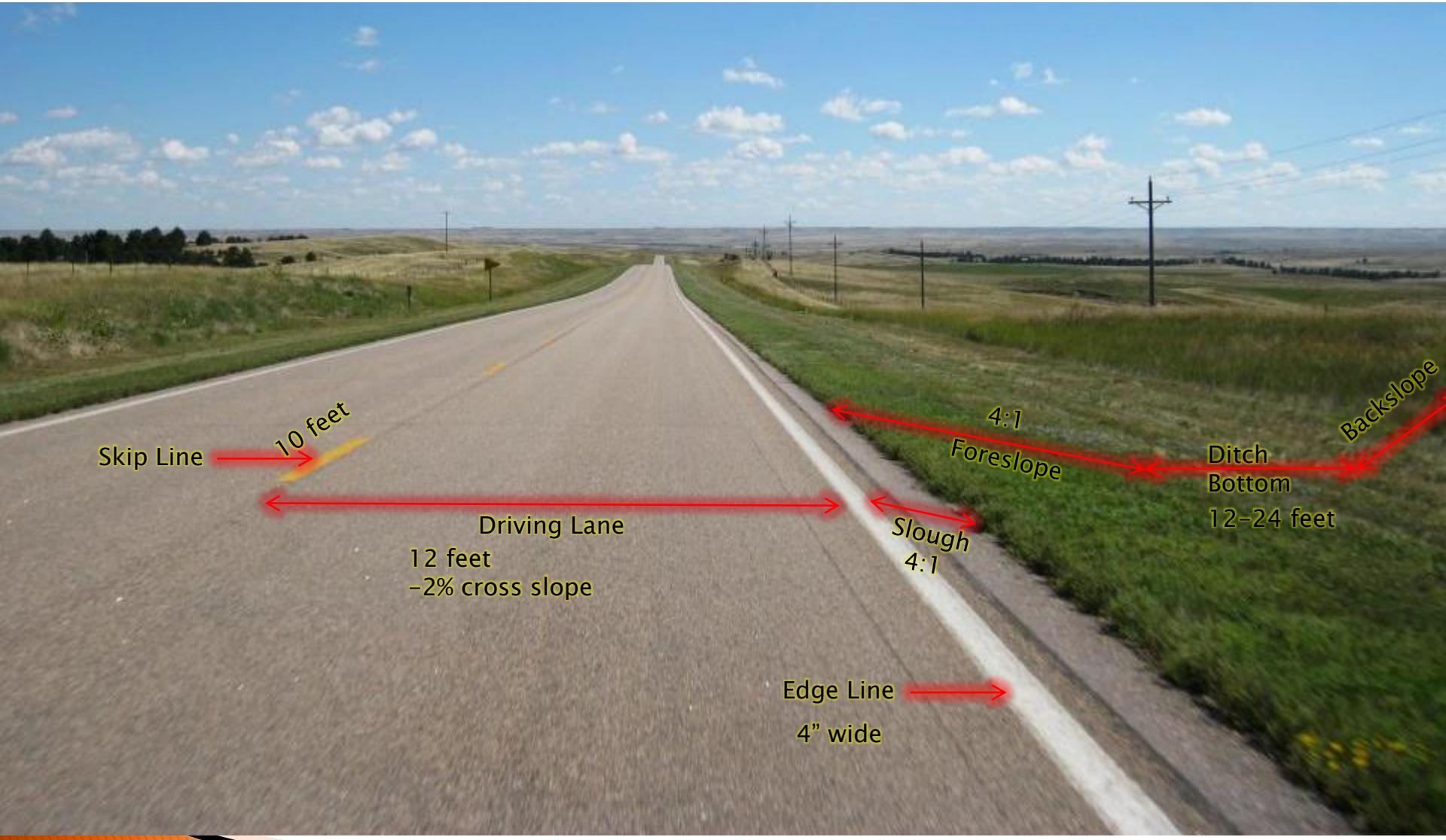
Clear Zone Concept



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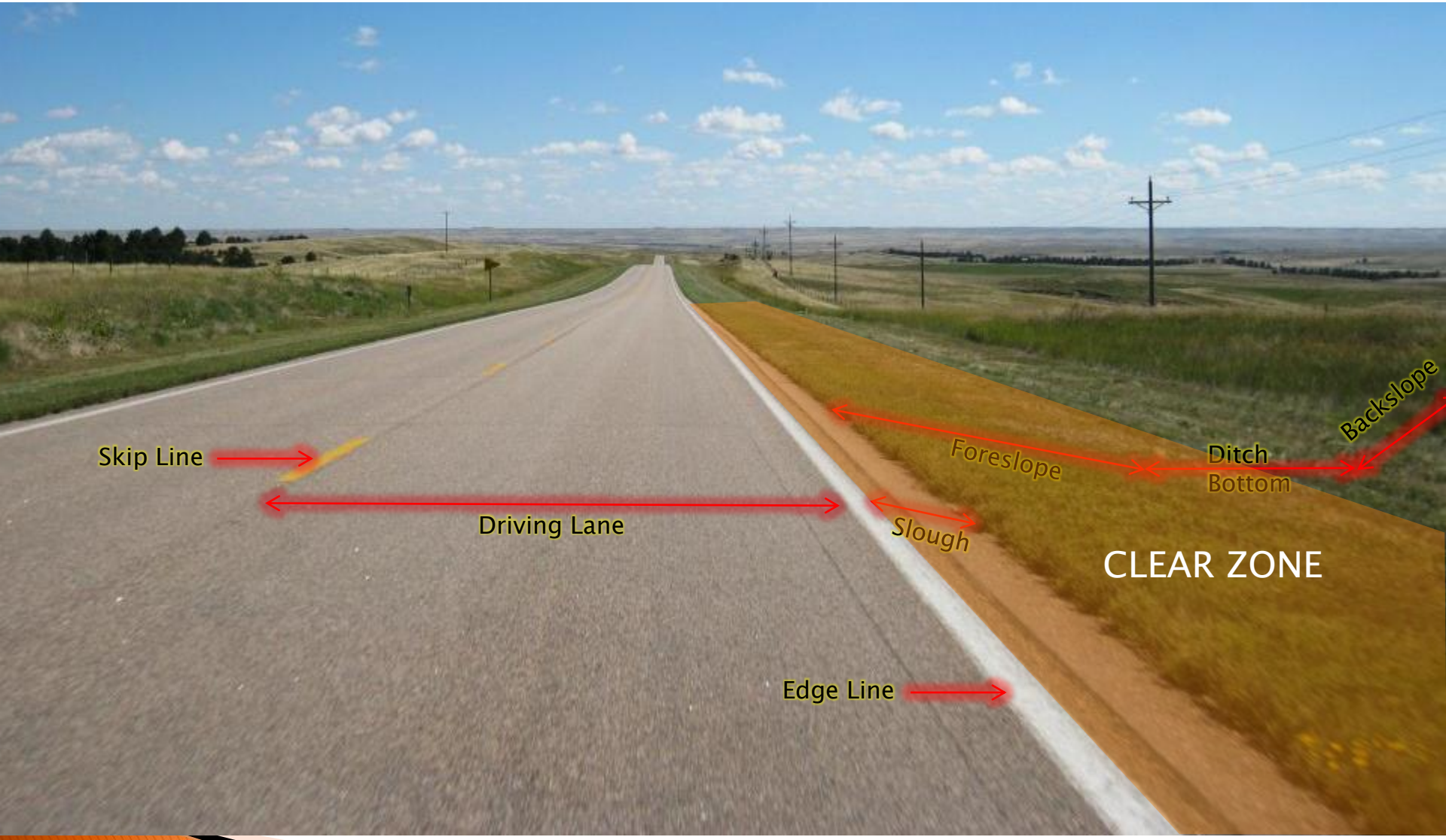
Clear Zone Concept

- Clear Zone
  - Designates the unobstructed, traversable area provided beyond the edge of the traveled way for recovery of errant vehicles.

Clear Zone Concept



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Clear Zone Concept

- The size, or overall width of the Clear Zone depends on:
  - Average Daily Traffic (ADT)
    and
  - Foreslope rate
    - Recoverable Foreslope = 4:1 or flatter
    - Non-Recoverable Foreslope = 3:1 ≤ 4:1
    - Critical Foreslope = steeper than 3:1

Clear Zone Concept

- Probably a Critical Foreslope rate..

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Clear Zone Concept

Table 1 **CLEAR ZONE DISTANCE (in Feet from Edge of Driving Lane)[1]**

DESIGN SPEED	DESIGN ADT***	FORESLOPE					BACKSLOPE				
		FLAT	1V: 6H	1V: 5H	1V: 4H	1V: 3H	1V: 3H	1V: 4H	1V: 5H	1V: 6H	FLAT
40 mph or less	Under 750	7-10	7-10	7-10	7-10	**	7-10	7-10	7-10	7-10	7-10
	750-1500	10	12	12	14	**	12-14	12-14	12-14	12-14	12-14
	1500-6000	12	14	14	16	**	14-16	14-16	14-16	14-16	14-16
	Over 6000	14	16	16	18	**	16-18	16-18	16-18	16-18	16-18
45-50 mph	Under 750	10	12	12	14	**	8-10	8	10	10	12
	750-1500	14	16	16	20	**	10-12	12	14	14	16
	1500-6000	16	18	20	26	**	12-14	14	16	16	18
	Over 6000	20	22	24	28	**	14-16	18	20	20	22
55 mph	Under 750	12	14	14	18	**	8-10	10-12	10-12	10-12	10-12
	750-1500	16	18	20	24	**	10-12	14	16	16	18
	1500-6000	20	22	24	30	**	14-16	16	18	20	22
	Over 6000	22	24	26	32*	**	16-18	20	22	22	24
60 mph	Under 750	16	18	20	24	**	10-12	12	14	14	16
	750-1500	20	24	26	32*	**	12-14	16	18	20	22
	1500-6000	26	30	32*	40*	**	14-18	18	22	24	26
	Over 6000	30	32*	36*	44*	**	20-22	24	26	26	28
65-75 mph	Under 750	18	20	20	26	**	10-12	14-16	14-16	14-16	14-16
	750-1500	24	26	28	36*	**	12-16	18	20	20	22
	1500-6000	28	32*	34*	42*	**	16-20	22	24	26	28
	Over 6000	30	34*	38*	46*	**	22-24	26	30	28	30

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Clear Zone Concept

- What happens with pipe openings that are within the Clear Zone?
  - If in the Clear Zone, use Traversable End Sections

Clear Zone Concept

- Transverse Slopes (head on slopes)
  - Common at driveways & medians
  - 6:1minimum and 10:1 desirable

Safety

- The motor vehicle fatality rate in the United States (the average number of deaths per passenger mile of driving) has dropped by roughly 80% in the past half century.
- In 2011, approximately 32,310 Americans died in auto accidents. If the 1962 fatality rate still held, there would be an extra 150,000 deaths annually, equivalent to losing the population of Pittsburgh every two years.
- Credit a mix of improvements, including crash impact standards, air bags, better tires, antilock brakes, and stability control.
- One of the biggest factors? SEAT BELTS! 84 percent of people now buckle up, compared with 14 percent three decades ago.

Thank you

- Matt Gangness, PE
  - Design Division
  - NDDOT

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