MOVES
Sensitivity Analysis Update

Transportation Research Board Summer Meeting 2012
ADC-20 Air Quality Committee

Presented by
Mark Glaze and Roger Wayson

John A. Volpe National Transportation Systems Center

U.S. Department of Transportation
Research and Innovative Technology Administration

OVERVIEW OF PRESENTATION

- Evaluation Parameters
- EPA's Sensitivity Analysis
- Comparison to Baseline Case
- MOVES Sensitivity Run Specification
- MOVES Sensitivity Input Parameters
- Results
- Uses of Study

EVALUATION PARAMETERS

- Sensitivity Analysis of MOVES
  - Conducted for Regional/County Scale
  - Focused on the running emissions process for CO, PM2.5, NOX, and VOCs
  - Temperature effects for Start and Evaporative emissions also included
  - Analysis results report the sensitivity of selected input parameters on predicted emissions rates by vehicle type

- MOVES Input Parameters Evaluated
  - Temperature
  - Humidity
  - Ramp Fraction
  - Analysis Year
  - Age Distribution
  - Average Speed Distribution
  - Vehicle Type
  - Drive Cycle

EPA SENSITIVITY STUDY

- *"MOVES Sensitivity Analysis: The Impacts of Temperature and Humidity of Emissions"*

- Focused on Temperature and Humidity
  - Included more temperature ranges for humidity sensitivity

- Analyzed impacts by fuel type (gasoline and diesel) and analysis year

- Majority of Sensitivity Analysis results showed the same trends as EPA analysis for temperature and humidity
  - Only difference was with CO and VOC results for diesel vehicle types

COMPARISON TO BASELINE CASE

- A ‘Baseline Case’ Developed For Comparison and For Efficiency of Analysis
  - Represents a regional (county level) scale analysis

- Utilized a Single Hour of Execution (run time consideration)
  - 8 AM Hour (morning peak)
  - 60º Fahrenheit*
  - 50% Relative Humidity*
    - * also evaluated

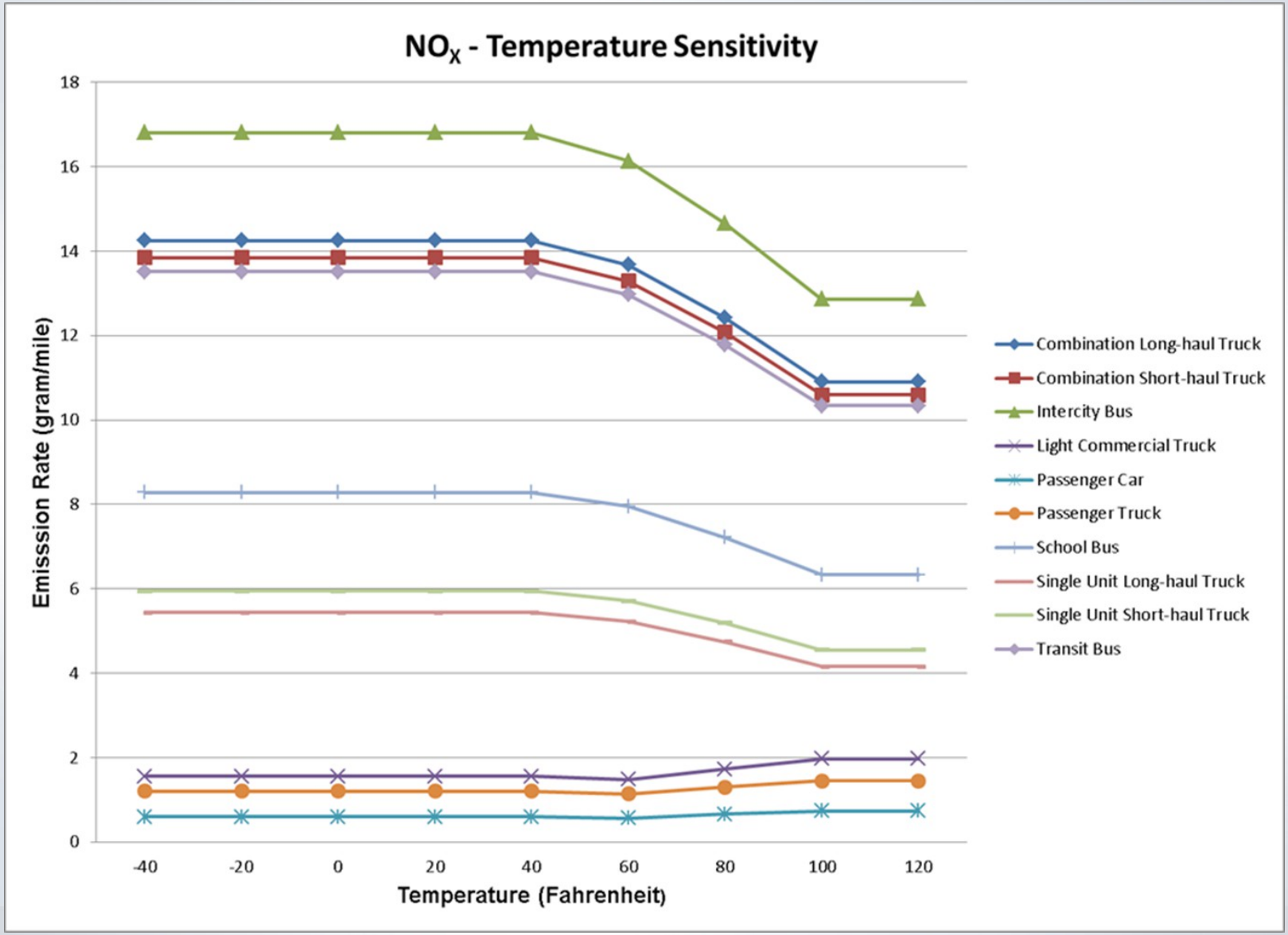
- National Defaults Utilized for General Input Parameters Required in Data Manager

MOVES SENSITIVITY RUN SPECIFICATIONS

Parameter	Description
Year	2010
Month	July
Day	Weekday
Hour	8:00 AM
Geographic Bounds	Nation
Road Type(s)	All
Age Distribution	2010 National default
Average Speed Distribution	National Default (8AM Weekday)
Fuel	National Default
Road Type Distribution	National Default
Ramp Fraction	National Default (0.08)
I/M Program	National Default
Vehicle Type VMT	Normalized - 1000 VMT per HPMS Vehicle Type
Source Type Population	Normalized - 1000 VMT per HPMS Vehicle Type
Temperature	60 degrees Fahrenheit
Humidity	50%

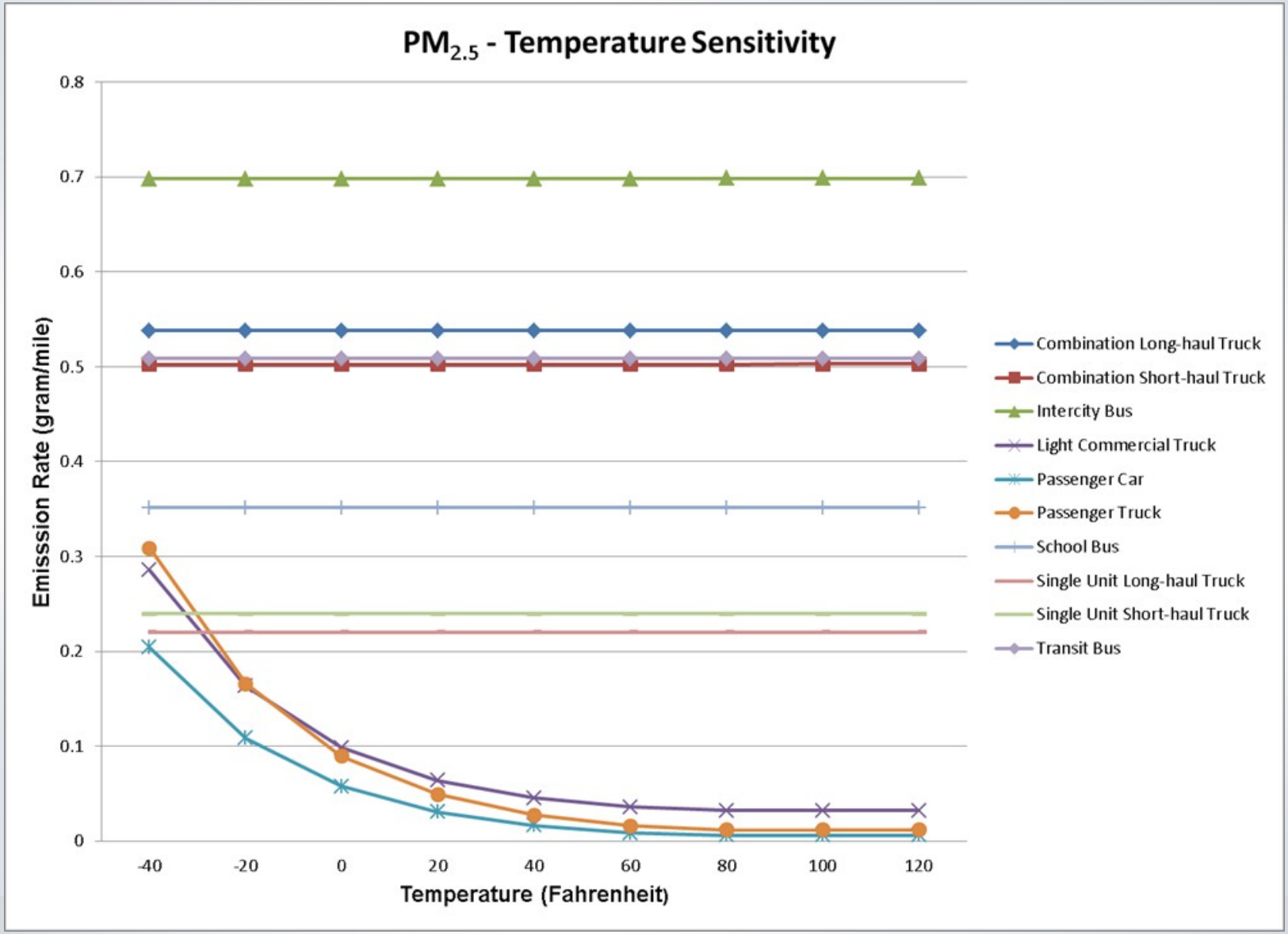
MOVES SENSITIVITY RUN INPUT PARAMETERS

Input Parameter	Parameter Values/Description
Temperature (Fahrenheit) includes starts and evaporative	-40º, -20º, 0º, 20º, 40º, 60º, 80º, 100º, 120º F
Humidity	0%, 20%, 40%, 50%, 60%, 80%, 100% (60º F and 80º F)
Ramp Fraction	0, 0.02, 0.04, 0.06, 0.10, 0.12 0.16, 0.20
Analysis Year	2010, 2020, 2030, 2040, 2050
Age Distribution	Group 1 = 0-10 years old Group 2 = 11-20 years old Group 3 = 21-30 years old
Average Speed Distribution - Urban Restricted Access - FC 11 Urban Interstate	LOS B,C,D,E,F
Average Speed Distribution - Urban Unrestricted Access - FC 12 Urban Principal Arterial Freeway	LOS C,D,E
Average Speed Distribution - Urban Restricted Access - FC 14 Urban Principal Arterial Other	LOS B,C,F


NOX - Temperature Sensitivity
Emission Rate (gram/mile)
0
2
4
6
8
10
12
14
16
18
-40
-20
0
20
40
60
80
100
120
Temperature (Fahrenheit)
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Passenger Car
Passenger Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus

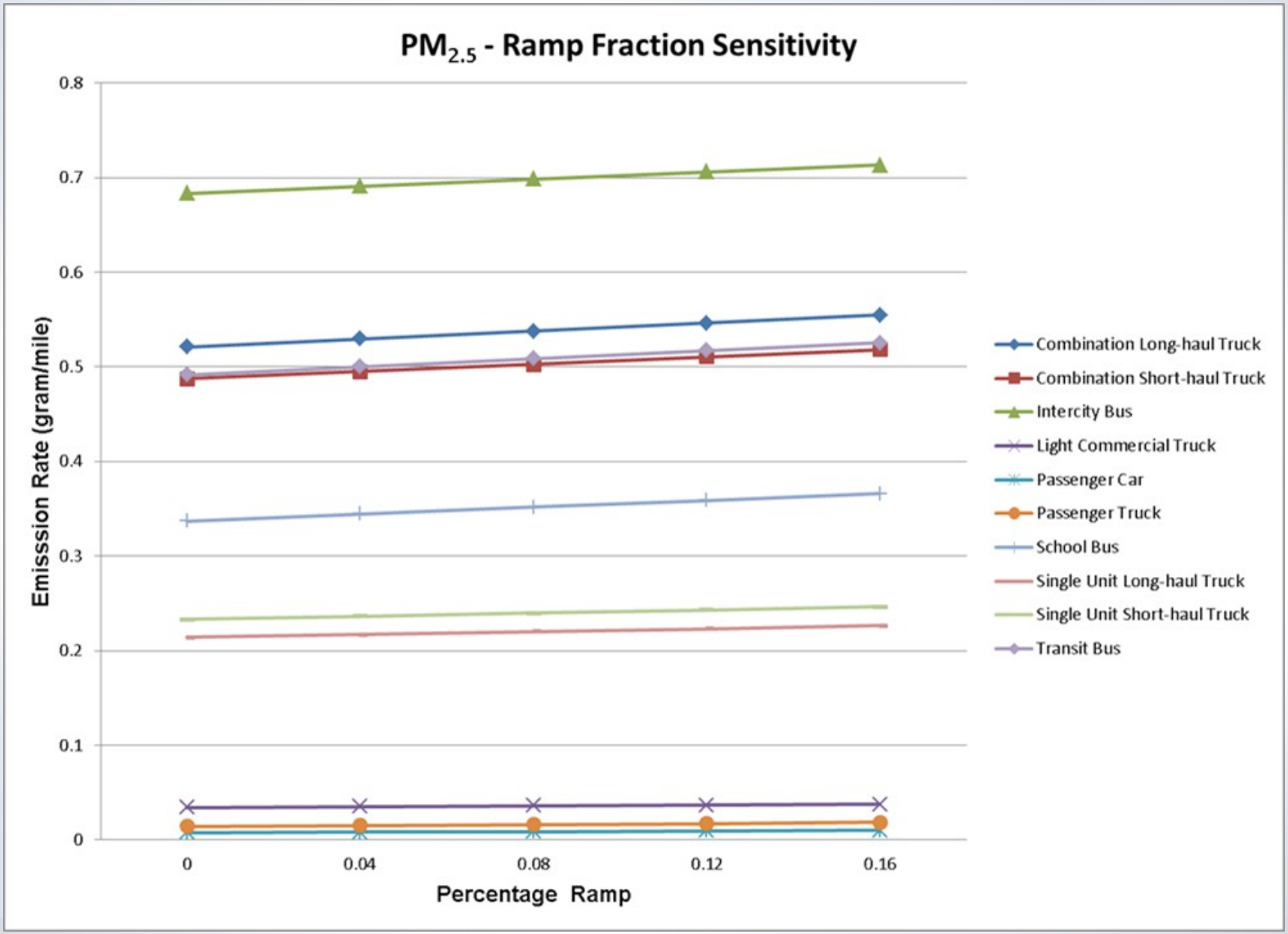
NOX TEMPERATURE SENSITIVITY RESULTS

Temperature (Fahrenheit)	Passenger Car		Passenger Truck		Single Unit Short-haul Truck		Combination Long-haul Truck	
	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
-40	0.593	6%	1.203	6%	5.947	4%	14.244	4%
-20	0.593	6%	1.203	6%	5.947	4%	14.244	4%
0	0.593	6%	1.203	6%	5.947	4%	14.244	4%
20	0.593	6%	1.203	6%	5.947	4%	14.244	4%
40	0.593	6%	1.203	6%	5.947	4%	14.244	4%
60	0.561	0%	1.137	0%	5.708	0%	13.673	0%
80	0.657	17%	1.306	15%	5.185	-9%	12.42	-9%
100	0.739	32%	1.449	27%	4.55	-20%	10.899	-20%
120	0.739	32%	1.449	27%	4.55	-20%	10.899	-20%


PM2.5 - Temperature Sensitivity
Emisssion Rate (gram/mile)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-40
-20
0
20
40
60
80
100
120
Temperature (Fahrenheit)
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Passenger Car
Passenger Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus

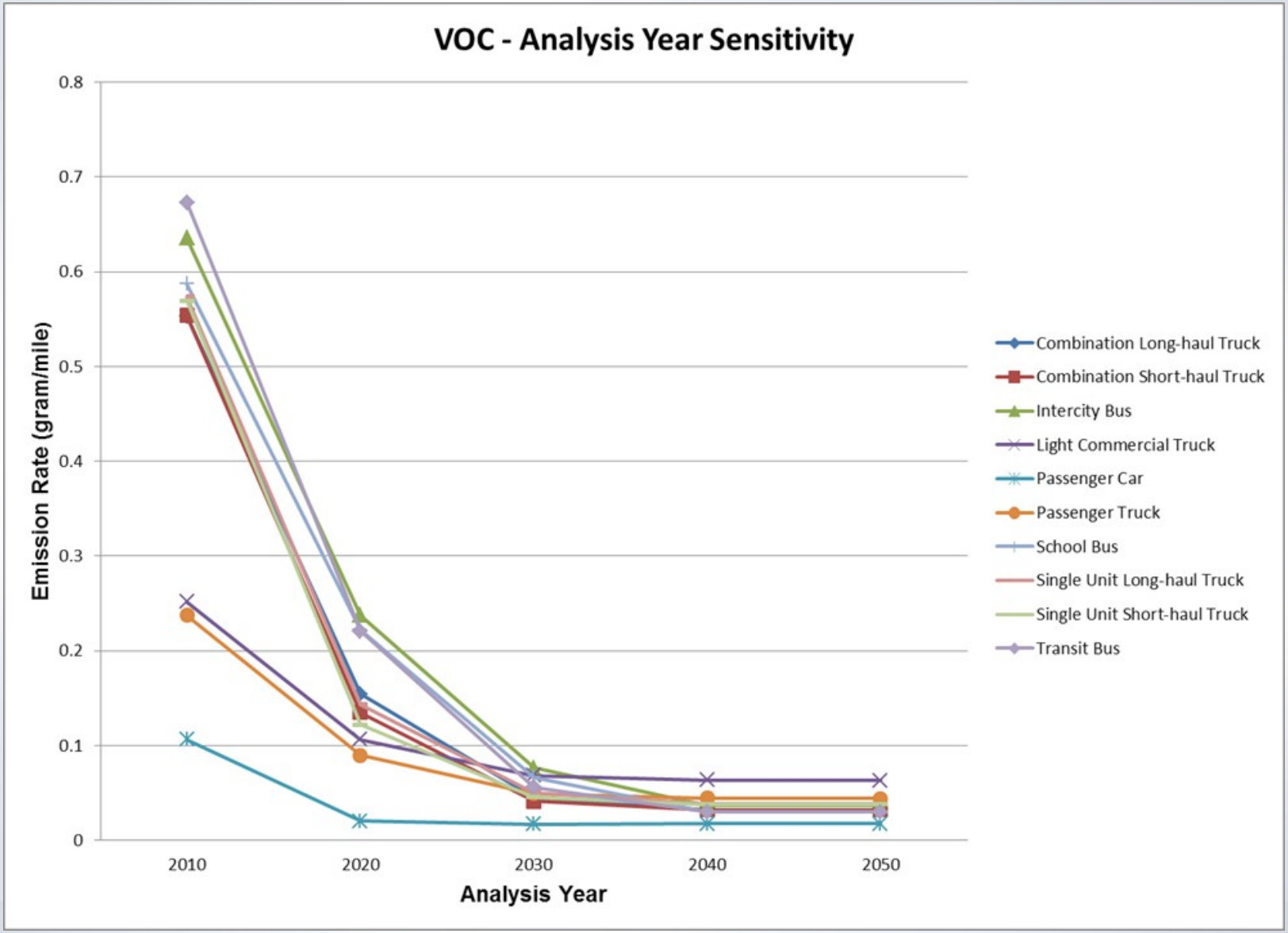
PM2.5 TEMPERATURE SENSITIVITY RESULTS

Temperature (Fahrenheit)	Passenger Car		Passenger Truck		Single Unit Short-haul Truck		Combination Long-haul Truck	
	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
-40	0.2039	2225%	0.3087	1794%	0.2397	0.00%	0.5378	0.00%
-20	0.1085	1137%	0.1657	916%	0.2397	0.00%	0.5378	0.00%
0	0.0577	558%	0.0896	450%	0.2397	0.00%	0.5378	0.00%
20	0.0307	250%	0.0492	202%	0.2397	0.00%	0.5378	0.00%
40	0.0164	87%	0.0277	70%	0.2397	0.00%	0.5378	0.00%
60	0.0088	0%	0.0163	0%	0.2397	0.00%	0.5378	0.00%
80	0.006	-32%	0.0121	-26%	0.2397	0.02%	0.5379	0.01%
100	0.006	-32%	0.0121	-26%	0.2398	0.04%	0.5379	0.03%
120	0.006	-32%	0.0121	-26%	0.2398	0.04%	0.5379	0.03%


PM2.5 - Ramp Fraction Sensitivity
Emisssion Rate (gram/mile)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.04
0.08
0.12
0.16
Percentage Ramp
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Passenger Car
Passenger Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus

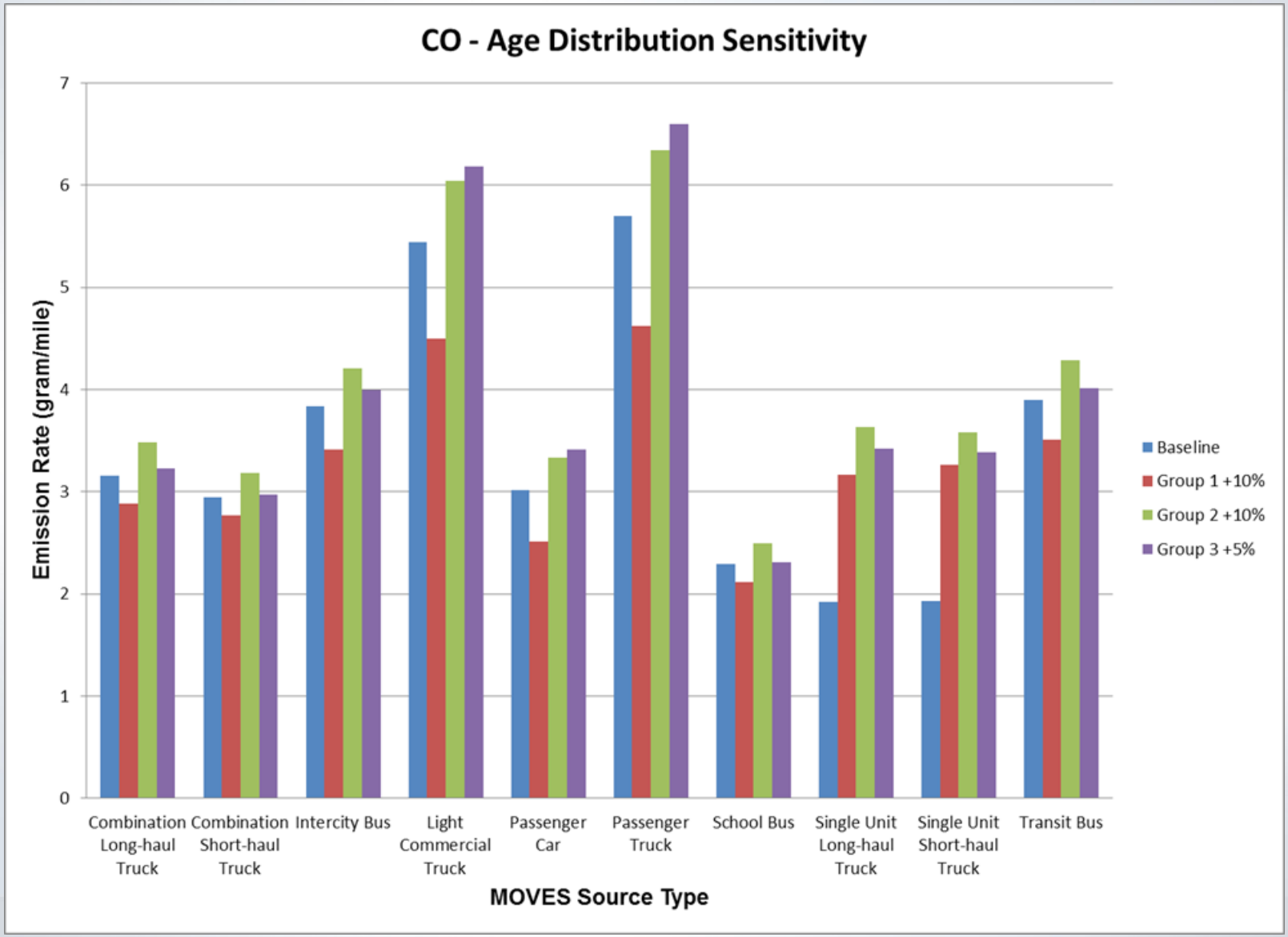
PM2.5 RAMP FRACTION SENSITIVITY RESULTS

Ramp Fraction	Passenger Car		Passenger Truck		Single Unit Short-haul Truck		Combination Long-haul Truck	
	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
0	0.0075	-15%	0.0143	-12%	0.233	2.70%	0.521	-3.10%
0.02	0.0078	-11%	0.0148	-9%	0.235	2.00%	0.525	-2.40%
0.04	0.0081	-7%	0.0153	-6%	0.236	1.40%	0.529	-1.60%
0.06	0.0085	-4%	0.0158	-3%	0.238	0.70%	0.534	-0.80%
0.08	0.0088	0%	0.0163	0%	0.24	0.00%	0.538	0.00%
0.1	0.0091	4%	0.0168	3%	0.241	0.70%	0.542	0.80%
0.12	0.0094	7%	0.0173	6%	0.243	1.40%	0.546	1.60%
0.16	0.0101	15%	0.0183	12%	0.246	2.70%	0.555	3.10%
0.2	0.0107	22%	0.0194	19%	0.249	4.10%	0.563	4.70%


VOC - Analysis Year Sensitivity
Emission Rate (gram/mile)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2010
2020
2030
2040
2050
Analysis Year
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Passenger Car
Passenger Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus

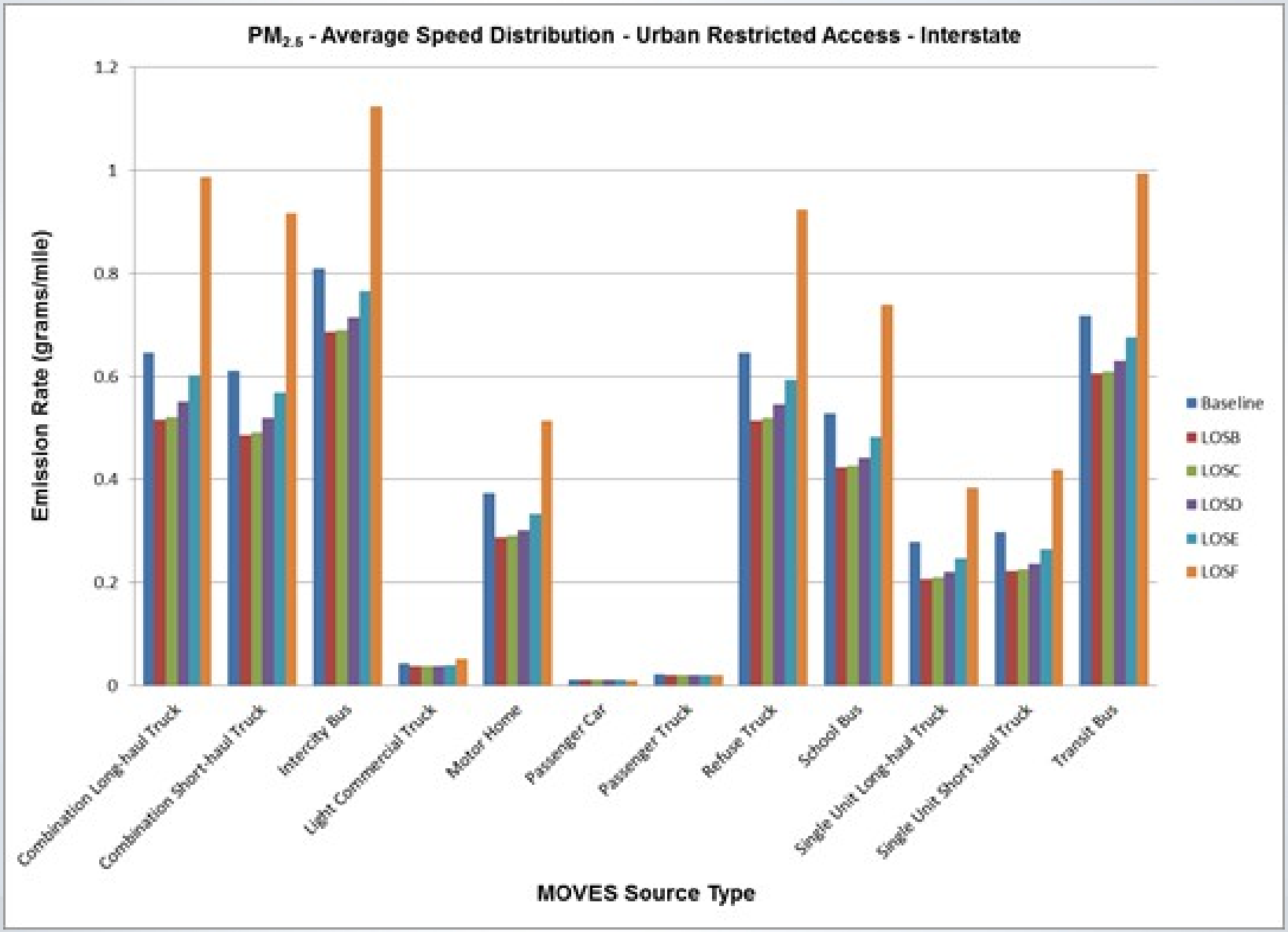
VOC ANALYSIS YEAR SENSITIVITY RESULTS

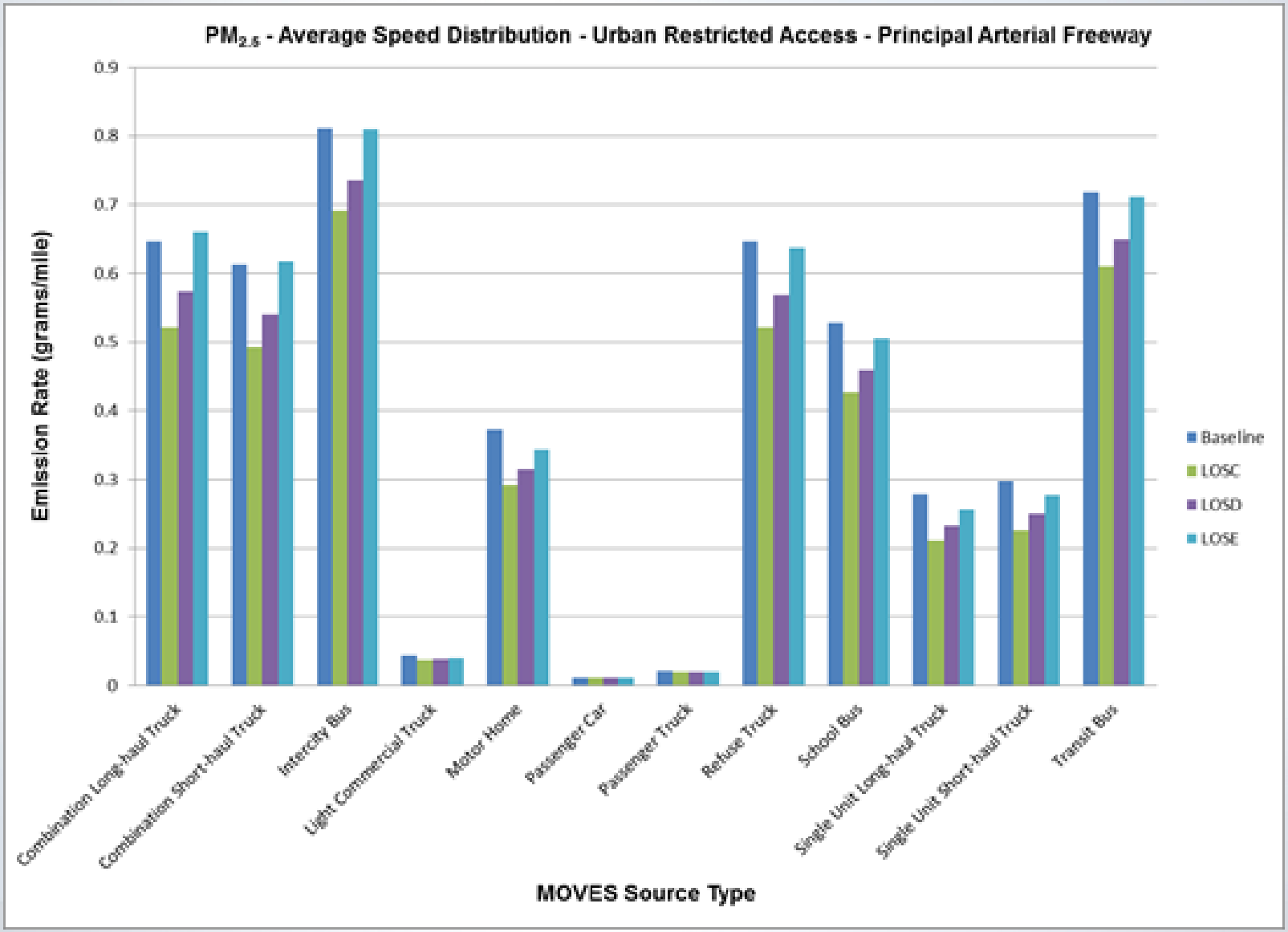
Analysis Year	Passenger Car		Transit Bus		Combination Long-haul Truck	
	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
2010	0.105	0.00%	0.6602	0%	0.7245	0%
2020	0.0202	-80.80%	0.217	-67.10%	0.253	-65.10%
2030	0.0167	-84.10%	0.0555	-91.60%	0.0831	-88.50%
2040	0.0172	-83.60%	0.0297	-95.50%	0.0397	-94.50%
2050	0.0173	-83.50%	0.0297	-95.50%	0.0396	-94.50%

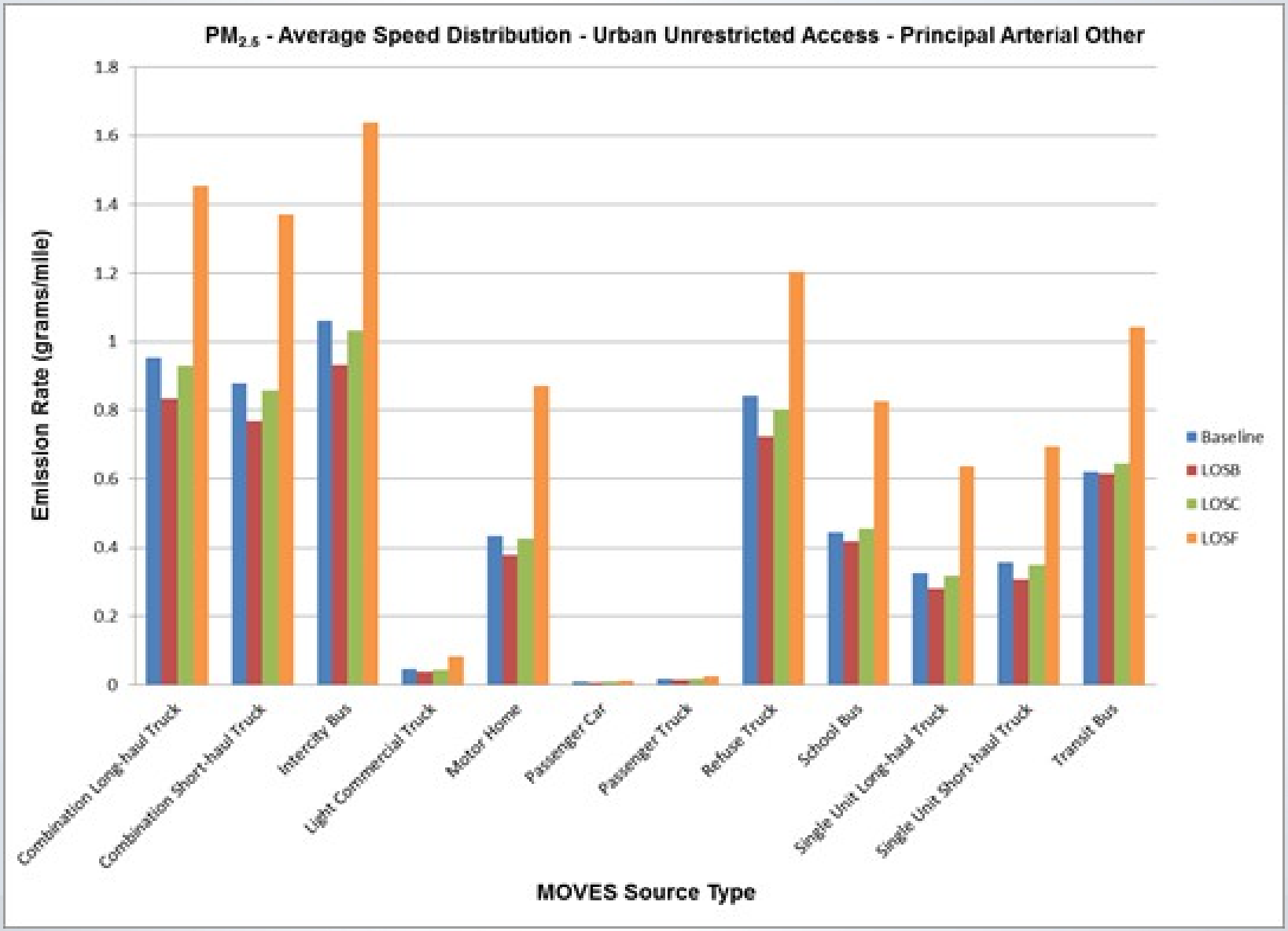

CO - Age Distribution Sensitivity
Emission Rate (gram/mile)
0
1
2
3
4
5
6
7
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Passenger Car
Passenger Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
MOVES Source Type
Baseline
Group 1 +10%
Group 2 +10%
Group 3 +5%

CO AGE DISTRIBUTION SENSITIVITY RESULTS

Age Distribution	Passenger Car		Passenger Truck		Transit Bus		Combination Long-haul Truck	
	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
Baseline	3.016	0%	5.699	0%	3.901	0%	3.156	0%
Group 1	2.513	-16.70%	4.624	-18.90%	3.509	-10.10%	2.882	-8.70%
Group 2	3.332	10.50%	6.342	11.30%	4.286	9.80%	3.485	10.40%
Group 3	3.416	13.30%	6.602	15.80%	4.016	2.90%	3.226	2.20%


PM2.5 - Average Speed Distribution - Urban Restricted Access - Interstate
Emission Rate (grams/mile)
1.2
1
0.8
0.6
0.4
0.2
0
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Motor Home
Passenger Car
Passenger Truck
Refuse Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
MOVES Source Type
Baseline
LOSB
LOSC
LOSD
LOSE
LOSF


PM2.5 - Average Speed Distribution - Urban Restricted Access - Principal Arterial Freeway
Emission Rate (grams/mile)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Motor Home
Passenger Car
Passenger Truck
Refuse Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
MOVES Source Type
Baseline
LOSC
LOSD
LOSE


PM2.5 - Average Speed Distribution - Urban Unrestricted Access - Principal Arterial Other
Emission Rate (grams/mile)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Combination Long-haul Truck
Combination Short-haul Truck
Intercity Bus
Light Commercial Truck
Motor Home
Passenger Car
Passenger Truck
Refuse Truck
School Bus
Single Unit Long-haul Truck
Single Unit Short-haul Truck
Transit Bus
Baseline
LOSB
LOSC
LOSF
MOVES Source Type

PM2.5 AVERAGE SPEED DISTRIBUTION SENSITIVY RESULTS

LOS	Functional Classification	Passenger Car		Passenger Truck		Light Commercial Truck	
		Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
Baseline	Urban Interstate/Principal Urban Arterial - Freeway	0.0115	-	0.0217	-	0.0431	-
B	Urban Interstate	0.0108	-6.46%	0.0203	-6.21%	0.0374	-13.14%
C	Urban Interstate	0.0109	-5.85%	0.0204	-5.68%	0.0375	-12.91%
D	Urban Interstate	0.0108	-6.09%	0.0204	-6.05%	0.0378	-12.22%
E	Urban Interstate	0.0106	-7.80%	0.0201	-7.39%	0.0393	-8.71%
F	Urban Interstate	0.0096	-16.48%	0.0191	-11.76%	0.0517	20.12%
C	Principal Urban Arterial -Freeway	0.0109	-5.94%	0.0204	-5.87%	0.0374	-13.07%
D	Principal Urban Arterial -Freeway	0.0110	-4.51%	0.0207	-4.68%	0.0386	-10.31%
E	Principal Urban Arterial -Freeway	0.0106	-8.43%	0.0200	-7.93%	0.0398	-7.72%
Baseline	Principal Urban Arterial - Other	0.0083	-	0.0163	-	0.0451	-
B	Principal Urban Arterial - Other	0.0073	-11.57%	0.0144	-11.43%	0.0387	-14.19%
C	Principal Urban Arterial - Other	0.0078	-5.16%	0.0156	-4.54%	0.0433	-4.05%
F	Principal Urban Arterial - Other	0.0118	43.38%	0.0244	49.35%	0.0830	84.13%

PM2.5 AVG SPEED DISTRIBUTION SENSITIVITY RESULTS

LOS	Functional Classification	Single Unit Short-haul Truck		Combination Short-haul Truck	
		Emission Rate (gram/mile)	% difference	Emission Rate (gram/mile)	% difference
Baseline	Urban Interstate/Principal Urban Arterial - Freeway	0.298	-	0.612	-
B	Urban Interstate	0.221	-25.80%	0.487	-20.50%
C	Urban Interstate	0.225	-24.46%	0.492	-19.60%
D	Urban Interstate	0.236	-20.86%	0.518	-15.30%
E	Urban Interstate	0.265	-11.08%	0.568	-7.16%
F	Urban Interstate	0.418	40.10%	0.917	49.85%
C	Principal Urban Arterial -Freeway	0.227	-24.08%	0.492	-19.56%
D	Principal Urban Arterial -Freeway	0.250	-16.21%	0.540	-11.73%
F	Principal Urban Arterial -Freeway	0.277	-7.19%	0.618	1.00%
Baseline	Principal Urban Arterial - Other	0.357	-	0.878	-
B	Principal Urban Arterial - Other	0.307	-14.17%	0.768	-12.53%
C	Principal Urban Arterial - Other	0.348	-2.64%	0.856	-2.41%
F	Principal Urban Arterial - Other	0.695	94.57%	1.370	56.09%

REPORT

- Report Preparation in Final Stages

HOPES

- Results Provide
  - Better Understanding of Input Sensitivity
  - Insight for Analysts
  - Highlights Areas of Importance