



Estimating Safety Benefits of Connected-Automated Vehicles (CAVs) – SR 70 Pilot

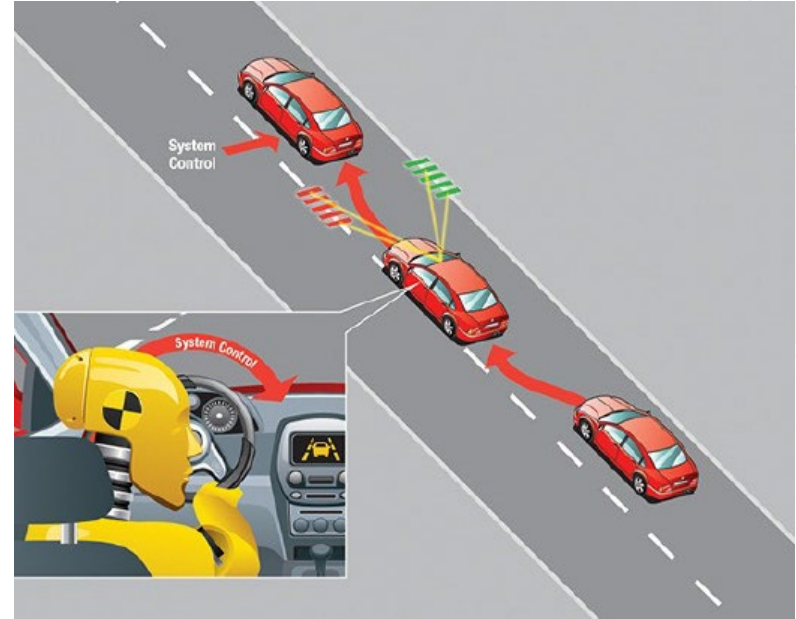
GIS-T

April 26, 2019



CAV Technologies to be Considered (currently available on the market)

- Control Loss Warning (CLW)
- Road Departure Crash Warning (RDCW)
- Lane-Keeping Assistance (LKA)
- Automatic Emergency Braking (AEB)
- Electronic Stability Control (ESC)
- Backup Collision Intervention (BCI)
- Blind Spot Warning (BSW)
- Lane Change Warning (LCW)
- Do Not Pass Warning (DNPW)
- Forward Collision Warning (FCW)



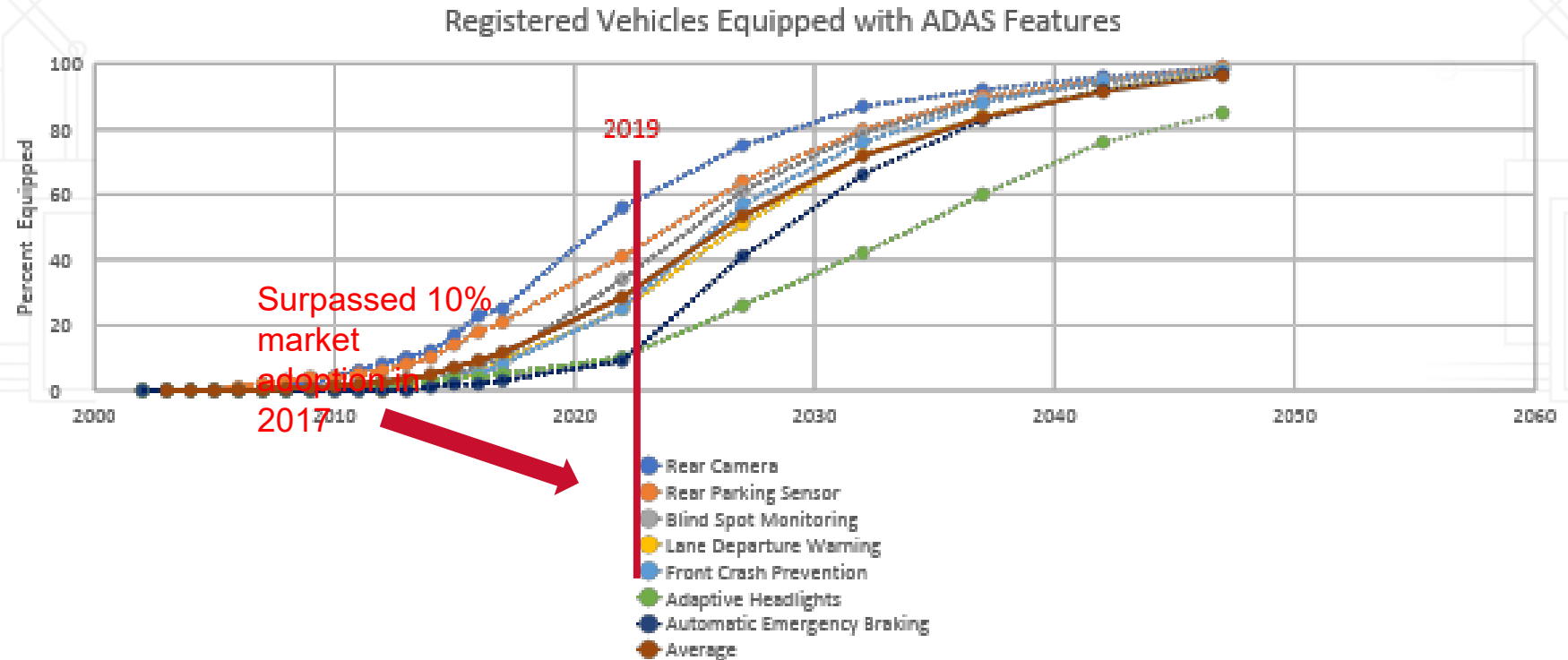
CAV Introduction

- 1) 94% of all vehicle crashes are a result of driver error
- 2) 80% of all crashes could be avoided and/or severity lessened as a result of CAV adoption
 - a) Generally assumes 100% CAV market adoption, 100% performance, 100 year horizon
- 3) CAV technologies are *now* starting to gain public acceptance

SAE Levels of Automation – J3016_201806

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver performs part or all of the DDT						
0	No Driving Automation	The performance by the <i>driver</i> of the entire DDT, even when enhanced by <i>active safety systems</i> .	<i>Driver</i>	<i>Driver</i>	<i>Driver</i>	n/a
1	Driver Assistance	The <i>sustained</i> and ODD-specific execution by a <i>driving automation system</i> of either the <i>lateral</i> or the <i>longitudinal vehicle motion control</i> subtask of the DDT (but not both simultaneously) with the expectation that the <i>driver</i> performs the remainder of the DDT.	<i>Driver and System</i>	<i>Driver</i>	<i>Driver</i>	Limited
2	Partial Driving Automation	The <i>sustained</i> and ODD-specific execution by a <i>driving automation system</i> of both the <i>lateral and longitudinal vehicle motion control</i> subtasks of the DDT with the expectation that the <i>driver</i> completes the OEDR subtask and <i>supervises the driving automation system</i> .	<i>System</i>	<i>Driver</i>	<i>Driver</i>	Limited
ADS ("System") performs the entire DDT (while engaged)			<i>System</i>	<i>System</i>	<i>Fallback-ready user (becomes the driver during fallback)</i>	Limited
3	Conditional Driving Automation	The <i>sustained</i> and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is <i>receptive to ADS-issued requests to intervene</i> , as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.				
4	High Driving Automation	The <i>sustained</i> and ODD-specific performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to <i>intervene</i> .				
5	Full Driving Automation	The <i>sustained</i> and unconditional (i.e., not ODD-specific) performance by an ADS of the entire DDT and DDT fallback without any expectation that a user will respond to a request to <i>intervene</i> .	<i>System</i>	<i>System</i>	<i>System</i>	Unlimited

Market Adoption of Advanced Driver Assistance Systems (ADAS)



Project Background

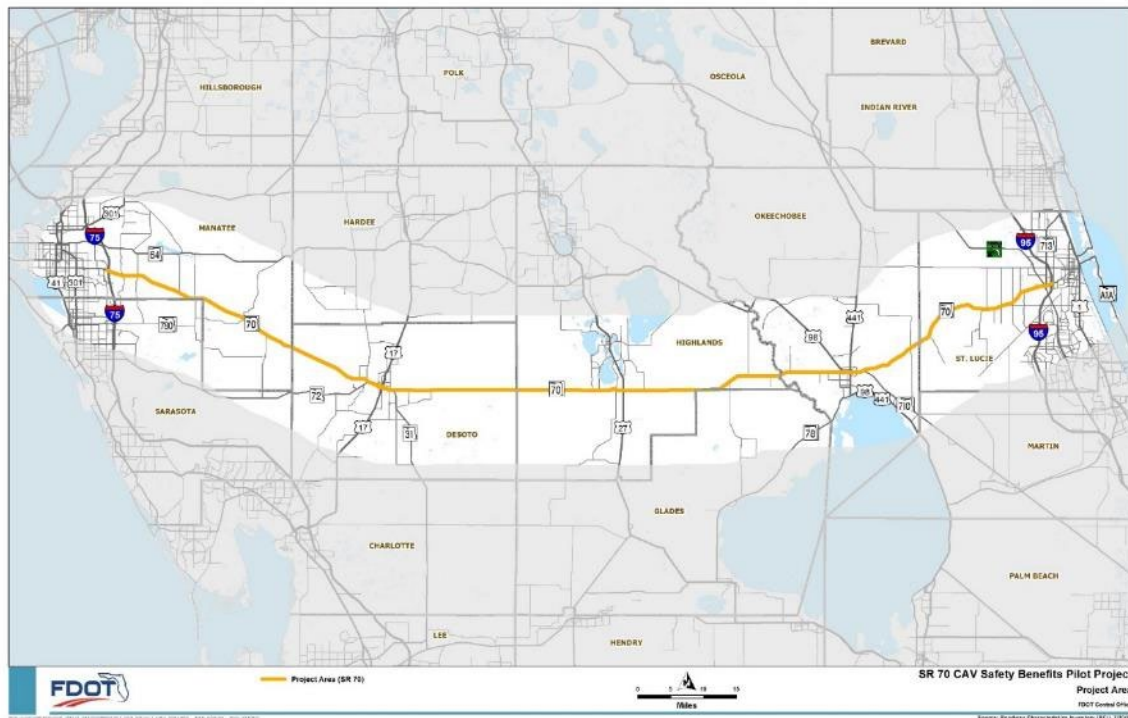
- 1) Legislatively mandated to account for advanced vehicles technologies in FDOT plans/policies
- 2) Understand realistic expectations of improved safety as a result of CAV market adoption, 10-15 year planning horizon
- 3) CAVs have not been incorporated into FDOT corridor analyses or HSM methodologies
 - a) This project will establish methodologies for doing so



Project Tasks

- 1) Data Gathering
- 2) Predict Volume of Future Crashes
- 3) Crash/ Technology Mapping and Crash Modification Factors
- 4) Autonomous Vehicle Crash Modification Factor Validation
- 5) Reporting

State Road (SR) 70 Corridor – Tampa to Fort Pierce



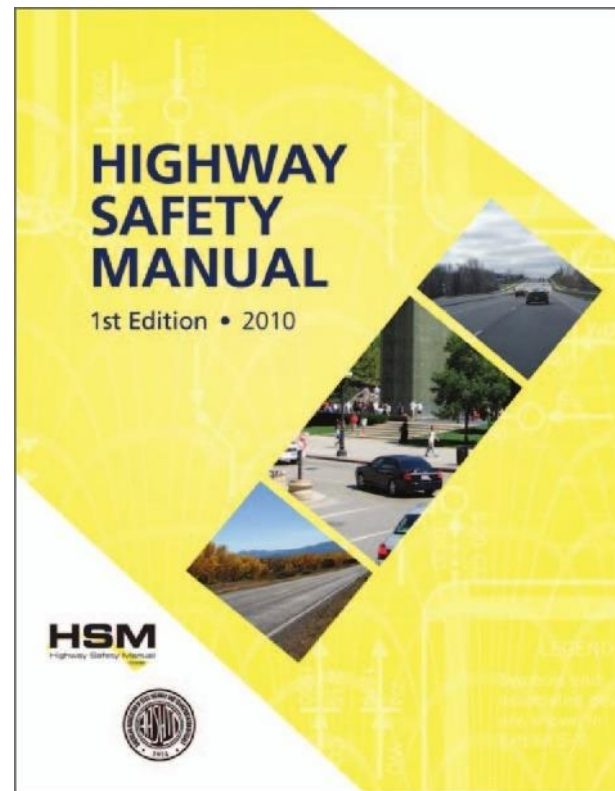
Data Sources

- 1) SSOGIS (FDOT State Safety Office (SSO) AGOL)
- 2) Signal 4 Analytics (UF)
- 3) FIRES (FL DHSMV)
- 4) FDOT CARS (SSO raw crash data)
- 5) RCI (FDOT roadway data)
- 6) Google Imagery



Utilize HSM Methodology

- 1) Safety Performance Functions (SPFs) that apply to the corridor (segments and intersections) Predict Volume of Future Crashes
- 2) Input data and Crash Modification Factors (CMFs) for each SPF
- 3) Crash prediction validation testing
- 4) Predicted number of crashes on SR 70 by segment over the next 40 years



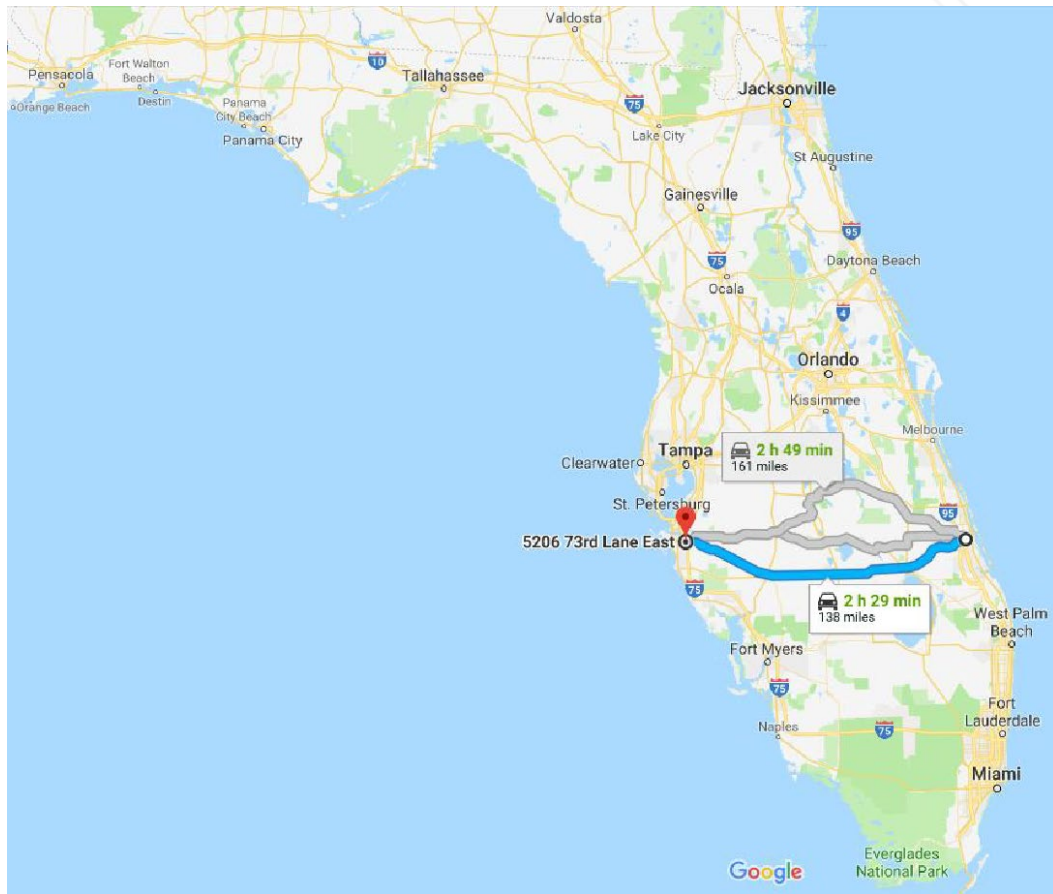
HSM Segmentation

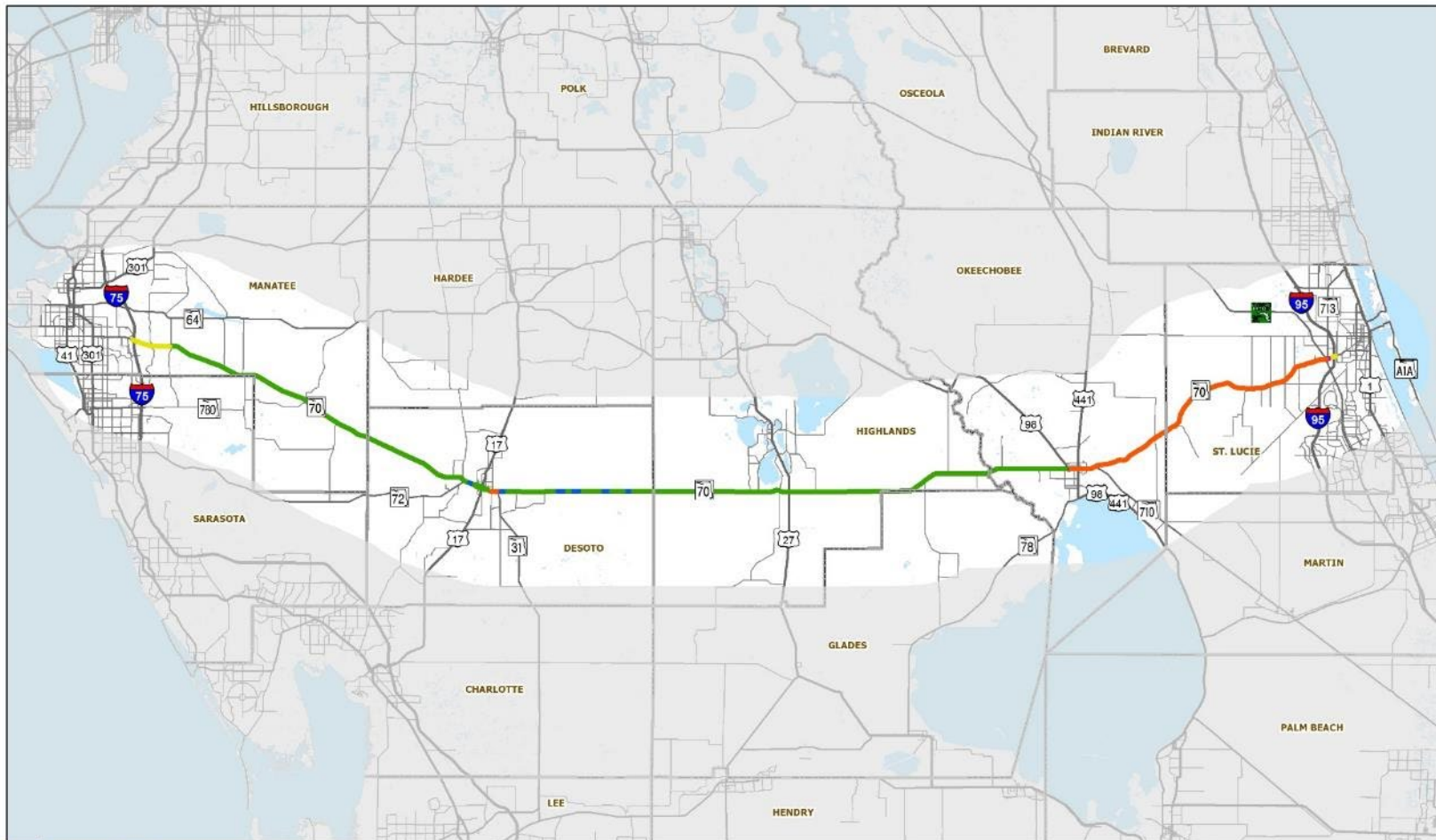
- 67 segments for analysis
- Aggregated to 7 segments for reporting



Map Series

- Spatial representation of RCI (roadway characteristics) & CARS (crash) data for SR 70
- Establishes baseline for estimating future crashes in the 'no build' (no consideration of CAVs) scenario
- Used to compare 'before' & 'after' CAV performance assumptions, market adoption, etc.





2 Lanes (Green)
 3 Lanes (Blue)
 4 Lanes (Orange)
 5 Lanes (Purple)
 6 Lanes (Yellow)



SR 70 CAV Safety Benefits Pilot Project
Number of Lanes (Total)

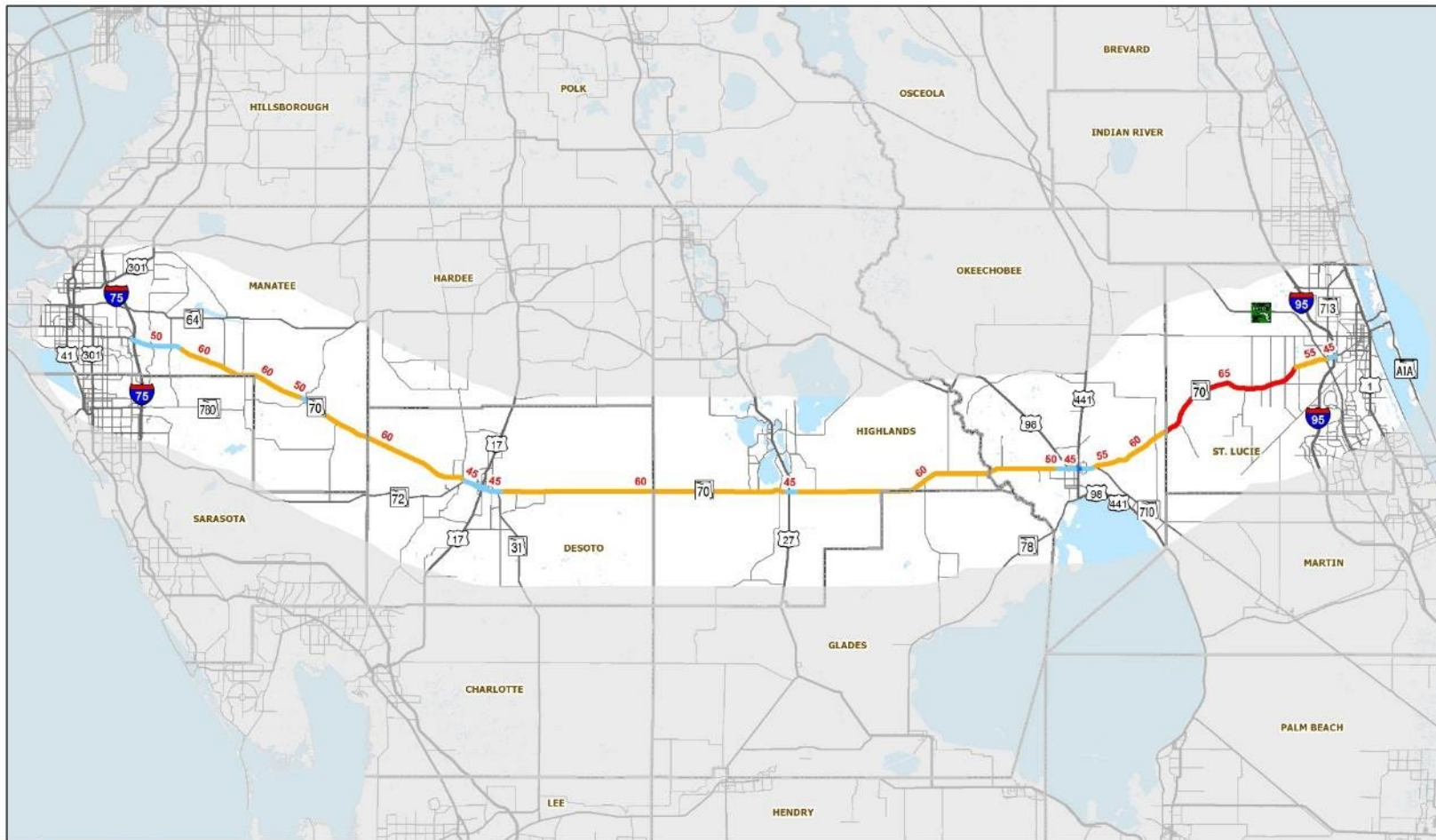
FDOT Central Office

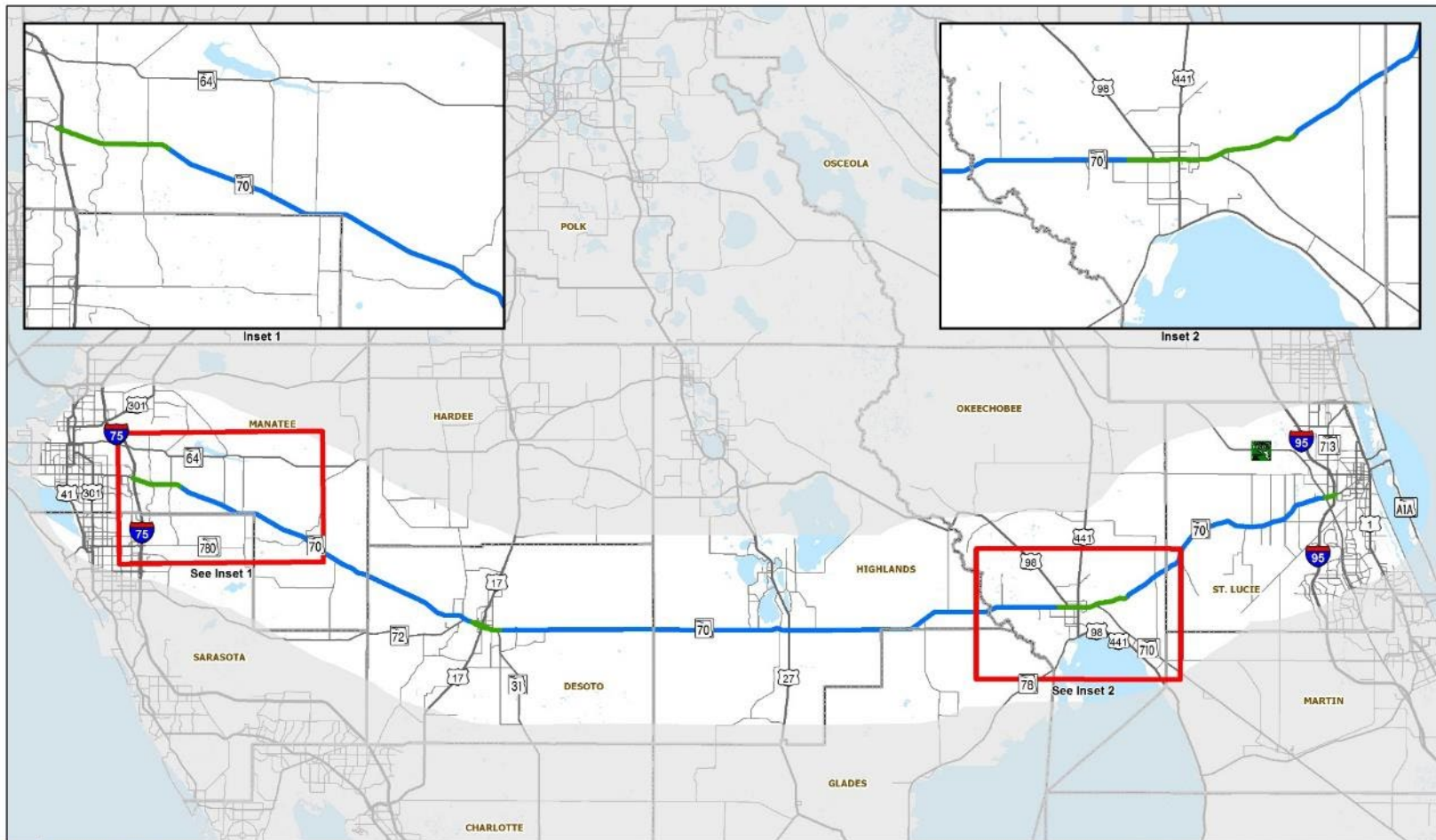
Source: Roadway Characteristics Inventory (RCI), 7/2018



FDOT Central Office

Source: Roadway Characteristics Inventory (RCI), 7/2018





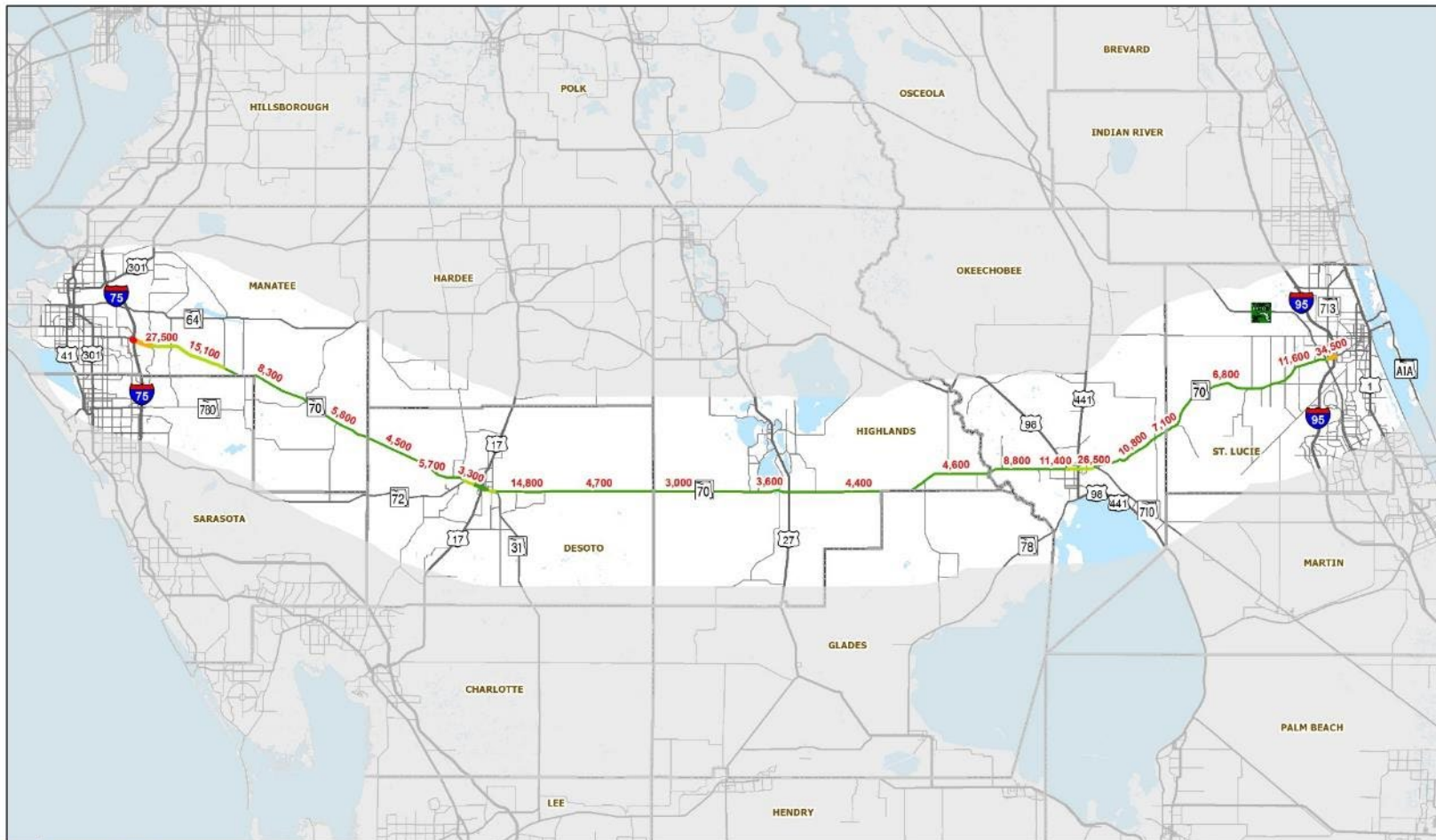
— 04 - Principal Arterial (Rural)
— 14 - Principal Arterial (Urban)



SR 70 CAV Safety Benefits Pilot Project
 Functional Classification

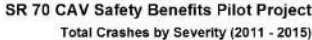
FDOT Central Office

Source: Roadway Characteristics Inventory (RCI), 7/2018

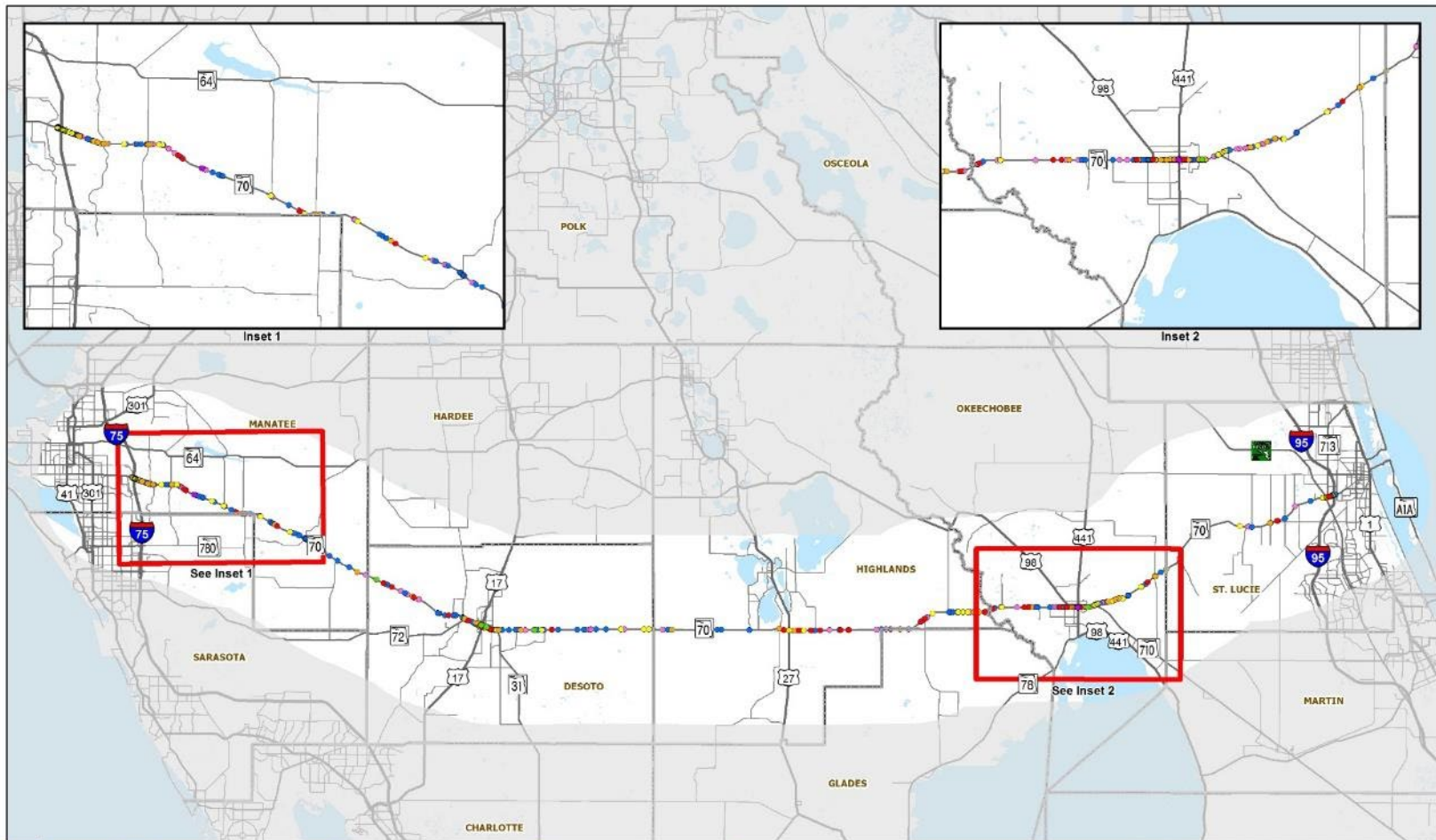






**FDOT Central Office**

Source: CARE, 2011 - 2015



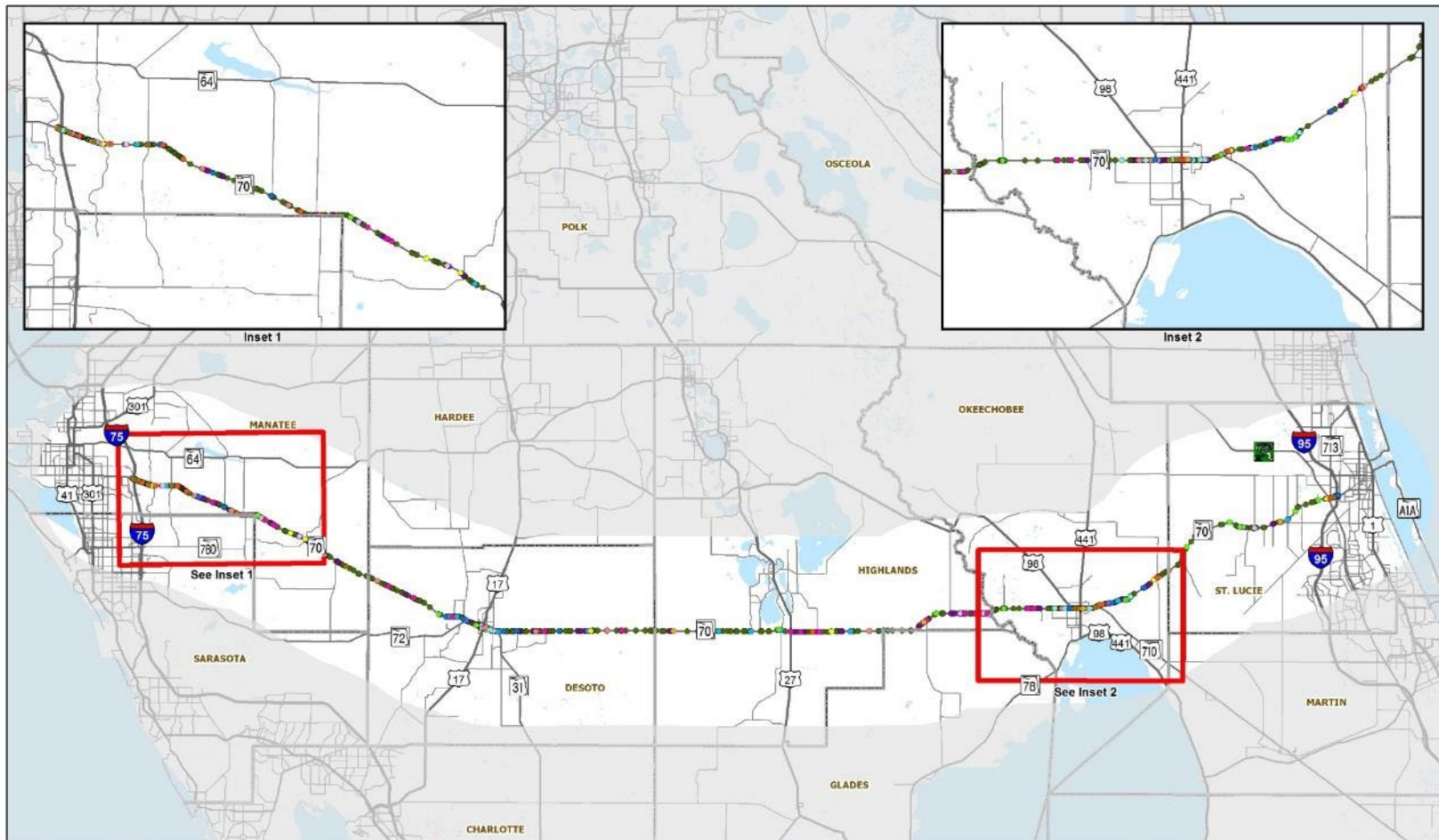
- Rear to Rear (3)
- Rear to Side (5)
- Sideswipe (Opposite Direction) (40)
- Front to Front (74)
- Sideswipe (Same Direction) (187)
- Angle (458)
- Front to Rear (744)



SR 70 CAV Safety Benefits Pilot Project
Manner of Crash (2011 - 2015)

FDOT Central Office

Source: CARE, 2011 - 2015



- Parked (5)
- Stopped in Traffic (12)
- Leaving Traffic Lane (14)
- Making U-Turn (19)

- Entering Traffic Lane (20)
- Backing (23)
- Negotiating a Curve (29)
- Overtaking/Passing (39)

- Slowing (42)
- Changing Lanes (89)
- Turning Right (119)
- Turning Left (292)

- Straight Ahead (1,374)



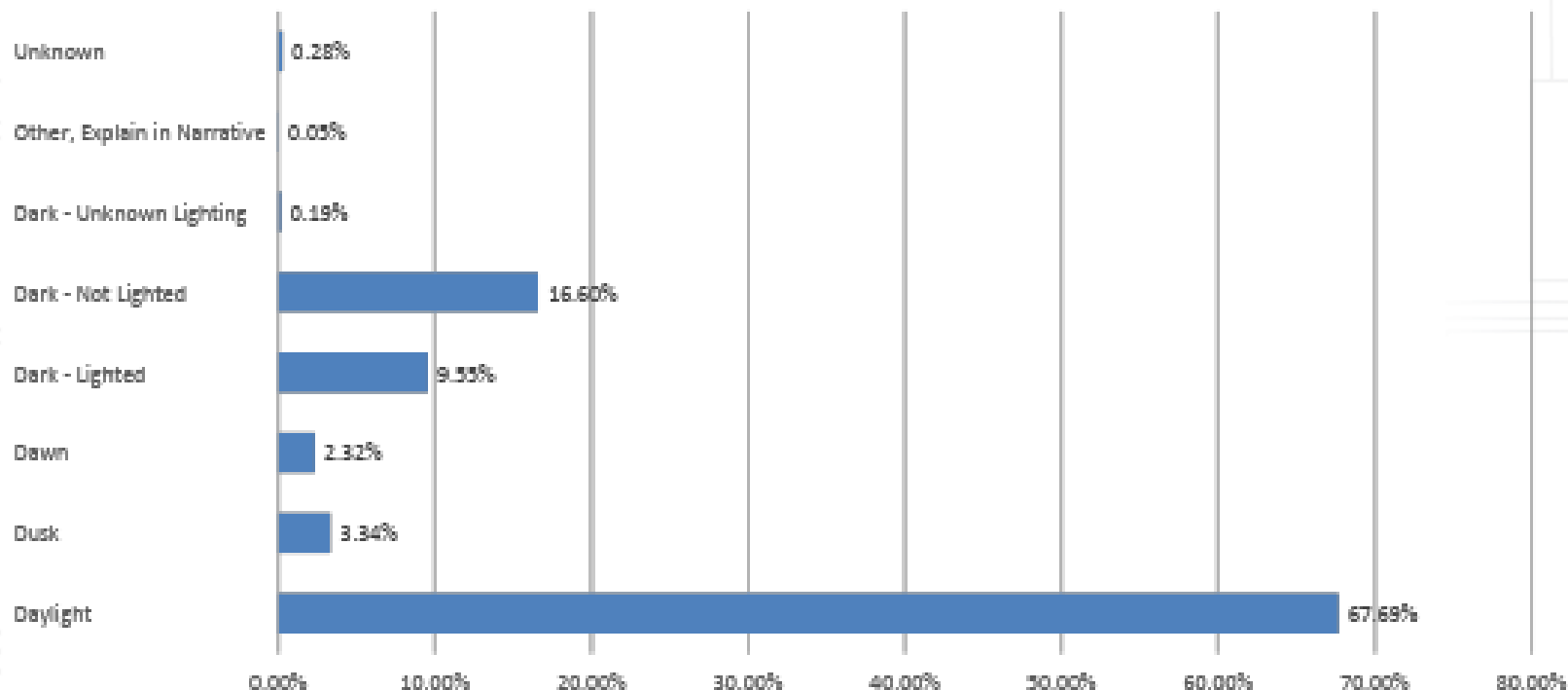
SR 70 CAV Safety Benefits Pilot Project Vehicle Maneuver (2011 - 2015)

FDOT Central Office

Source: CARE, 2011 - 2015

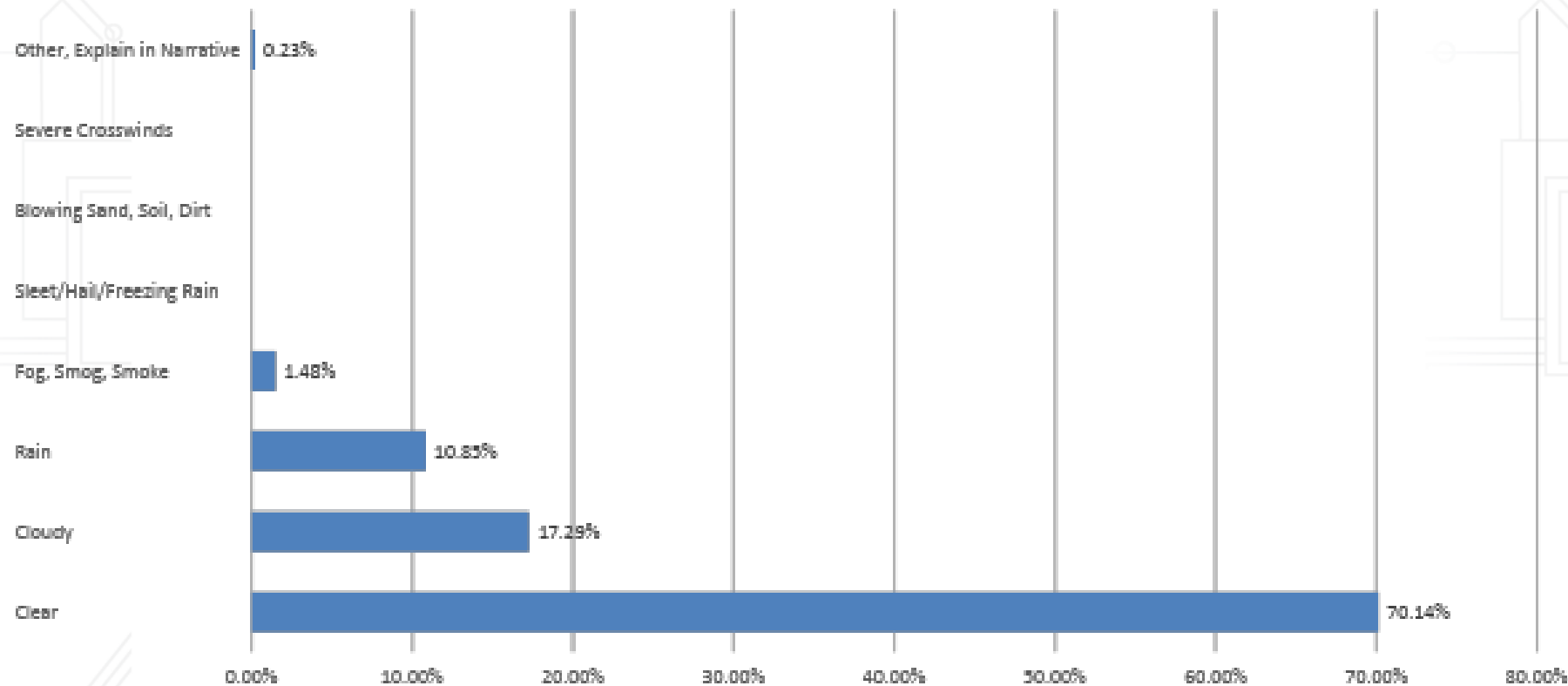
Crash Summary Statistics

Light Condition During Crash



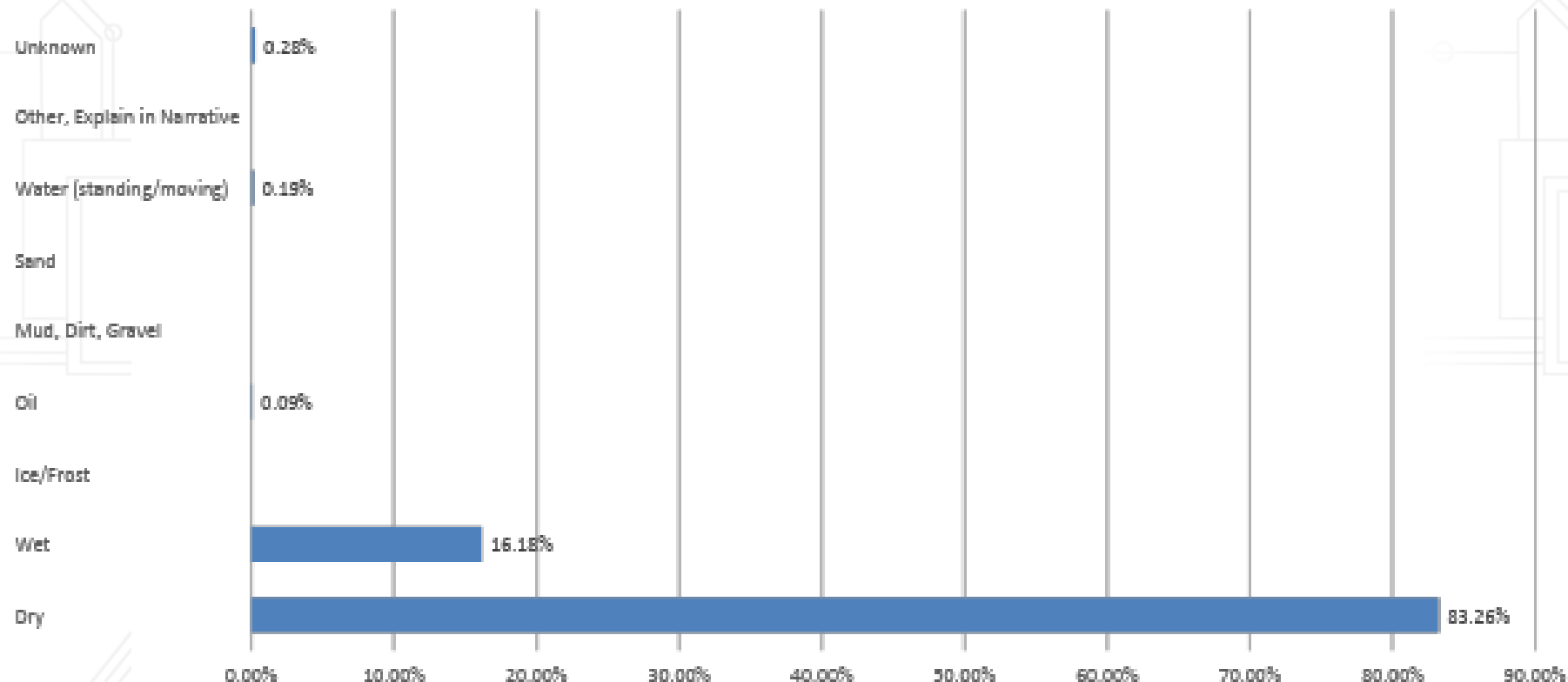
Crash Summary Statistics

Weather Condition During Crash



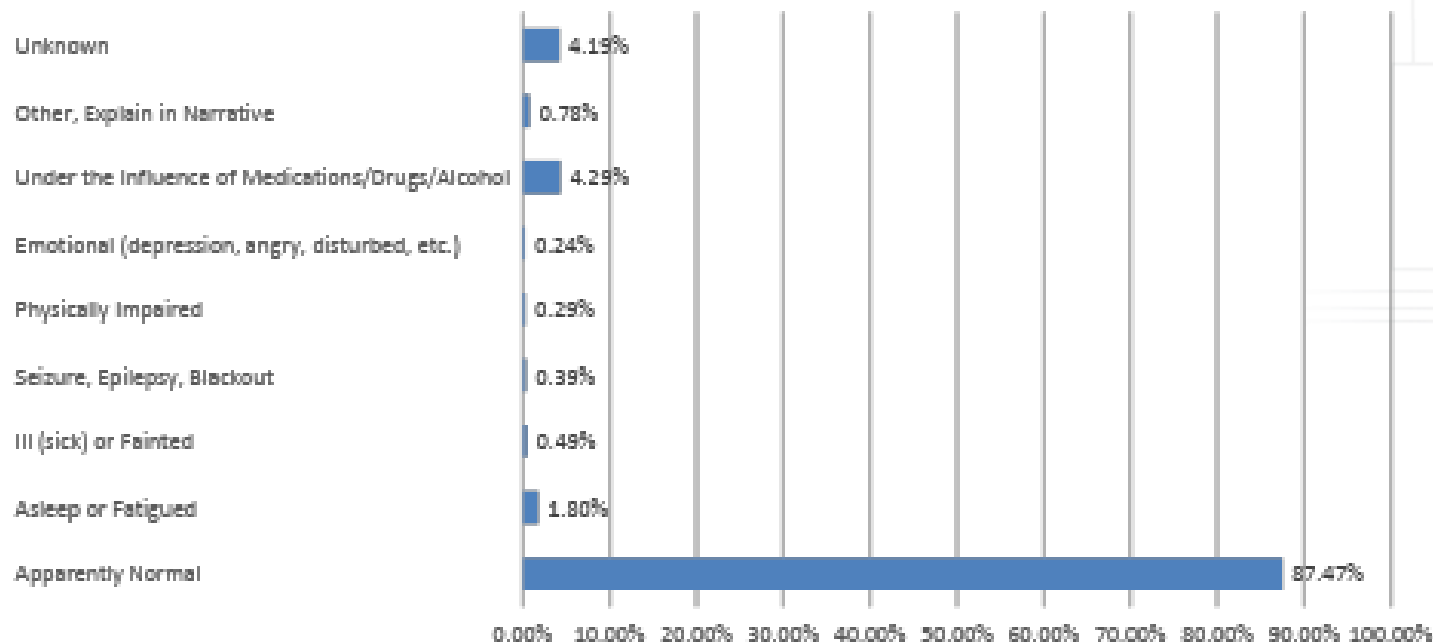
Crash Summary Statistics

Surface Condition During Crash



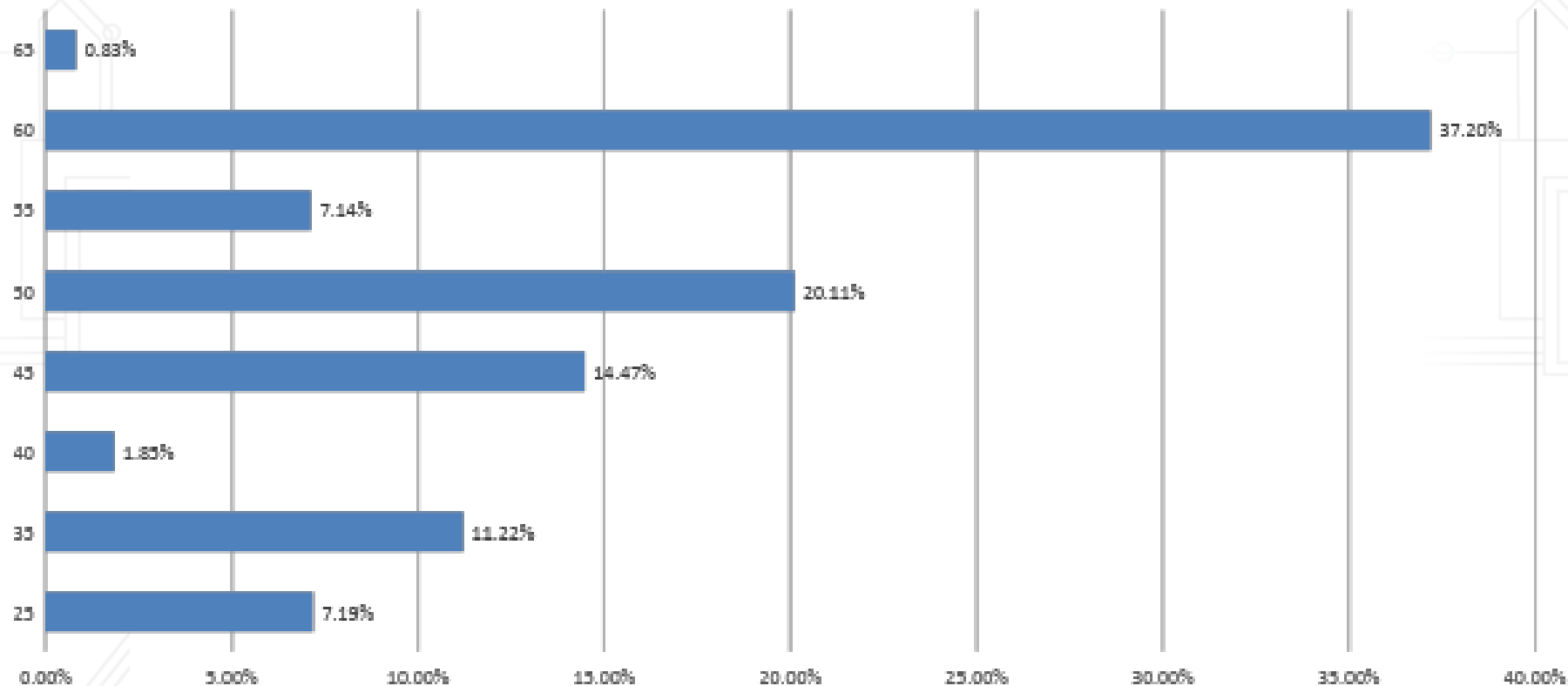
Crash Summary Statistics

Driver Condition During Crash

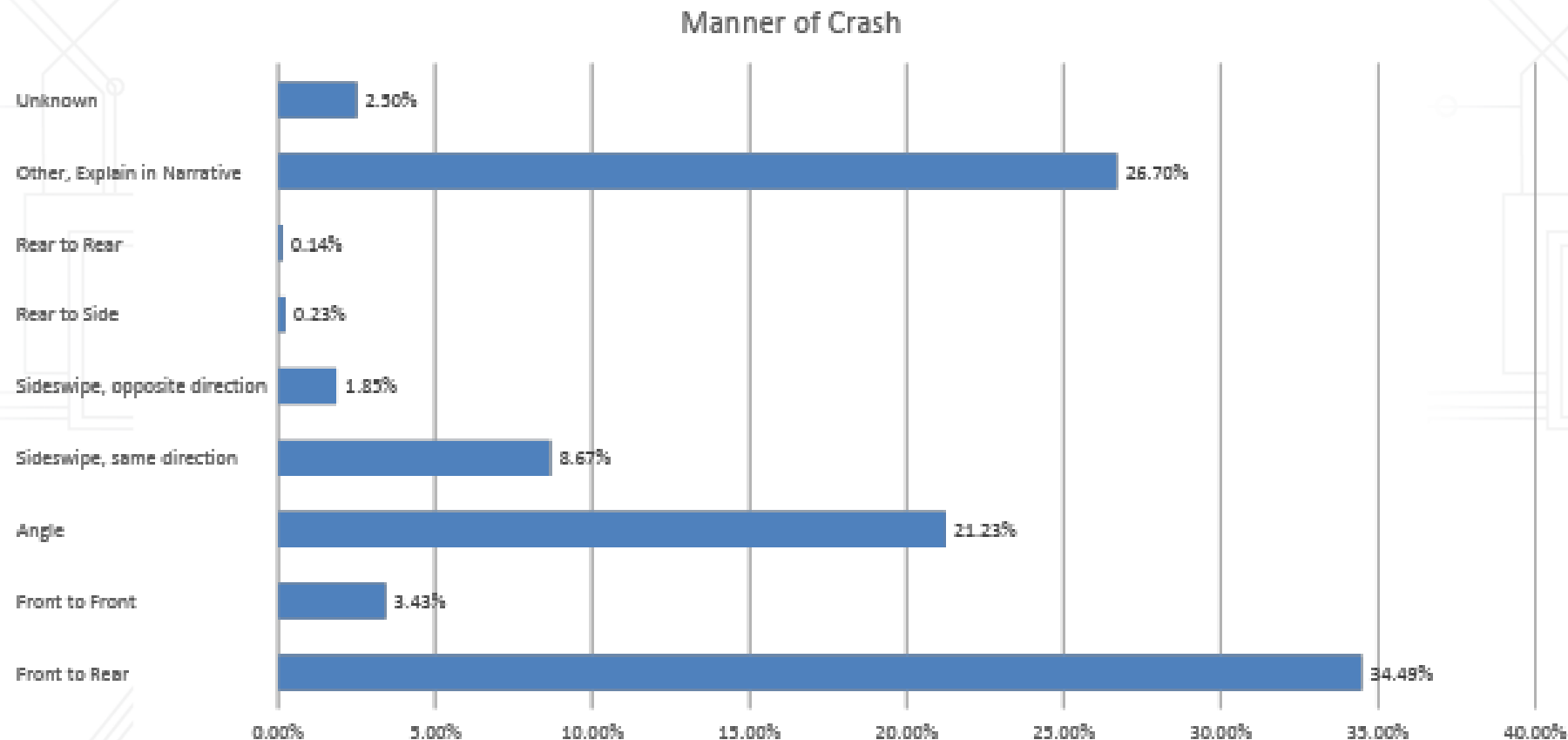


Crash Summary Statistics

Maximum Speed (mph)

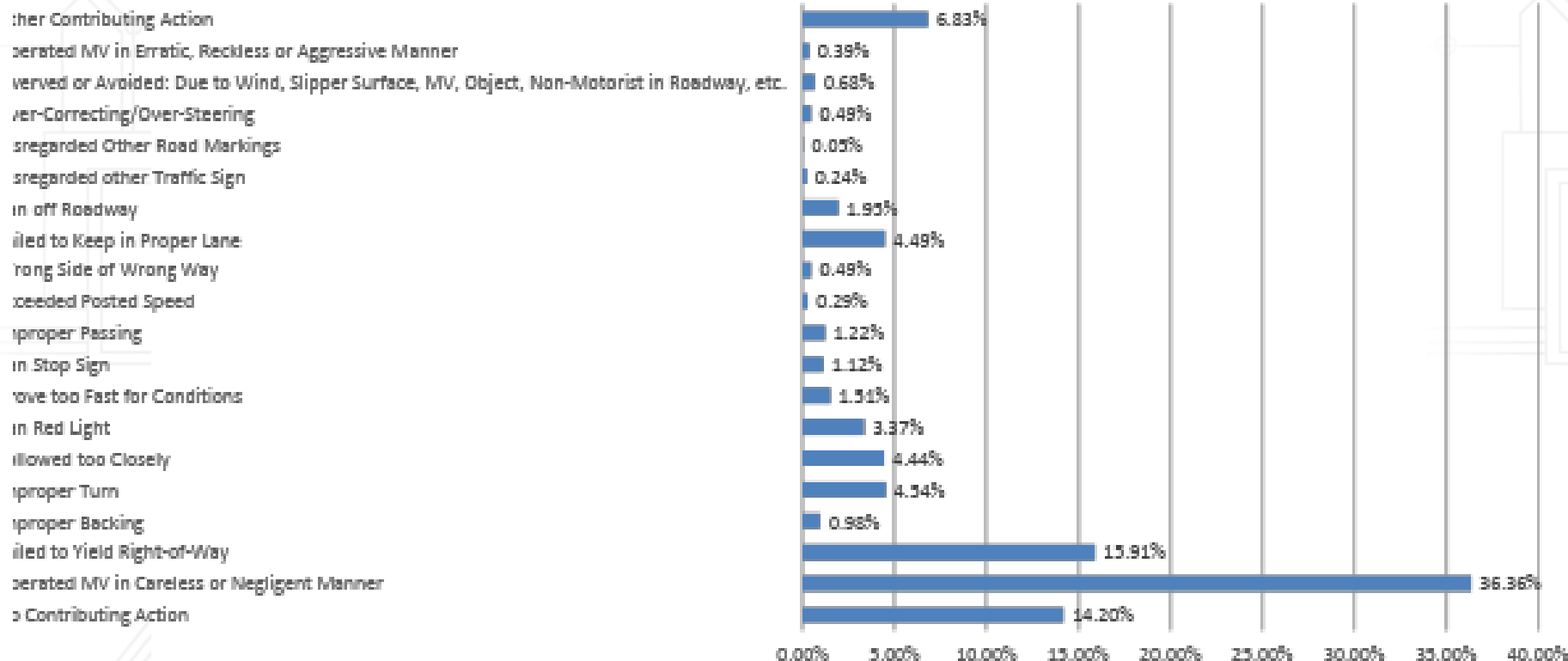


Crash Summary Statistics

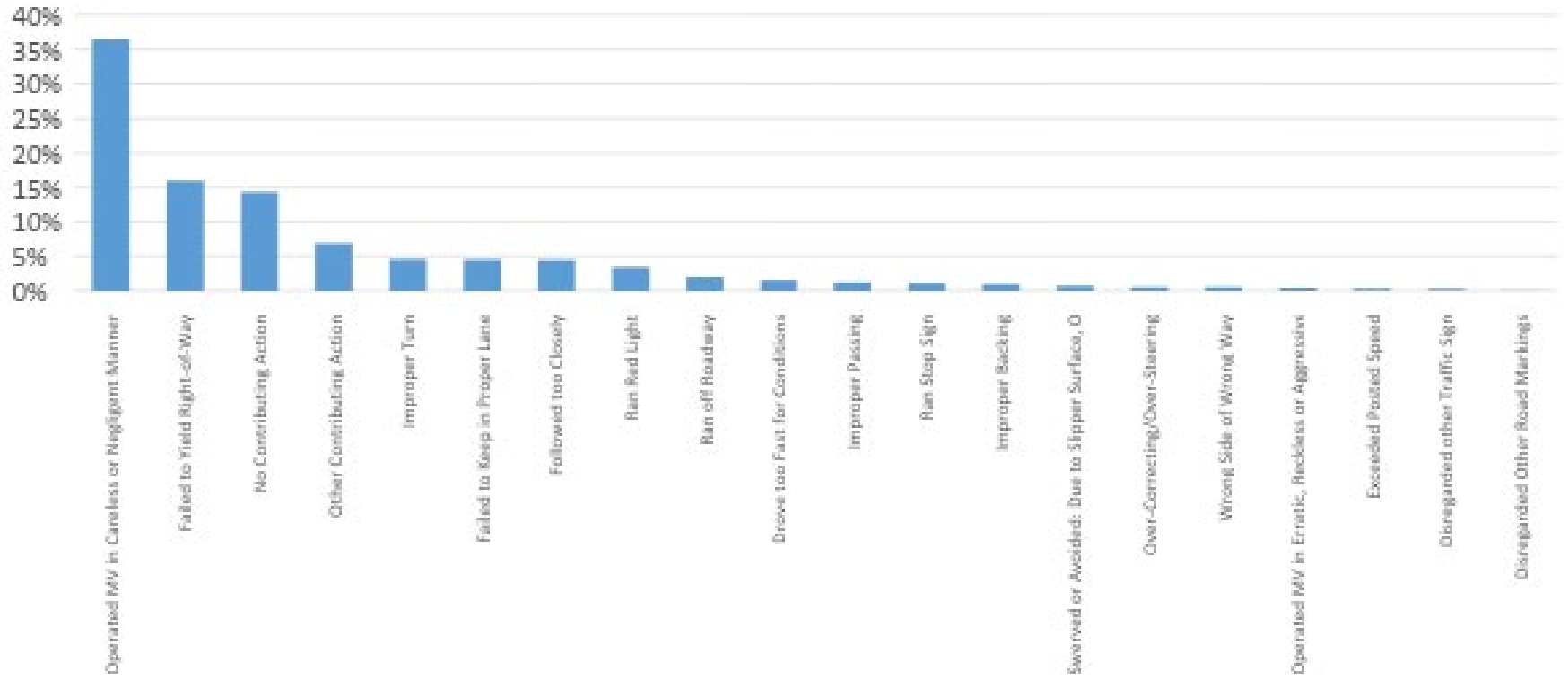


Crash Summary Statistics

Driver's Action During Crash



Crash Summary Statistics



Comparison of SR 70 Predicted Crashes with Actual Crashes

Segments	Annual Average Crashes (2011 - 2015)		Difference	Percent Difference
	Observed	Predicted		
I-75 to Lorraine Road	104	108	4	4%
Lorraine Road to Peace River	75	77	2	3%
Peace River to Arcadia Walmart	37	41	4	11%
Arcadia Walmart to US 98	76	82	6	8%
US 98 to SR 710	66	69	3	5%
SR 710 to Florida's Turnpike	44	44	0	0%
Florida's Turnpike to I-95	29	33	4	14%
SR 70 (I-75 to I-95) Total Crashes	431	454	23	5%

Future Year Predicted Total Crashes

Segments	Year 2020	Year 2025	Year 2030	Year 2035	Year 2040	Year 2045	Year 2050	Year 2055	Year 2060
I-75 to Lorraine Road	123	128	132	136	140	143	147	151	154
Lorraine Road to Peace River	100	105	109	113	117	121	125	129	133
Peace River to Arcadia Walmart	57	60	62	65	68	71	73	76	79
Arcadia Walmart to US 98	106	120	133	147	161	174	188	201	215
US 98 to SR 710	76	82	88	95	101	108	115	121	128
SR 710 to Florida's Turnpike	62	70	77	85	92	100	108	115	124
Florida's Turnpike to I-95	41	43	45	47	48	50	52	53	55
SR 70 (I-75 to I-95) Total Crashes	565	608	646	688	727	767	808	846	888

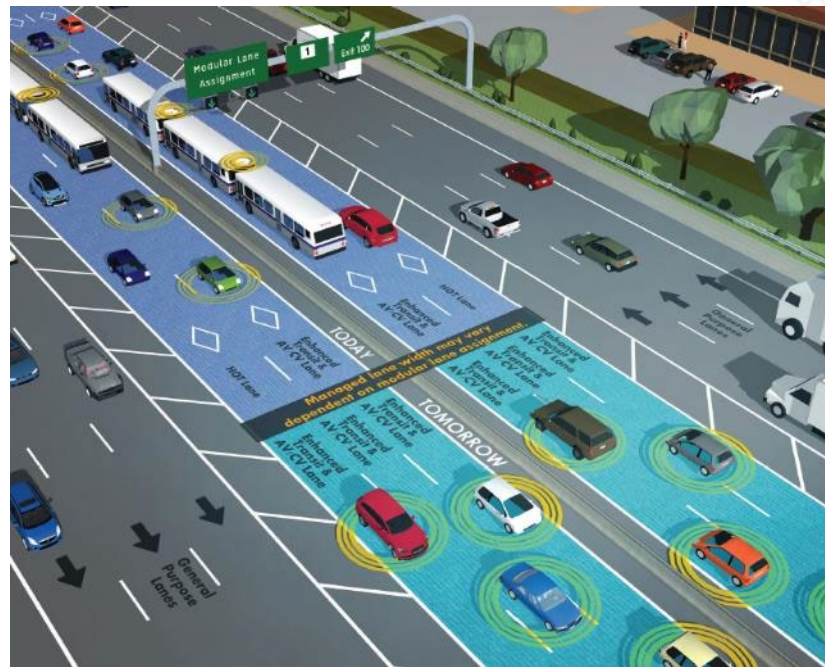
Crash/ Technology Mapping and Crash Modification Factors

- 1) Utilize HDR refined methodology for estimating CMFs that are based on new vehicle technology solutions
- 2) Update methodology to reflect new vehicle technology crash statistics
- 3) Identify the root cause of each crash from the crash records
- 4) Identify which technologies could have potentially reduced the severity of each crash, or prevented each crash
- 5) Apply assumed effectiveness of each technology to each crash



CAV Crash Modification Factor Validation

- Take findings and apply factors for various rates of adoption of CAVs
- Provides a validation of the estimates as well as provide a lower bound on the anticipated crash reductions for future conditions as a function of AV/CV adoption



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