Safety and Congestion Scores of Selected First/Last Mile Freight Connectors in Tennessee

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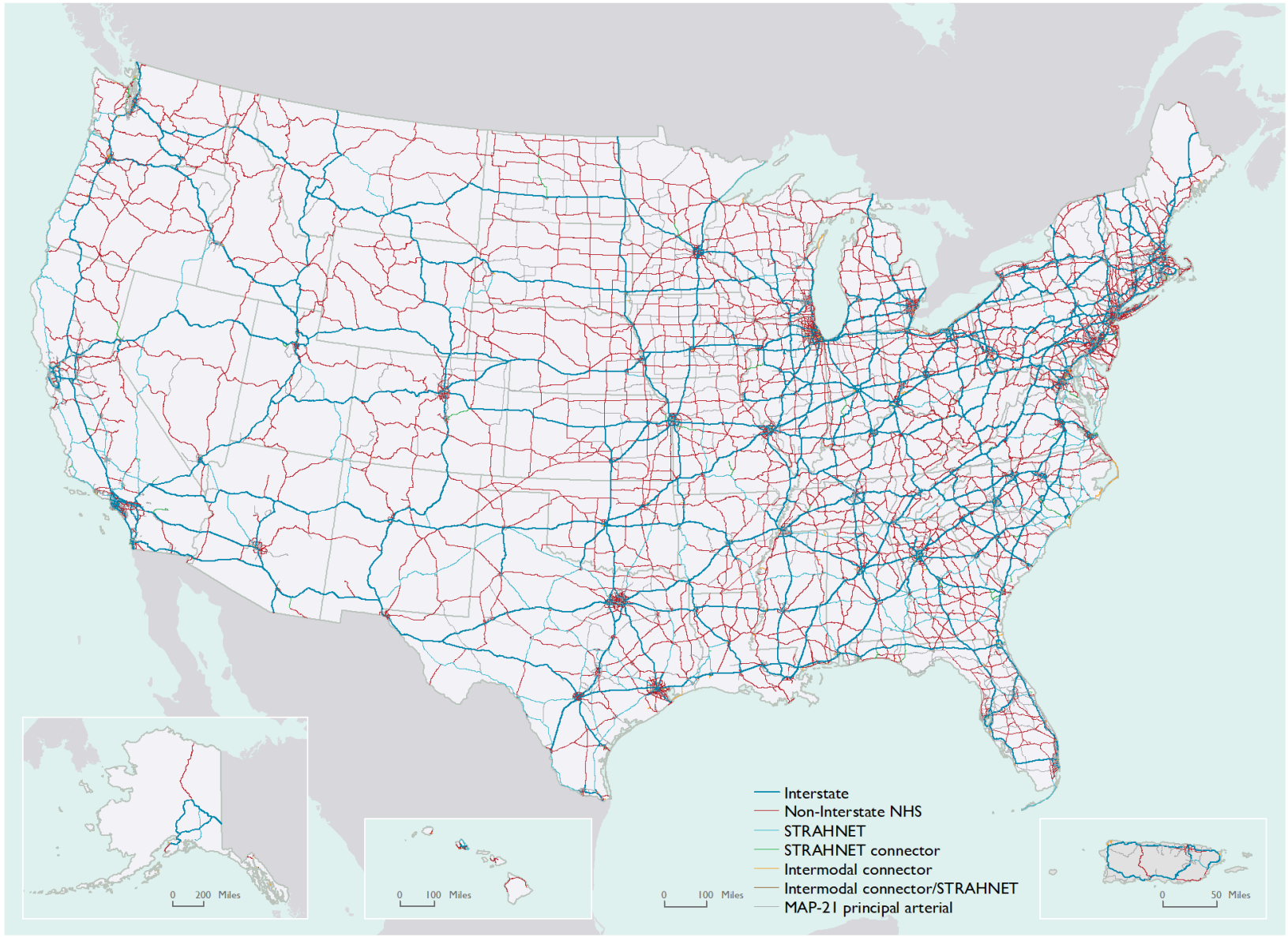
FREIGHT INTERMODAL CONNECTORS (FICs)

- FICs which are also known as **“First mile/last mile roadways”** are connector facilities that link freight-intensive land uses to main freight routes.
- They are generally the shortest portion of a freight trip; however, often times they are the most difficult to complete.
- According to TDOT, First-mile, last-mile connections, especially in well-populated urban areas, may experience issues such as traffic congestion, safety, freight-incompatible roadway geometry, and configurations resulting in delays to moving freight.

National Highway System, Intermodal Connectors, and Principal Arterials: 2018



KEY: NHS = National Highway System or the interstate highway system; STRAHNET = Strategic Highway Network or a network of highways that are important to the U.S. strategic defense policy. MAP-21 principal arterials = those rural and urban roads serving major population centers not already categorized above.

SOURCE: U.S. Department of Transportation (USDOT), Federal Highway Administration, Highway Performance Monitoring System, as cited in USDOT, Bureau of Transportation Statistics, National Transportation Atlas Database, available at www.bts.gov as of September 2018.

Freight Facts and Figures

Previous Editions

Freight Intermodal Connectors on the National Highway System by State

Year: 2018

	Port terminal	Truck/rail facility	Airport	Truck/pipeline terminal	Grand Total
New York	8	16	17	0	41
Michigan	15	8	11	0	34
Washington	11	6	14	0	31
Georgia	5	13	4	7	29
Wisconsin	19	4	5	0	28
Massachusetts	5	10	12	0	27
Mississippi	22	2	3	0	27
Oregon	15	5	6	1	27
Pennsylvania	8	8	5	4	25
Louisiana	8	5	8	0	21
North Carolina	2	4	9	5	20
Tennessee	5	8	4	2	19
Kentucky	4	7	3	3	17
Arkansas	3	7	3	3	16
Missouri	4	8	4	0	16
Virginia	6	3	7	0	16
Alaska	8	0	7	0	15
Colorado	0	5	6	4	15
Hawaii	10	0	5	0	15

Tennessee
19 Connectors

Source: U.S. Department of Transportation, Federal Highway Administration, Office of Planning, Environment, and Realty, Intermodal Connectors, available at https://www.fhwa.dot.gov/planning/national_highway_system/intermodal_connectors/ as of February 2020.

TENNESSEE FICs

County	Airport	Intercity Bus Terminal	Port Terminal	Truck/ Pipeline Terminal	Truck/ Rail Facility	Total
Davidson	0	1	0	0	1	**2**
Hamilton	1	1	4	1	0	**7**
Knox	0	1	0	1	0	**2**
Shelby	2	1	1	0	6	**10**
Sullivan	1	0	0	0	1	**2**
Total	**4**	**4**	**5**	**2**	**8**	**23**

Facility Type	Type	No.	Connector Description	Miles	Id
Chattanooga Metropolitan Airport	Airport	1	Shepherd Road (Airport Connector) Between SR-153 And Airport Road	0.7	TN2A
Colonial & Plantation Pipeline Co. - Knx	Truck/Pipeline Terminal	1	Middlebrook Pike (SR-169), Ed Shouse Drive, Western Ave From Terminal Entrance To I-75	1.3	TN11L
Colonial Pipeline - Chattanooga	Truck/Pipeline Terminal	1	Jersey Pike From Enterprise Park Drive To SR-153	0.5	TN1L
CSX Corporation - Kingsport	Truck/Rail Facility	1	Linc0ln Street From John B. Dennis Highway (SR-93) To Facility Entrance	0.8	TN10R
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	1	Southern Avenue From Lamar Ave. (SR-4) To East Parkway (SR-277)	0.8	TN13R
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	2	East Parkway (SR-277) From Lamar Ave. (SR-4) To Southern Avenue	0.8	TN13R
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	3	Spottswood Avenue From Airways (SR-277) To Forrest Yard	0.3	TN13R
Greyhound Bus Terminal - Chattanooga	Intercity Bus Terminal	1	West 4th Street And Chestnut Street From I-124 To West 5th Street	0.3	TN8B
Greyhound Bus Terminal - Knoxville	Intercity Bus Terminal	1	Cherry Street And Magnolia Avenue (SR-1) From I-40 To Central Street	2.3	TN12B
Greyhound Bus Terminal - Memphis	Intercity Bus Terminal	1	Union Avenue (SR-3) Between Danny Thomas Blvd (SR-1) And 4th Street	0.2	TN20B
Greyhound Bus Transp Center - Nashville	Intercity Bus Terminal	1	Demonbreun Between I-40 And 8th Avenue South (SR-1)	0.4	TN21B
J.I.T. Terminals - Chattanooga	Port Terminal	1	Manufactures Road From SR-29 To Terminal Entrance	0.2	TN4P
Johnston Yards - Memphis Illinois Centra	Truck/Rail Facility	1	Mallory Avenue And Riverport Road Between I-55 And Rail Yard	1.5	TN19R
Leewood Yards - Memphis CSX	Truck/Rail Facility	1	Jackson Avenue (SR-14) And Chelsea Avenue Between I-40 And Warford Street	2.5	TN17R
Memphis International Airport	Airport	1	Tchulahoma And Democrat Rd Between Lamar Ave (SR-4) And Airways Blvd	2.4	TN15A
Memphis International Airport	Airport	2	Plough Blvd Between I-240 And The Airport Entrance	2	TN15A
Mid-South Terminals	Port Terminal	1	Hudson Rd. To Pineville Rd. To Moccasin Bend Rd. To Hamm Rd. To S. R. 29	2.8	TN3P
President's Island - Memphis	Port Terminal	1	Mclemore Av, Riverside Blvd, Jack Carley Causeway, Harbor Av, Channel Av, Jetty St Btw I-55 & Port	5.3	TN14P
Radnor Yards - Nashville CSX	Truck/Rail Facility	1	Armory Ave And Sidco Drive Between I-65 And Harding Place (SR-255)	2	TN22R
Southern Foundry Supply - Chattanooga	Port Terminal	1	West 19th Street From Riverfront Parkway (SR-58) To The Port Entrance	0.3	TN6P
Tennessee Yards - Memphis Burlington Nor	Truck/Rail Facility	1	Shelby Drive Between Lamar Avenue (SR-4) And The Tennessee Yard	0.6	TN18R
Tri-Cities Regional Airport - Kingsport	Airport	1	Airport Access Road (SR-357) From I-81 To Airport Entrance	3.1	TN9A
Vulcan Materials Company -Chattanooga	Port Terminal	1	River Street From Evans Street To Riverfront Parkway (SR-58)	0.1	TN5P
Total				31.2	

STUDY OBJECTIVE

Study performed multimodal inventory check and evaluate some of critical freight connectors in Tennessee by identifying improvement needs

- Safety Needs
- Congestion/capacity Needs
- environmental (Air Pollution) Needs

FICs MOE's Evaluation

- FICs was assigned a score on congestion/capacity, safety, risk, and emission basis, relying on what is known about the issues from the field review, data review, simulation, and stakeholders' input etc.
- The scores for each measure for each connector is ranked in order according to the score.
- The following measures were used to evaluate the FICs:
  - **Safety Score:** Crash frequency, crash rates, injury severity levels, collision patterns, etc
  - **Safety Economic Risk Score:** Risk impact and likelihood.
  - **Congestion/Capacity Score**: FICs congestion levels such as flow, speed, travel time & queuing.
  - **Emission Score**

SAFETY EVALUATION

Crash Data

- Three years of crash data (2012-2015) along each of the connectors was downloaded from the Tennessee Roadway Information Management System (eTRIMS) database.
- Each crash is embedded with attributes such as county name, roadway ID, the roadway log mile in which crash occurred, injury severity (type of crash), total killed and injured, first harmful event, roadway location, pavement condition, manner of collision, year of crash, time of crash, lighting condition, weather condition, relation to junction, and urban or rural classification among others.
- The attributes such as log mile, county and roadway ID were used to merge each crash with information such as traffic volume and roadway geometry.

Traffic Characteristics and Geometric Data

- The average annual daily traffic (AADT) for three years (2012 to 2014) was gathered through eTRIMS and TDOT traffic history website.
- Included in the traffic data are AADT, percentage of passenger cars and trucks (single and multi-units), peak hour volume percentage, and directional splits.
- Geometric data was downloaded from eTRIMS database that provide information such as terrain, land use, number of lanes, travel way width, posted speed limit, illumination, access control class, one-way or two way street information, and roadside features.
- Maintenance features in eTRIMS provided median type and width among others for each connector.
- Google Earth was used for the verification of downloaded geometric data as well as for gathering the information not found in eTRIMS.

Identification of FICs Safety Deficiencies

- Crash analysis along the study FICs
- Identification of injury severity patterns
- Identification of collision patterns
- Identification of crash contributing causes
- Identification of first harmful events
- Identification of crash locations (segment, intersections, ramps etc)
- Identification of crashes in relation to time of the day, day of the week

Safety Analysis

- The number of crashes for all roadway segments were tabulated with the highest number of crashes being along Jackson Ave (SR-14) in Memphis. Jackson Ave and Chelsea Ave roadway segments connect Leewood yards a truck/rail facility from I-40.
- The second and third connector segments with highest number of crashes are also from facilities in Memphis, which are Democrat Rd and Shelby Dr respectively.
- However, E. Magnolia Ave segment in Knoxville has the highest number of fatal and incapacitating injury crashes combined

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Total				31.2	

Connectors/Segments Ranked based on Number of Crashes and Crash Rates

Segments Ranked by Number of Crashes

Connector Segment	Length	AADT	Fatal	Incap.	Non Incap	PDO	Crashes
Jackson Ave-Rail-Shelby	1.55	24343	0	2	83	179	264
Democrat Rd-Airport-Shelby	2.45	14595	0	3	46	143	192
Shelby Dr-Rail-Shelby	0.63	25365	1	1	33	130	165
Plough Blvd-Airport-Shelby	1.78	34315	1	0	34	116	151
East Parkway S -Airways Blvd-Rail-Shelby	0.7	21848	2	0	45	92	139
Western Ave-Pipeline-Knox	0.174	42871	0	1	12	104	117
E. Magnolia Ave-Intercity Bus terminal-Knox	1.532	11443	0	10	24	64	98
Tchulahoma-Airport-Shelby	0.63	20218	0	1	17	54	72
N. Cherry St-Intercity bus terminal-Knox	0.49	13984	0	3	12	45	60
Jersey Pike-Pipeline-Hamilton	0.59	11102	0	0	17	41	58
Middlebrook Pike-Pipeline-Knox	0.507	23665	1	2	10	42	55
Manufactures Rd-Port-Hamilton	0.15	12504	0	1	5	48	54
S. 3rd St-Rail-Shelby	0.53	27448	0	1	16	36	53
Mallory Ave-Rail-Shelby	1.13	6747	0	1	17	30	48
Sidco Dr (4161) -Rail-Davidson	0.92	10707	0	1	11	34	46
Airways Blvd	0.24	49655	1	0	10	30	41
Chelsea Ave-Rail-Shelby	1.31	5600	0	0	18	23	41
Shepherd Rd-Airport-Hamilton	0.73	12352	0	1	6	28	38
Airport Access Rd-Airport-Sullivan	2.44	8450	1	2	10	24	37
Airport Rd-Hamilton	0.86	5314	0	1	7	27	35
Harbor Ave-Port-Shelby	2.856	7861	0	1	11	23	35
Ed shouce Dr -Pipeline-Knox	0.53	22954	0	1	3	25	29
Armory Ave(4162)-Rail-Davidson	0.17	7191	0	0	4	18	22
Jack carley Causeway-Port-Shelby	1.08	12941	0	3	7	12	22
Channel Ave-Port-Shelby	3.02	4865	0	0	5	14	19
Riverport Rd-Rail-Shelby	1.03	8514	0	0	4	14	18
Southern Ave-Rail-Shelby	0.92	8410	0	1	1	14	16
Armory Ave (4888)-Rail-Davidson	0.34	17955	0	0	3	12	15

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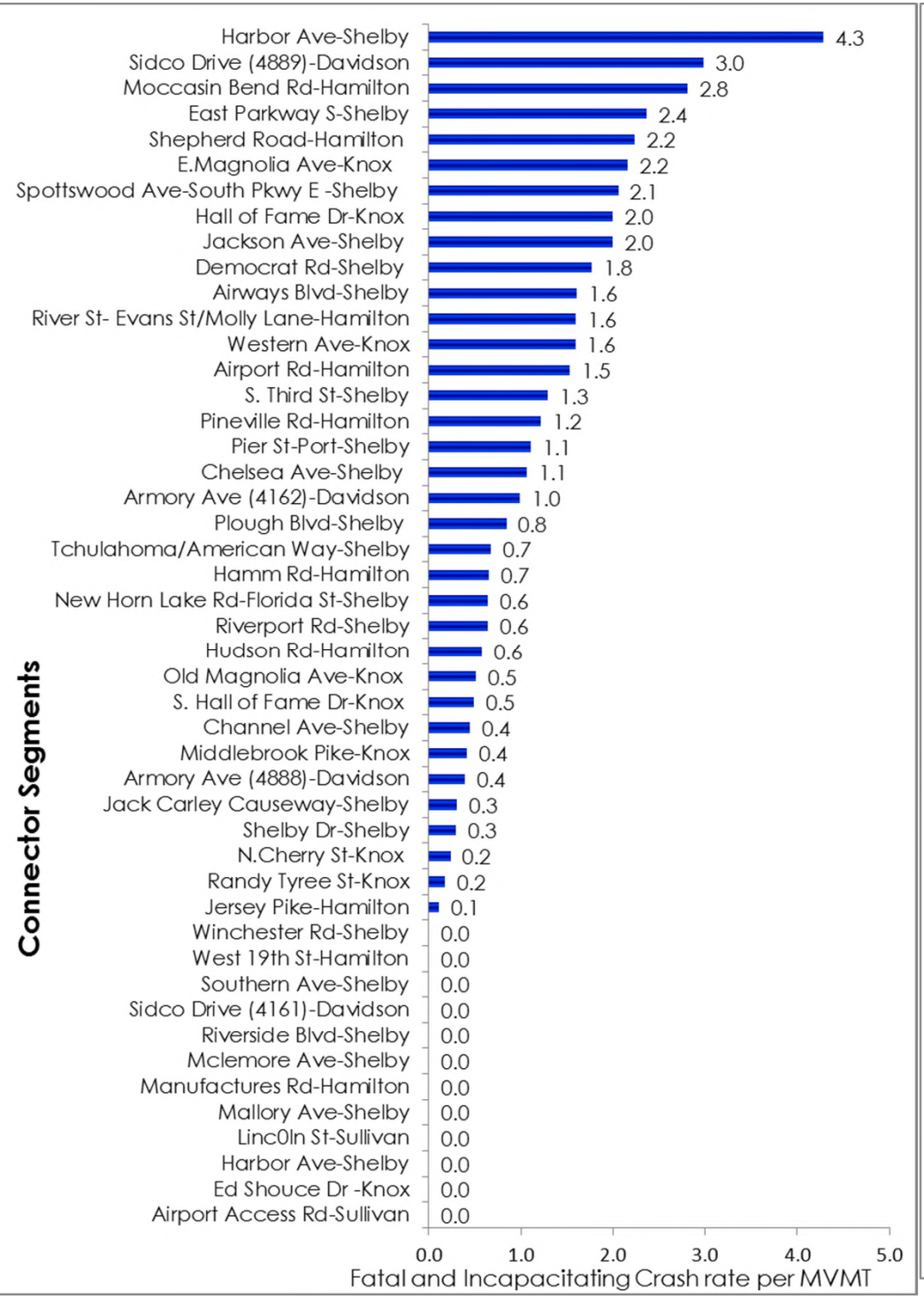
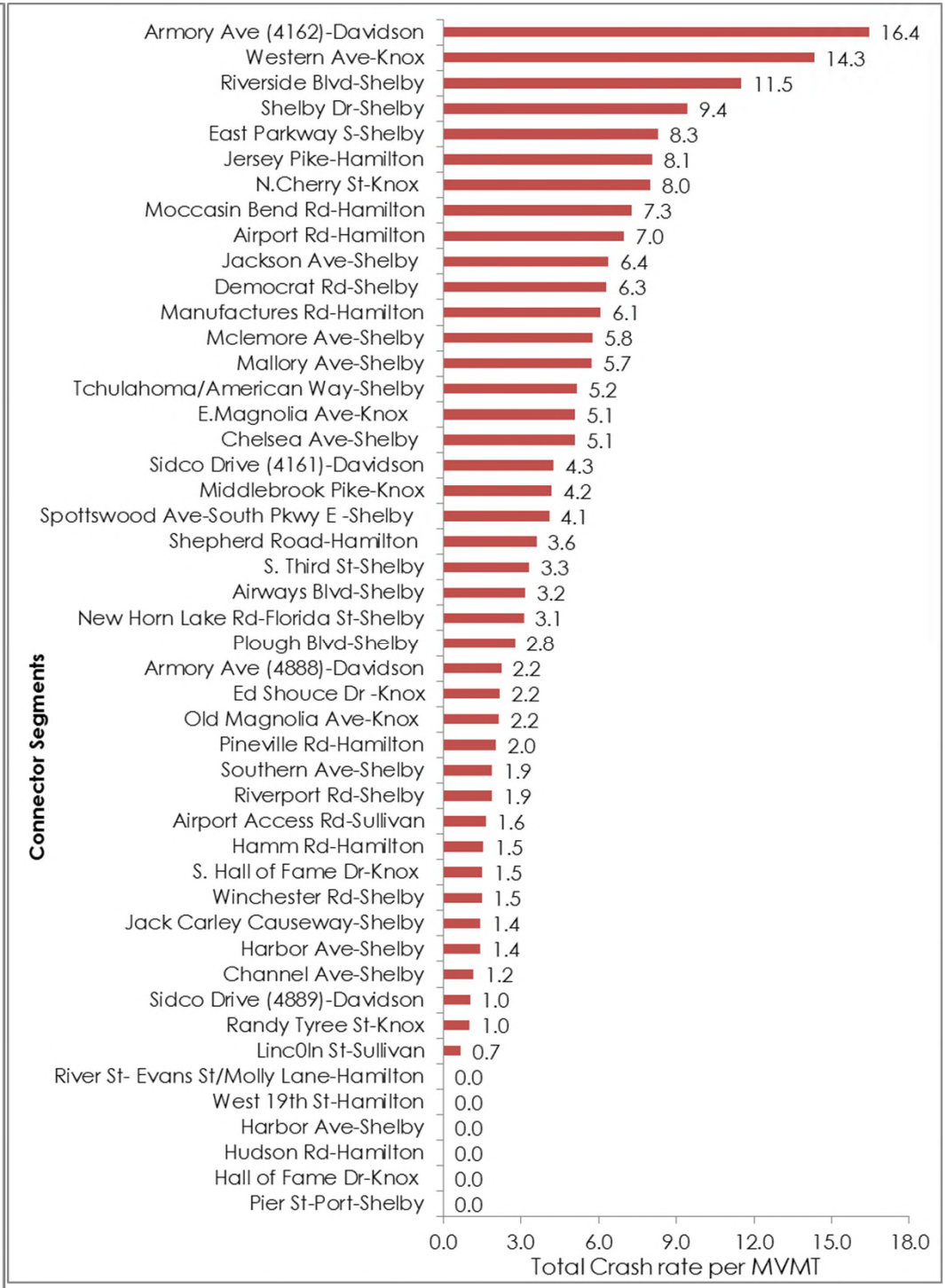
N. Cherry St-Intercity bus terminal-Knox	0.49	13984	0	3	12	45	60
Jersey Pike-Pipeline-Hamilton	0.59	11102	0	0	17	41	58

Segments Ranked by Crash Rates

$$\text{Crash Rate} = \frac{\text{Five Years Number of Crashes} * 1{,}000{,}000}{365 * \text{AADT} * \text{Connector Length (miles)} * \text{Five Years}}$$

Connector Segment	Fatal & Injury crash rate	Total crash rate	Total Crash rate (No Ramp Related)	Total Crash rate (Ramp Related Only)
Armory Ave (4162)-Rail-Davidson	2.99	16.44	10.46	5.98
Western Ave-Pipeline-Knox	1.59	14.32	8.32	6
Riverside Blvd-Port-Shelby	0	11.52	11.52	0
Shelby Dr-Rail-Shelby	2	9.43	9.43	0
East Parkway S -Airways Blvd-Rail-Shelby	2.81	8.3	8.3	0
Jersey Pike-Pipeline-Hamilton	2.37	8.09	5.86	2.23
N. Cherry St-Intercity bus terminal-Knox	2	8	6	2
Moccasin bend Rd-Port-Hamilton	1.21	7.28	7.28	0
Airport-Hamilton	1.6	6.99	6.99	0
Jackson Ave-Rail-Shelby	2.06	6.39	6.27	0.12
Democrat Rd-Airport-Shelby	1.61	6.29	5.96	0.33
Manufactures Rd-Port-Hamilton	0.67	6.07	4.83	1.24
Mclemore Ave-Port-Shelby	0.64	5.77	3.85	1.92
Mallory Ave-Rail-Shelby	2.16	5.75	5.51	0.24
Tchulahoma-Airport-Shelby	1.29	5.16	5.16	0
E. magnolia Ave-Intercity bus terminal-Knox	1.77	5.11	5.11	0
Chelsea Ave-Rail-Shelby	2.24	5.1	5.1	0
Sidco Dr (4161) -Rail-Davidson	1.11	4.26	4.26	0
Middlebrook Pike-Pipeline-Knox	0.99	4.19	4.19	0
Spottswood Ave-South Pkwy E - Rail-Shelby	1.53	4.09	4.09	0
Shepherd Rd-Airport-Hamilton	0.85	3.6	2.46	1.14
S. 3rd St-Rail-Shelby	1.07	3.33	3.14	0.19
Airways Blvd	0.84	3.14	3.14	0
New horn lake Rd-Florida St-Rail-Shelby	0	3.12	3.12	0
Plough Blvd-Airport-Shelby	0.64	2.77	2.26	0.51
Armory Ave (4888) -Rail-Davidson	0.45	2.24	1.94	0.3
Ed shouce Dr -Pipeline-Knox	0.3	2.18	2.18	0
Old Magnolia Ave-Intercity bus terminal-Knox	0	2.16	2.16	0
Pineville Rd-Port-Hamilton	0.51	2.04	2.04	0
Southern Ave-Rail-Shelby	0.24	1.89	1.89	0
Riverport Rd-Rail-Shelby	0.42	1.87	1.87	0
Airport Access Rd-Airport-Sullivan	0.58	1.64	1.46	0.18
Hamm Rd-Port-Hamilton	0	1.53	1.53	0
S. Hall of Fame Dr-Intercity Bus Terminal-Knox	0	1.52	1.52	0
Winchester Rd.	0.4	1.49	1.39	0.1
Jack carley Causeway-Port-Shelby	0.65	1.44	1.44	0
Harbor Ave-Port-Shelby	0.49	1.42	1.42	0
Channel Ave-Port-Shelby	0.31	1.18	1.18	0
Sidco Dr (4889) -Rail-Davidson	0.17	1.04	1.04	0
Randy Tyree St-Pipeline-Knox	0	1.02	1.02	0
Lincoln St-Rail-Sullivan	0.11	0.67	0.67	0
Hall of Fame Dr-Intercity bus terminal-Knox	0	0	0	0
Hudson Rd-Port-Hamilton	0	0	0	0
Pier St-port-Shelby	0	0	0	0
River St-Port-Hamilton	0	0	0	0
West 19th St-Port-Hamilton	0	0	0	0


Connector Segments
Harbor Ave-Shelby 4.3
Sidco Drive (4889)-Davidson 3.0
Moccasin Bend Rd-Hamilton 2.8
East Parkway S-Shelby 2.4
Shepherd Road-Hamilton 2.2
E.Magnolia Ave-Knox 2.2
Spottswood Ave-South Pkwy E -Shelby 2.1
Hall of Fame Dr-Knox 2.0
Jackson Ave-Shelby 2.0
Democrat Rd-Shelby 1.8
Airways Blvd-Shelby 1.6
River St- Evans St/Molly Lane-Hamilton 1.6
Western Ave-Knox 1.6
Airport Rd-Hamilton 1.5
S. Third St-Shelby 1.3
Pineville Rd-Hamilton 1.2
Pier St-Port-Shelby 1.1
Chelsea Ave-Shelby 1.1
Armory Ave (4162)-Davidson 1.0
Plough Blvd-Shelby 0.8
Tchulahoma/American Way-Shelby 0.7
Hamm Rd-Hamilton 0.7
New Horn Lake Rd-Florida St-Shelby 0.6
Riverport Rd-Shelby 0.6
Hudson Rd-Hamilton 0.6
Old Magnolia Ave-Knox 0.5
S. Hall of Fame Dr-Knox 0.5
Channel Ave-Shelby 0.4
Middlebrook Pike-Knox 0.4
Armory Ave (4888)-Davidson 0.4
Jack Carley Causeway-Shelby 0.3
Shelby Dr-Shelby 0.3
N.Cherry St-Knox 0.2
Randy Tyree St-Knox 0.2
Jersey Pike-Hamilton 0.1
Winchester Rd-Shelby 0.0
West 19th St-Hamilton 0.0
Southern Ave-Shelby 0.0
Sidco Drive (4161)-Davidson 0.0
Riverside Blvd-Shelby 0.0
Mclemore Ave-Shelby 0.0
Manufactures Rd-Hamilton 0.0
Mallory Ave-Shelby 0.0
Linc0ln St-Sullivan 0.0
Harbor Ave-Shelby 0.0
Ed Shouce Dr -Knox 0.0
Airport Access Rd-Sullivan 0.0
0.0 1.0 2.0 3.0 4.0 5.0
Fatal and Incapacitating Crash rate per MVMT


Connector Segments
Armory Ave (4162)-Davidson 16.4
Western Ave-Knox 14.3
Riverside Blvd-Shelby 11.5
Shelby Dr-Shelby 9.4
East Parkway S-Shelby 8.3
Jersey Pike-Hamilton 8.1
N.Cherry St-Knox 8.0
Moccasin Bend Rd-Hamilton 7.3
Airport Rd-Hamilton 7.0
Jackson Ave-Shelby 6.4
Democrat Rd-Shelby 6.3
Manufactures Rd-Hamilton 6.1
Mclemore Ave-Shelby 5.8
Mallory Ave-Shelby 5.7
Tchulahoma/American Way-Shelby 5.2
E.Magnolia Ave-Knox 5.1
Chelsea Ave-Shelby 5.1
Sidco Drive (4161)-Davidson 4.3
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Spottswood Ave-South Pkwy E -Shelby 4.1
Shepherd Road-Hamilton 3.6
S. Third St-Shelby 3.3
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Plough Blvd-Shelby 2.8
Armory Ave (4888)-Davidson 2.2
Ed Shouce Dr -Knox 2.2
Old Magnolia Ave-Knox 2.2
Pineville Rd-Hamilton 2.0
Southern Ave-Shelby 1.9
Riverport Rd-Shelby 1.9
Airport Access Rd-Sullivan 1.6
Hamm Rd-Hamilton 1.5
S. Hall of Fame Dr-Knox 1.5
Winchester Rd-Shelby 1.5
Jack Carley Causeway-Shelby 1.4
Harbor Ave-Shelby 1.4
Channel Ave-Shelby 1.2
Sidco Drive (4889)-Davidson 1.0
Randy Tyree St-Knox 1.0
Linc0ln St-Sullivan 0.7
River St- Evans St/Molly Lane-Hamilton 0.0
West 19th St-Hamilton 0.0
Harbor Ave-Shelby 0.0
Hudson Rd-Hamilton 0.0
Hall of Fame Dr-Knox 0.0
Pier St-Port-Shelby 0.0
0.0 3.0 6.0 9.0 12.0 15.0 18.0
Total Crash rate per MVMT

Connectors/Segments Ranked based on whether Actual Crash Rates exceed Critical Crash Rates

Ranking Connector Segment by Critical Crash rate

- The Critical Crash Rate criteria are detailed in the Highway Safety Manual (2010 HSM) Chapter 4 section 4.4.2.5.
- The critical rate method utilizes a statistical test to determine whether the accident rate at a particular connector segment is significantly higher than TDOT provided average rate for similar type of functional class segment

$$\textbf{CRITICAL CRASH RATE} = \text{TDOT Average Rate} + 1.96\sqrt{\frac{\text{TDOT Statewide Average Rate}}{(\text{MVMT})}} + \frac{0.5}{\text{MVMT}}$$

$$\text{Where MVMT} = \frac{365 * \text{AADT} * \text{L} * 3}{1000000}$$

Tennessee Department of Transportation

Statewide Average Crash Rates for Sections and Spots

Study: 2012 - 2014 HSIP LIST

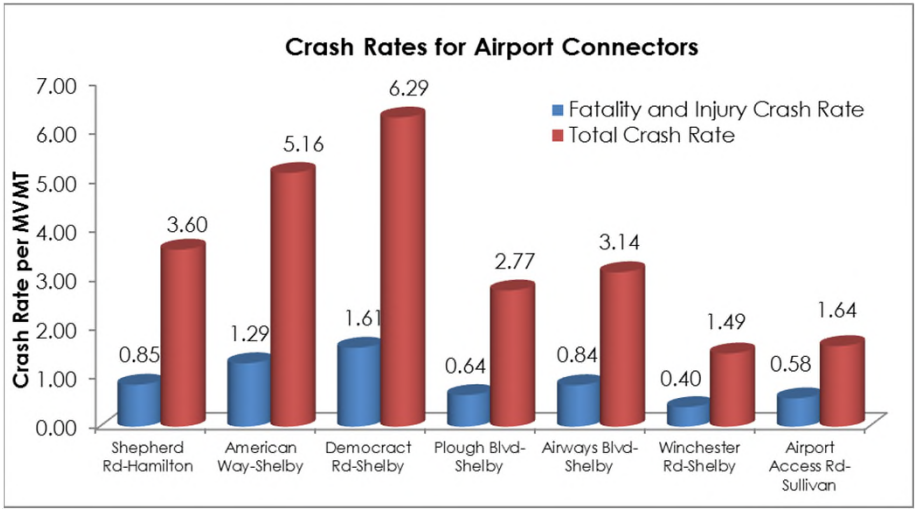
Begin Date: 1/1/2012 End Date: 12/31/2014

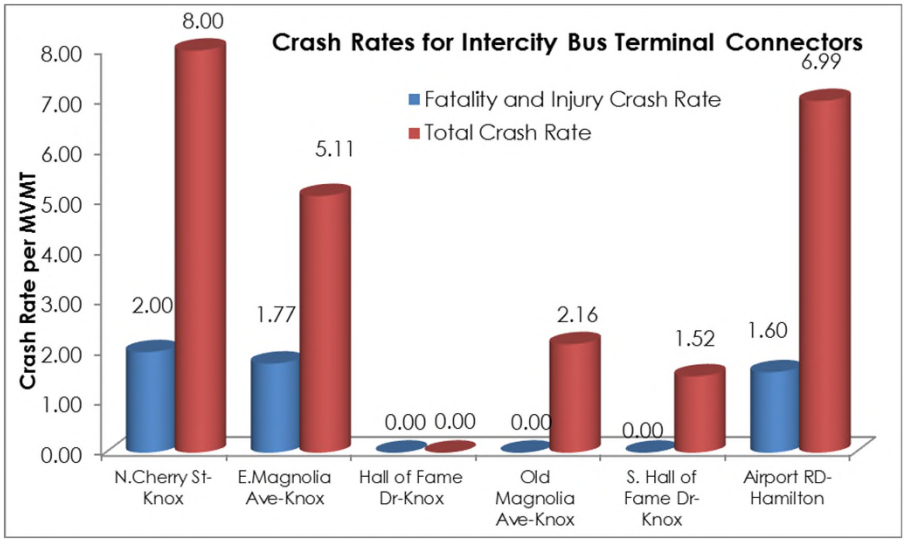
Route Type	Rural / Urban	Location Type	Highway Type	Fatal Rate	Incap. Rate	Other Inj. Rate	Pd. Rate	Total Rate	Severe Crash Rate	VMT
FUNCT.	Urban	Section	2 OR 3 LN	0.014	0.102	0.770	2.608	3.493	0.116	13,315
FUNCT.	Urban	Section	2 OR 3 LN W/TL	0.004	0.062	0.624	2.426	3.115	0.066	1,515
FUNCT.	Urban	Section	4 OR MORE UNDIV	0.013	0.075	0.873	3.049	4.010	0.087	2,648
FUNCT.	Urban	Section	4 OR MORE DIV	0.008	0.047	0.563	2.298	2.916	0.055	3,421
FUNCT.	Urban	Section	4 OR MORE W TL	0.013	0.066	0.676	2.452	3.206	0.078	4,441
FUNCT.	Urban	Section	FREEWAY	0.008	0.039	0.523	2.047	2.616	0.047	386

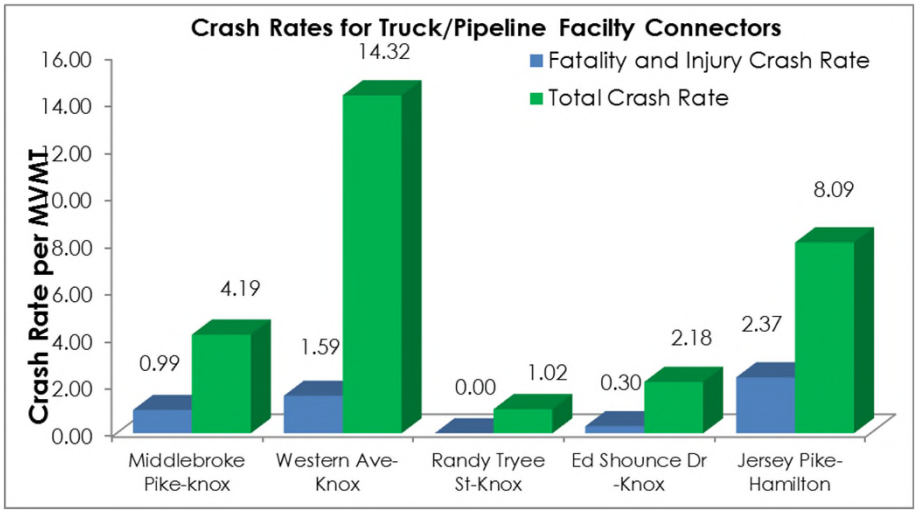
Connector Segments Exceeding Critical Total Crash rate

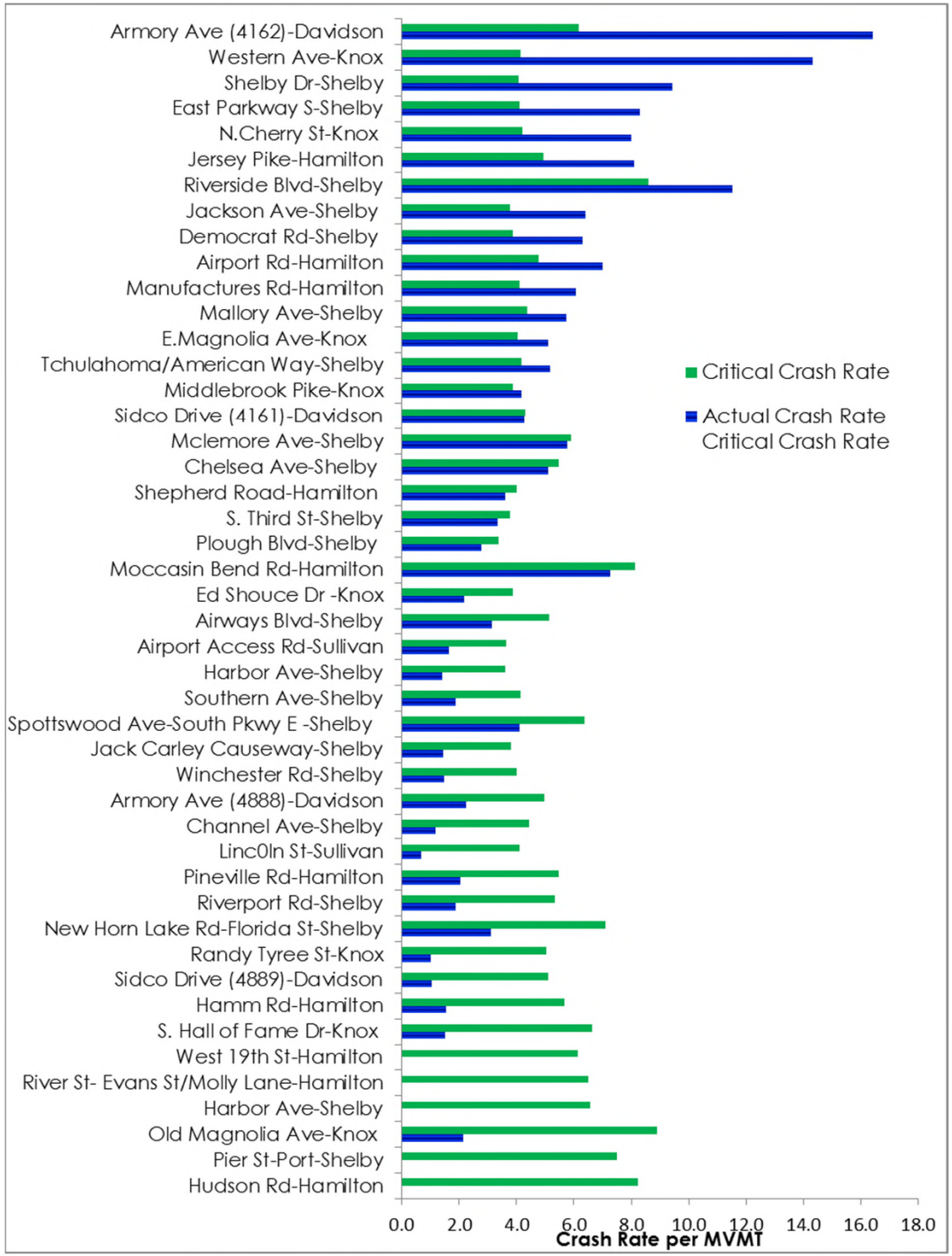
Connector Segment	Actual Total Crash Rate	Critical Total Crash Rate
Armory Ave (4162)-Davidson	16.44	6.18
Western Ave-Knox	14.32	4.15
Riverside Blvd-Shelby	11.52	8.61
Shelby Dr-Shelby	9.43	4.07
East Parkway S -Shelby	8.30	4.09
Jersey Pike-Hamilton	8.09	4.93
N.Cherry St-Knox	8.00	4.20
Airport Rd-Hamilton	6.99	4.76
Jackson Ave-Shelby	6.39	3.76
Democrat Rd-Shelby	6.29	3.86
Manufactures Rd-Hamilton	6.07	4.09
Mallory Ave-Shelby	5.75	4.37
Tchulahoma/American Way-Shelby	5.16	4.18
E.Magnolia Ave-Knox	5.11	4.03
Middlebrook Pike-Knox	4.19	3.88

Facility Type	Type	No.	Connector Description	Miles
Chattanooga Metropolitan Airport	Airport	1	Shepherd Road (Airport Connector) Between SR-153 And Airport Road	0.7
Colonial & Plantation Pipeline Co. - Knx	Truck/Pipeline Terminal	1	Middlebrook Pike (SR-169), Ed Shouse Drive, Western Ave From Terminal Entrance To I-75	1.3
Colonial Pipeline - Chattanooga	Truck/Pipeline Terminal	1	Jersey Pike From Enterprise Park Drive To SR-153	0.5
CSX Corporation - Kingsport	Truck/Rail Facility	1	Linc0ln Street From John B. Dennis Highway (SR-93) To Facility Entrance	0.8
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	1	Southern Avenue From Lamar Ave. (SR-4) To East Parkway (SR-277)	0.8
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	2	East Parkway (SR-277) From Lamar Ave. (SR-4) To Southern Avenue	0.8
Forrest Yards - Memphis Norfolk Southern	Truck/Rail Facility	3	Spottswood Avenue From Airways (SR-277) To Forrest Yard	0.3
Greyhound Bus Terminal - Chattanooga	Intercity Bus Terminal	1	West 4th Street And Chestnut Street From I-124 To West 5th Street	0.3
Greyhound Bus Terminal - Knoxville	Intercity Bus Terminal	1	Cherry Street And Magnolia Avenue (SR-1) From I-40 To Central Street	2.3
Greyhound Bus Terminal - Memphis	Intercity Bus Terminal	1	Union Avenue (SR-3) Between Danny Thomas Blvd (SR-1) And 4th Street	0.2
Greyhound Bus Transp Center - Nashville	Intercity Bus Terminal	1	Demonbreun Between I-40 And 8th Avenue South (SR-1)	0.4
J.I.T. Terminals - Chattanooga	Port Terminal	1	Manufactures Road From SR-29 To Terminal Entrance	0.2
Johnston Yards - Memphis Illinois Centra	Truck/Rail Facility	1	Mallory Avenue And Riverport Road Between I-55 And Rail Yard	1.5
Leewood Yards - Memphis CSX	Truck/Rail Facility	1	Jackson Avenue (SR-14) And Chelsea Avenue Between I-40 And Warford Street	2.5
Memphis International Airport	Airport	1	Tchulahoma And Democrat Rd Between Lamar Ave (SR-4) And Airways Blvd	2.4
Memphis International Airport	Airport	2	Plough Blvd Between I-240 And The Airport Entrance	2
Mid-South Terminals	Port Terminal	1	Hudson Rd. To Pineville Rd. To Moccasin Bend Rd. To Hamm Rd. To S. R. 29	2.8
President's Island - Memphis	Port Terminal	1	Mclemore Av, Riverside Blvd, Jack Carley Causeway, Harbor Av, Channel Av, Jetty St Btw I-55 & Port	5.3
Radnor Yards - Nashville CSX	Truck/Rail Facility	1	Armory Ave And Sidco Drive Between I-65 And Harding Place (SR-255)	2
Southern Foundry Supply - Chattanooga	Port Terminal	1	West 19th Street From Riverfront Parkway (SR-58) To The Port Entrance	0.3
Tennessee Yards - Memphis Burlington Nor	Truck/Rail Facility	1	Shelby Drive Between Lamar Avenue (SR-4) And The Tennessee Yard	0.6
Tri-Cities Regional Airport - Kingsport	Airport	1	Airport Access Road (SR-357) From I-81 To Airport Entrance	3.1
Vulcan Materials Company -Chattanooga	Port Terminal	1	River Street From Evans Street To Riverfront Parkway (SR-58)	0.1
Total				31.2


Crash Rates for Airport Connectors
Fatality and Injury Crash Rate
Total Crash Rate
Crash Rate per MVMT
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.85
3.60
1.29
5.16
1.61
6.29
0.64
2.77
0.84
3.14
0.40
1.49
0.58
1.64
Shepherd Rd-Hamilton
American Way-Shelby
Democract Rd-Shelby
Plough Blvd-Shelby
Airways Blvd-Shelby
Winchester Rd-Shelby
Airport Access Rd-Sullivan


Crash Rates for Intercity Bus Terminal Connectors
Fatality and Injury Crash Rate
Total Crash Rate
Crash Rate per MVMT
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2.00
8.00
1.77
5.11
0.00
0.00
0.00
2.16
0.00
1.52
1.60
6.99
N.Cherry St-Knox
E.Magnolia Ave-Knox
Hall of Fame Dr-Knox
Old Magnolia Ave-Knox
S. Hall of Fame Dr-Knox
Airport RD-Hamilton


Crash Rates for Truck/Pipeline Facilty Connectors
Fatality and Injury Crash Rate
Total Crash Rate
Crash Rate per MVMT
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.99
4.19
1.59
14.32
0.00
1.02
0.30
2.18
2.37
8.09
Middlebroke Pike-knox
Western Ave-Knox
Randy Tryee St-Knox
Ed Shounce Dr -Knox
Jersey Pike-Hamilton


Armory Ave (4162)-Davidson
Western Ave-Knox
Shelby Dr-Shelby
East Parkway S-Shelby
N.Cherry St-Knox
Jersey Pike-Hamilton
Riverside Blvd-Shelby
Jackson Ave-Shelby
Democrat Rd-Shelby
Airport Rd-Hamilton
Manufactures Rd-Hamilton
Mallory Ave-Shelby
E.Magnolia Ave-Knox
Tchulahoma/American Way-Shelby
Middlebrook Pike-Knox
Sidco Drive (4161)-Davidson
Mclemore Ave-Shelby
Chelsea Ave-Shelby
Shepherd Road-Hamilton
S. Third St-Shelby
Plough Blvd-Shelby
Moccasin Bend Rd-Hamilton
Ed Shouce Dr -Knox
Airways Blvd-Shelby
Airport Access Rd-Sullivan
Harbor Ave-Shelby
Southern Ave-Shelby
Spottswood Ave-South Pkwy E -Shelby
Jack Carley Causeway-Shelby
Winchester Rd-Shelby
Armory Ave (4888)-Davidson
Channel Ave-Shelby
Linc0ln St-Sullivan
Pineville Rd-Hamilton
Riverport Rd-Shelby
New Horn Lake Rd-Florida St-Shelby
Randy Tyree St-Knox
Sidco Drive (4889)-Davidson
Hamm Rd-Hamilton
S. Hall of Fame Dr-Knox
West 19th St-Hamilton
River St- Evans St/Molly Lane-Hamilton
Harbor Ave-Shelby
Old Magnolia Ave-Knox
Pier St-Port-Shelby
Hudson Rd-Hamilton
Critical Crash Rate
Actual Crash Rate
Critical Crash Rate
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
Crash Rate per MVMT

EVALUATING ROADWAY FEATURES AND TRAFFIC CHARACTERISTICS IMPACTING CRASHES ALONG FICs

Modeling Crashes along the FICs

- The impact of roadway cross sectional features and traffic characteristics to the crash frequency along the FICs connectors were evaluated through statistical modeling.
- The primary objective was to evaluate the impact of different variables to crash frequency.
- The frequency here is defined as the number of crashes per segment for the three years of the study data.
- Only segments longer than 0.1 miles were used in the model.
- The research evaluated the impact of access density, signal density, percentage of trucks, presence or absence of TWLTL, presence or absence of median and other variables to the safety along the FICs.
- In addition to these geometric features, the study evaluated the impact of number of lanes, shoulder width, median width and traffic characteristics (traffic volume and posted speed limits) to the safety of the connectors.
- The Crash Frequency along the FICs connectors was analyzed and fitted using two count data models, Poisson and Negative Binomial (NB).

NB MODELING APPROACH

- Negative Binomial (NB) model is expressed as:

$$p(y)=\frac{\Gamma\left(y+\alpha^{-1}\right)}{\Gamma\left(\alpha^{-1}\right)\Gamma(y+1)}\left(\frac{1}{1+\alpha\mu}\right)^{1/\alpha}\left(\frac{\alpha\mu}{1+\alpha\mu}\right)^{y}$$

Where the mean $\mu = E(y) = \exp(X\beta)$

The variance $Var(y) = \mu + \alpha\mu^2$

Overdispersion Factor

$$E(y) = \mu = e^{(\beta_1 x_1+\beta_2 x_2+\beta_3 x_3+\cdots+\beta_n x_n)}$$

General Form of the Crash Model

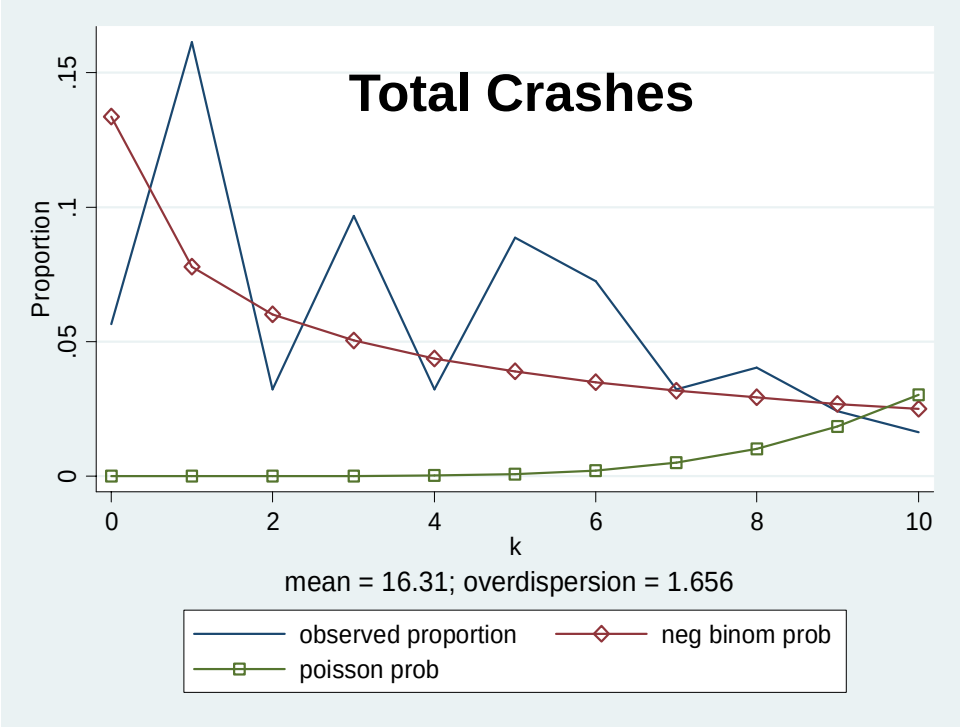
$$Yi = e^{\sum X_i \beta}$$

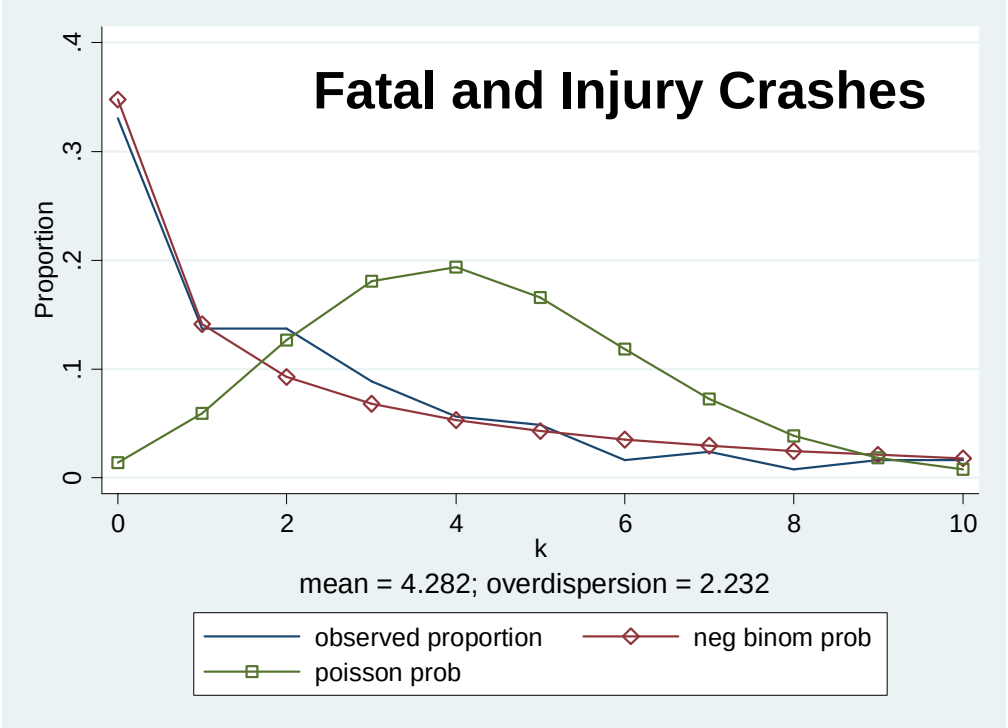
$$Y_i = e^{\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 \ldots + \beta_n x_n}$$

- ✓ $\mathbf{Y_i}$= a random variable representing number of crashes per year per FICs segment
- ✓ $\mathbf{X_i}$= variable which is related to the occurrence of crash
- ✓ β=the coefficient of the corresponding variables

Poisson vs. Negative Binomial

	Mean	Variance (Stdev)
Total Crash Frequency	16.31	910 (30.17)
Fatal and Injury Crashes Frequency	4.282	75 (8.66)





- Therefore the NB was used for Crash frequency Modeling.
- Negative binomial (NB) model estimation was performed based on the Maximum Likelihood Estimation (MLE) criterion using STATA software.

FREQUENCY MODELING VARIABLES ALONG THE FICs

- Traffic Volume—AADT
- Truck Volume
- Number of Lanes
- Median Width
- Inside Shoulder Width
- Signalized Intersections Density
- Access Density
- Percent Directional traffic volume Split
- Percent of Peak Hour traffic volumes
- Percentage of Trucks and Passenger Cars
- Posted Speed Limit
- Terrain
- Median Type
- Presence of Absence of Ramp
- Presence or Absence of Railroad Crossing

SUMMARY OF SEGMENT VARIABLES

Variable	Mean	Min	Max
AADT	15716	1742	49655
Trucks volume	1536	86	4312
Number of Lanes	4	2	7
Median width (ft)	12.7	0	35
Outside shoulder Width (ft)	3.58	0	16
Signalized Intersection density	0.50	0	3
Access density	7.13	0	67
% Passenger Cars	89	61	99
%Peak hour volume	11	9	14
Directional split	64	51	75

SUMMARY OF SEGMENT VARIABLES

Variable	Description	Code for modelling	Count	%
Posted speed-miles per hour (mph)	<40	0	68	55
	40-55	1	56	45
Terrain	Flat	0	58	31
	Rolling	1	86	69
Median	Presence	1	54	44
	Absence	0	70	56
Outside shoulder	Presence	1	92	74
	Absence	0	32	26
Two way Left Turn Lane (TWLTL)	Presence	1	23	19
	Absence	0	101	81
Ramp	Presence	1	97	78
	Absence	0	27	22
Railroad crossing	Presence	1	100	87
	Absence	0	16	13

STATA SOFTWARE

nbreg allcrash aadt lanes signallizedintersection accessdensity ramp twltl outshoulder gutter if length>0.1, dispersion(mean) offset(length)

```
Negative binomial regression                    Number of obs   =         73
                                                LR chi2(8)      =      60.24
Dispersion     = mean                           Prob > chi2     =     0.0000
Log likelihood = -265.02566                     Pseudo R2       =     0.1020
```

allcrash	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
aadt	.0000765	.0000172	4.45	0.000	.0000428	.0001102
lanes	-.0894368	.1340945	-0.67	0.505	-.3522571	.1733836
signallizedintersection	.2914481	.1271629	2.29	0.022	.0422133	.5406829
accessdensity	.0444363	.0166217	2.67	0.008	.0118583	.0770143
ramp	.334966	.2576693	1.30	0.194	-.1700565	.8399885
twltl	-.9810575	.2520983	-3.89	0.000	-1.475161	-.486954
outshoulder	-.4666318	.2951406	-1.58	0.114	-1.045097	.111833
gutter	.1017663	.2768933	0.37	0.713	-.4409346	.6444672
_cons	1.665625	.4337781	3.84	0.000	.8154356	2.515815
length	1	(offset)				
/lnalpha	-.4336502	.1890003			-.8040839	-.0632165
alpha	.648139	.1224984			.4474977	.9387403

```
Likelihood-ratio test of alpha=0:  chibar2(01) =  512.20 Prob>=chibar2 = 0.000
```

NEGATIVE BINOMIAL FREQUENCY MODEL RESULTS

Variables	Coefficient	Z-Statistics	P-value
AADT along Connectors*	7.7E-05	4.450	0.000
Signal Density along Connectors*	0.291	2.290	0.022
Access Density along Connectors*	0.044	2.670	0.008
Presence Ramp along Connectors	0.335	1.300	0.194
Presence of Curb and Gutter along Connectors	0.102	0.370	0.713
Presence of Outside Shoulder along Connectors	-0.467	-1.580	0.114
Presence of TWLTL*	-0.981	-3.890	0.000
Number of lanes	-0.089	-0.670	0.505
Constant	1.666	3.840	0.000
Length	Offset		

- **POSITIVE COEFFICIENT**—As that independent variable increases, it causes the response variable (in this case Crashes) to increase. The likelihood increases as the measure of that particular variable increases.
- **NEGATIVE COEFFICIENT**—As that independent variable increases, it causes the response variable (in this case Crashes) to decrease.

FICs OPERATIONS AND CAPACITY ANALYSIS

Operations Analysis

- Operations Analysis tries to identify deficiencies and issues along selected FICs based on:
  - Delay at intersections
  - Level of Service (LOS) at Intersections
  - Queue storage lengths being exceeded
  - Turning radii at intersections
  - Access and connectivity
  - Bottlenecks
  - Travel time reliability

Operations (Capacity) Analysis

- The TMC were collected in July 2017 for twelve hours from 6:00 AM to 6:00 PM
- Turning Movement Counts (TMC) collected on 19 selected intersections for.
  - 3 Intersections in Knox County
  - 9 Intersections in Shelby County
  - 1 Intersection in Davidson County
  - 2 Intersections in Sullivan County
  - 4 intersections in Hamilton County
- Signal Timing and Phasing data requested and provided by respective jurisdictions.
- Operational analysis was conducted at these 19 selected intersections.

Data-TMC

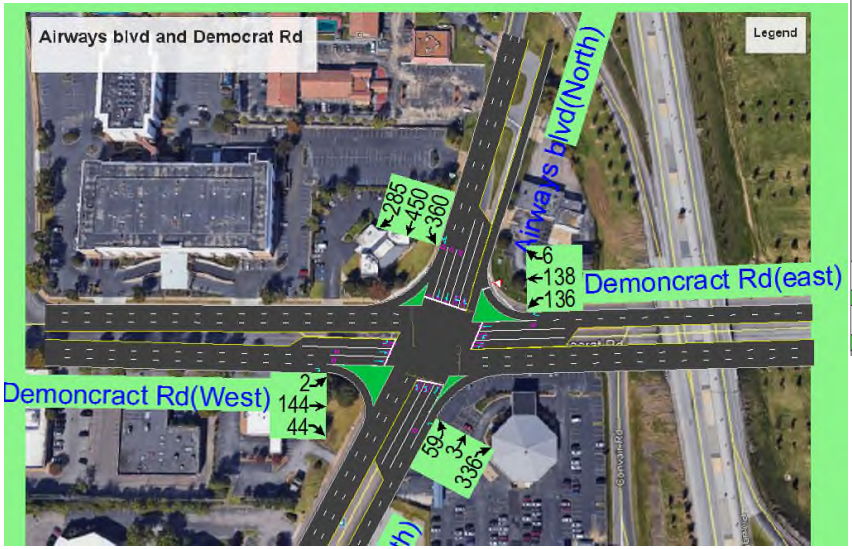
S/N	Intersection	County	TMC	
			AM	PM
1	Airways Blvd and Democrat Rd	Shelby	1964	2402
2	Cooper St. and Southern Ave	Shelby	794	1156
3	Lamar Ave and Airways Blvd	Shelby	2922	3934
4	S Pkwy E,Spottwood Ave and E-Pkwy S (SR-277)	Shelby	1856	2489
5	River port Rd and W Mallory Ave	Shelby	1263	1268
6	Chelsea Ave and Watford St	Shelby	671	728
7	Democract Rd, Tchulahoma Rd and American way	Shelby	2284	2514
8	SR-4 (Lamar Ave) and American Way/Tchulahoma	Shelby	3985	4693
9	SR-175 E Shelby Dr and SR-4 (Lamar Ave)	Shelby	3620	3965
10	Manufactures Rd and SR-29 N/Bound on Ramp	Hamilton	1181	1334
11	Airport Connector Rd and SR-153 S/Bound off Ramp	Hamilton	1000	1500
12	Airport Rd, SR-2 and US Hwy 64	Hamilton	1999	2188
13	jersey Pike and SR-317 Bonny Oaks Dr	Hamilton	2238	2747
14	SR-169 Middlebrook Pike and Ed shouse Dr	Knoxville	2566	3014
15	N Cherry St and E Magnolia Ave	Knoxville	1559	2366
16	Hall of Fame Dr and SR-1 E Magnolia Ave	Knoxville	1253	1622
17	12th Ave and Lincoln St	Sullivan	1204	1560

Percentage of Trucks volume to/from the Freight facility

Intersection	County	Type of facility	Percentage of Intersection Trucks volume to/from the Freight facility
Middlebrook Pike and Ed shouse Dr	Knoxville	Truck/Pipeline	92%
River port Rd and W Mallory Ave	Shelby	Truck/Rail facility	90%
Flagship Dr and Airport Pkwy	Sullivan	Airport	78%
Airways Blvd and Democrat Rd	Shelby	Airport	72%
Democract Rd and Tchulahoma Rd	Shelby	Airport	70%
Cooper St. and Southern Ave	Shelby	Truck/Rail facility	68%
12th Ave and Lincoln St	Sullivan	Truck/Rail facility	68%
N Cherry St and E Magnolia Ave	Knoxville	Intercity bus terminal	65%
Lamar Ave and Airways Blvd	Shelby	Truck/Rail facility	59%
Chelsea Ave and Watford St	Shelby	Truck/Rail facility	45%
Hall of Fame Dr and E Magnolia Ave	Knoxville	Intercity bus terminal	42%
Spottwood Ave and E-Pkwy S	Shelby	Truck/Rail facility	30%
E Shelby Dr and Lamar Ave	Shelby	Truck/Rail facility	29%
Lamar Ave and American Way	Shelby	Airport	24%

Operational Analysis of Intersections

- Synchro was used for the intersection capacity analysis
- **Analysis followed procedures in H**ighway Capacity Manual (HCM)



Synchro 7 - C:\Users\...apacity\1shelby\AM\Airways blvd and Dem

File Edit Transfer Options Optimize Help

2 Demoncract Rd(West) & Airways blvd(North)

NODE SETTINGS	
Node #	2
Zone:	
X East (ft):	765
Y North (ft):	-595
Z Elevation (ft):	0
Description	
Control Type	Actd-Coord
Cycle Length (s):	120.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	120.0
Natural Cycle(s):	65.0
Max v/c Ratio:	0.72
Intersection Delay (s):	27.6
Intersection LOS:	C
ICU:	0.57
ICU LOS:	B
Offset (s) :	25.0
Referenced to:	Begin of Green
Reference Phase:	2+6 - NBT SBT
Master Intersection:	☐
Yield Point:	Single

TIMING SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													–	–
Traffic Volume (vph)	2	144	44	136	138	6	59	3	336	360	450	285	–	–
Turn Type	Perm	–	Perm	Prot	–	Perm	Prot	–	Perm	Prot	–	–	–	–
Protected Phases		4		3	8		5	2		1	6	–		
Permitted Phases	4		4			8			2			–	–	–
Detector Phases	4	4	4	3	8	8	5	2	2	1	6	–	–	–
Switch Phase	0	0	0	0	0	0	0	0	0	0	0	–	–	–
Leading Detector (ft)	20	100	20	20	100	20	20	100	20	20	100	–	–	–
Trailing Detector (ft)	0	0	0	0	0	0	0	0	0	0	0	–	–	–
Minimum Initial (s)	10.0	10.0	10.0	4.0	10.0	10.0	4.0	10.0	10.0	7.0	4.0	–	–	–
Minimum Split (s)	22.0	22.0	22.0	9.0	22.0	22.0	8.0	22.0	22.0	12.0	20.0	–	–	–
Total Split (s)	26.0	26.0	26.0	22.0	48.0	48.0	18.0	47.0	47.0	25.0	54.0	–	–	–
Yellow Time (s)	4.0	4.0	4.0	3.0	4.0	4.0	3.5	4.0	4.0	3.0	3.5	–	–	–
All-Red Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	0.5	2.0	2.0	2.0	0.5	–	–	–
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–
Lagging Phase?	☑	☑	☑	☐	–	–	☐	☑	☑	☐	☑	–	–	–
Allow Lead/Lag Optimize?	☑	☑	☑	☑	–	–	☑	☑	☑	☑	☑	–	–	–
Recall Mode	None	None	None	None	None	None	None	C Max	C Max	None	C Max			
Actuated Effct. Green (s)	11.1	11.1	11.1	10.4	26.6	26.6	7.6	57.9	57.9	18.5	73.8	–	–	–
Actuated g/C Ratio	0.09	0.09	0.09	0.09	0.22	0.22	0.06	0.48	0.48	0.15	0.62	–	–	–
Volume to Capacity Ratio	0.02	0.47	0.25	0.49	0.36	0.02	0.29	0.00	0.38	0.72	0.26	–	–	–
Control Delay (s)	48.5	56.2	17.1	57.3	41.3	19.0	56.5	19.7	3.5	56.2	9.3	–	–	–
Queue Delay (s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–
Total Delay (s)	48.5	56.2	17.1	57.3	41.3	19.0	56.5	19.7	3.5	56.2	9.3	–	–	–
Level of Service	D	E	B	E	D	B	E	B	A	E	A	–	–	–
Approach Delay (s)	–	47.0	–	–	48.6	–	–	11.4	–	–	24.7	–	–	–
Approach LOS	–	D	–	–	D	–	–	B	–	–	C	–	–	–
Queue Length 50th (ft)	1	62	0	57	100	0	24	1	0	150	77	–	–	–
Queue Length 95th (ft)	10	95	37	89	153	12	47	8	58	195	119	–	–	–

ø1 25 s ø2 47 s

ø5 18 s ø6 54 s

Traffic Operations at Critical Intersections

- Operational analysis was performed with respect to approaches and critical movements at intersections to and from the freight facilities.
- For AM peak hours, intersection delays were found to vary from 10 seconds to 47 seconds, critical movement delays varied from 13 seconds to 69 seconds while critical approach delays varied from 14 to 66 seconds.
- Jersey Pike/SR-153 Bonny Oaks Dr, an intersection along pipeline connector in Hamilton County recorded the highest delay (47 seconds)
- Lincoln Street, an intersection along truck-rail connector segment in Sullivan County had the lowest delay (10 seconds).
- It was observed that intersection delays varied randomly for different type of connectors without specific pattern related to the type of intermodal connector.

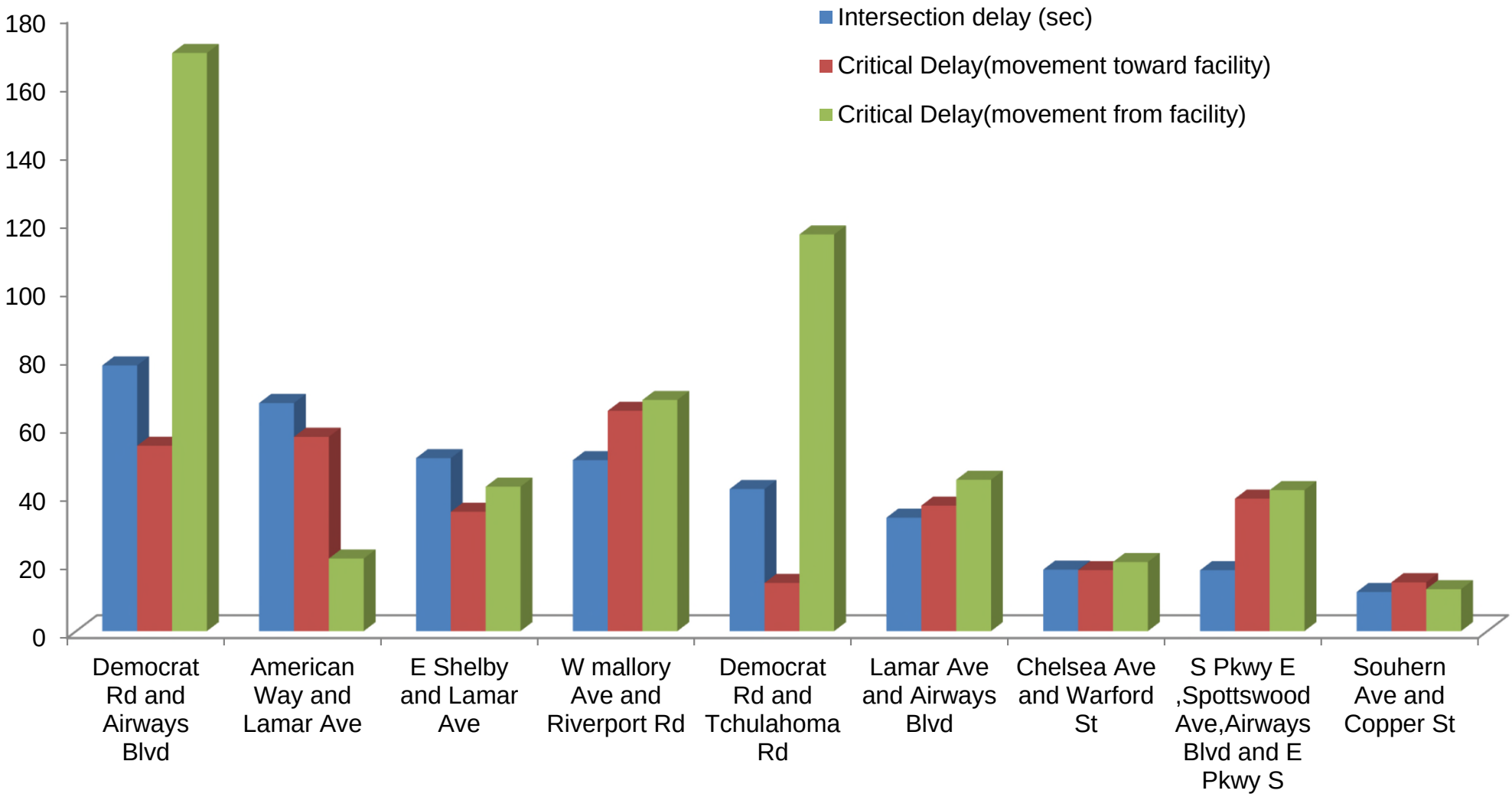
Results-Delay

Signalized Intersection	AM Intersection delay (sec)	PM Intersection delay(sec)
SR-4 Lamar Ave and Tchulahoma Rd/American Way	28.2	42
Jersey Pike and SR-153 Bonny Oaks Dr	47.4	48
SR-175 E Shelby Dr and SR-4 Lamar Ave	44.8	50.3
Airport Rd and SR-02	15.3	19.5
Airport connector Rd and SR-153 S off/on ramp	10.5	14.8
Democrat Rd and Airways Blvd	30.4	77.6
Democract Rd and Tchulahoma Rd/American Way	28.6	41.3
Manufactures Rd and SR-29 N bound off/On Ramp	28.3	41.3
W Mallory Ave and Riverport Rd	23.9	49.7
SR-4 Lamar Ave and Airways Blvd	20.8	33
Chelsea Ave and Watford St	17.9	17.4
SR-169 Middlebrook Pike and Ed shouse Dr	17.1	22
Hall of Fame Dr and SR-1 E Magnolia Ave	10	9.4
Southern Ave and Cooper St	11.9	11.4
East Pkwy S/Airways Blvd and Spottswood Ave/S Pkwy E	10.2	17.7
N Cherry St and E Magnolia Ave	11.5	11.4
12th St and Lincoln St	9.6	7.1

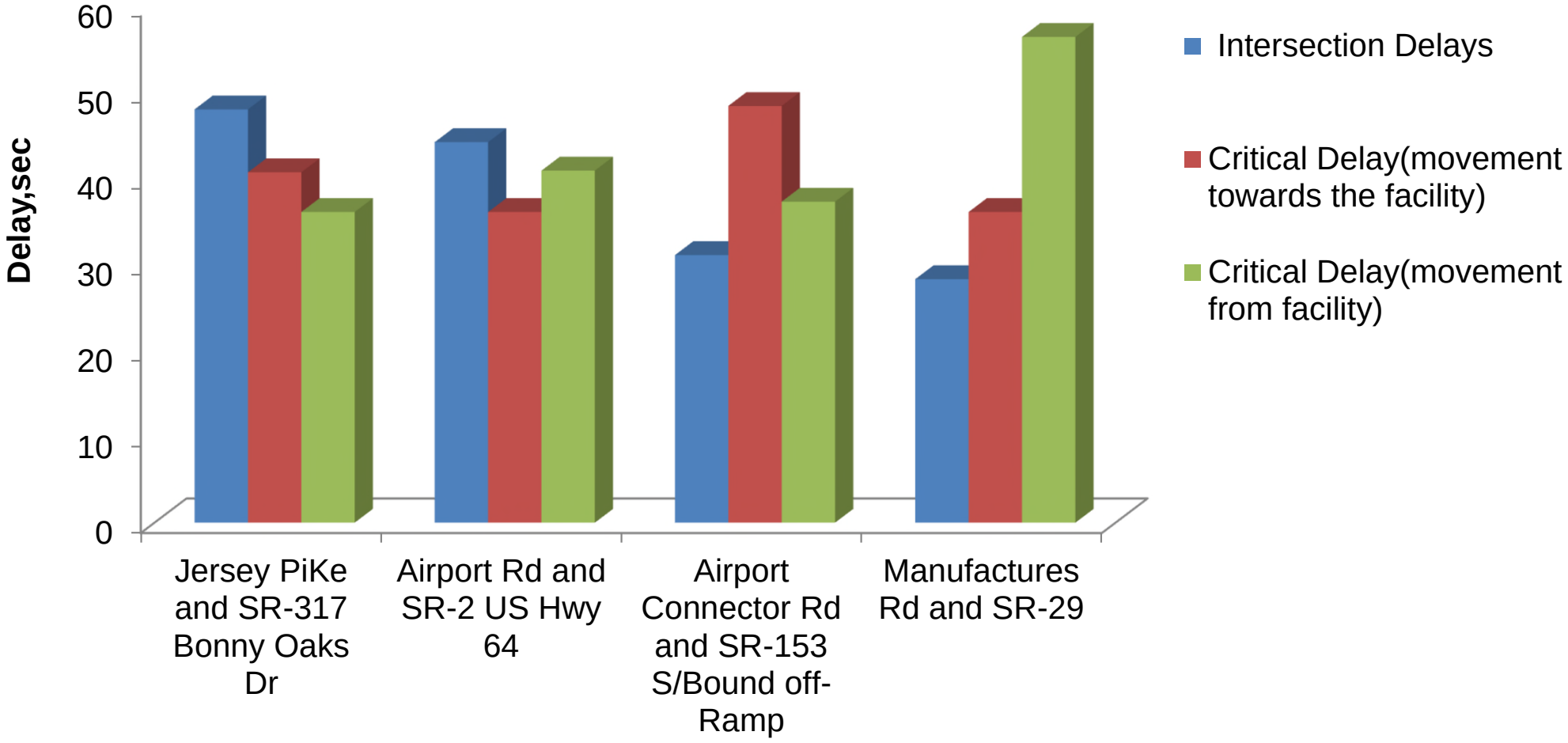
Results-Queue Length

Intersection	AM Critical queue length(ft.)	PM Critical queue length(ft.)
SR-4 Lamar Ave and Tchulahoma Rd/American Way	649	713
Jersey Pike and SR-153 Bonny Oaks Dr	416	589
SR-175 E Shelby Dr and SR-4 Lamar Ave	601	686
Airport Rd , SR-02 and US Hwy 64	283	309
Airport connector Rd and SR-153 S off/on ramp	116	231
Democrat Rd and Airways Blvd	195	459
Democract Rd and Tchulahoma Rd/American Way	388	264
Manufactures Rd and SR-29 N bound off/On Ramp	337	325
SR-4 Lamar Ave and Airways Blvd	197	289
Chelsea Ave and Warford St	68	55
SR-169 Middlebrook Pike and Ed shouse Dr	285	302
Hall of Fame Dr and SR-1 E Magnolia Ave	54	67
N Cherry St and E Magnolia Ave	67	120
Southern Ave and Cooper St	50	58
East Pkwy S/Airways Blvd and Spottswood Ave/S Pkwy E	184	386
N Cherry St and E Magnolia Ave	67	120
12th St and Lincoln St	132	75

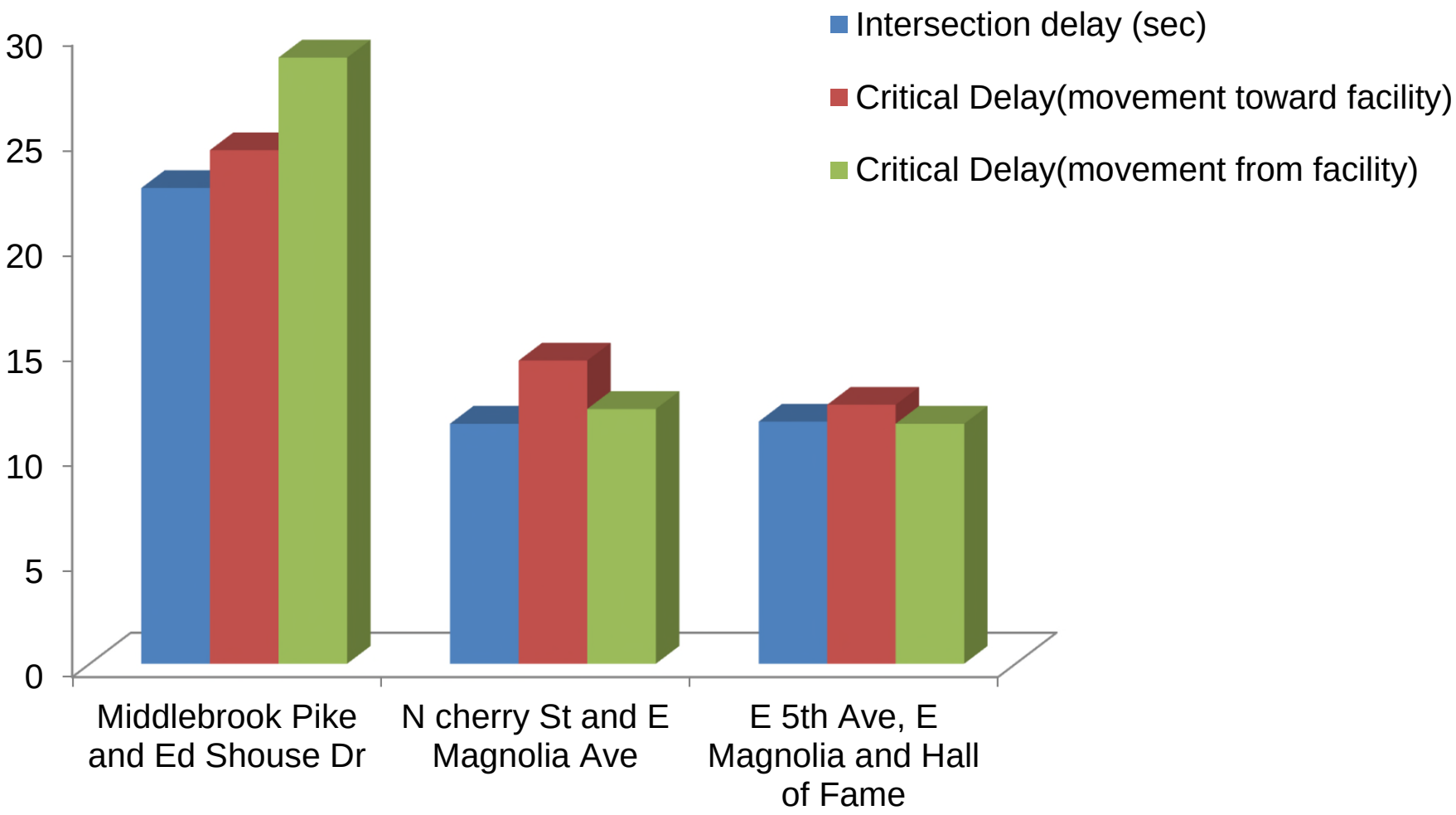
FICs Intersections in Shelby



FICs Intersections in Hamilton



FICs Intersections in Knox



TRUCK DRIVER SURVEY ANALYSIS

- The survey was conducted to evaluate FICs in Tennessee from truck drivers' perspective
- Targeted 42 freight facilities, and feedback was obtained from 36 drivers.
- 18 multiple choice questions and four free-response questions, and the results obtained were analyzed in MS Excel

Please select the road segment(s) along the FICs in Tennessee that you frequently use:

Memphis:	Jack Carley Causeway	☐	Riverport Rd	☐	Spottswood Ave	☐
	Democrat Rd	☐	Chelsea Ave	☐	East Shelby Dr	☐
	Southern Ave	☐	West Mallory Ave	☐	New Horn Lake Rd	☐
	Plough Blvd	☐				
Chattanooga:	Jersey Pike	☐	Airport Rd	☐	Shepherd Rd	☐
	Manufacturers Rd	☐	Moccasin Bend Rd	☐	West 19th Street	☐
	River St	☐				
Knoxville:	East Magnolia Ave	☐	Middlebrook Pike	☐		
Kingsport:	Airport Access Rd	☐	Lincoln Street	☐		
Smyrna:	Sam Ridley Pkwy W	☐	Lee Victory Pkwy	☐		
Clarksville:	Hwy 76	☐	Guthrie Hwy	☐		
Portland:	Hwy 52 W	☐	Ronnie Mc Dowell Pkwy	☐		
Nashville:	Sidco Dr	☐				
Other:						

The following questions are in relation to the road segment(s) identified above:

1. Signage or striping concerns along the segment/corridor? **Yes** ☐ or **No** ☐
2. Roadway or shoulder width issues along the segment/corridor? **Yes** ☐ or **No** ☐
3. Adequate turning radii at some of the intersection(s)? **Yes** ☐ or **No** ☐
4. Train impediment issues along the segment/corridor? **Yes** ☐ or **No** ☐
5. Vertical clearance or weight restrictions? **Yes** ☐ or **No** ☐
6. Intersection turning movement issues? **Yes** ☐ or **No** ☐
7. Traffic accidents/safety concerns along the segment/corridor? **Yes** ☐ or **No** ☐
8. Recurring congestion along the segment/corridor? **Yes** ☐ or **No** ☐

9. Issues related to interacting with other vehicles, pedestrians, cyclists, and conflicting lan uses along the segment/corridor? **Yes** ☐ or **No** ☐

10. To move freight more efficiently how important are the following transportation factors?

	Critical	Important	Neutral	Unimportant
• Infrastructure condition	☐	☐	☐	☐
• On-time delivery	☐	☐	☐	☐
• Direct/indirect cost of congestion	☐	☐	☐	☐
• Bottlenecks	☐	☐	☐	☐
• Safety and security	☐	☐	☐	☐
• Signage	☐	☐	☐	☐

11. How would you rate the transportation infrastructure along the Freight Intermodal Connectors?

	Inadequate	Poorly Maintained	Average	Well Maintained
• Signage and road markings	☐	☐	☐	☐
• Road geometrics	☐	☐	☐	☐
• Pavement conditions	☐	☐	☐	☐
• Traffic signals and timing	☐	☐	☐	☐
• Roadway connectivity	☐	☐	☐	☐
• Roadway capacity	☐	☐	☐	☐
• Interstate/highway accessibility	☐	☐	☐	☐
• Street lighting	☐	☐	☐	☐
• Safety features	☐	☐	☐	☐

12. How often do you encounter the following barriers that affect freight transportation?

	Never	Rarely	Often	Always
• Bridge/tunnel restrictions for freight	☐	☐	☐	☐
• Access to freight facility (turning lane)	☐	☐	☐	☐
• Congestion due to freight trucks	☐	☐	☐	☐
• Congestion due to crashes on the road segment	☐	☐	☐	☐
• Traffic congestion during Off-peak hours	☐	☐	☐	☐
• Traffic congestion during peak period	☐	☐	☐	☐
• Truck queuing at the terminal gate	☐	☐	☐	☐

13. Pavement conditions of the road segment(s): **Good** ☐ **Fair**☐ **Poor**☐
- Good condition describes a road pavement that is smooth and does not possess any potholes, bumps, or rough spots.
- Fair condition describes a road pavement that has a few and minor potholes, bumps, or rough spots, and can generally be described as mostly smooth.
- Poor condition describes a road pavement characterized by major potholes, bumps, or rough spots.

14. Are any of these features available?

	Present	Absent
• Bike lanes along the connectors	☐	☐
• Sidewalks along the connectors	☐	☐
• Pedestrian crossing features	☐	☐

15. In your opinion what causes traffic congestion along this road segment(s)? Please respond with one of the following:
Too many vehicles ☐, **Pedestrians & Cyclists** ☐, **Road Geometry** ☐, **Access Points**☐.

16. Do you experience any negative environmental issues while traveling along the road segment(s) (air pollution, noise)? **Yes** ☐ or **No** ☐

17. Rate the peak hour traffic congestion along the road segment(s)
Light ☐ **Moderate** ☐ **Heavy** ☐

18. How often do you have to reroute to get to the freight facility?
Often ☐ **Rarely** ☐ **Never** ☐

19. What is the average travel time from the interstate to freight facility or vice versa?

20. What is the average traveling speed?

21. Any recommendations on improvements?

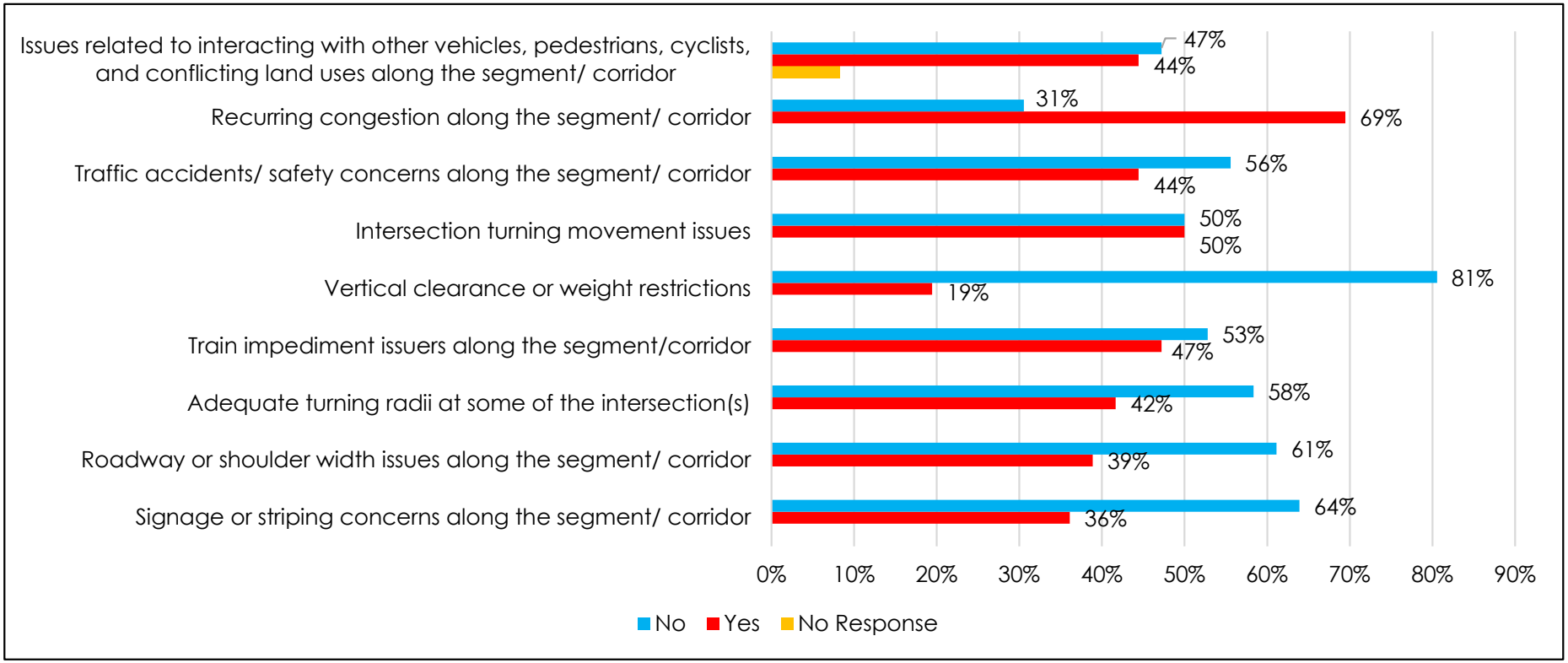
22. Do you have any other preferred/ alternative routes that help you get to the facility quicker? Or that help navigate from the freight facility to the interstate road?

Concerns

The following questions are in relation to the road segment(s) identified above:

1. Signage or striping concerns along the segment/corridor? **Yes** ☐ or **No** ☐
2. Roadway or shoulder width issues along the segment/corridor? **Yes** ☐ or **No** ☐
3. Adequate turning radii at some of the intersection(s)? **Yes** ☐ or **No** ☐
4. Train impediment issues along the segment/corridor? **Yes** ☐ or **No** ☐
5. Vertical clearance or weight restrictions? **Yes** ☐ or **No** ☐
6. Intersection turning movement issues? **Yes** ☐ or **No** ☐
7. Traffic accidents/safety concerns along the segment/corridor? **Yes** ☐ or **No** ☐
8. Recurring congestion along the segment/corridor? **Yes** ☐ or **No** ☐

- Biggest issue that the drivers are currently facing is recurring congestion
- Turning movement at intersections is also another issue of concern

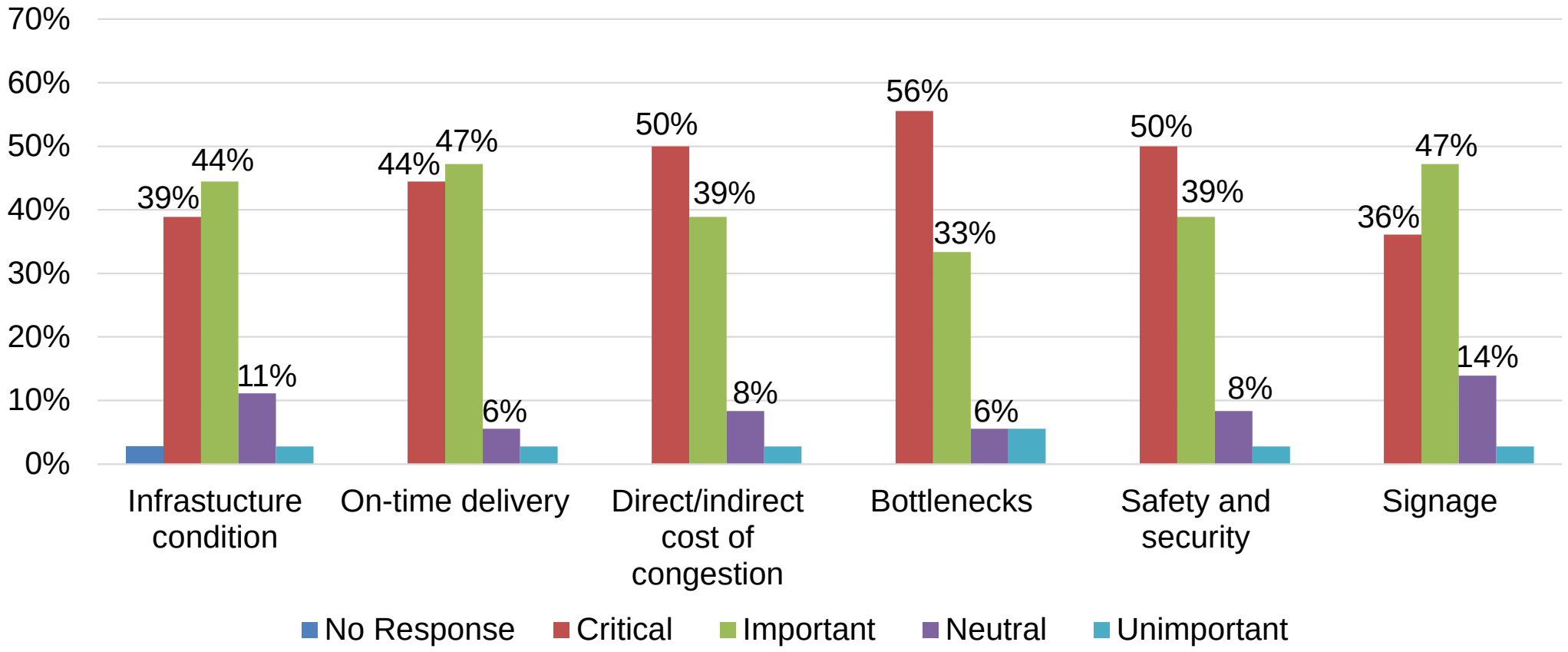


Freight Efficiency Factors

10. To move freight more efficiently how important are the following transportation factors?

	Critical	Important	Neutral	Unimportant
• Infrastructure condition	☐	☐	☐	☐
• On-time delivery	☐	☐	☐	☐
• Direct/indirect cost of congestion	☐	☐	☐	☐
• Bottlenecks	☐	☐	☐	☐
• Safety and security	☐	☐	☐	☐
• Signage	☐	☐	☐	☐

- ❑ Bottlenecks were deemed to be most critical
- ❑ Most of the respondents rated all the factors as either critical or important

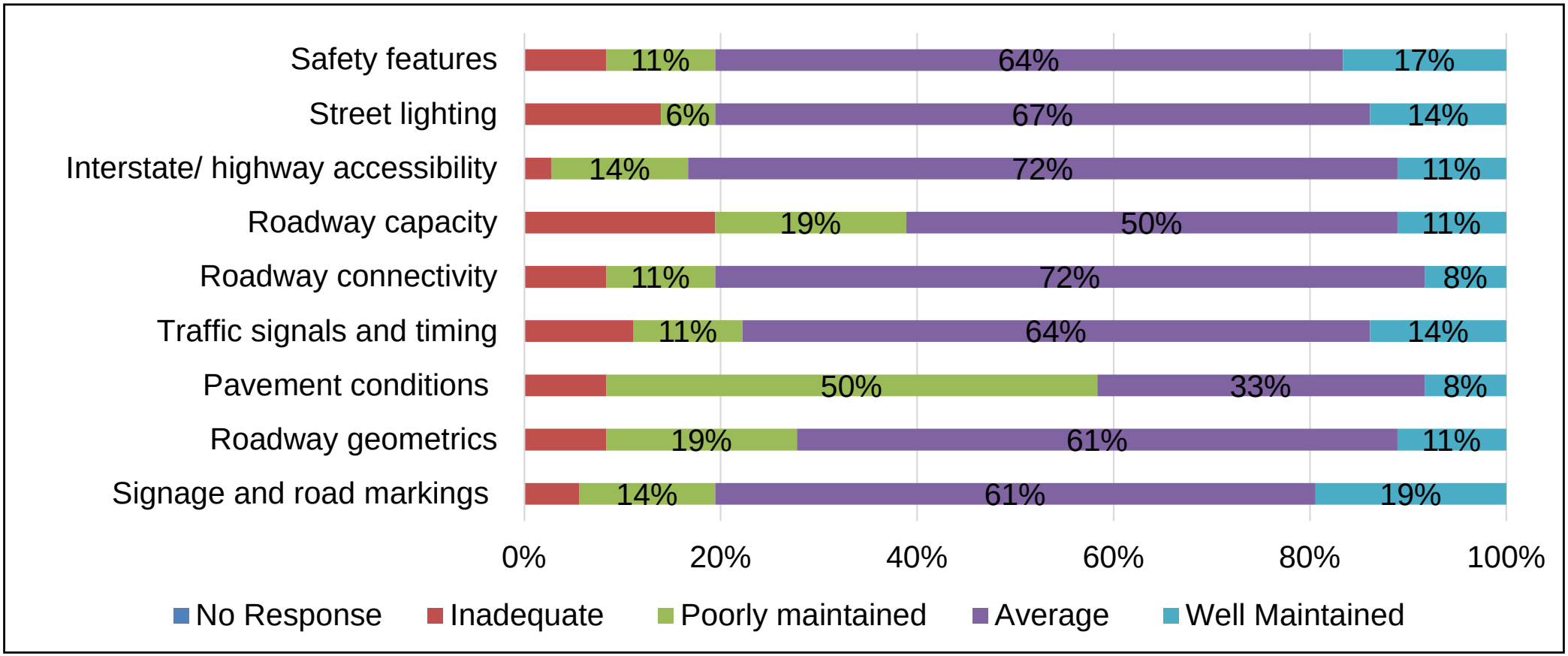


Infrastructure Conditions

11. How would you rate the transportation infrastructure along the Freight Intermodal Connectors?

	Inadequate	Poorly Maintained	Average	Well Maintained
• Signage and road markings	☐	☐	☐	☐
• Road geometrics	☐	☐	☐	☐
• Pavement conditions	☐	☐	☐	☐
• Traffic signals and timing	☐	☐	☐	☐
• Roadway connectivity	☐	☐	☐	☐
• Roadway capacity	☐	☐	☐	☐
• Interstate/highway accessibility	☐	☐	☐	☐
• Street lighting	☐	☐	☐	☐
• Safety features	☐	☐	☐	☐

- ❑ Pavement condition is being poorly maintained
- ❑ 25% of the truck drivers perceive the pavement conditions of the road segments as good

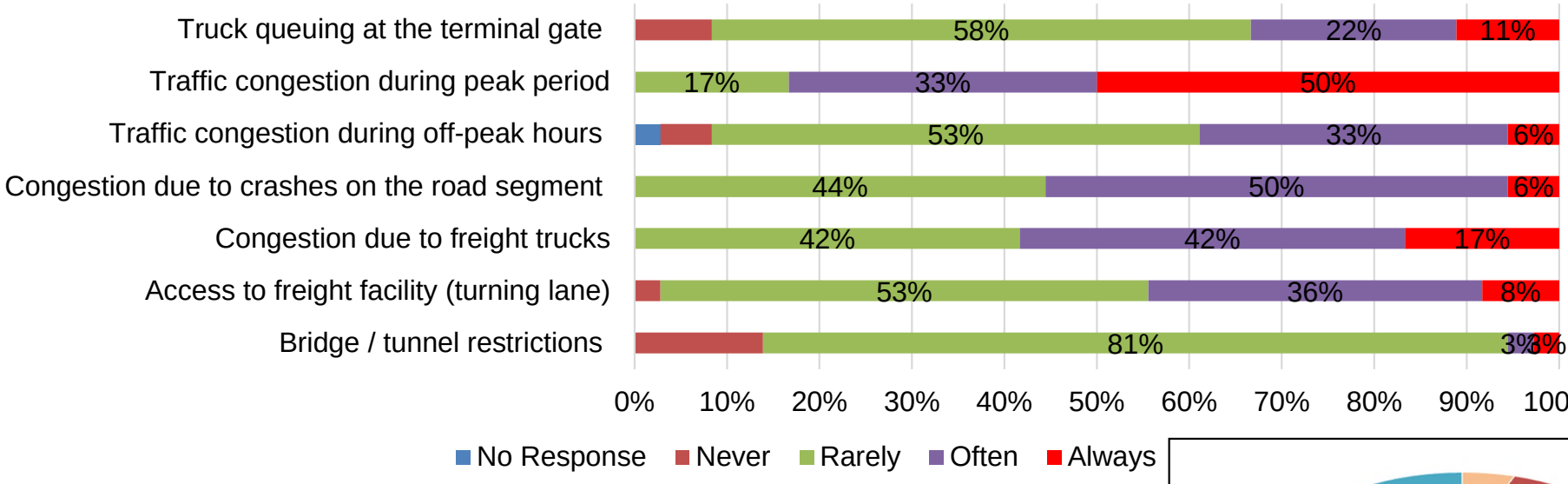


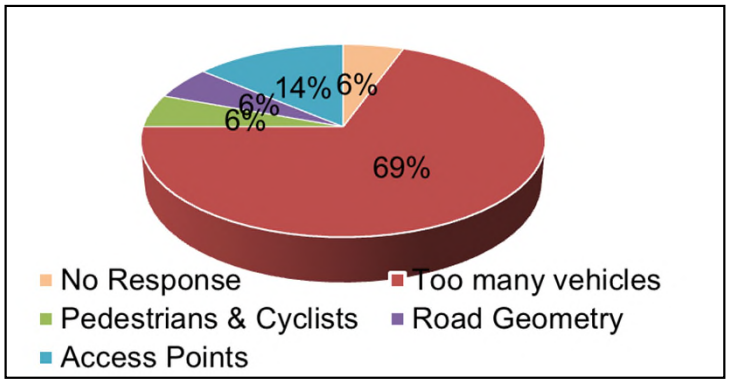
Freight Transportation Barriers

12. How often do you encounter the following barriers that affect freight transportation?

	Never	Rarely	Often	Always
• Bridge/tunnel restrictions for freight	☐	☐	☐	☐
• Access to freight facility (turning lane)	☐	☐	☐	☐
• Congestion due to freight trucks	☐	☐	☐	☐
• Congestion due to crashes on the road segment	☐	☐	☐	☐
• Traffic congestion during Off-peak hours	☐	☐	☐	☐
• Traffic congestion during peak period	☐	☐	☐	☐
• Truck queuing at the terminal gate	☐	☐	☐	☐

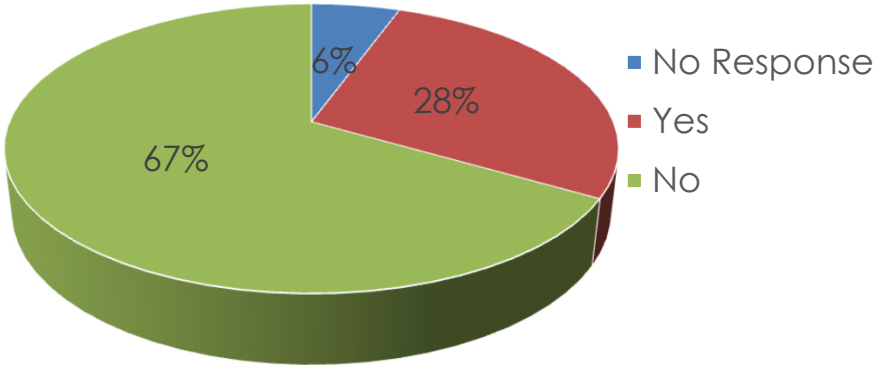
- ❑ Traffic congestion during peak period is the most recurrent barrier
- ❑ 83 % of the truck drivers reported ‘often’ or ‘always’



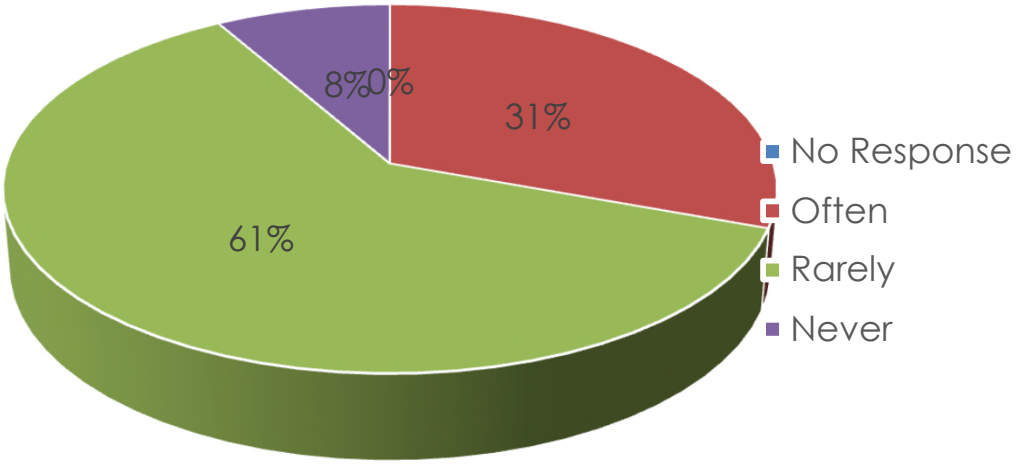


Evaluation of Survey Results

- Do you experience any environmental issues while traveling along the road segment(s) (air pollution)?



- How often do you have to reroute to get to the freight facility?



Survey Summary

- The biggest issue that the drivers are currently facing is recurring congestion along the FICs.
- Turning movement at intersections is also another issue of concern.
- Signage, safety, and security, bottlenecks, direct/ indirect cost of congestion, on-time delivery, and infrastructure condition are critical factors for freight efficiency
- The absence of safety features such as bike lanes, sidewalks, and pedestrian features ought to be addressed.
- The respondents provided the following recommendations and concerns:
    a. Potholes
    b. Bottlenecks
    c. Clearer signs
    d. Better access points

Publications Resulting from this Study

1. **Chimba, D.,** Masindoki, E., Li, X., and Langford, C. Safety Evaluation of Freight Intermodal Connectors in Tennessee. Transportation Research Record: Journal of the Transportation Research Board (TRR), *2673*(3), 237–246, 2019.
2. **Jonga, T., Chimba, D, and Swai, S., Kosanovic, A.** Emission estimations along first or last mile Freight Connectors. Submitted for Presentation and Publication considerations at 2020 Transportation Research Board (TRB) Annual Meeting, Paper # 20-03608.
3. **Swai, S., Chimba, D and Jonga, T ., Kosanovic, A.** Reliability Measures in Bottlenecks Identification along Freight Arterial Segments. Submitted for Presentation and Publication considerations at 2020 Transportation Research Board (TRB) Annual Meeting, Paper # 20-03934.
4. **Swai, S., Chimba, D and Jonga, T ., Kosanovic, A.** Operational Performance Evaluation of Freight Intermodal Connectors. Submitted for Presentation and Publication considerations at 2020 Transportation Research Board (TRB) Annual Meeting, Paper # 20-00556.
5. **Jonga, T., Chimba, D.** Vehicle Emissions on Intersections along first-last mile Freight Intermodal Connectors. Published in the Proceedings of 98th Transportation Research Board (TRB) Annual Meeting, 2019. # 19-00283.
6. **Chimba, D.,** Masindoki, E., and Langford, C. Safety Evaluation of Freight Intermodal Connectors in Tennessee. Published in the Proceedings of 98th Transportation Research Board (TRB) Annual Meeting, 2019. # 19-00083.
7. Xiaoming Li., **Chimba, D** and Emmanuel Masindoki. The Economic and Societal Impact of Motor Vehicle Crashes on Freight Intermodal Connectors in Tennessee: A Risk Management Approach. Published in the Proceedings of *Transportation Research Board (TRB)* Annual Meeting, 2018. # 17-00881.

Thank you!

Summary of Findings

Safety Analysis Summary of Findings

- Using 2012 to 2015 Crash data, the highest number of crashes was found along **Jackson Ave (SR-14)** connector to and from Leewood Yards - Memphis CSX, a Truck/Rail Facility in Memphis to I-40.
- The second and third connector segments with highest number of crashes are also from facilities in Memphis, which are **Democrat Rd** (to Memphis International Airport) and **Shelby Dr** (Tennessee Yards - Memphis Burlington) respectively.
- **E. Magnolia Ave** segment (to Greyhound Bus Terminal) in Knoxville has the highest number of fatal and incapacitating injury crashes combined.
- The top FICs connectors that exceeded critical total crash rates include **Armory Ave** to and from Radnor Yards in Nashville CSX, Western Ave to and from Pipeline facility in Knoxville, **Riverside Blvd** to and from President's Island in Memphis, **Shelby Dr** to and from Tennessee Yards - Memphis Burlington and **East Parkway S** to and from Forrest Yards Memphis Norfolk Southern.

Operational Analysis Summary of Findings

- Intersection with **Shelby Dr** to and from Tennessee Yards - Memphis Burlington and Jersey Pike/SR-153, an intersection along pipeline connector in Hamilton County recorded the highest AM delay
- Intersections with **Winchester Rd, Airways Blvd** and **Plough Blvd** which are connectors to and from Memphis International Airport recorded the highest PM delays.
- The intersection with Lincoln Street to and from truck-rail connector segment in Sullivan County and **E. Magnolia Ave and North Cherry St** segment to and from Greyhound Bus Terminal in Knoxville had the lowest delays.
- It was observed that intersection delays varied randomly for different type of connectors without specific pattern related to the type of intermodal connector.
- Reliability Measures for Fluidity analysis was used to identify Bottlenecks and related delay costs for some connector segments.
- The top three segments are **Democratic Rd** to and from Memphis International Airport has the highest delay cost followed by **Ed Shouse Dr** to and from Colonial & Plantation Pipeline in Knoxville, **E. Magnolia Ave** segment to and from Greyhound Bus Terminal in Knoxville.
- The segment with the lowest delay cost is **West 19th St** to and from Southern Foundry Supply, a Port Terminal connector in Chattanooga

Safety Modeling Summary of Findings

- To understand influence of evaluated variables on FICs crash occurrence, the sign and magnitude of respective variable coefficient was observed
- Three variables were found with negative coefficients meaning their increase or presence tends to decrease number of crashes along FICs connectors; number of lanes, presence of two way left turn lane (TWLTL) and the presence of outside shoulder. This means FICs segment are safer at segments with multilane, TWLTL medians and in the presence of outer shoulder
- Variables with positive coefficient including AADT, signal density, access density, presence of Curb and Gutter meaning FICs segment are more hazardous with increase/presence of these variables.

Emission Analysis Summary of Findings

- The FICS connectors which generated the highest amount of emission are those to Memphis International Airport followed by those to Colonial & Plantation Pipeline Co, Tennessee Yards-Memphis Burlington, Johnston Yards-Memphis Illinois Central, Leewoods Yards-Memphis CSX in that order respectively.
- The FICS connectors which generated the highest amount of NOx emission are those to Tennessee Yards-Memphis Burlington, Memphis International Airport and President's Island-Memphis.
- The FICS connectors which generated the highest amount of PM2.5 emission are those to Tennessee Yards-Memphis Burlington, President's Island-Memphis, Johnston Yards-Memphis Illinois Central, and Memphis International Airport.

Questionnaire Survey Summary of Findings

- The questionnaire survey showed the biggest issue that the drivers are currently facing is recurring congestion along the FICs.
- Turning movement at intersections is also another issue of concern.
- Signage, safety, and security, bottlenecks, direct/ indirect cost of congestion, on-time delivery, and infrastructure condition are critical factors for freight efficiency
- The absence of safety features such as bike lanes, sidewalks, and pedestrian features ought to be addressed.
- The respondents provided the following recommendations and concerns:
    a. Potholes
    b. Bottlenecks
    c. Clearer signs
    d. Better access points