C2SMART
CONNECTED CITIES WITH SMART TRANSPORTATION

NYU

Data-driven Determination of the Impact of Truck Traffic on Traffic Safety using Weigh-In-Motion Data

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VISION ZERO
Building a Safer City

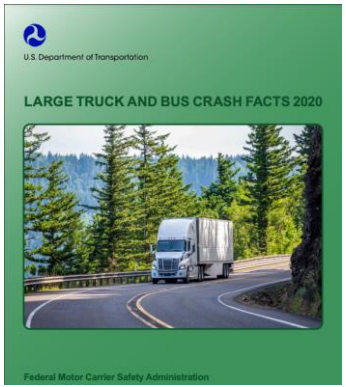
NYC DDC

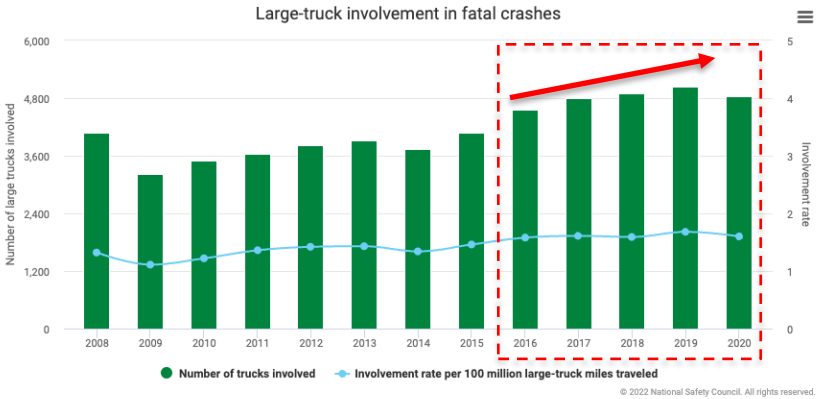
TOWN +GOWN: NYC

Content

Truck, Truck Weight and Traffic Safety

- Compared to passenger vehicles, trucks are **more difficult to operate safely** because:
  - Larger size
  - Heavier weight
  - Greater stopping distance
  - More likely to encounter brake failure
  - Larger turning radius
  - More blind spots
- The likelihood of **severe injury or fatal crashes involving large trucks is higher** because:
  - Difficult to stop
  - Higher energy release if a crash occurs
- An up trend of large-truck involvement in **fatal crashes** is observed.

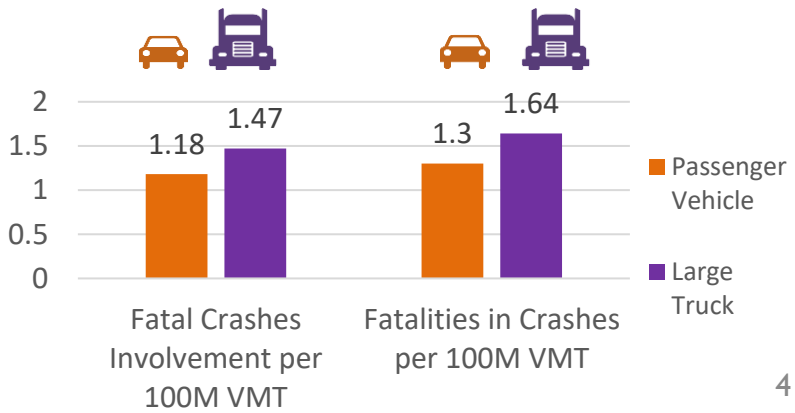




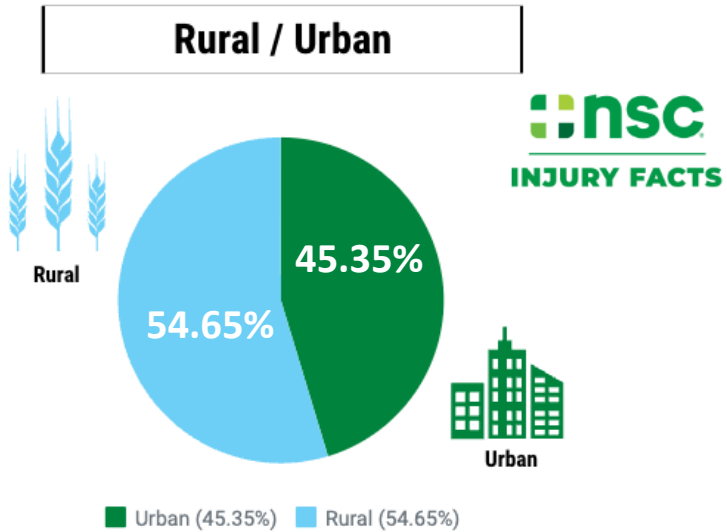
Data Source: FMCSA, Large Truck and Bus Crash Facts 2020. A large truck is defined as a truck with a gross vehicle weight rating (GVWR) greater than 10,000 pounds

Facts on Large Trucks Crashes

Large-Truck vs. Passenger Car In 2020, compared to a passenger vehicle, large trucks involvement in fatal crashes per 100 million VMT is **25% higher**, the number of fatalities in large truck crashes per 100 million VMT is **26% higher**.



Fatal Large Truck Crash 2020 Urban vs. Rural



Data Source: FMCSA, Large Truck and Bus Crash Facts 2020;NSC Injury Facts

Crash Frequency by Severity Levels

- Although ***Highway Safety Manual (HSM)*** provides the methods to calculate **crash frequency by severity levels, truck traffic is not considered** when estimating crash frequency by severity levels
- Data unavailability is a possible reason.

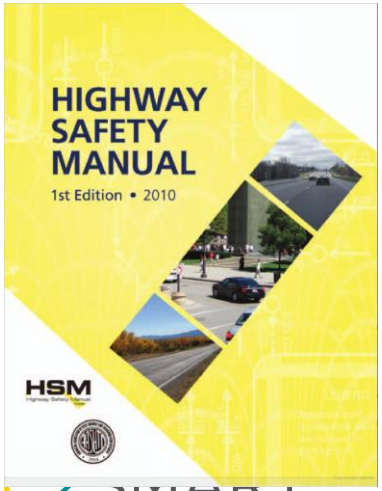


Table 10-3. Default Distribution for Crash Severity Level on Rural Two-Lane, Two-Way Roadway Segments

Crash Severity Level	Percentage of Total Roadway Segment Crashes[a]
Fatal	1.3
Incapacitating Injury	5.4
Nonincapacitating injury	10.9
Possible injury	14.5
Total fatal plus injury	32.1
Property damage only	67.9
Total	100.0

[a]Based on HSIS data for Washington (2002–2006)

Table 11-3. SPF Coefficients for Total and Fatal-and-Injury Crashes on Undivided Roadway Segments (for use in Equations 11-7 and 11-8)

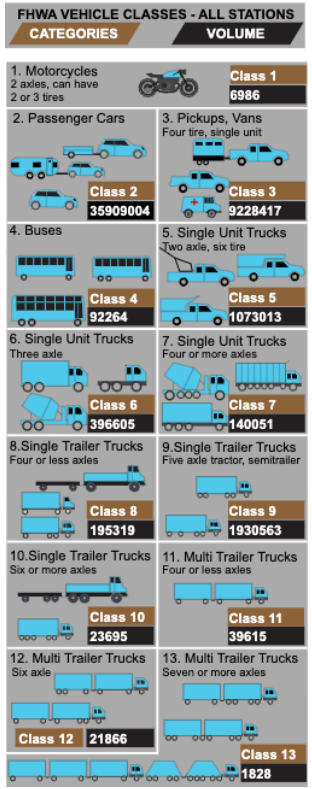
Crash Severity Level	a	b	c
4-lane total	−9.653	1.176	1.675
4-lane fatal and injury	−9.410	1.094	1.796
4-lane fatal and injury[a]	−8.577	0.938	2.003

Table 12-3. SPF Coefficients for Multiple-Vehicle Nondriveway Collisions on Roadway Segments

	Coefficients Used in Equation 12-10		
Road Type	Intercept (a)	AADT (b)	Overdispersion Parameter (k)
Total crashes			
2U	−15.22	1.68	0.84
3T	−12.40	1.41	0.66
4U	−11.63	1.33	1.01
4D	−12.34	1.36	1.32
5T	−9.70	1.17	0.81
Fatal-and-injury crashes			
2U	−16.22	1.66	0.65
3T	−16.45	1.69	0.59
4U	−12.08	1.25	0.99
4D	−12.76	1.28	1.31
5T	−10.47	1.12	0.62
Property-damage-only crashes			
2U	−15.62	1.69	0.87
3T	−11.95	1.33	0.59
4U	−12.53	1.38	1.08
4D	−12.81	1.38	1.34
5T	−9.97	1.17	0.88

Weigh In Motion (WIM)

- **WIM systems**
  - Devices installed on the road or rail track
  - Capture the axle weights and gross vehicle weights (GVW), speed, vehicle classification, etc.
  - Measure truck weight without interrupting the traffic
- **Common applications**
  - Pavement/Bridge design and monitoring
  - Planning and freight movement studies
  - Toll by weight
- **Safety application**
  - Provide truck volume and detail truck weight information for more accurate traffic safety modeling



https://www.njtms.org/njwimsite/

Motivation

- **Truck traffic information is important for estimating crash frequency by severity levels which is missing in HSM's predictive methods**
- **WIM Data that provides truck traffic information including truck volume, truck weight enables us to study the relationship between truck traffic and crash by severity**

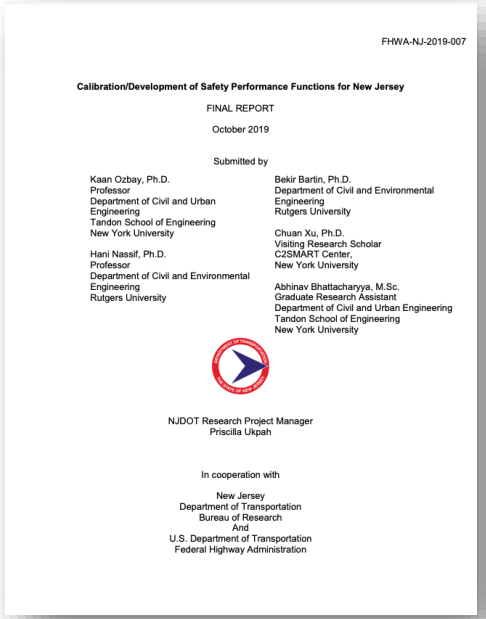
Does truck traffic, especially truck weight, have an impact on the crash severity of road segments?

Data Source: FMCSA, Large Truck and Bus Crash Facts 2019

Data Source

- **WIM Data**
  - Capture and record axle weights and **total vehicle weights** as vehicles pass a measurement site
  - Available Features:
    - Vehicle Classification
    - Vehicle Weight
    - Traffic Volume
- **Road Feature Data**
  - **Data Source**: Straight Line Diagrams for New Jersey
- **Crash Data**
  - **Data Source**: Voyager Safety Database

Calibration/Development of Safety Performance Functions for New Jersey



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Calibration/Development of Safety Performance Functions for New Jersey

FINAL REPORT

October 2019

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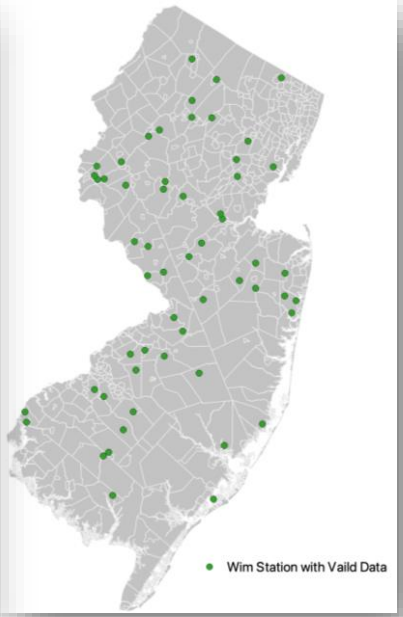
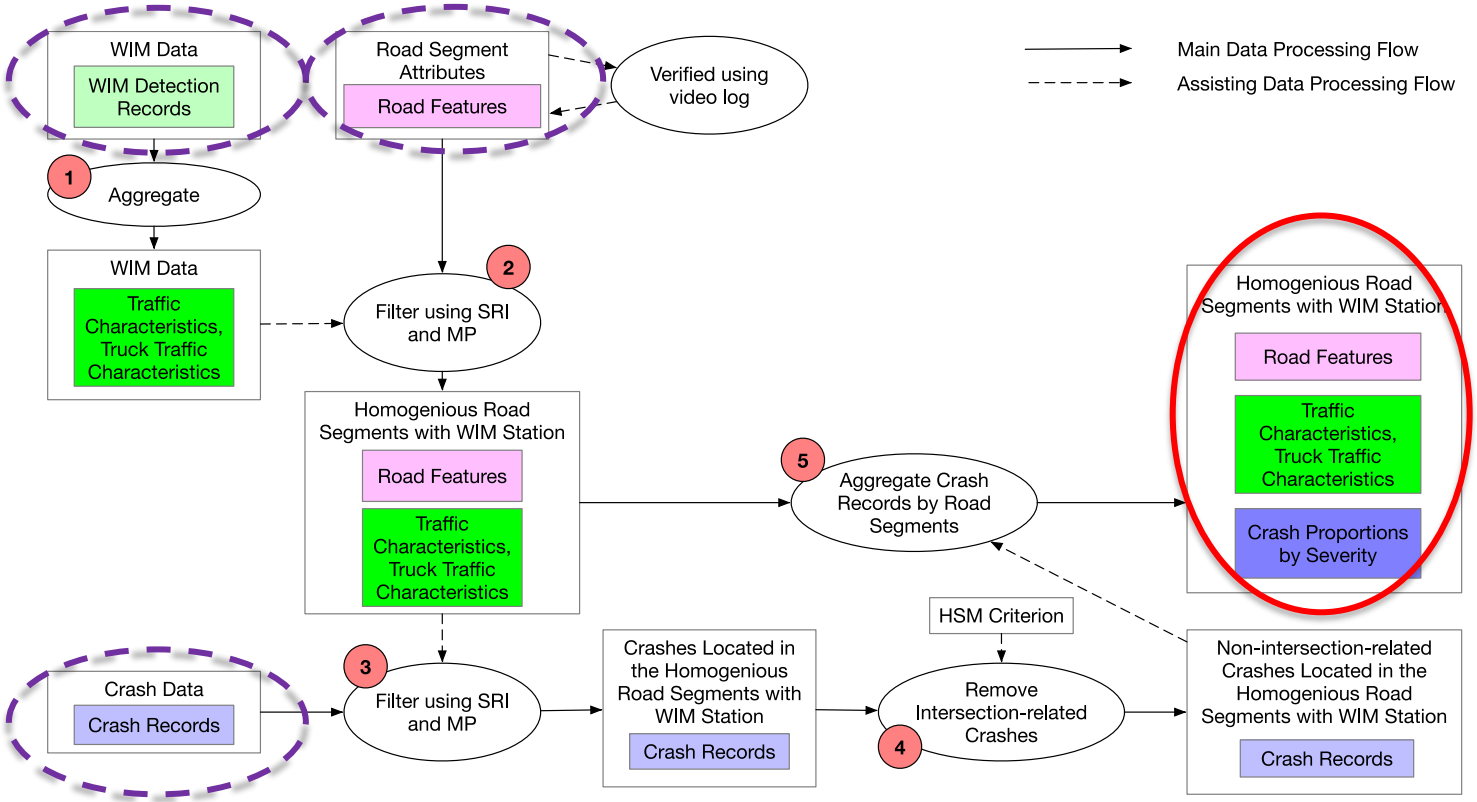
U.S. Department of Transportation
Federal Highway Administration



https://www.njdottechtransfer.net/wp-content/uploads/2020/07/FHWA-NJ-2019-007.pdf

Data Processing and Fusion

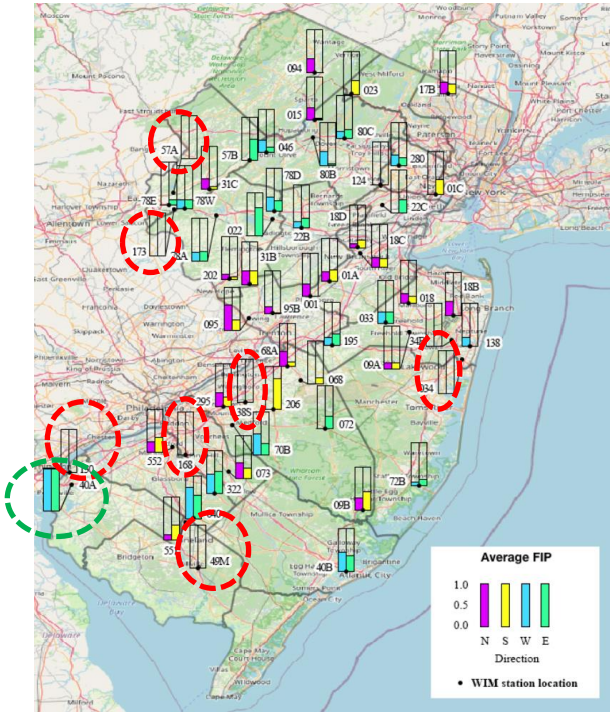


Data Variables

Type	Variable	Description	Mean	S.D.
Response Variable	FIP	Fatal & injury crash proportion	0.25	0.25
Road Features	M_d	Median type: 1-The road segment is divided by a physical median; otherwise, 0.	0.67	0.47
	N_{lane}	Number of lanes	2.44	0.72
	L_{ru}	Location: 1- urban, 0- rural.	0.81	0.39
	S_{limit}	Posted speed limit (mph)	55.00	7.20
	S_{Width}	The width of road segment shoulder in feet	10.33	3.08
	S_{length}	Segment length (mile)	0.99	1.01
Truck Traffic Characteristics	AADTT	Annual average daily truck traffic (vehicle/day)	1143	1672
	P_{tt}	Truck traffic proportion	0.05	0.03
	SD_{tw}	SD of truck weight (kips)	20.16	4.66
	M_{tw}	Mean of truck weight (kips)	34.73	7.17
	N_{50Kips}	The count of trucks over 50 kips (10^4)	9.89	22.59
Traffic Characteristics	AADT	Annual average daily traffic (vehicle/day)	20,023	16,809

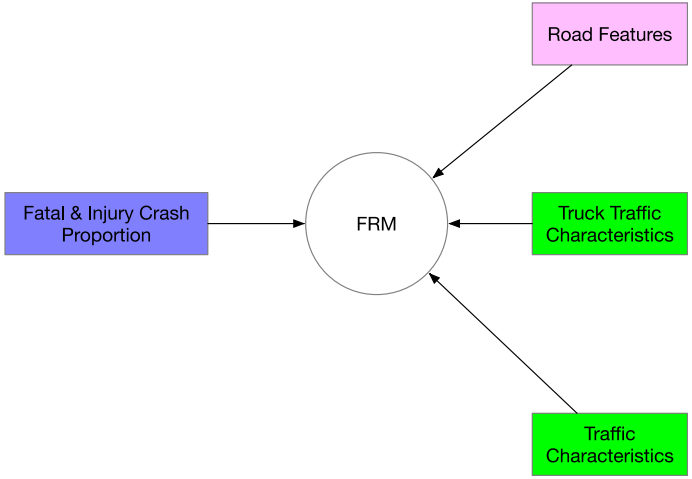
Average Fatal and Injury Proportion

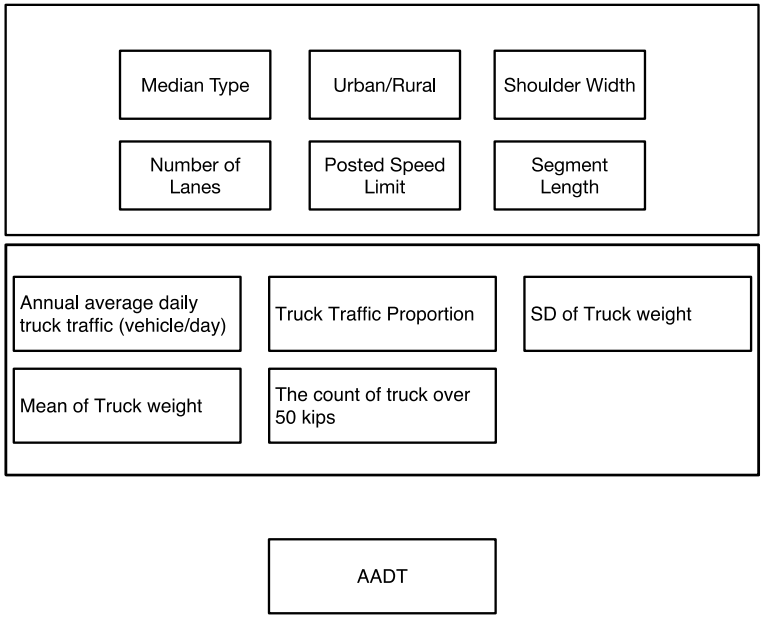
The average FIP varies greatly among different road segments



Methodology: Fractional Regression Model

- Fractional Regression Model (FRM):
  - FRM is applied when the response variable is a proportion
  - FRM model forms can be one-part, or two-part model, we use P test and Mean Absolute Error (MAE) to find which model form is better
  - We can find the optimal link function G(.) using the following test methods
    - Goodness-of-Functional Form (GOFF) test
    - Regression Specification Error Test (RESET) test
    - P test

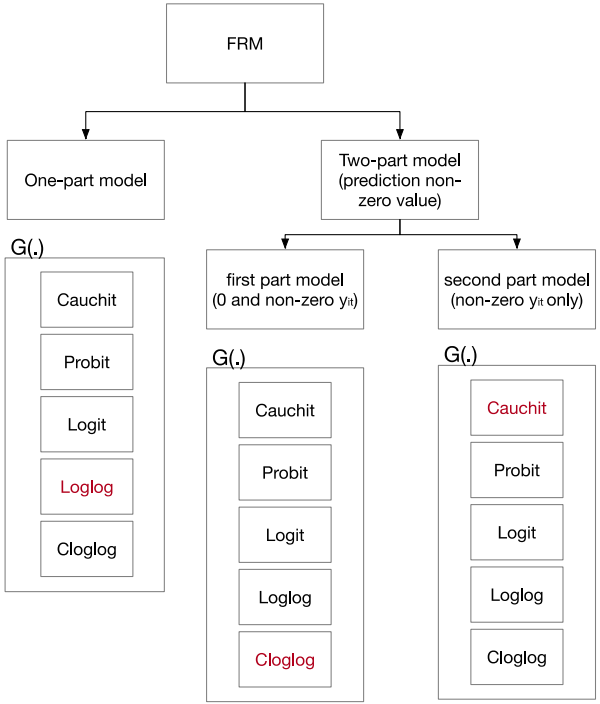




Specification Tests for One-part and Two-part Models

- To account for the bounded nature of FIP, one-part and two-part Fractional Regression Models (FRMs) are developed:
  - For the one-part FRM, loglog link function is favored (fitting the distribution of FIP)
  - For the two-part FRM, the cloglog and Cauchit link functions are preferred for the first and second parts respectively
  - The mean absolute error indicates that the one-part FRM is slightly better in prediction accuracy than the two-part FRM, P tests suggest insignificant performance difference between these two models.
  - The findings are based on both models

Optimal link functions



Finding Highlights

- The mean of truck weight are statistically significant and positively related to FIP
- Truck traffic proportion are statistically significant and positively related to FIP
- The FIPs of road segments divided by physical median are found to be lower than those of undivided roads.
- AADT, Segment Length were not significant in FRM models.
- No significant association was found between FIP and truck weight variance.

→ Higher **mean of truck weight**, higher proportion of fatal and injury crash (+)

→ Higher **truck percentage** in the traffic flow, higher proportion of fatal and injury crash (+)

→ **Physical median** can lower the proportion of fatal and injury crash (−)

→ **AADT, segment length**, exposure variables, insignificant (●)

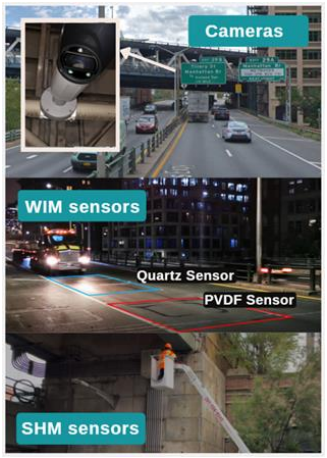
→ **Truck weight variance**, insignificant (●)

Truck weight has a significant negative impact on traffic safety.

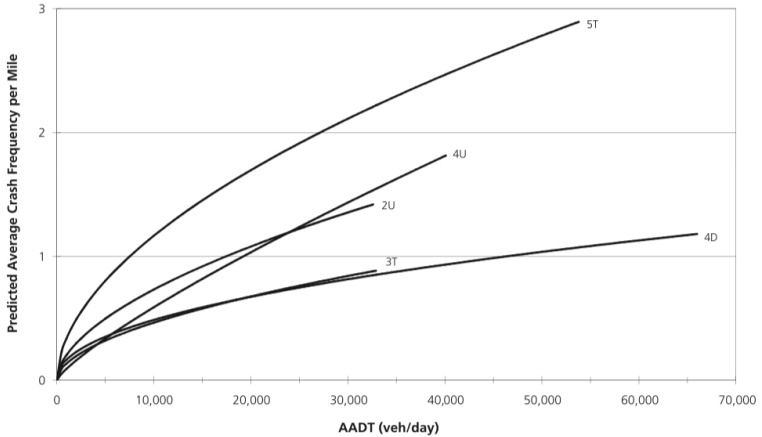
Potential Applications in NYC

- Develop Safety Performance Functions (SPF) for roads in NYC and including truck traffic as a crash modification factor in the context of overall safety analysis and improvements

Data Source: NYC crash mapper



C2SMART Brooklyn-Queens Expressway Testbed



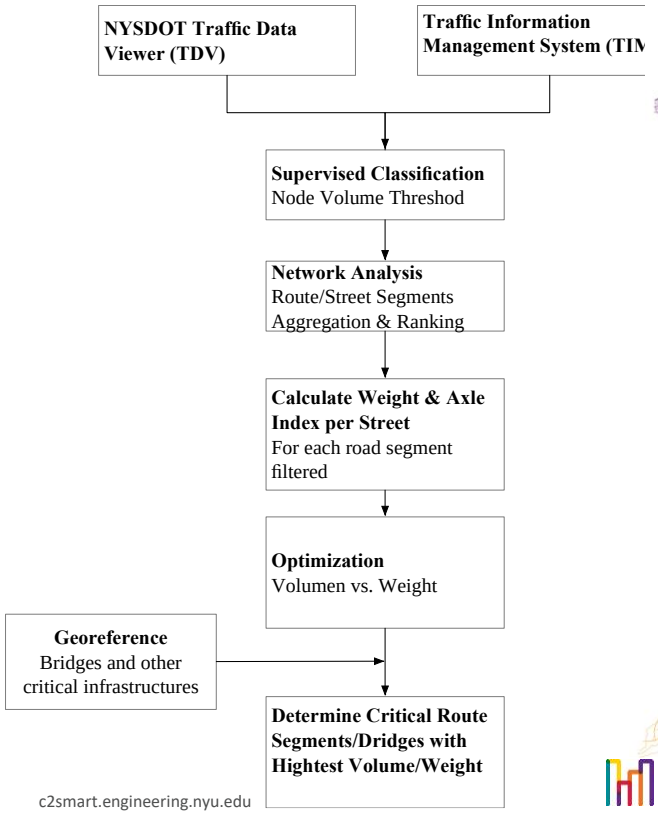
SPF, Highway safety manual

2021/1-12, NYC: Truck involved crash 3209, fatality 42, injury 4476

NYC Overweight Truck Impact Study & WIM Selection

Conducted by C2SMART & Funded by NYCDOT through T&G

- Evaluate bridges and other critical infrastructures performance and deterioration under overweight truck loads
- Decide the optimal locations for WIM station installation



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Quantifying and Visualizing City Truck Route Network Efficiency Using a Virtual Testbed

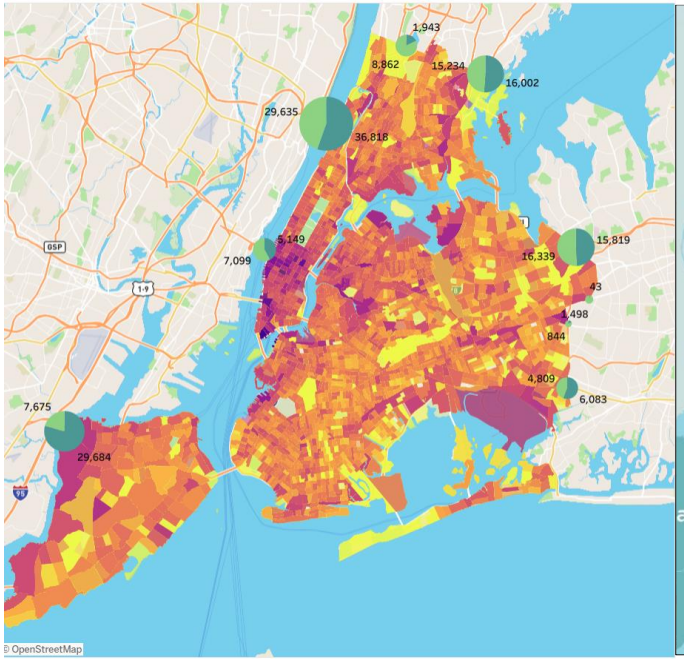
Conducted by C2SMART and Funded by USDOT with matching from NYCDOT

Freight Trips Produced

- Heatmap of Freight Trips Produced by zone
- Truck Counts at city gateways include (light green- measured, dark green-estimated)

Borough Level Truck Flow

- Measured at screen lines on funneling links (Bridges, Tunnels, major arterials)



Freight Trips Produced (FTP)

Borough Level Truck Flow

Truck Safety is NOT the Only Problem!

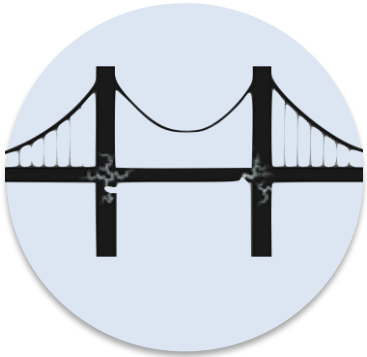
A **holistic approach** is needed to provide integrated solutions:

Analyze traffic safety using WIM & Other Data

Traffic Safety

Truck route study to understand truck flow

Mobility & Congestion



Infrastructure Resilience

Understand overweight truck impacts on roadways and bridges

Quantify infrastructure life cycle costs considering truck related externalities

Emission & Air Pollution

Explore truck double parking severity & loading zone options

Truck Parking

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THANK YOU

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