



# Overview

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- ❑ Analysis
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  - Fleet Mixture
  - Average Speed compared to user defined Operating Mode Distributions
- ❑ Results
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- ❑ Questions



# Background

- ❑ Project sponsored by Federal Highway Administration (FHWA)
- ❑ MOVES Regional Level Sensitivity Analysis
  - Report released in December of 2012
- ❑ MOVES Project Level Sensitivity Analysis
  - Was a follow up analysis to the Regional Level Sensitivity Analysis
  - Parameters chosen to be analyzed for the Project Level analysis were based on some of the findings from the Regional Level Analysis
  - Final Report completed in March

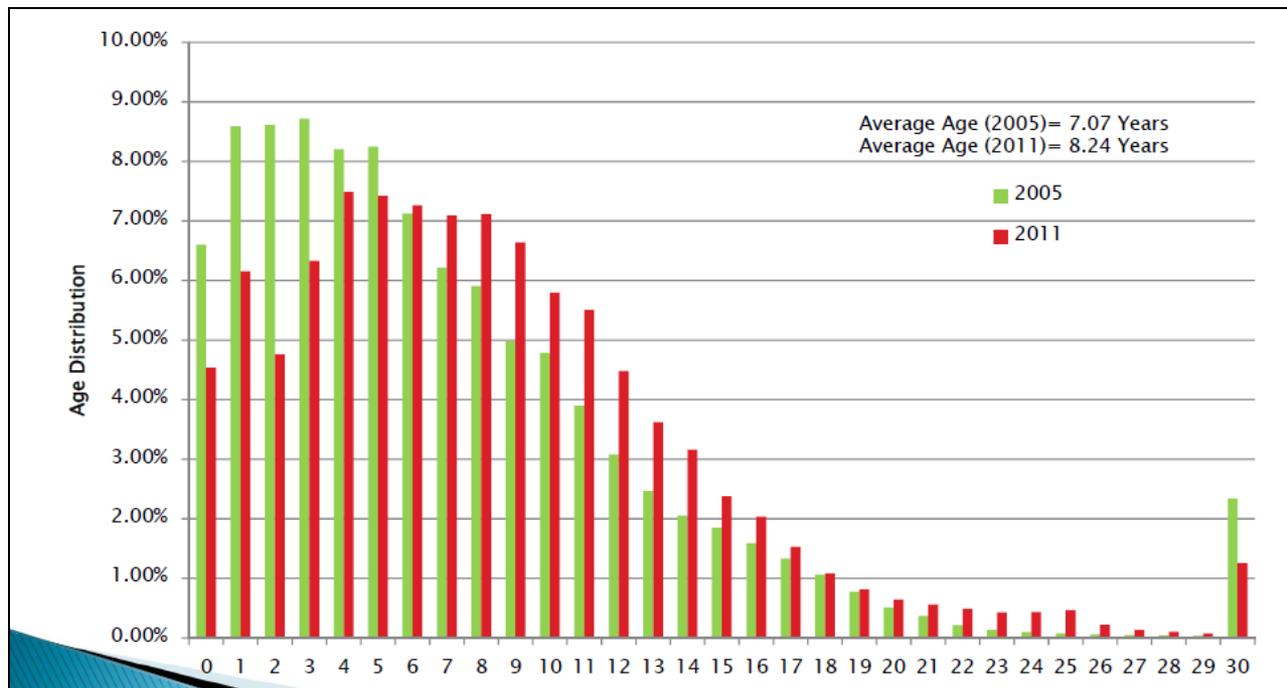


# Age Distribution

- ❑ Age Distribution was analyzed for the Regional Level Sensitivity Analysis
- ❑ The Project Level Analysis applied more meaningful variations
  - Reached out to the Metropolitan Washington Council of Governments (MWCOCG) to obtain data.
- ❑ Analyzed multiple vehicle types
  - Passenger Cars
  - Transit Buses
  - Single Unit Trucks
  - Combination Trucks

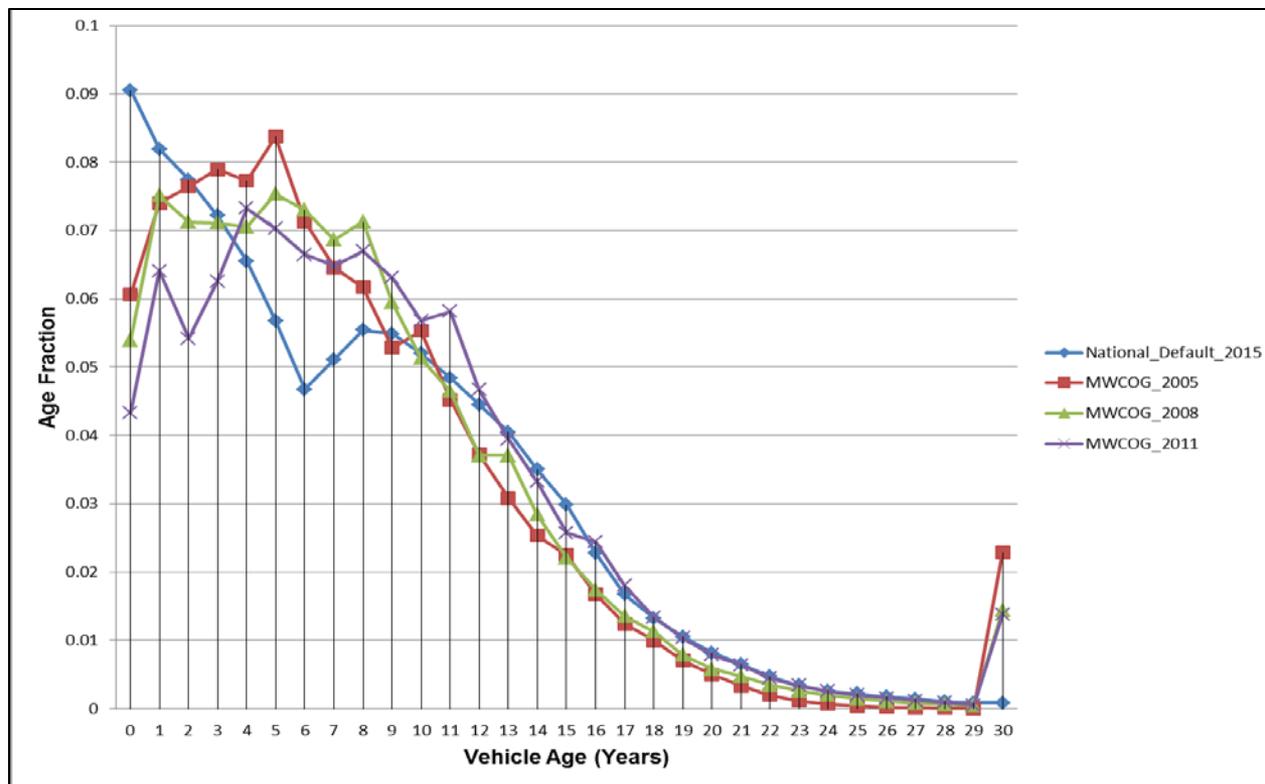
# Age Distribution

- ❑ MWCOG provided data for 2005, 2008, and 2011
- ❑ The data showed the fleet aging throughout the years



# Passenger Car Age Distribution Trends

- ❑ More variable for newer model years
- ❑ Less variable for latter years
- ❑ Age Groupings were based on these observed trends



# Passenger Car Age Distribution Groupings

- ❑ Passenger Cars were put into five age groups
- ❑ Five Scenarios were analyzed
- ❑ Scenario 1 has the least amount of variation based upon the observed data
- ❑ Scenario 5 has the highest amount of variation base upon the observed data

Vehicle Age Range	Baseline Age Fractions	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
<b>0-3 years</b>	0.32	-5%	-10%	-20%	-30%	-45%
<b>4-7 years</b>	0.22	-2%	-5%	-7.50%	-10%	-20%
<b>8-12 years</b>	0.26	+5%	+10%	+20%	+30%	+50%
<b>13-17 years</b>	0.14	+4%	+8%	+15%	+20%	+30%
<b>18-30 years</b>	0.06	+2.5%	+5%	+7.5%	+10%	+25%
<b>Average Vehicle Age</b>	<b>7.48</b>	<b>7.68</b>	<b>7.86</b>	<b>8.21</b>	<b>8.53</b>	<b>9.24</b>

# Passenger Car Age Distribution Results

Source Type	Pollutant	Case	Average Age	Emission Rate (gram/vehicle-mile)	Percent Change
Passenger Car	CO	Baseline	7.48	1.484	-
		Scenario 1	7.68	1.516	2.15%
		Scenario 2	7.86	1.548	4.14%
		Scenario 3	8.21	1.604	7.49%
		Scenario 4	8.53	1.653	10.24%
		Scenario 5	9.24	1.776	16.47%
	NO <sub>x</sub>	Baseline	7.48	0.2929	-
		Scenario 1	7.68	0.3017	2.91%
		Scenario 2	7.86	0.3104	5.63%
		Scenario 3	8.21	0.3246	9.76%
		Scenario 4	8.53	0.3367	12.99%
		Scenario 5	9.24	0.3700	20.84%
	VOC	Baseline	7.48	0.0398	-
		Scenario 1	7.68	0.0409	2.88%
		Scenario 2	7.86	0.0421	5.56%
		Scenario 3	8.21	0.0439	9.51%
		Scenario 4	8.53	0.0455	12.62%
		Scenario 5	9.24	0.0502	20.78%
	PM <sub>2.5</sub>	Baseline	7.48	0.0067	-
		Scenario 1	7.68	0.0068	1.16%
		Scenario 2	7.86	0.0069	2.27%
Scenario 3		8.21	0.0070	4.01%	
Scenario 4		8.53	0.0071	5.56%	
Scenario 5		9.24	0.0075	9.94%	



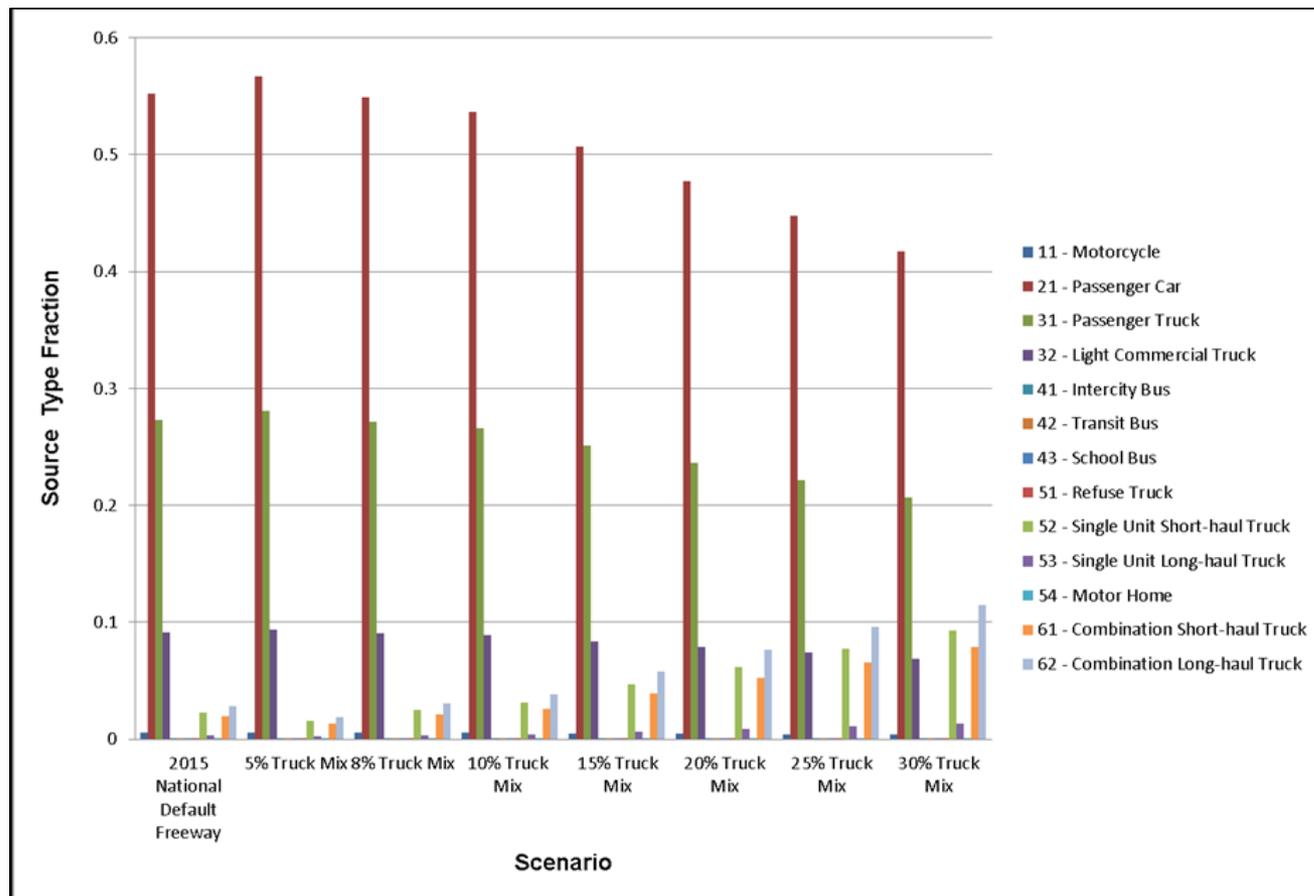
# Fleet Mix

- ❑ Analyzed five cases to determine how sensitive fleet can be a specific MOVES link
- ❑ The five cases include
  - Geographic area comparisons of fleet mix(Georgia Tech provided data)
  - Passenger Car to Passenger Truck ratio
  - Percent Truck Mix
  - Truck Type Mix
  - Transit Bus Mix



# Percent Truck Mix Sensitivity

- Varied the truck mix while proportionally adjusting the other MOVES source types



# Percent Truck Mix Results

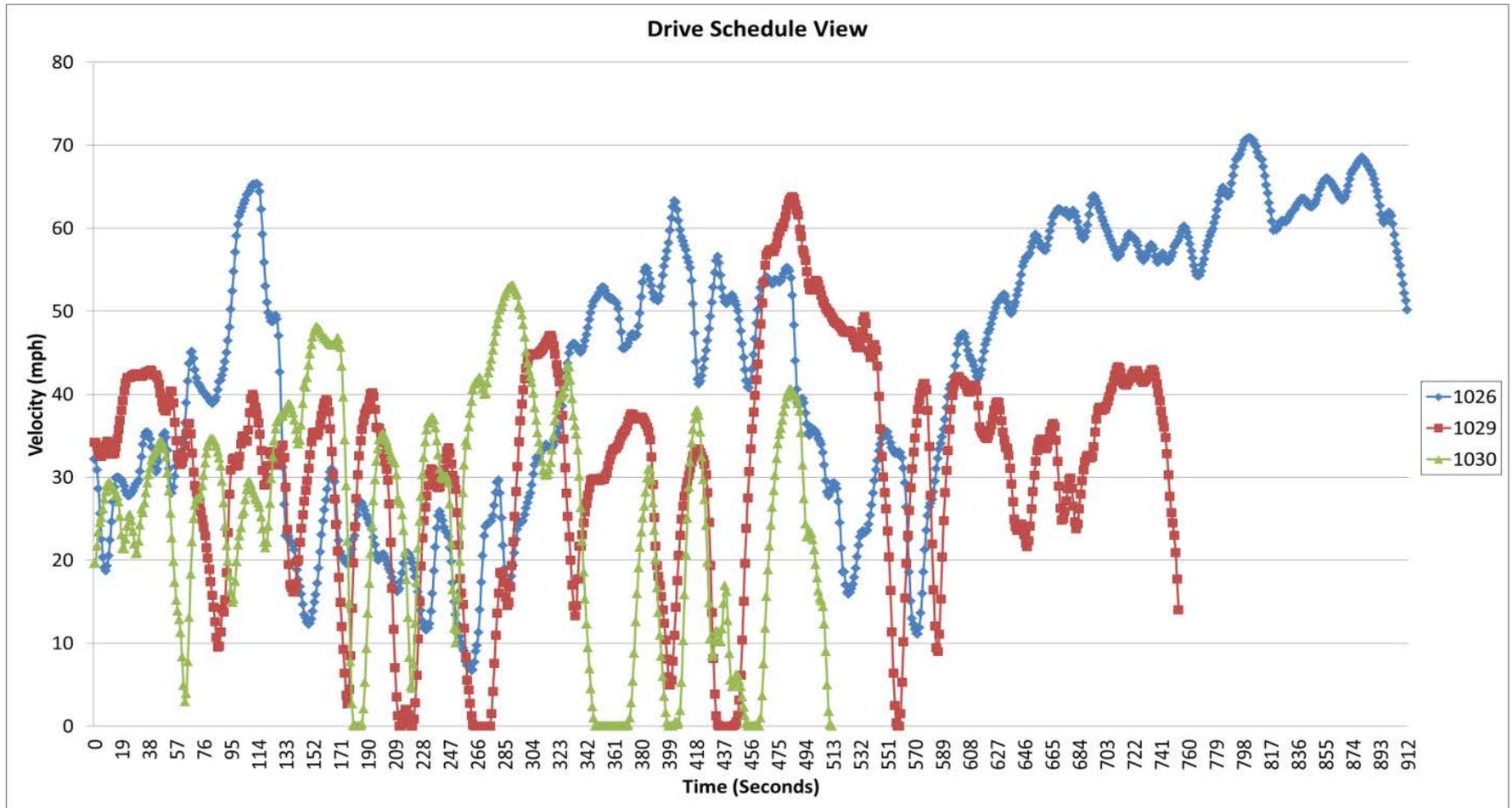
Pollutant	Description	Emission Rate (gram/vehicle-mile)	Percent Change
NO <sub>x</sub>	Baseline_Highway	1.2006	-
	5% Truck Mix	1.0046	-16.33%
	8% Truck Mix	1.2464	3.82%
	10% Truck Mix	1.4077	17.25%
	15% Truck Mix	1.8108	50.83%
	20% Truck Mix	2.214	84.41%
	25% Truck Mix	2.6172	117.99%
	30% Truck Mix	3.0204	151.57%
PM <sub>2.5</sub>	Baseline_Highway	0.0342	-
	5% Truck Mix	0.0268	-21.55%
	8% Truck Mix	0.0359	5.04%
	10% Truck Mix	0.042	22.77%
	15% Truck Mix	0.0571	67.08%
	20% Truck Mix	0.0722	111.41%
	25% Truck Mix	0.0874	155.73%
	30% Truck Mix	0.1025	200.06%



# Average Speed and Operating Mode Distribution Comparison

- ❑ Compared utilizing average speed for a link to a user defined operating mode distribution
  - When using average speed with MOVES, default drive schedules are applied
- ❑ Highway Capacity Manual (HCM) based drive schedules
- ❑ Georgia Tech provided operating mode distributions

# Example of MOVES Default Drive Schedules



# Intersection Analysis

## □ Intersection

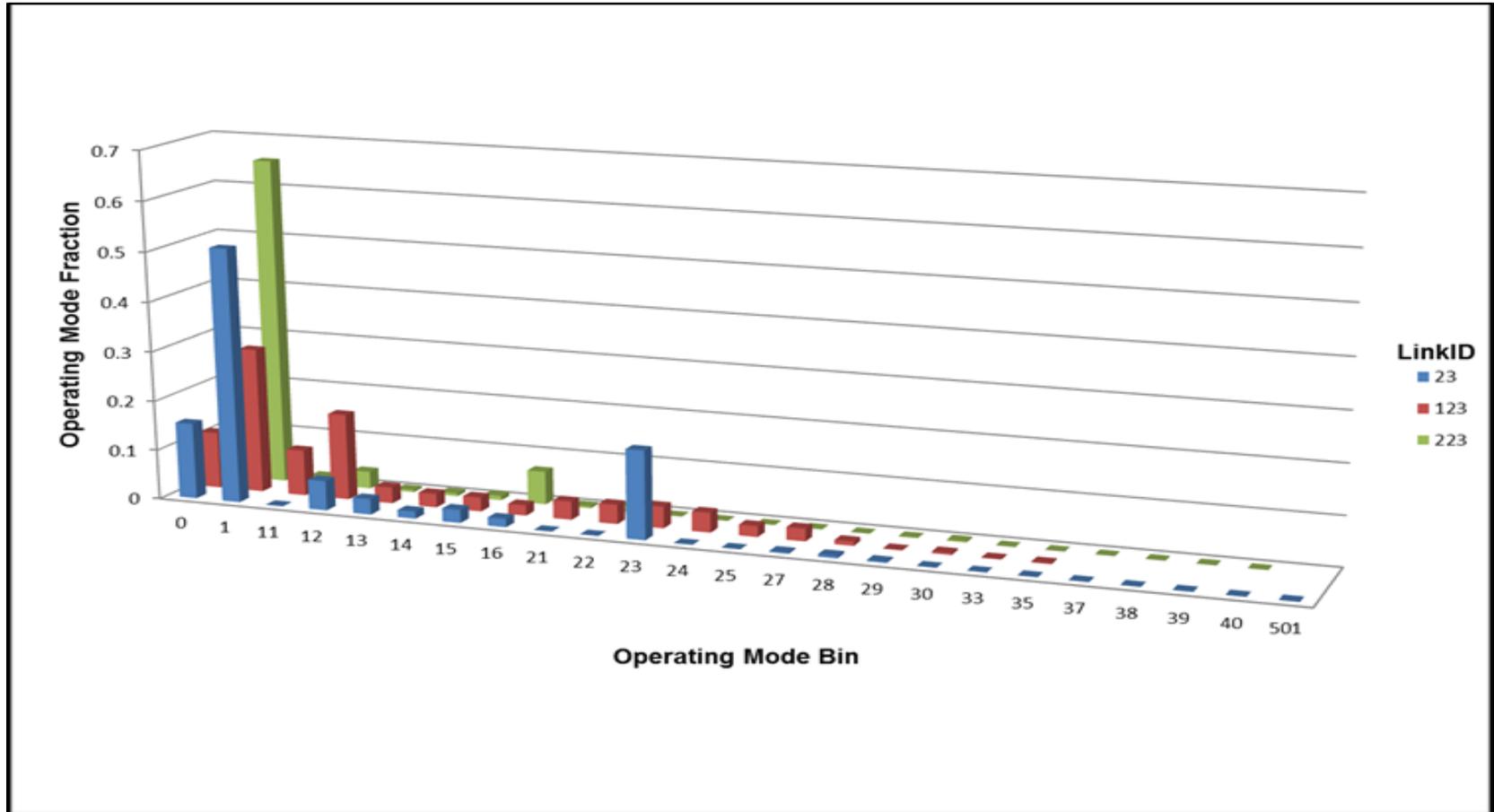
- 25 mph, 35 mph, 45 mph approach speeds
- LOS B,D, and E
- Consisted of approach, queue, and departure (acceleration) links

**45 mph Scenario Intersection Data**

Approach Speed (mph)	LOS	Signal Cycle Length (Seconds)	Yellow Time (seconds)	Green Time (seconds)	Red Time (seconds)	Vehicle Headway (seconds)	Deceleration Rate (mph/s)	Acceleration Rate (mph/s)	Volume per Cycle
45	B	55	4	10	41	14	-5	3	4
	D	95	4	23	68	10			9
	E	100	4	24	72	9			11

# Operating Mode Distributions

45 mph Intersection Scenario – Queue Links LOS D Operating Mode Distributions





# Intersection Results

Link Description	LinkID	Modeled Average Speed (mph)	Level of Service	CO Emission Rate (gram/veh-mile)	CO % Difference Compared to Average Speed	PM <sub>2.5</sub> Emission Rate (gram/veh-mile)	PM <sub>2.5</sub> % Difference Compared to Average Speed
Intersection Queue Link Average Speed	120	14.84	LOS B	3.135	-	0.0214	-
Intersection Queue Link HCM	20			1.555	-50.40%	0.01506	-29.62%
Intersection Queue Link GATech	220			1.644	-47.57%	0.0189	-11.72%
Intersection Queue Link Average Speed	123	13.24	LOS D	3.256	-	0.02276	-
Intersection Queue Link HCM	23			2.028	-37.71%	0.01679	-26.25%
Intersection Queue Link GATech	223			1.842	-43.41%	0.02118	-6.95%
Intersection Queue Link Average Speed	126	11.8	LOS E	3.393	-	0.02356	-
Intersection Queue Link HCM	26			2.345	-30.89%	0.01877	-20.32%
Intersection Queue Link GATech	226			2.067	-39.07%	0.02302	-2.27%



# Some of the Findings

- ❑ Variations in Age Distribution from year to year can impact emission rates
- ❑ Passenger Car to Passenger Truck Ratio is important
- ❑ The proportion of combination trucks in your fleet mix has a large influence on composite emission rates
- ❑ Although a small sample size from this analysis:
  - There is large variation in emissions rates when comparing average speed to the HCM based operating mode distribution and/or Georgia Tech operating mode distribution.

# Acknowledgments

- ❑ Michael Claggett and Paul Heishman from FHWA
- ❑ Ann Xu, Randy Guensler, and Vetri Elango from Georgia Tech
- ❑ Ron Kirby from the Metropolitan Washington Council of Governments (MWCOCG)

# Questions?