ANALYSIS OF A SENSOR-BASED SYSTEM FROM SEVERAL CLASS 8 TRUCKS DURING A LONG TERM MEASUREMENT STUDY

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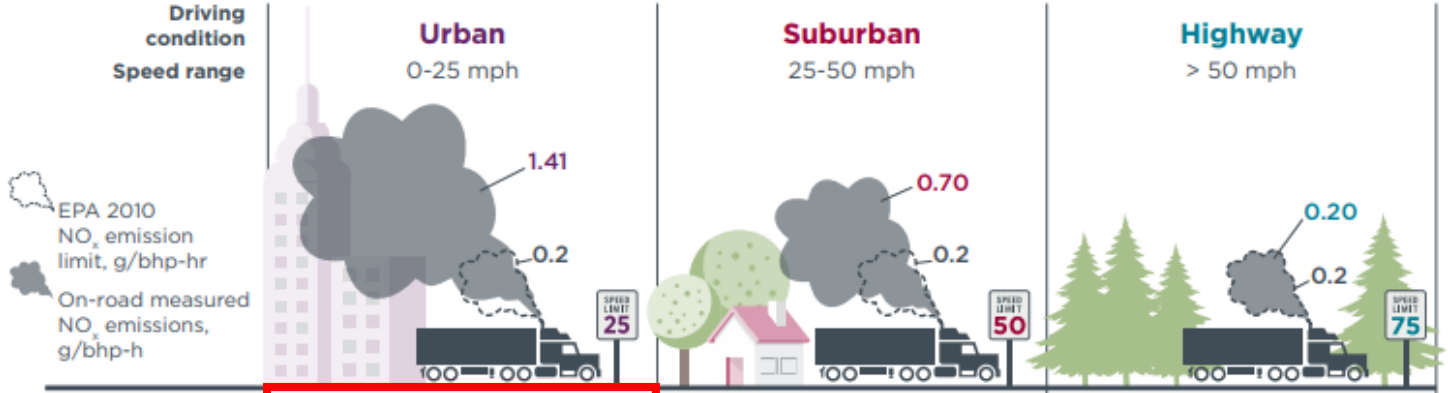
In-use Emissions Are Higher



Driving condition	Urban	Suburban	Highway
Speed range	0-25 mph	25-50 mph	> 50 mph
Average time spent at this condition	43%	11%	46%
Average share NO_x mass	40%	23%	37%
Brake specific NO_x emissions, g/bhp-hr	1.41*	0.70	0.20
Conformity Factor - CF	7.1*	3.5	1.0
Distance-specific NO_x emissions, g/mile	7.0*	2.4	0.6

** Brake and distance specific NOx emissions for Urban bin do not include Idle operation, only 1-25 mph operation is included*

- 189 tests between 2010 and 2019
- MY 2010-2016 with SCR Technology

- **43%** of the activity is between 0-25 mph
- This represents **40%** of the NOx mass

Source: ICCT white paper Nov 2019

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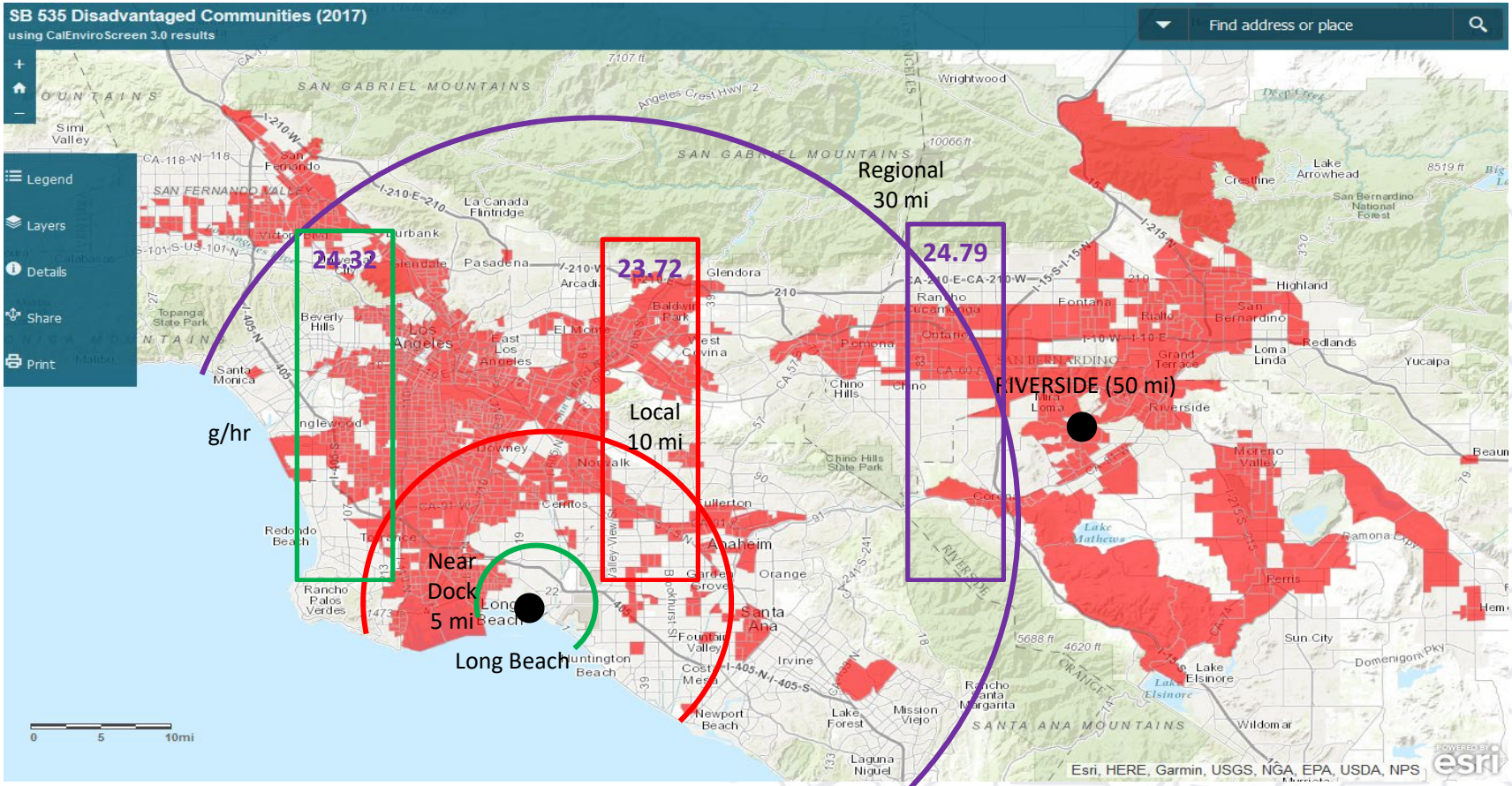
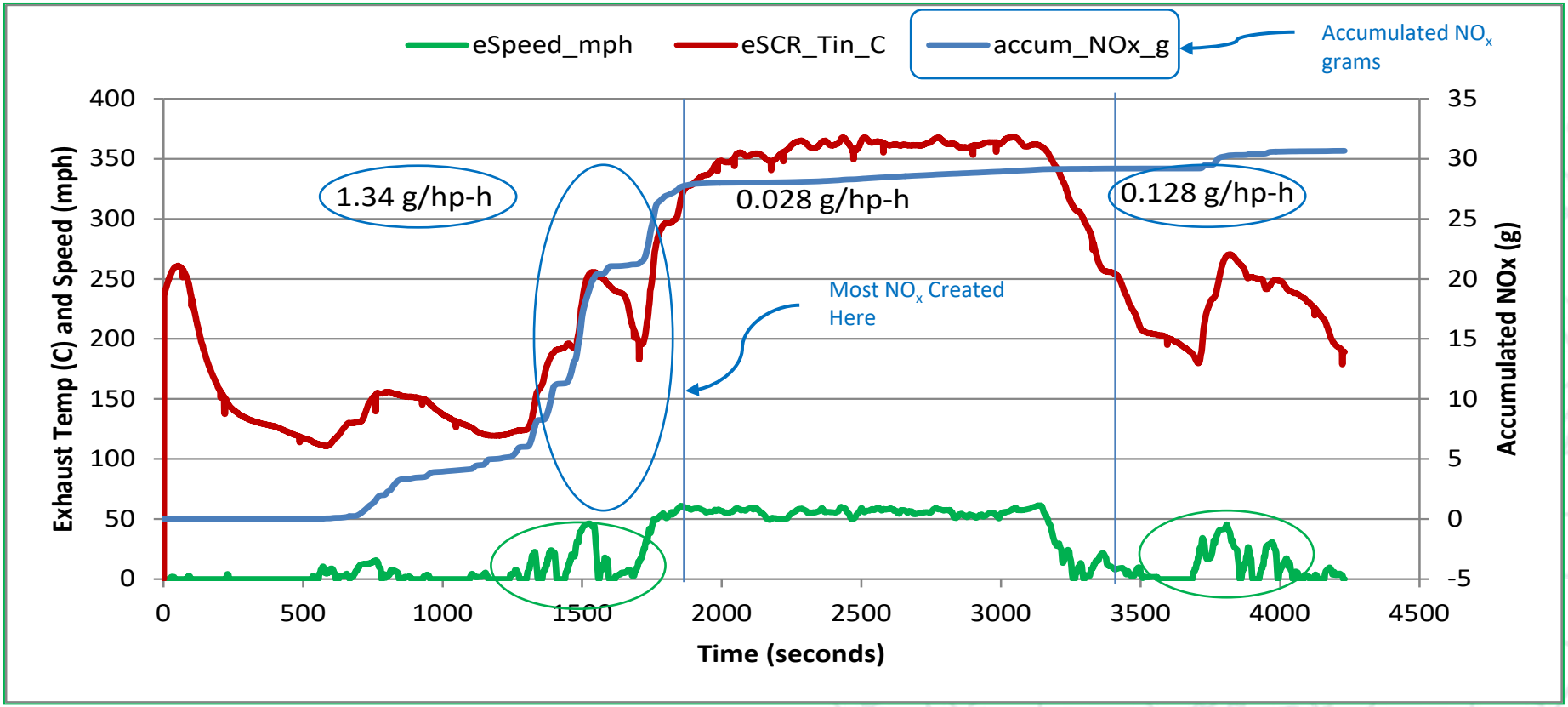
Community Impacts Are Important



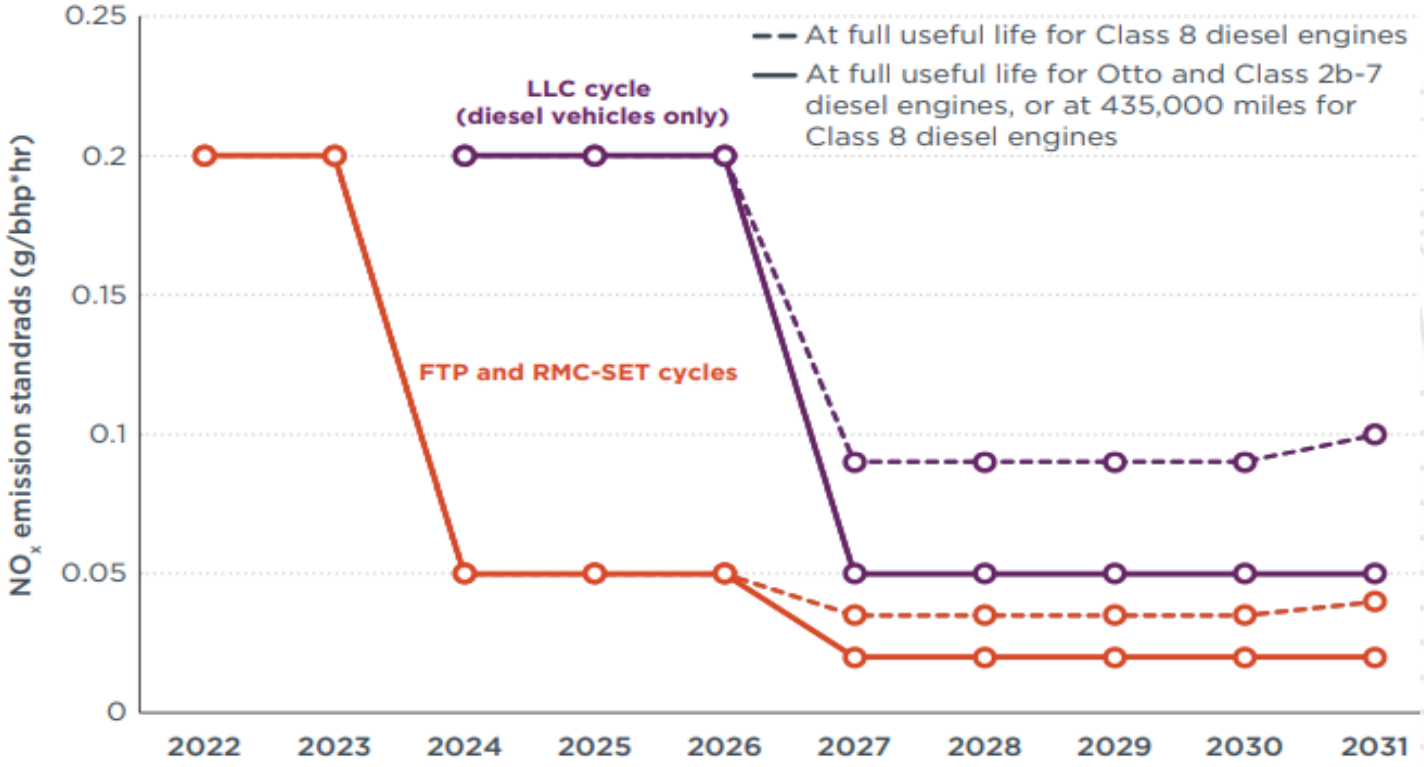
Why Does This Occur? Predictable?

2011 SCR Diesel Vehicle



Source: UCR Miller et al (2013), Final report to SC-AQMD and CWI "In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy Duty Engines", Sep 2013

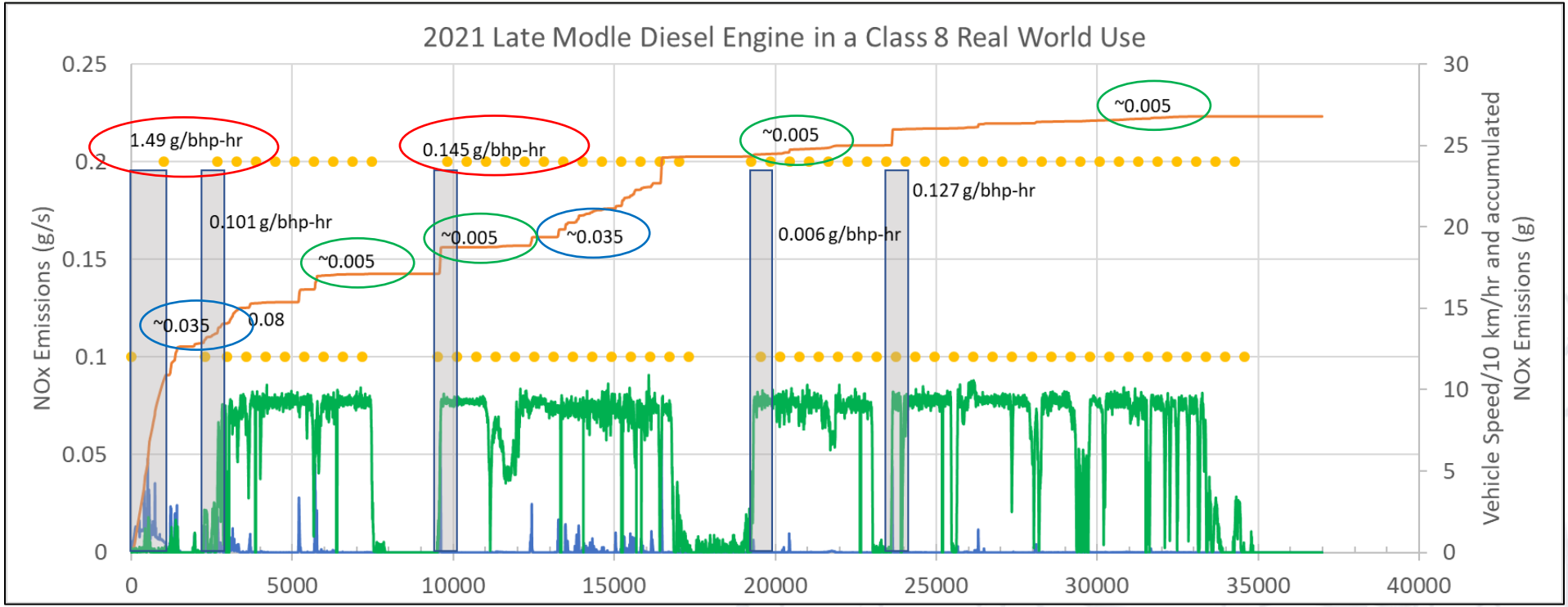
NO_x Emissions: Further Reductions



- CARB and EPA are reducing NOx further from 0.2 to 0.02 g/hp-hr
- There is also the introduction of a low load cycle targeting 0.05 g/hp-hr.

Ref: ICCT policy update: Heavy-Duty Omnibus Regulation Dec 2021(CARB)

It Still Occurs on 2021 Diesel Trucks



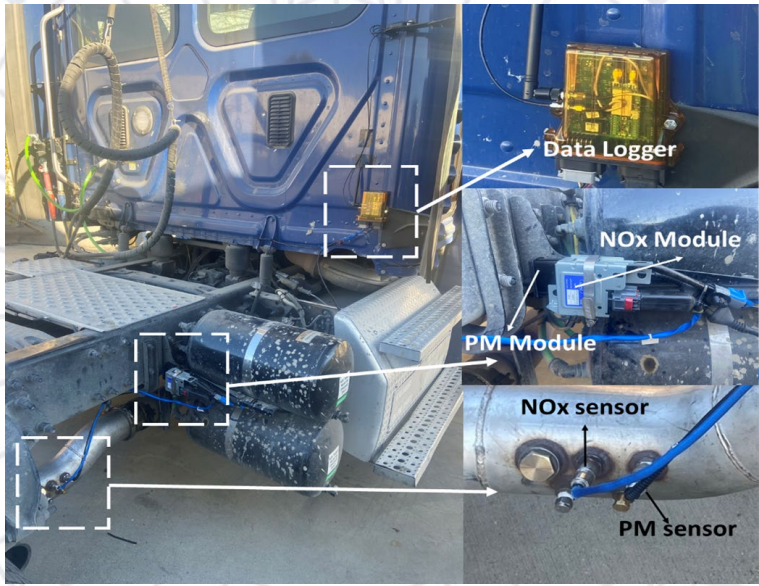
- Localized emissions ranged from 1.49, 0.145, 0.035, to 0.005 g/hp-hr
- Cycle average emissions for this 10 hr shift was 0.023 g/hp-hr
- This truck/**route** meets the future EPA in-use compliance 3BIN MAW

Source: Johnson et al (2022) OSAR Board Meeting, "On-Board Sensing, Analysis, and Reporting (OSAR) Update" Presentation March 30, 2022

OSAR Project Goals

- Onboard Sensing Analysis and Reporting (OSAR) was developed for continuous monitoring of diesel technologies annually
- OSAR started out as a consortium lead research initiative, but has now grown to over nine funded programs
- OSAR includes
  - NOx, PM, GPS, CAN, and other sensors
  - Auto starting and shutdown to capture cold starts and all truck operation

NOx/O2 Module | PM Module | Data Logger (CAN, GPS, LTE) | GPS & LTE Antennas



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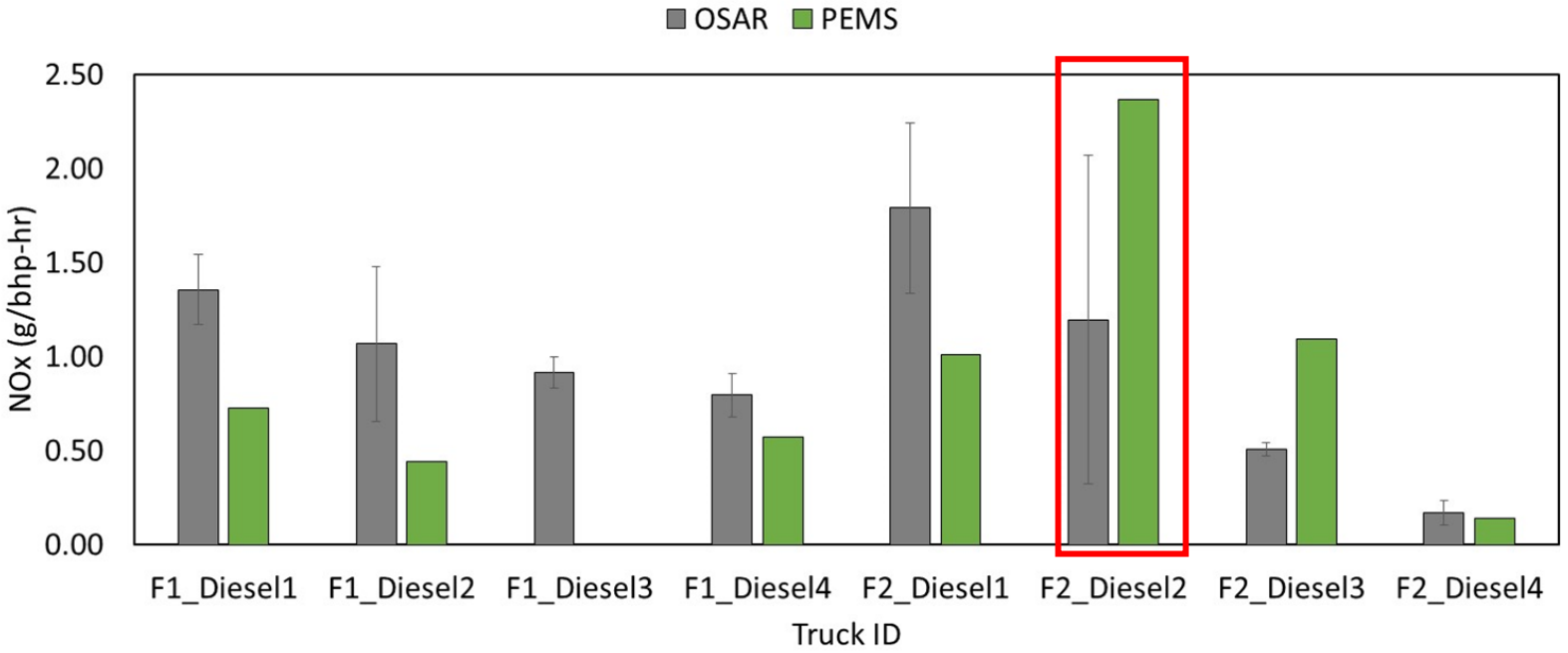
OSAR Existing Research

- **System development**
  - SC-AQMD: Phase 1
  - CARB: ZANZEFF
  - CARTEEH: Binning
- **Aging evaluation**
  - EPA
- **New Sensors and Advances**
  - CARB: 100 + Installs, New Sensors (exg. lasers), On-Road, Off Road
- **Community impacts, mitigation, and eco routing**
  - Attorney General (AG): VW Funds 1.6Mil OMEGA
  - AQMD: Phase 2
- **Fuels impacts**
  - DOT: Bio Fuels
  - CARB: Low NOx Engines

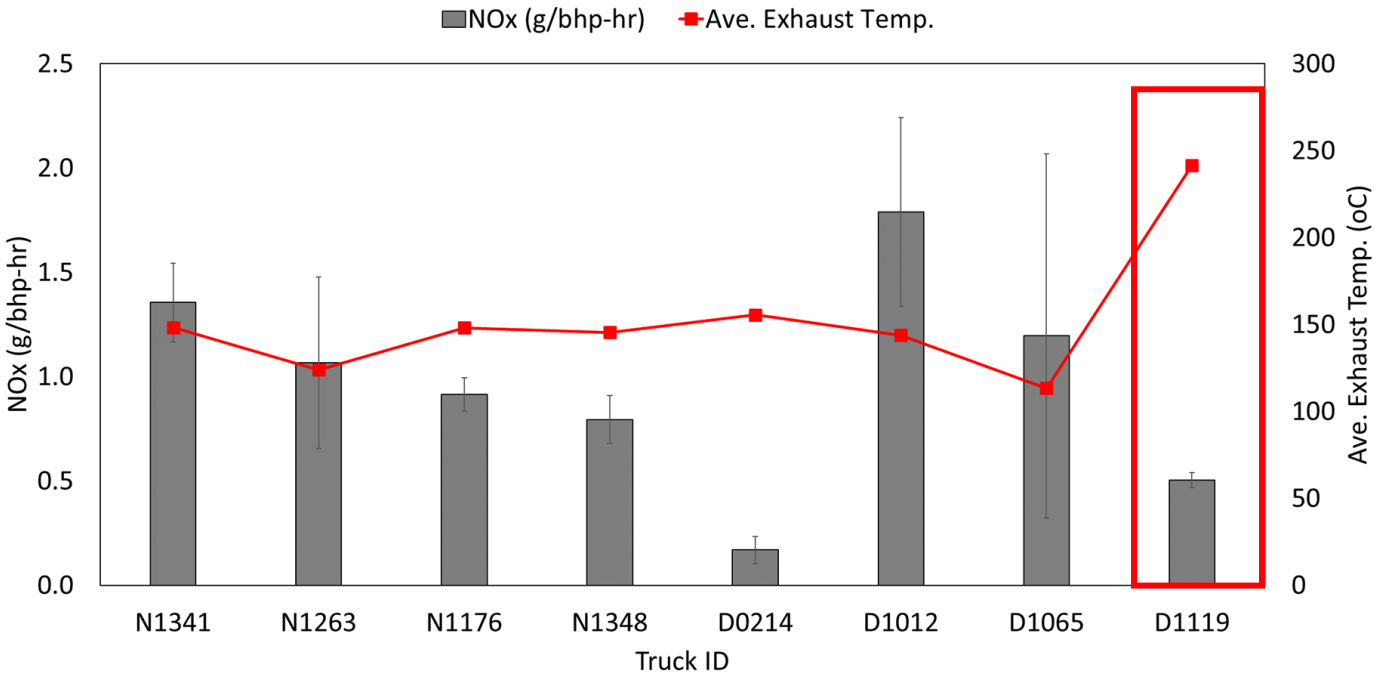
One Day Is Not Enough



- The one day result for truck F2_D2 was 2.3 but the two week result varied day to day from 2.3 to 0.2 g/hp-hr for the same truck.
- NO_x emissions are heavily dependent on the route.

Source: Johnson et al (2021), Final report to SC-AQMD "CALIFORNIA AIR RESOURCES BOARD ZERO- AND NEAR-ZERO EMISSIONS FREIGHT FACILITY (ZANZEFF) GRANT", July 2021

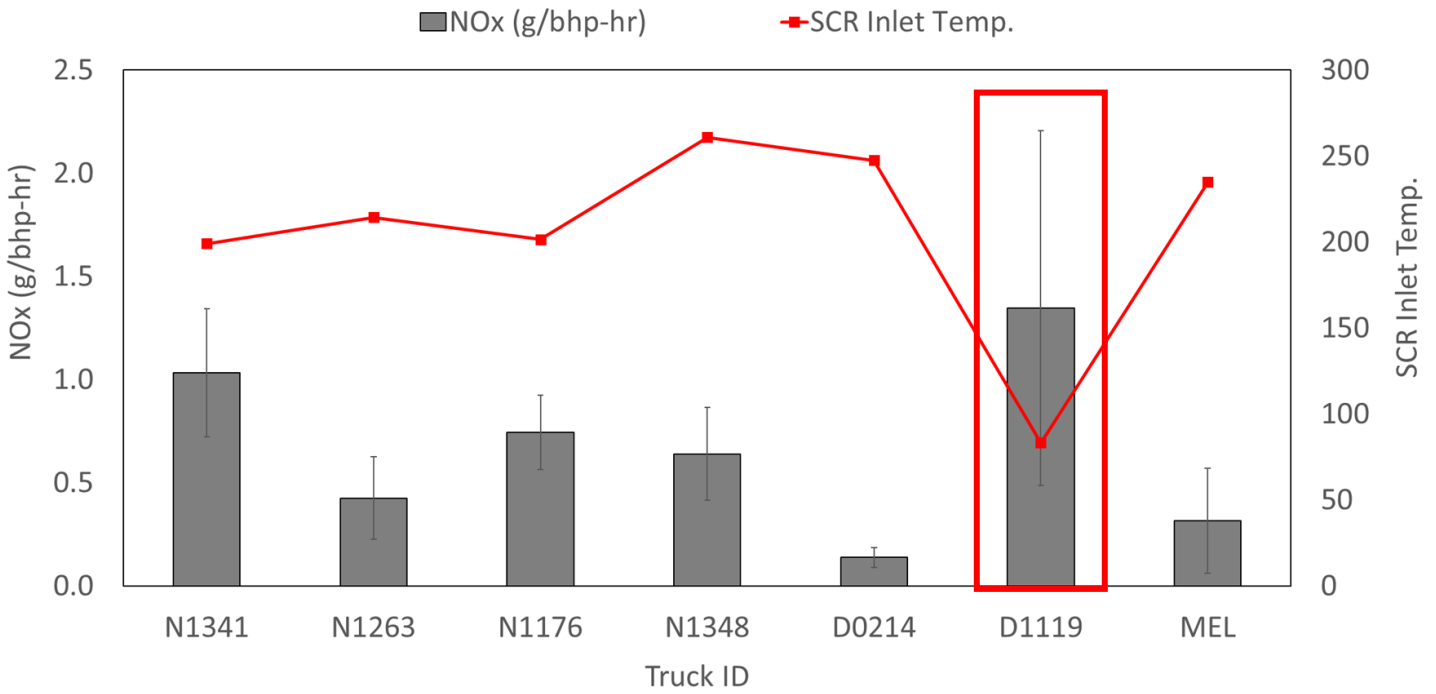
Are Two Weeks Enough?



- The two week results for truck D1119 was 0.5 g/hp-hr and had a small range (varied from 0.6 to 0.4)
- What will the two months NO_x emissions look like?

Source: Johnson et al (2022), Final report to SC-AQMD "Onboard Sensing, Analysis, and Reporting (OSAR): Phase 1 Sensor Evaluation on Heavy Duty Trucks", Nov 2022

Two Weeks Are Not Enough



- The two month results for D1119 changed from 0.5 to a range covering 2.4 to 0.4 g/hp-hr.
- This suggests two weeks is not sufficient. Are Two Months?

Source: Johnson et al (2022), Final report to SC-AQMD "Onboard Sensing, Analysis, and Reporting (OSAR): Phase 1 Sensor Evaluation on Heavy Duty Trucks", Nov 2022

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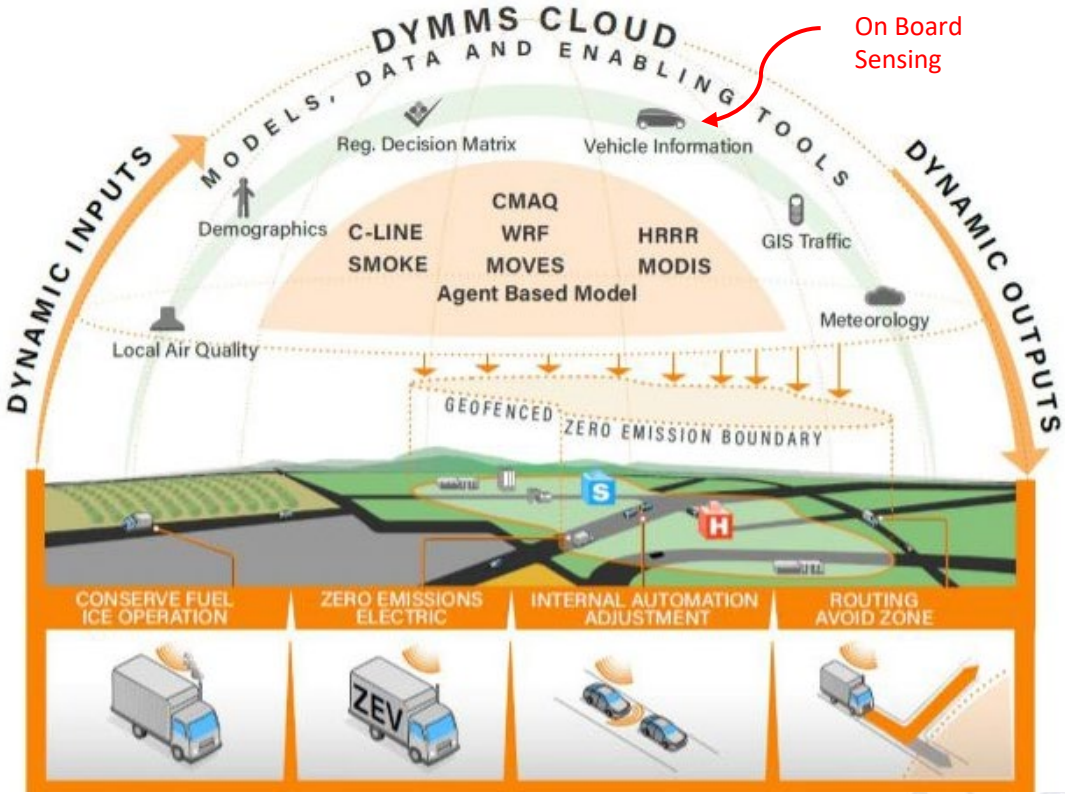
Summary

- Diesel mobile sources are heavily dependent on the routes, payload, traffic, maintenance, weather, and other environmental conditions.
- Diesel mobile sources appear to vary from day to day where one day, two weeks, and two months were all significantly different by as much as 2-3 times.
- These results suggest constant measurements are necessary to understand community impacts and exposure from mobile diesel sources.

- It is unknown how the 2027 designed low NO_x and low duty cycle designed engines will perform

Ultimate Vision of OSAR

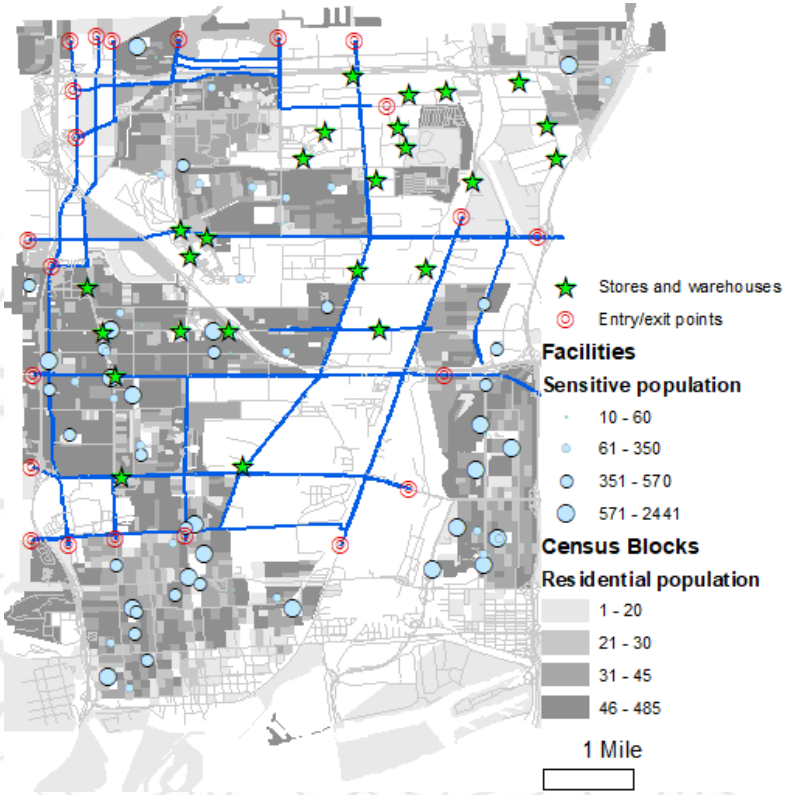


- The **Dynamic Mobility Management System** will collect data from vehicles, the transportation system, and the atmosphere and use these inputs to implement real-time decisions on vehicle behavior and energy management.

Geofencing Exg: Exposure

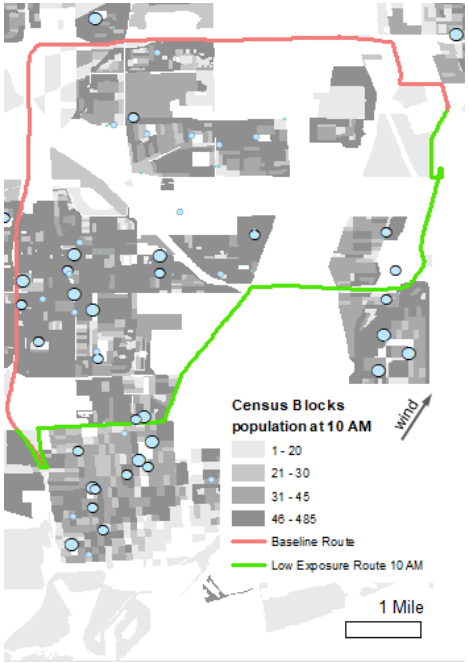
- Truck trip origins/destinations
  - 22 entry/exit points to/from the city
  - 25 truck trip attractions (e.g., large retail stores, logistic centers, and warehouses) inside the city
  - 22 x 25 x 2 = 1,100 trips

- For each trip, calculate multiple routes for comparison:
  - Low exposure route (LER)
  - Baseline route (BR)

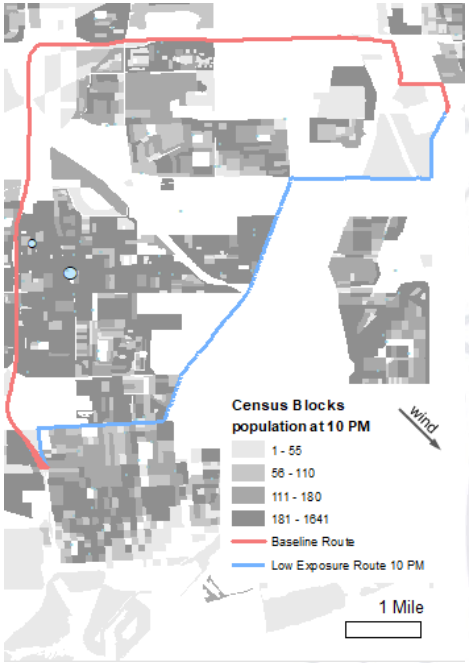


Low Exposure Route (LER)

10 A.M.



10 P.M.



	10 A.M.		
	BR	LER	% Diff.
Trip Distance (miles)	11.9	9.3	-22%
Trip Time (minutes)	16.4	17.0	4%
Inhaled Mass of PM2.5 (µg)	0.3	0.1	-73%
Inhaled Mass of NOx (µg)	29.9	20.6	-31%
Tailpipe emission of CO2 (kg)	17.6	15.9	-9%

	10 P.M.		
	BR	LER	% Diff.
Trip Distance (miles)	11.9	8.7	-27%
Trip Time (minutes)	15.9	17.6	11%
Inhaled Mass of PM2.5 (µg)	3.7	0.9	-77%
Inhaled Mass of NOx (µg)	369.0	205.7	-44%
Tailpipe emission of CO2 (kg)	17.4	15.5	-11%

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What is Still Needed

- Use binning method to predict local community impacts
- Measurement based metric for carbon and emissions trading
- Databasing for other evaluations
- What is the impact of Marine OGV and port communities
- What is impact of locomotives on communities
- What is impact of Construction on communities
- Evaluation of 2027 designed low load engine technology

Acknowledgement

We acknowledge funding from the South Coast Air Quality Management District, the California Air Resources Board, the Environmental Protection Agency and EmiSense. We also acknowledge our consortium members for their vision to support the program on a yearly basis

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South Coast AQMD

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

OSAR Consortium

Emisense

CALIFORNIA AIR RESOURCES BOARD