



*Accelerating solutions for highway safety, renewal, reliability, and capacity*

# Regional Operations Forum

## Safety and Operations

TRANSPORTATION RESEARCH BOARD  
OF THE NATIONAL ACADEMIES

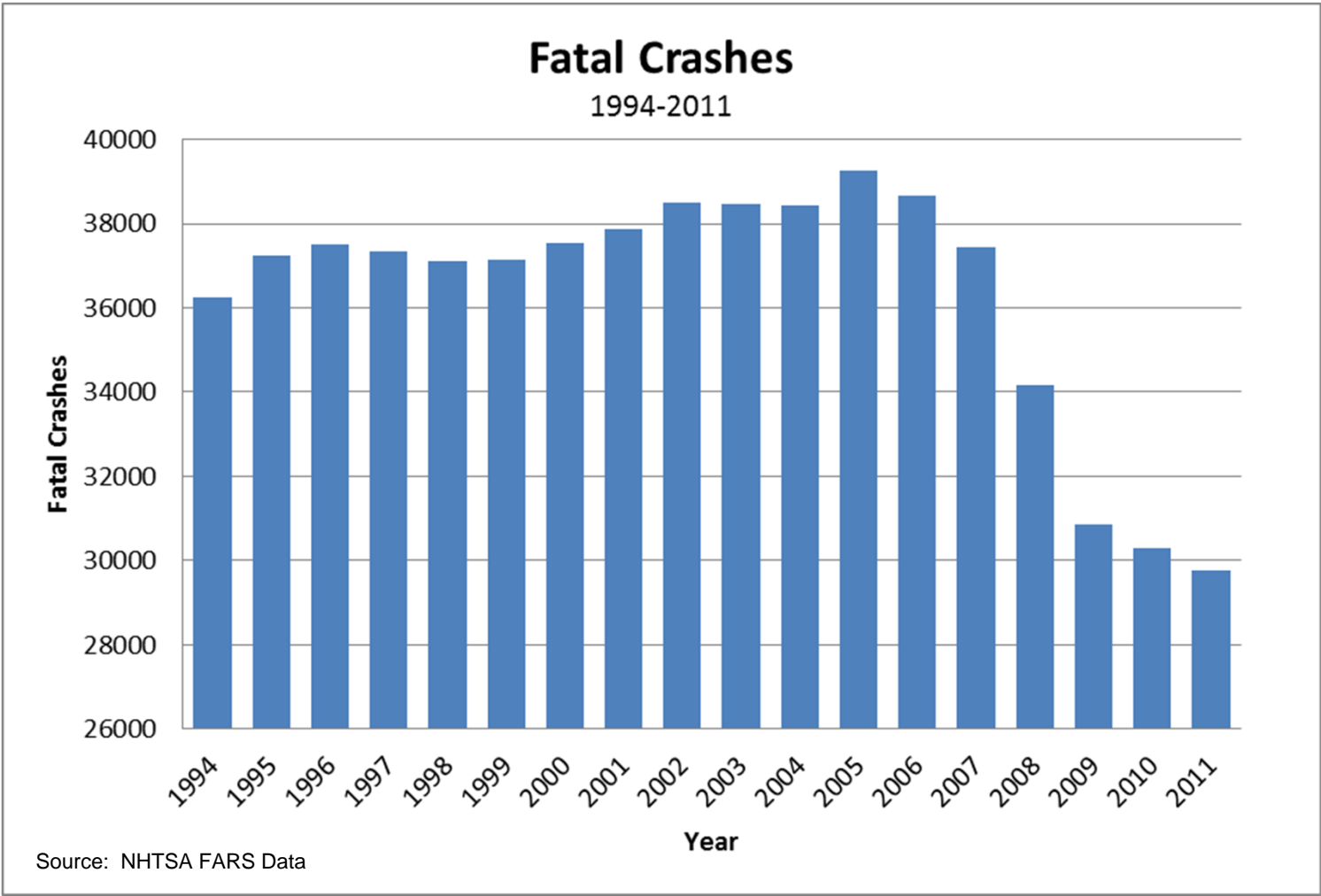
# Linking Safety and Operations

- State DOTs facing numerous challenges
- Prior to ISTEA, DOTs focused separately on
  - Construction
  - Maintenance
  - Operations
  - Safety
- Limited resources has shifted focus
  - Operating and maintaining system

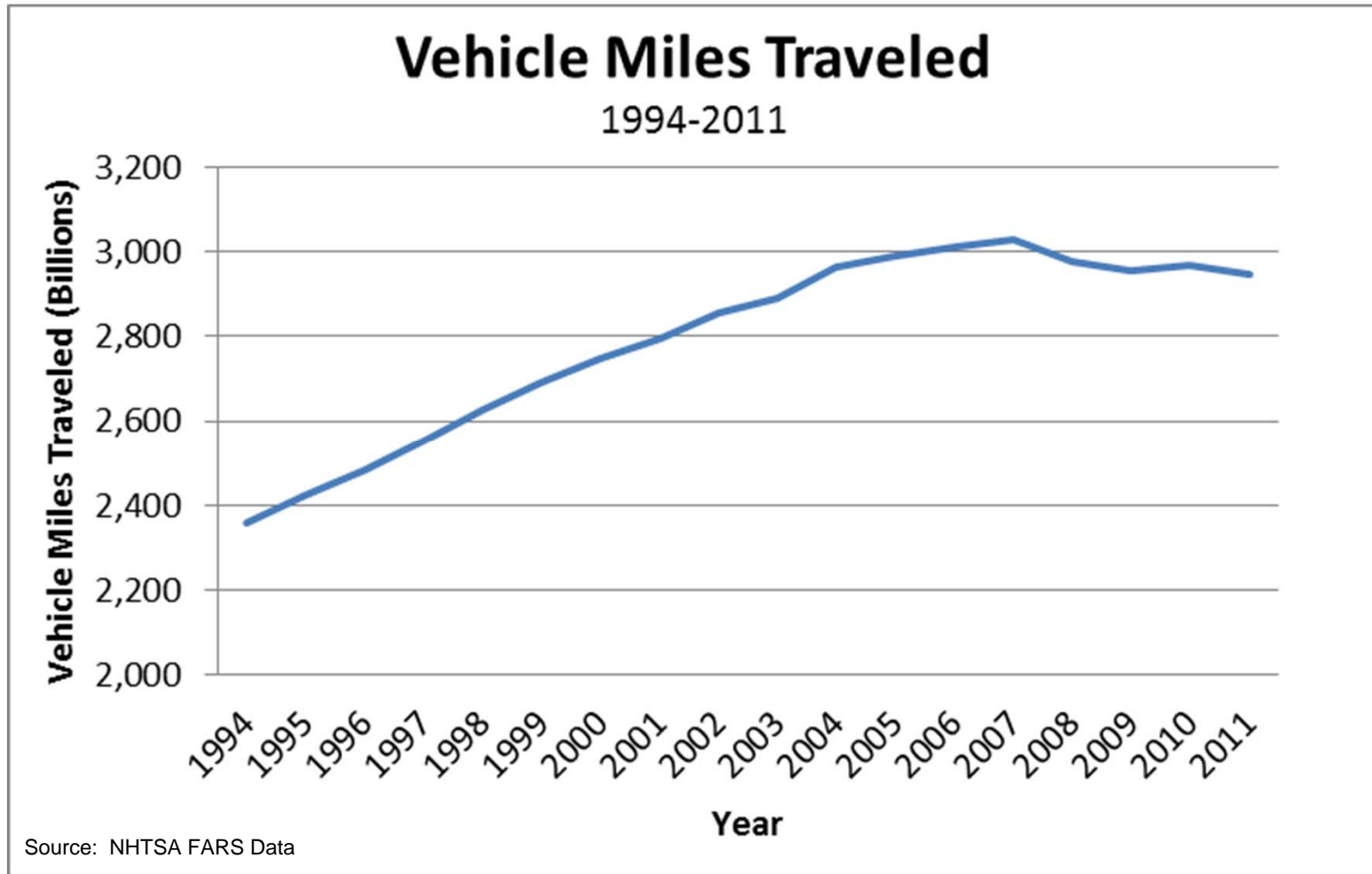
# Why Link Safety and Operations?

- Highway fatalities and serious injuries at unacceptable levels
- 29,757 fatalities in 2011
  - Press coverage not significant for highway fatalities
  - Boeing 747-400 carries 520 passengers
  - 2011 highway fatalities = 56 airline crashes

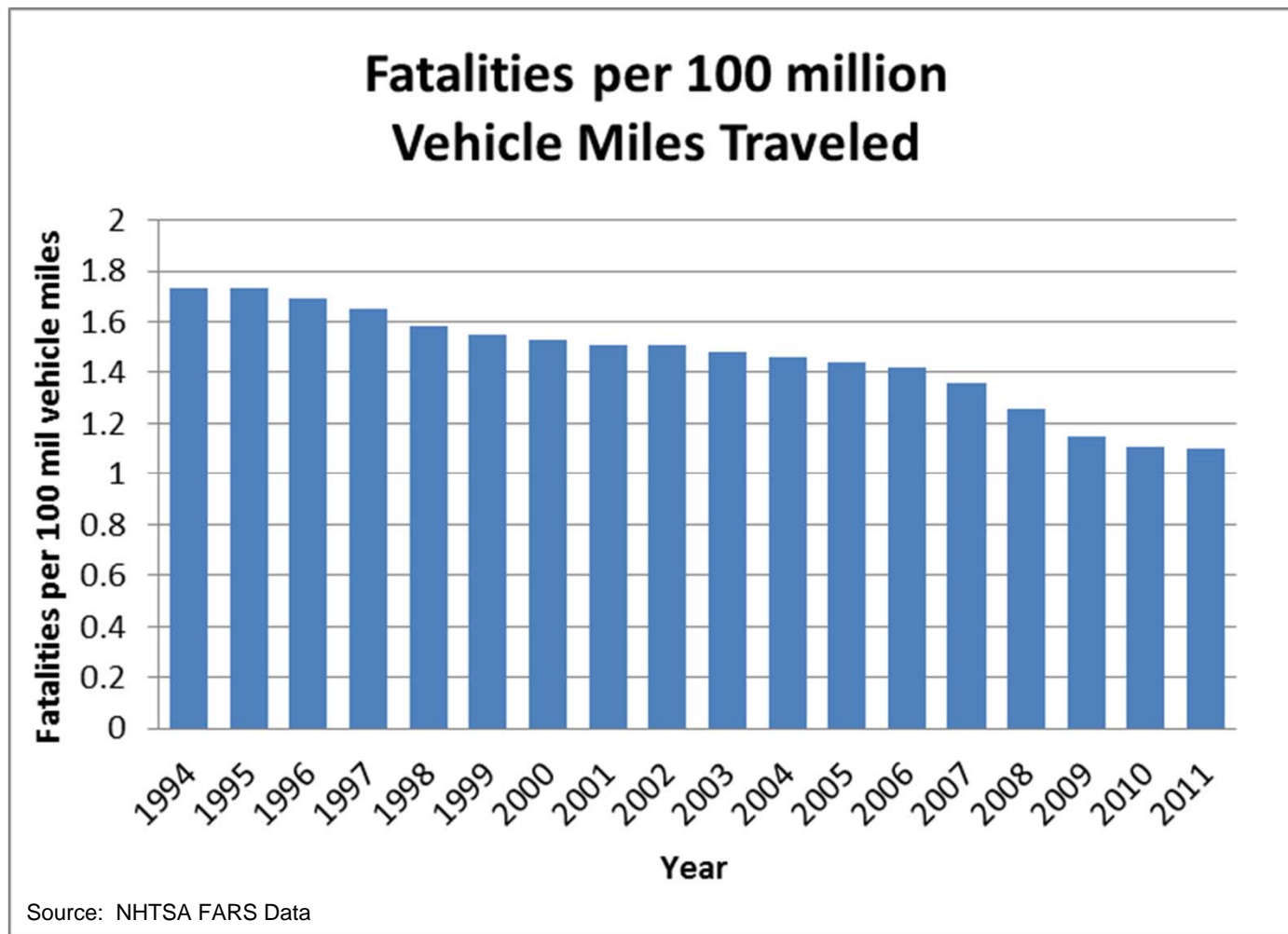
# U.S. Fatal Crash Trends



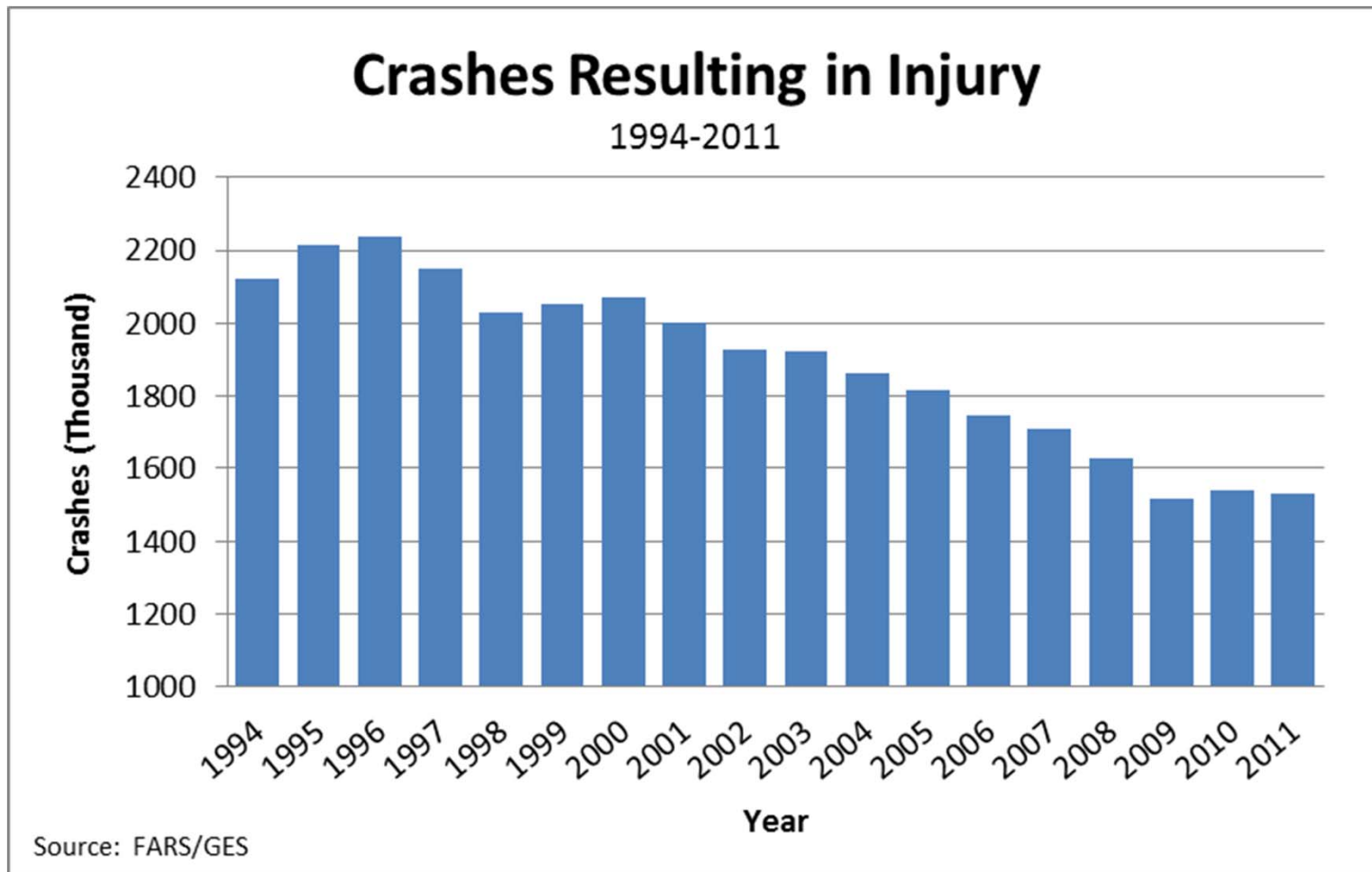
# VMT Trends



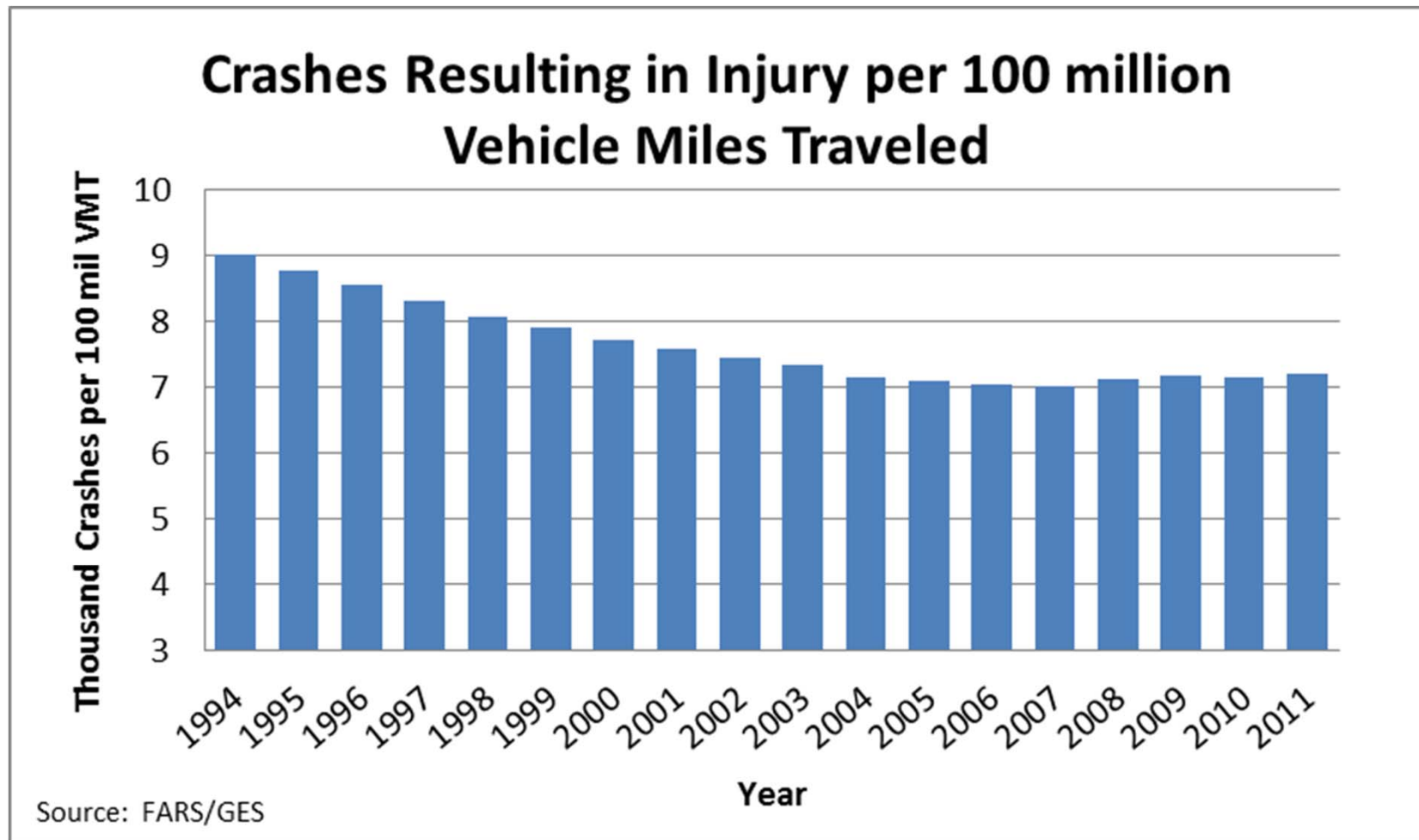
# Fatal Crash Rate Trends



# U.S. Injury Crash Trends



# Injury Crash Rate Trends





# Traffic Congestion

- Congestion continues to plague our transportation system
  - 2.9 billion gallons of wasted fuel
    - Enough to fill 4 superdomes
  - 5.5 billion hours of wasted time
- Significantly impacts communities
  - Quality of life
  - Safety
  - Health

# Types of Traffic Congestion

- Recurring congestion
  - Predictable in cause
    - Location
    - Time of day
    - Duration
  - Surge overwhelms roadway's capacity
  - Examples
    - Lane drops, grades, narrow lanes
    - Poorly timed traffic signals

# Types of Traffic Congestion

- Non-recurring congestion
  - Unpredictable in nature
    - Location
    - Time of day
    - Duration
  - Examples
    - Crashes, disabled vehicles, weather
    - Work zones and planned special events
- Dramatically reduces capacity and reliability

# MAP-21 Requirements

- Creates national goals and performance management measures
  - Safety
  - Congestion reduction
  - System reliability
- Performance targets currently being developed

# Safety and Throughput

- Low cost operational improvements can create significant improvements in traffic flow
  - Equate to having safer roads
- Low cost operational improvements
  - Signal phasing (permissive vs. protected)
  - Signal timings and progression
  - Appropriate clearance intervals
  - Pavement markings, signing, and delineation
  - Installation or extension of turn lane

# Opportunities to Affect Safety and Operations

**DETERMINING WHERE SAFETY AND  
OPERATIONS ARE MOST EFFECTIVE**

# Static Data

Virginia Department of Transportation  
Traffic Engineering Division  
2012  
Annual Average Daily Traffic Volume Estimates By Section of Route  
Primary and Interstate Routes

Route	Jurisdiction	Length	AADT	QA	4Tire	Bus	Truck				QC	K Factor	QK	Dir Factor
							2Axle	3+Axle	1Trail	2Trail				
1 301 Jefferson Davis Hwy	City of Richmond	0.86	13000	A	95%	1%	1%	1%	2%	0%	C	0.099	A	0.507
1 301 Jefferson Davis Hwy	City of Richmond	1.01	19000	F	95%	1%	1%	1%	2%	0%	F	0.085	F	0.503
1 301 Cowardin Ave	City of Richmond	0.39	22000	F	95%	1%	1%	1%	2%	0%	F	0.09	F	0.589
1 301 Lee Bridge	City of Richmond	0.76	31000	F	97%	1%	1%	0%	1%	0%	F	0.092	F	0.571
1 301 Belvidere St	City of Richmond	0.92	27000	F	97%	1%	1%	0%	1%	0%	F	0.089	F	0.567
1 301 Belvidere St	City of Richmond	0.15	31000	F	97%	1%	1%	0%	1%	0%	F	0.084	F	0.505
1 301 Belvidere St	City of Richmond	0.40	32000	F	97%	1%	1%	0%	1%	0%	F	0.083	F	0.611
1 301 Chamberlayne Ave	City of Richmond	1.02	23000	F	97%	1%	1%	0%	1%	0%	C	0.081	F	0.661
1 301 Chamberlayne Ave	City of Richmond	0.31	21000	F	97%	1%	1%	0%	1%	0%	C	0.083	F	0.679
1 301 Chamberlayne Ave	City of Richmond	0.86	17000	F	97%	1%	1%	0%	1%	0%	C	0.089	F	0.683
1 301 Chamberlayne Ave	City of Richmond	0.26	14000	F	97%	1%	1%	0%	1%	0%	F	0.093	F	0.683
1 301 Chamberlayne Ave	City of Richmond	0.94	15000	F	97%	1%	1%	0%	1%	0%	C	0.095	F	0.681
1 Azzalea Ave	City of Richmond	0.26	17000	F	97%	1%	1%	0%	1%	0%	F	0.096	F	0.525
1 Brook Rd	Henrico County	0.30	18000	G	97%	1%	1%	0%	1%	0%	F	0.087	F	0.573
1 Brook Rd	Henrico County	0.83	22000	G	98%	0%	1%	0%	1%	0%	C	0.092	F	0.509
1 Brook Rd	Henrico County	0.72	18000	G	98%	0%	1%	0%	1%	0%	F	0.095	F	0.576
1 Brook Rd	Henrico County	0.48	20000	G	98%	0%	1%	0%	1%	0%	F	0.092	F	0.507
1 Brook Rd	Henrico County	1.42	21000	G	98%	0%	1%	0%	1%	0%	C	0.089	F	0.542

6/25/2013

12

Commonwealth of Virginia • Department of Motor Vehicles FR300 P (Rev 7/07)

### Police Crash Report

Revised Report  GPS Lat.  GPS Long.  Page  of

**CRASH**

Crash Date:  Day of Week:  Mile/Day Time (24 hr clock):  County of Crash:  Official DMV Use:

City or Town Name:  Landmarks at Scene:

Location of Crash (state/street):  Railroad Crossing ID no. (if within 150ft.):  Local Case Number:

Location of Crash (state/street):  Mile Marker Number:  Number of Vehicles:

**VEHICLE #**

**DRIVER**

Driver's Name (Last, First, Middle):  Driver's License Number:  State:  DL:  CGL:

Address (Street and Number):  City:  State:  ZIP:

Birth Date:  Safety Equip. Used:  Air Bag:  Ejected:  Date of Death:  Injury Type:  EMS Transport:

Summons Issued:  Arrested:  Offense Charged to Driver:

**VEHICLE**

Vehicle Owner's Name (Last, First, Middle):  Same as Driver:

Address (Street and Number):  City:  State:  ZIP:

Vehicle Year:  Vehicle Make:  Vehicle Model:  Disabled:  CMV:  Towed:

Vehicle Plate Number:  State:  Approximate Repair Cost:

VIN:  Overdrive:  Cargo Spill:

Name of Insurance Company (last agent):  Overdrive:  Underdrive:

Speed Before Crash:  Speed Limit:  Maximum Safe Speed:  Under:  Over:

**PASSENGER (only if injured or killed)**

Name of Injured (Last, First, Middle):  EMS Transport:  Date of Death:

Position in Vehicle:  Safety Equip. Used:  Air Bag:  Ejected:  Injury Type:  Birthdate:  Gender:

Name of Injured (Last, First, Middle):  EMS Transport:  Date of Death:

Position in Vehicle:  Safety Equip. Used:  Air Bag:  Ejected:  Injury Type:  Birthdate:  Gender:

Name of Injured (Last, First, Middle):  EMS Transport:  Date of Death:

Position in Vehicle:  Safety Equip. Used:  Air Bag:  Ejected:  Injury Type:  Birthdate:  Gender:

**Codes**

**POSITION IN/ON VEHICLE**

1. Driver
2. Passenger
3. Cargo Area
4. Riding/Missing
5. On Outside
6. Other
7. Buckle Seat
8. No Restraint Used
9. Not Applicable

**SAFETY EQUIPMENT USED**

1. Lap Belt Only
2. Shoulder Belt Only
3. Lap and Shoulder Belt
4. Child Restraint
5. Helmet
6. Other
7. Buckle Seat
8. No Restraint Used
9. Not Applicable

**AIRBAG**

1. Deployed - Front
2. Not Deployed
3. Unavailable/Not Applicable
4. Keyed Off
5. Unknown
6. Deployed - Side
7. Deployed - Other (Knee Air Belt, etc.)
8. Deployed - Combination

**EJECTED FROM VEHICLE**

1. Not Ejected
2. Partially Ejected
3. Totally Ejected

**SUMMONS ISSUED AS A RESULT OF CRASH**

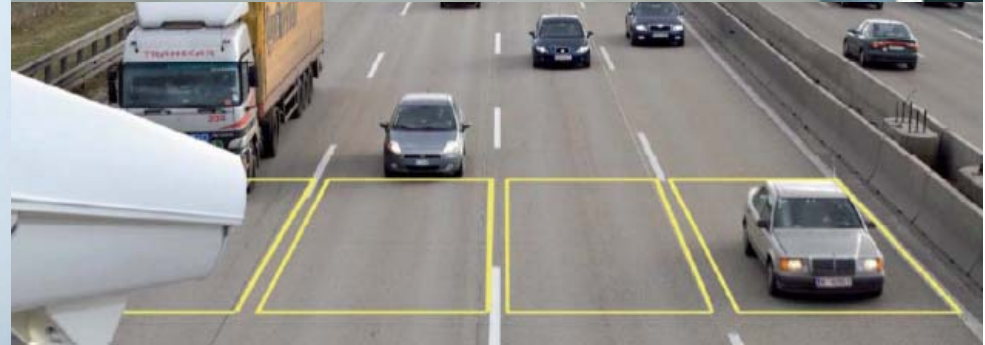
1. Yes
2. No
3. Pending

**INJURY TYPE**

1. Dead Before Report Made
2. Visible Signs of Injury, no Bleeding Wound or Distorted Member or Head to be Carried From Scene.
3. Other Visible Injury, no Bleeding, Abrasion, Swelling, Laceration, etc.
4. No Visible Injury, But Complaint of Pain, or Mandatory Unconsciousness.
5. No Injury (Driver only)

Investigating Officer:  Badge/Code Number:  Agency/Department Name and Code:  Reviewing Officer:  Report File Date:

# Real Time Data Acquisition

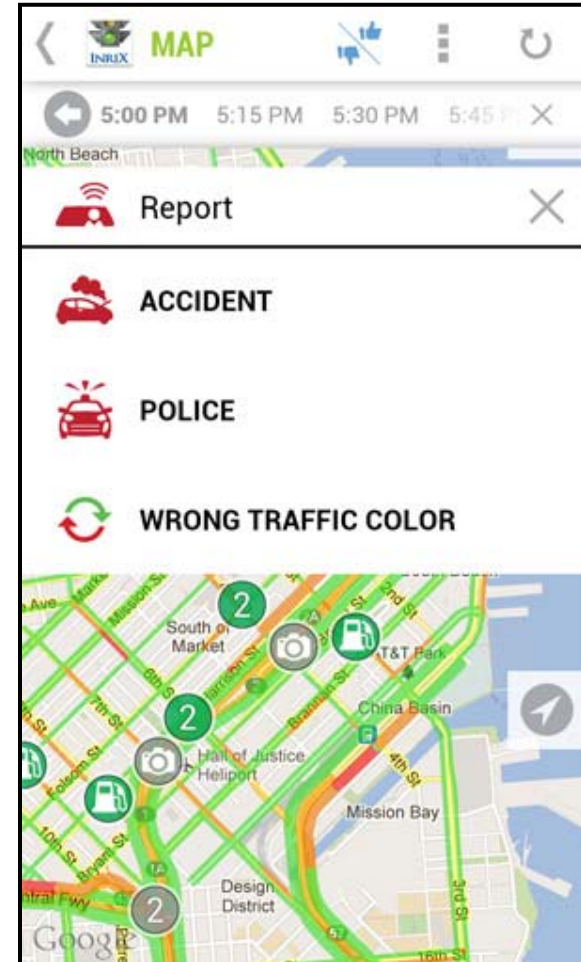
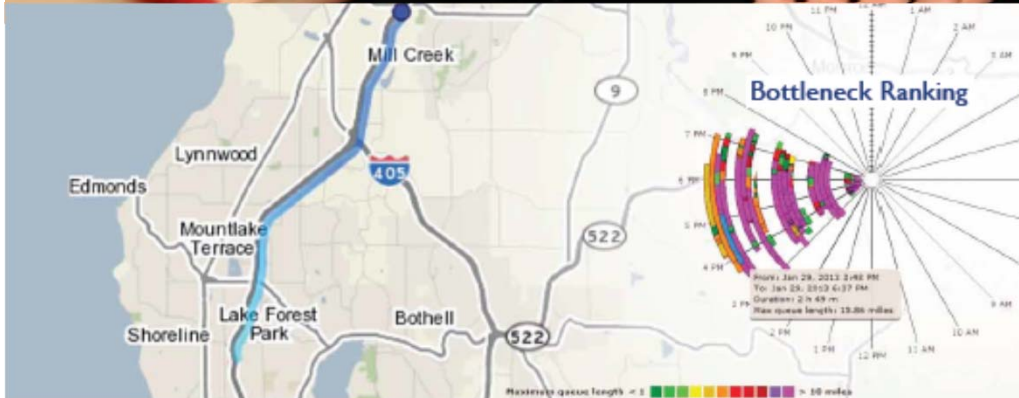




# Real Time Data Acquisition



# Real Time Data Acquisition



# Real Time Data Acquisition

The collage illustrates real-time data acquisition in a navigation application. It includes:

- Construction Alerts:** A pop-up notification for 'Construction between WATERSIDE DR/EXIT 9 and DOWNTOWN TUNL - Construction work - right lane blocked' with start and end times.
- Route Planning:** A regional map showing a route from Charlottesville, VA to Virginia Beach (City) with a table of current traffic conditions and a list of driving instructions.
- Search and Listings:** A search interface for 'virginia beach' displaying a list of results and advertisements for vacation packages and hotels.
- Map Interface:** A detailed map of the Virginia Beach area with navigation controls and a search bar.

# Roadway Weather Information

**RWIS Road Weather Information System**

Station Listing For:  Nevada  Reno Area (N.West NV)  Elko Area (N.East NV)  Las Vegas Area (Southern NV)

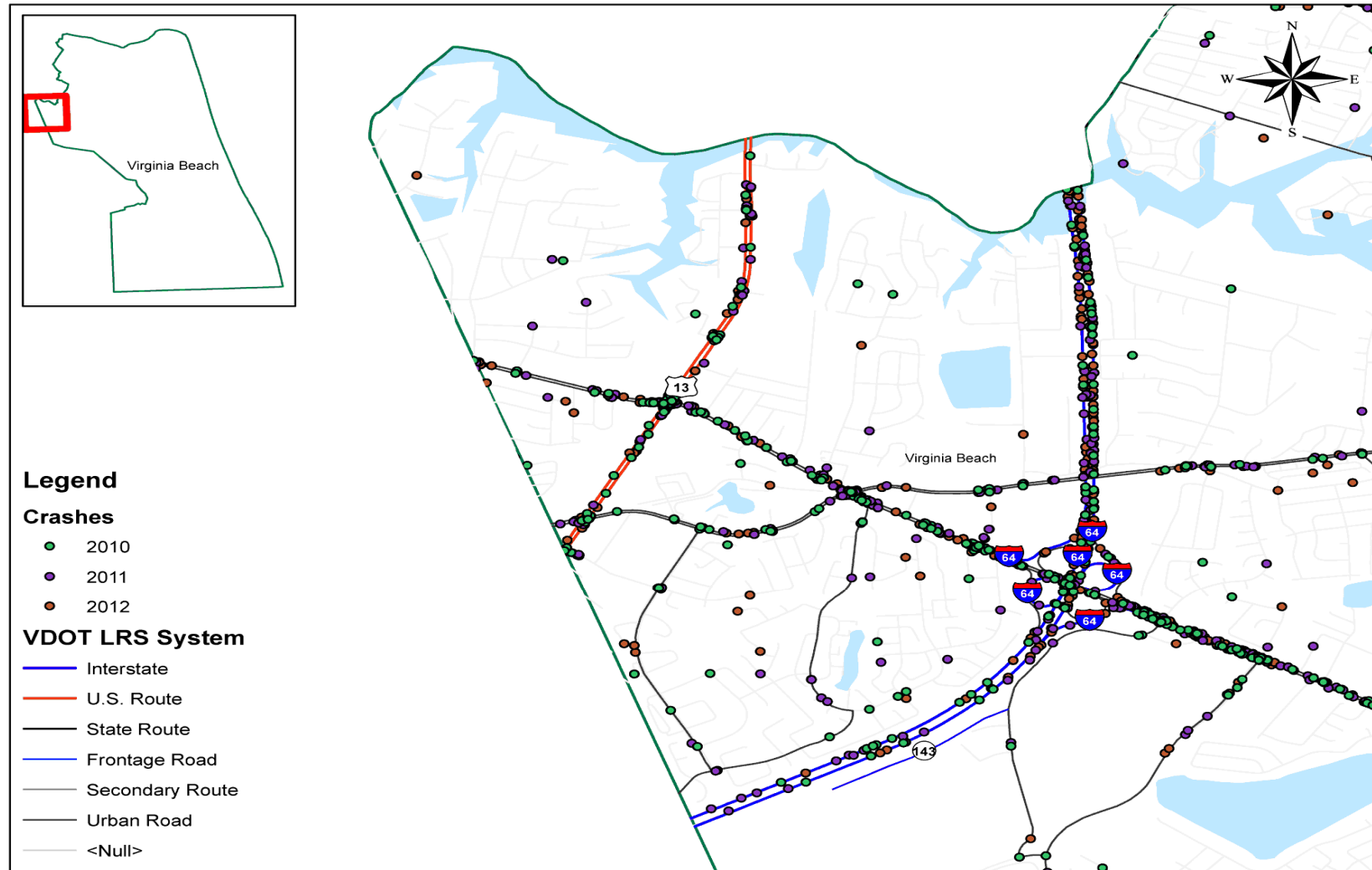
Station Name	Station	Gauge Display	Date / Time (pst)	Atmospheric Readings								
				Wind Speed (mph)	Wind Dir (compass)	Gust Speed (mph)	Gust Dir (compass)	Air Temp (°F)	Rel. Humid (%)	Dew Point (°F)	Rain? (y/n)	Rain Rate (in/hr)
1580/US395 - Arrowhead Drive	↓	⊗	7/31/2014 8:51 AM	0	SW	0	SW	76	25	87	No	0
1580/US395 - Browns Creek Bridge	↓	⊗	7/31/2014 8:58 AM	5	ENE	12	SE	72	26	86	No	0
1580/US395 - Galena Bridge	↓	⊗	7/31/2014 8:59 AM	8	ESE	7	W	71	28	87	No	0
1580/US395 - So. Virginia St. (Exit 61)	↓	⊗	7/31/2014 8:52 AM	8	NNW	12	SSE	78	26	86	No	0
1580/US395 - Washoe Valley	↓	⊗	7/31/2014 8:57 AM	0	NE	2	SE	78	81	41	No	0
180 - Battle Mountain	↓	⊗	7/31/2014 8:56 AM	8	ENE	6	S	80	12	24	No	0
180 - Carlin Road EB	↓	⊗	7/31/2014 8:52 AM	1	S	8	WNW	76	17	28	No	0
180 - Carlin Road WB	↓	⊗	7/31/2014 8:46 AM	0	S	0	S	76	20	82	No	0
180 - Carlin Tunnel EB	↓	⊗	7/28/2014 4:18 PM						12	88	No	0
180 - Carlin Tunnel WB	↓	⊗	7/31/2014 8:45 AM	0	S	0	S	75	19	80	No	0
180 - Death	↓	⊗	7/31/2014 8:52 AM	2	SW	4	W	78	80	40	No	0
180 - Elko West	↓	⊗	7/31/2014 8:44 AM	8	SSE	8	SW	78	84	47	No	0
180 - Emigrant Summit	↓	⊗	7/31/2014 8:55 AM	5	SSE	9	SW	76	22	84	No	0
180 - Golconda Summit	↓	⊗	7/31/2014 8:48 AM	2	NNE	4	NE	79	11	21	No	0
180 - Halleck	↓	⊗	7/31/2014 8:41 AM	8	S	7	NNW	78	7	4	No	0
180 - Humboldt House	↓	⊗	7/31/2014 8:51 AM	9	S	18	SW	82	12	24	No	0
180 - Moor/Wells Summit	↓	⊗	7/31/2014 8:49 AM	18	SE	22	S	77	21	84	No	0
180 - Pequot Summit	↓	⊗	7/31/2014 8:42 AM	11	SSW	21	WNW	78	24	84	err	0
180 - Pilot	↓	⊗	7/31/2014 8:54 AM	2	ESE	5	S	82	22	40	No	0
180 - Rose Creek	↓	⊗	7/31/2014 8:28 AM	0	SW	0	NW	75	14	22	No	0
180 - Sparks Boulevard	↓	⊗	8/1/2014 10:32 AM									



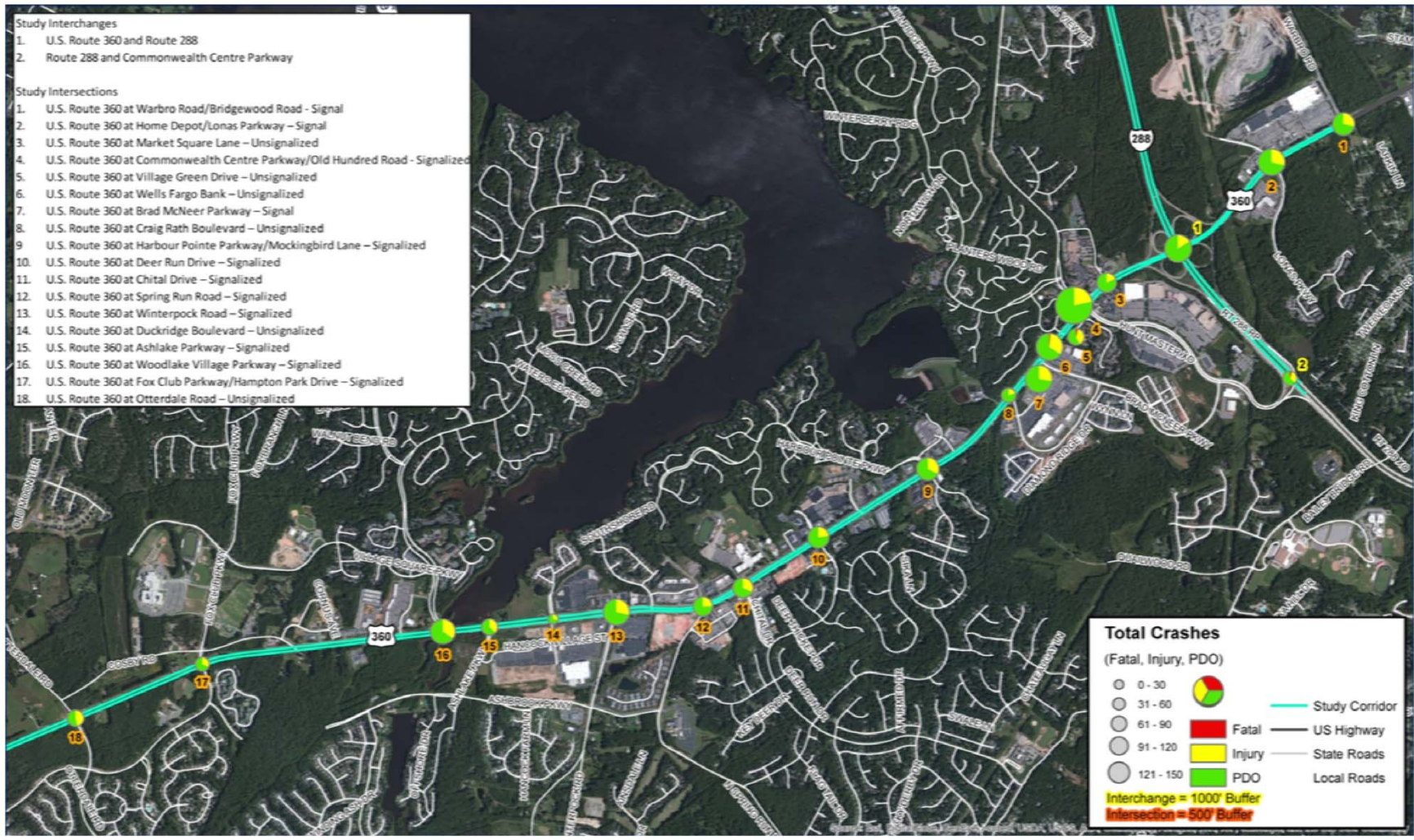
# Opportunities to Affect Safety and Operations

## ANALYSIS TECHNIQUES

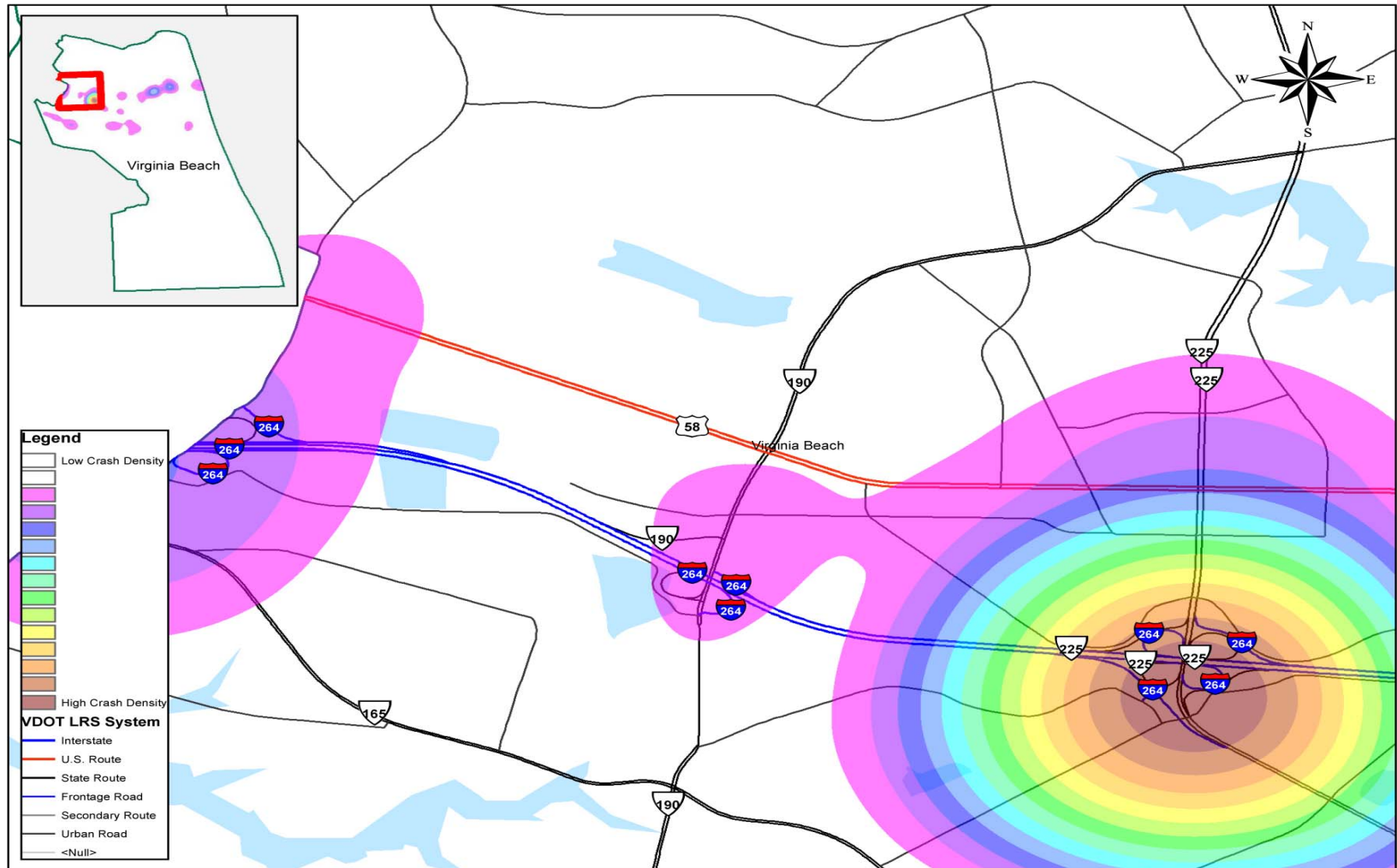
# Crash Locations Through GIS



# Intersection Crash Analysis

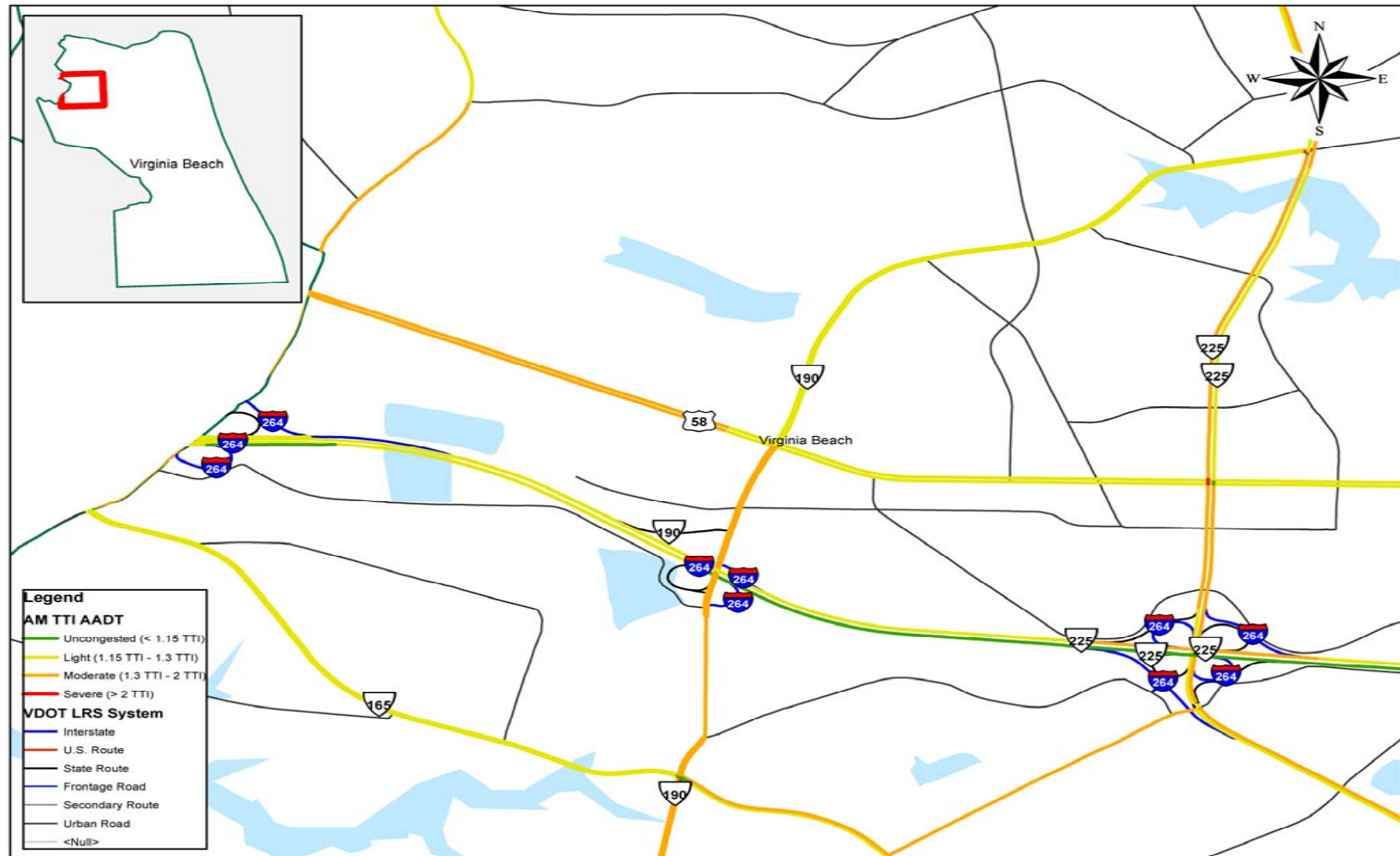


# Crash Density Maps

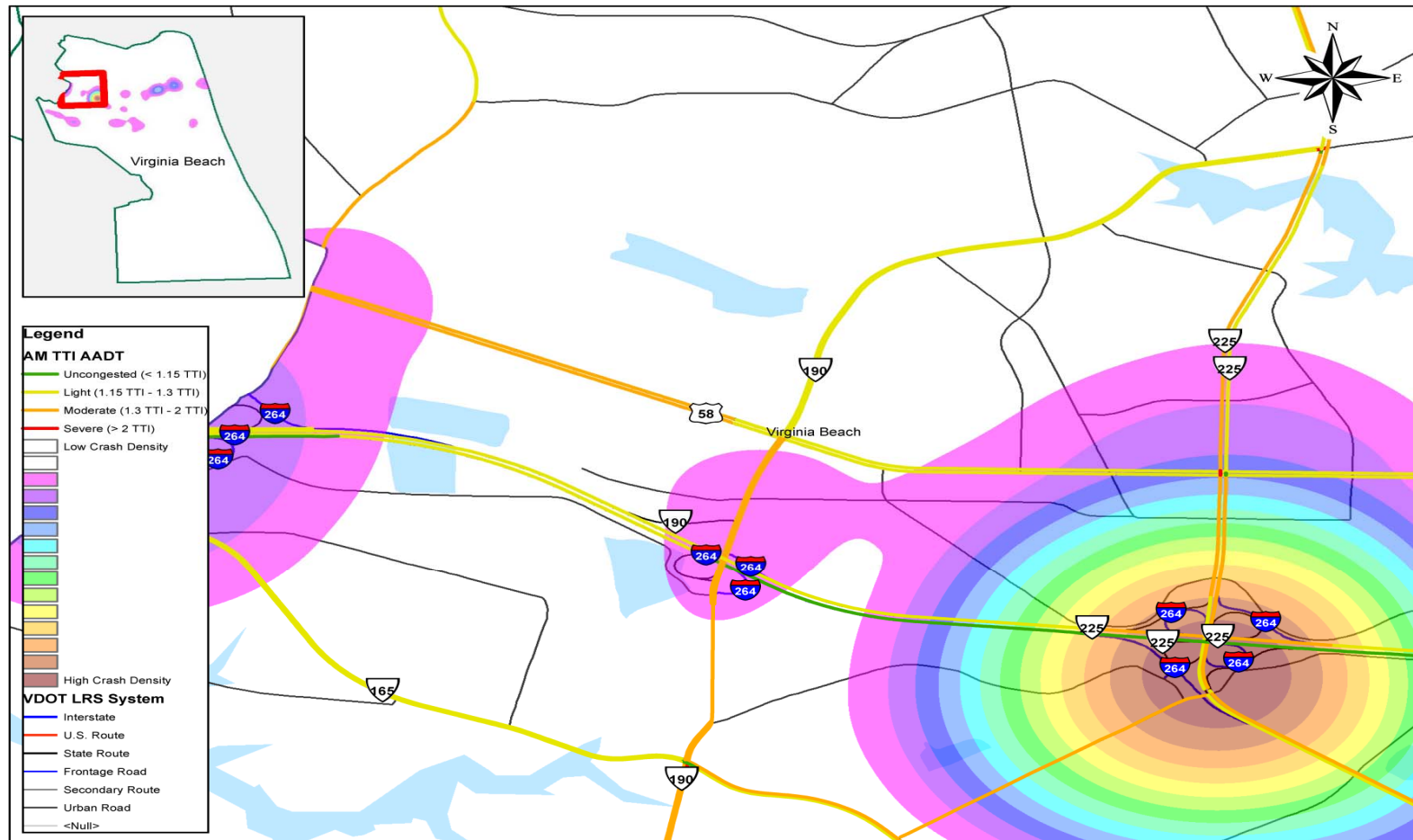




# Peak Hour Travel Time Index



# Crash Density with AM Peak Travel Time Index



# Project Examples

# Median/Pedestrian Refuge



# Road Diets

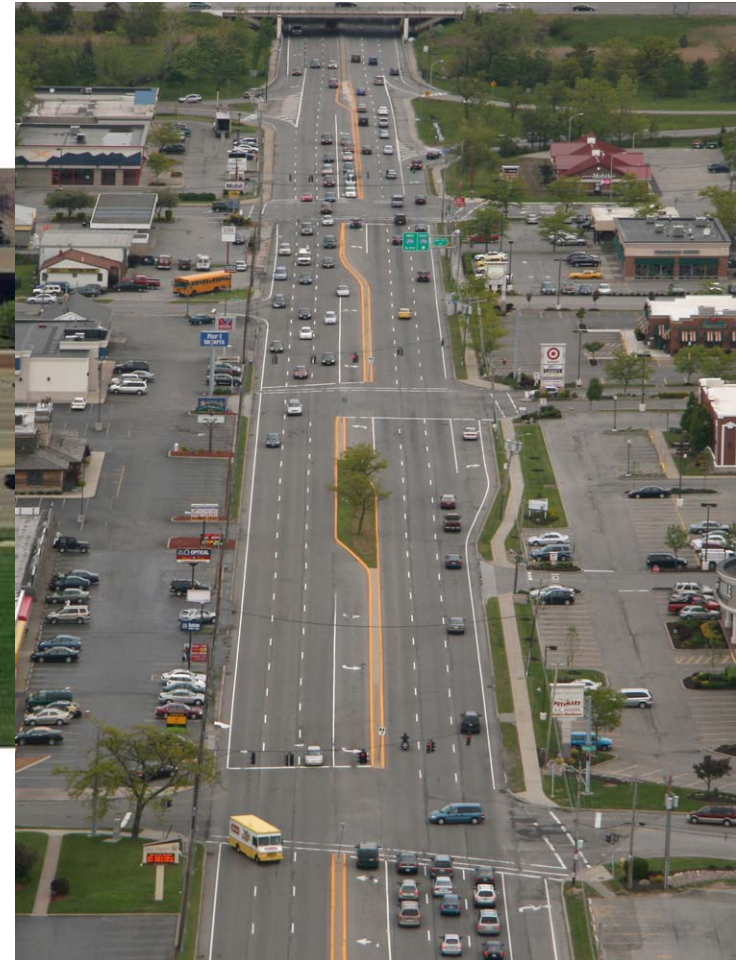


*Road Before*



*Road After*

# Access Management

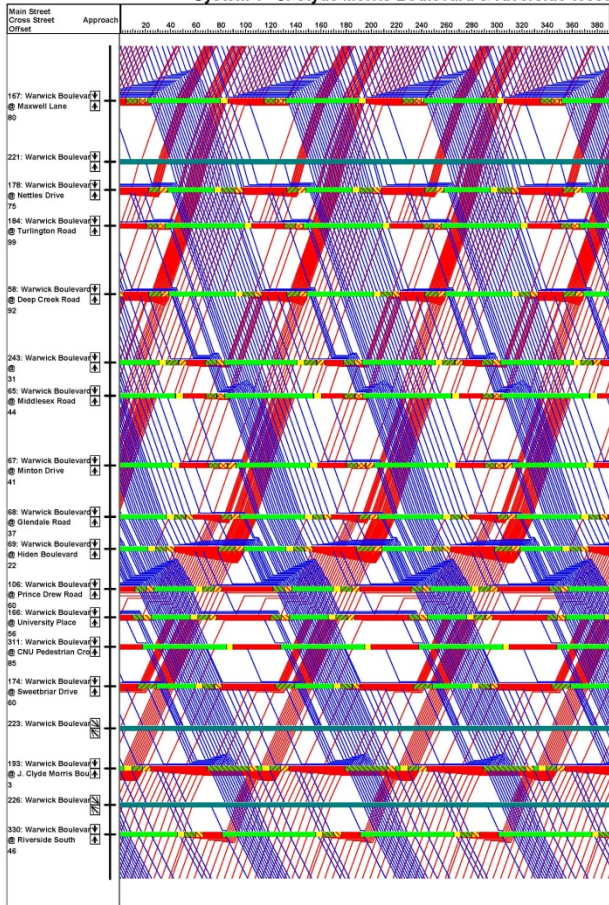


# Turn Lanes



# Signal Timing and Improvements

Time-Space Diagram - Warwick Boulevard  
System 1 - J. Clyde Morris Boulevard & Riverside West



System 1 - J. Clyde Morris Boulevard & Riverside West Timing Plan: AM Peak  
Kimley-Horn and Associates, Inc.



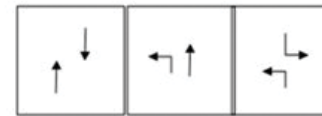
Leading Lefts



Lead-Lag



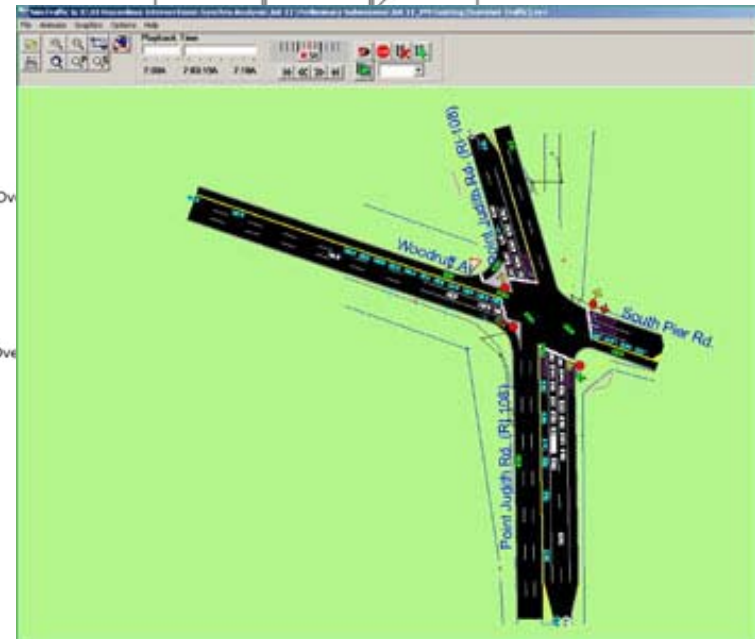
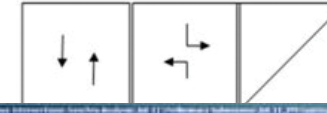
Leading Left with Overlap



Lagging Left with Overlap



Lead-Lag

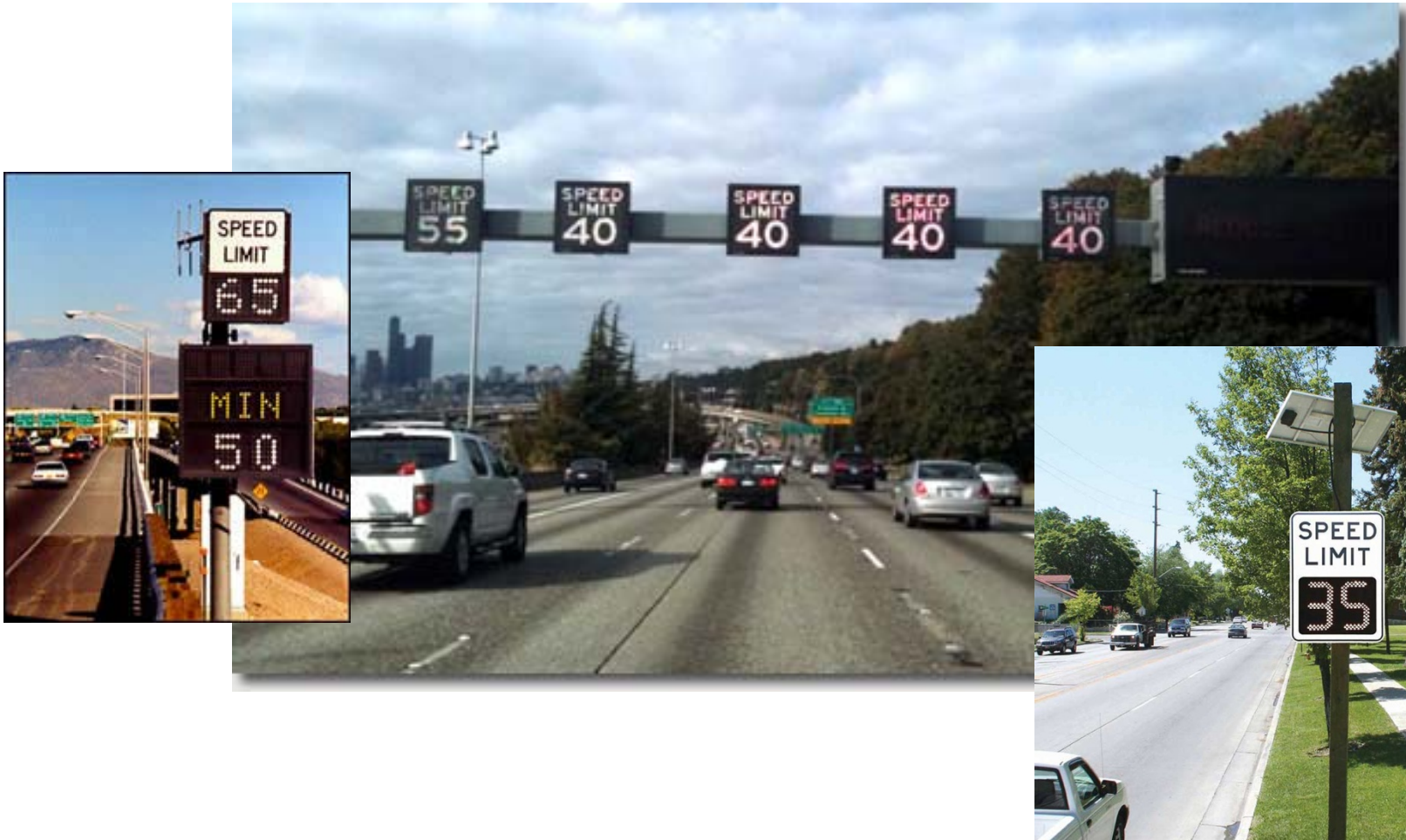




# Ramp Metering



# Variable Speed Limits



# Adaptive Signal Timing



# Advanced Traveler Information Systems



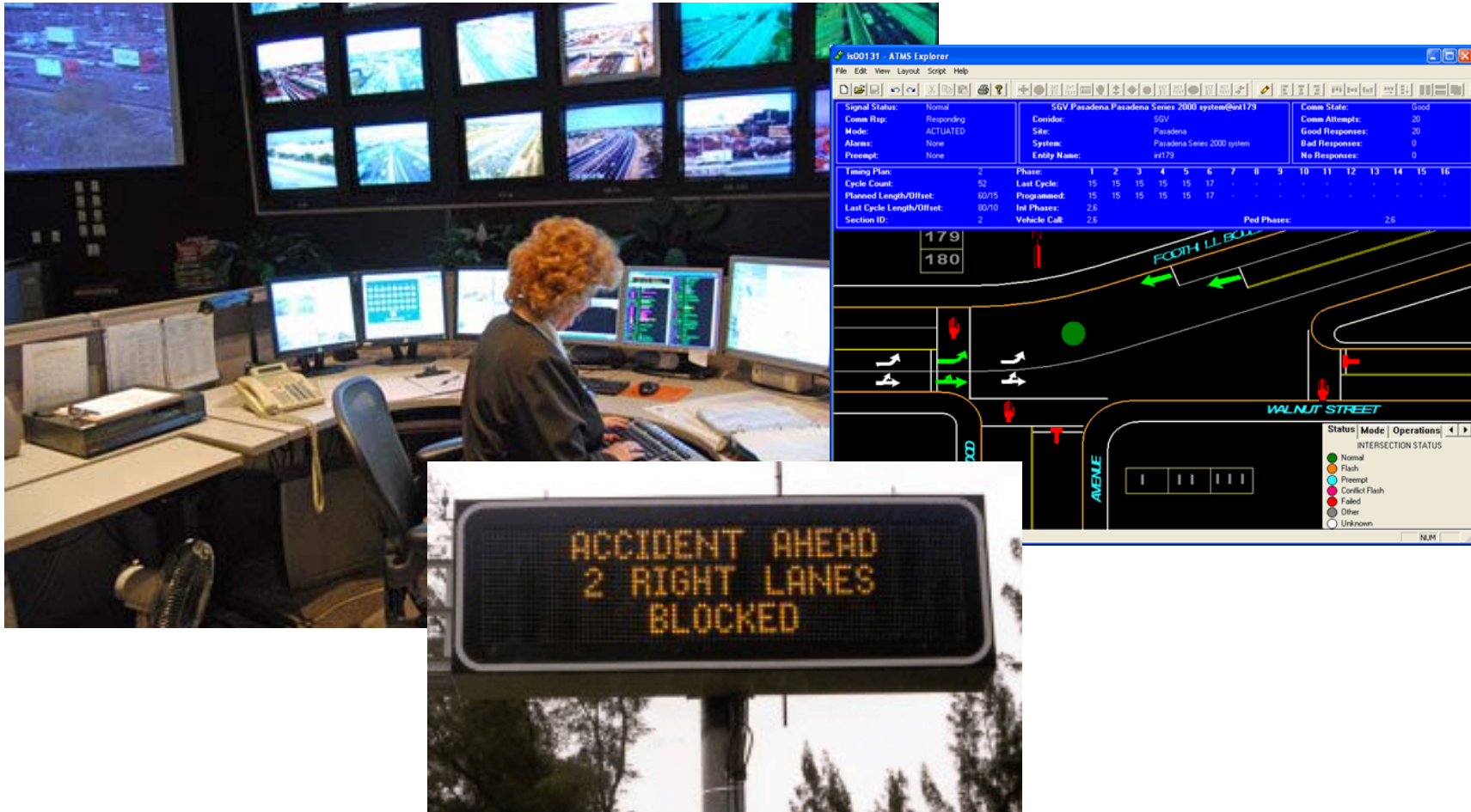
# Incident Management



# End of Queue Detection Systems



# Advanced Traffic Management



# SHRP 2 Project L07

Automatically Recalculate:  Yes

Print Save Save As Close Help

### Site Inputs

Geometry Demand Incident Weather Event Work Zn Graphs

#### Location

Route: I-35  
 County: Johnson  
 Dir: NB  
 From: 95th Street  
 To: 87th Street

#### Geometry

Length, mi: 0.5  
 Terrain: Level  
 Grade, %: 0.0  
 Urban/Rural: Urban  
 Lanes: 6  
 Lane Width, ft: 12  
 Right-side lateral Clearance, ft: 4  
 Interchanges per mile: 0.7

#### Speed

Measured FFS, mph: 70.0  
 Base FFS, mph: 75.4  
 HCM FFS, mph: 70.0

### Treatment Data and Calculations

Accessible Shoulder Emergency Access Emergency Crossovers Control(Gated) Turnarounds Drivable Shoulder

#### Drivable Shoulder

Treatment Description

#### Operational Inputs

Note: Defaults assume only one shoulder is to be made drivable (either left or right)

Shoulder Capacity, vph: 1800

Percent of each incident type for which vehicles are expected to be diverted to the drivable shoulder:

#### Crashes

PDO: 5 %  
 Minor Injury: 15 %  
 Major Injury & Fatal: 25 %

#### Non-Crash Incidents

Disabled Vehicle (Lane-blocking): 0 %  
 Other: 0 %

Apply Treatment to Work Zones

#### Inputs

Treatment Service Life, yrs: 20  
 Discount Rate: 7.0%  
 Uniform Series Present Worth Factor: 10.6

#### Costs

Construction Cost, \$: 195000  
 Annualized Construction Cost, \$: \$18,407  
 Annual Maintenance Cost, \$: 1000  
**Total Annual Cost, \$: \$19,407**

#### Benefits

Annual Delay Reduction, veh-hr: 1,310  
 Standard Dev. Change Indicator: 0.2  
**Annual Operational Benefit (AOB), \$**  
 Delay Component: \$20,540  
 Reliability Component: \$309  
**Total AOB: \$20,849**  
**Annual Safety Benefit (ASB), \$**  
 Benefits due to Congestion Reduction  
 Fatal/Maj Inj: \$20,465  
 Minor Injury: \$8,276  
 PDO: \$1,200  
 Benefits due to Treatment Effects  
 Fatal/Maj Inj: \$0  
 Minor Injury: \$0  
 PDO: \$0  
**Total ASB: \$27,941**  
 Other Annual Benefits, \$ (User-Specified): 0  
**Total Annual Benefits, \$48,790**

#### Cost Effectiveness

Net Present Value of Cost: \$205,594  
 Net Present Value of Benefits: \$516,879  
**Net Present Benefit: \$311,285**  
 BC Ratio: 2.51

### Results

Reliability Inputs TTI Reliability MOEs

#### Drivable Shoulder

#### Critical demand/capacity ratio (d/c crit)

Untreated: Min: 0.033 2:00, Max: 0.854 7:00  
 Treated: Min: 0.033 2:00, Max: 0.600 3:00

#### Lane-hours lost (LHL)

Untreated: Min: 8.585 0:00, Max: 17.72 16:00  
 Treated: Min: 8.549 0:00, Max: 16.73 16:00

#### Hours of rainfall > 0.05" (R0.05) Hours of snowfall > 0.01" (S0.01)

Rain: Untreated: Min: 8.700 10:00, Max: 12.20 17:00; Treated: Min: 8.700 10:00, Max: 12.20 17:00  
 Snow: Untreated: Min: 0.600 3:00, Max: 1.700 22:00; Treated: Min: 0.600 3:00, Max: 1.700 22:00

Refresh Graphs



# Group Discussion