MEASURING "REAL WORLD" HEAVY-DUTY DIESEL EMISSIONS WITH A MOBILE LAB

8th Diesel Engine Emissions Reduction-DEER Conference

San Diego, CA.

August 29, 2002

University of California, Riverside
Bourns College of Engineering
Center for Environmental Research and Technology
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CE-CERT Personnel

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Today's Topics

- Project Objectives
- Verification activities
  - Calibration checks
  - Independent checks
- Data from various cycles
  - Stationary
  - Certification-like
  - Model building
  - In-use/real world

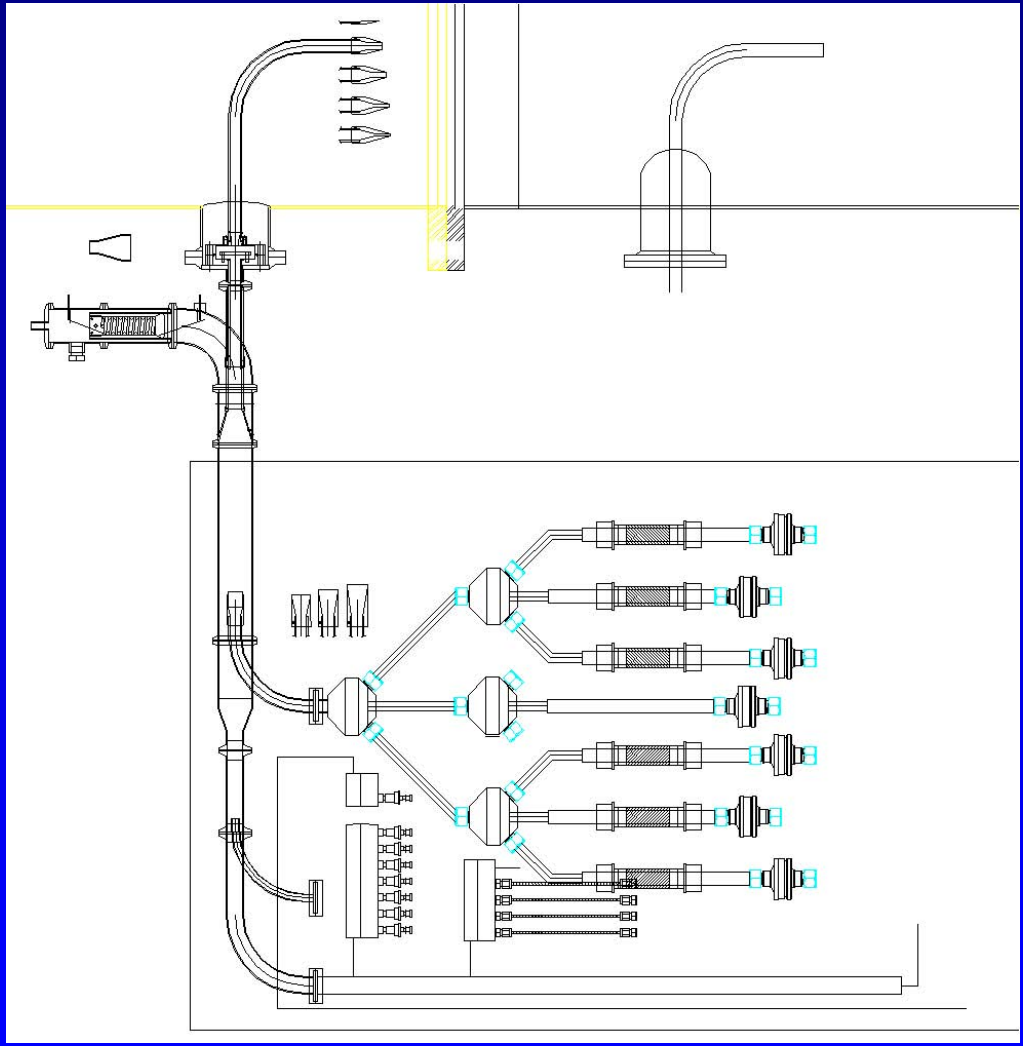
Project Objectives

- Measure “real world” emissions at CFR quality
  - Regulated
  - Air Toxics
- Develop models to predict emissions based on engine and fuel parameters, control technologies and other factors.

CE-CERT's HDD Mobile Lab

Inside the Mobile Laboratory

Secondary Dilution Tunnel



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Verification Approach

- Analytical Bench
  - Calibration gases
  - Multiple analytical instruments
- System checks
  - Propane recovery at >98%
  - CO_2 mass balance at >98%
- External lab

Verification with CARB Lab

- Verification testing performed at CARB HDDT test facility
- 2000 Freightliner Tractor, CAT C-15
- Hot UDDS Cycle

	NO_x	CO_2	CO	THC	PM
UCR/CARB	8%	2.7%	18%	12%	0.1%

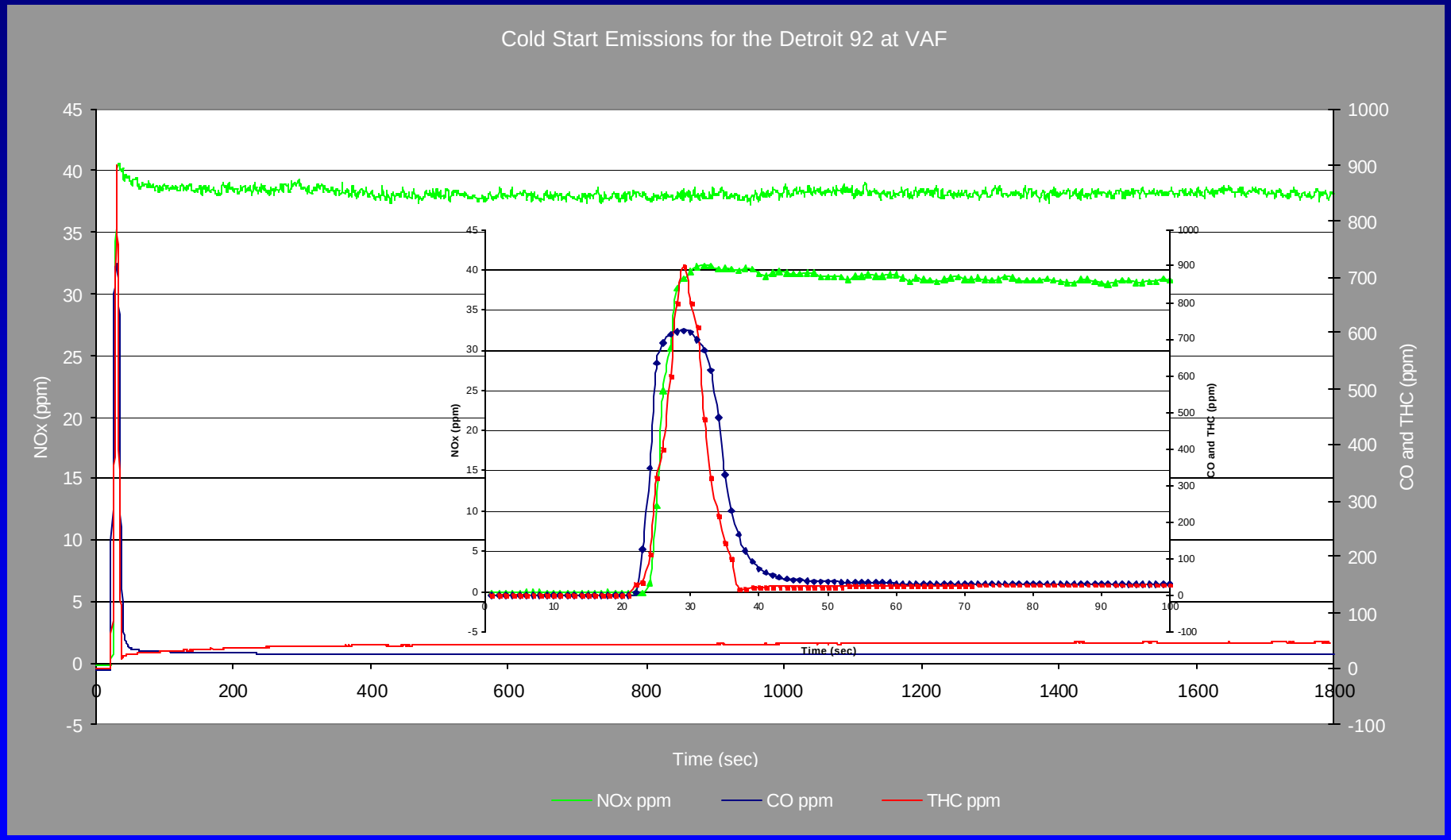
Stationary Testing

600 kw load bank

600 kg

Steps: 1kw @ 415volt

Emissions from a BUG



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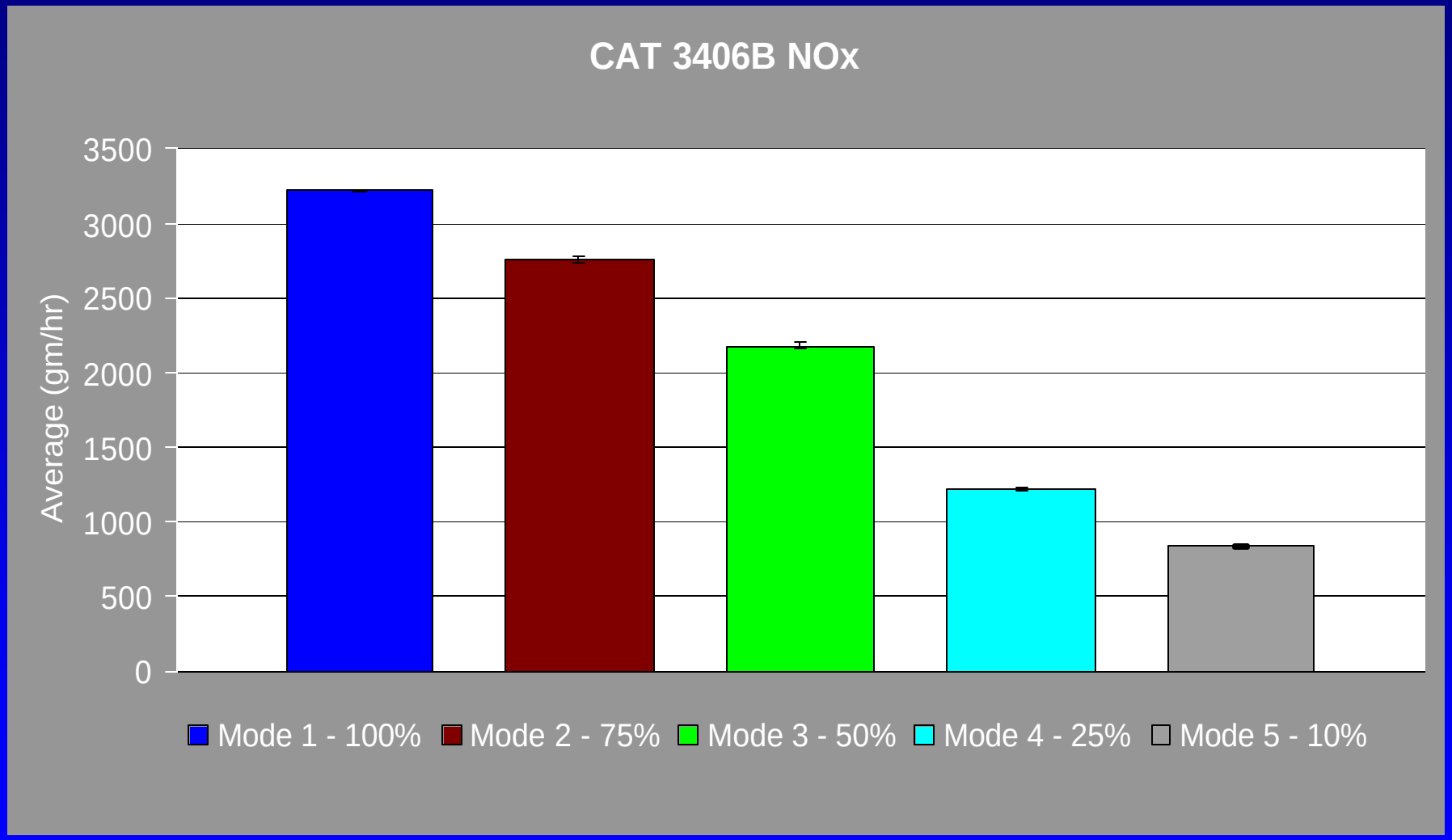
Emissions from a BUG



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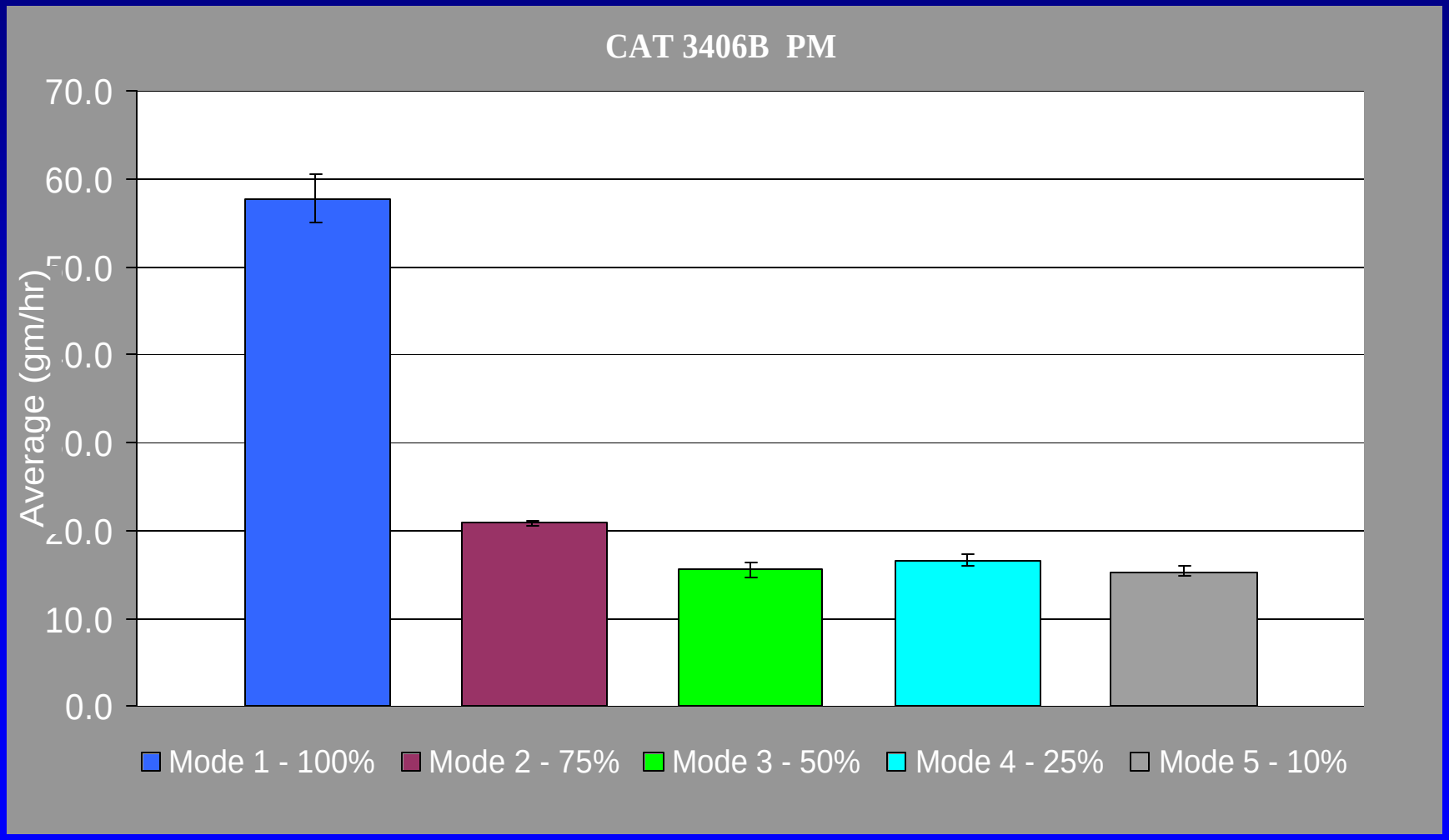
Emissions from a BUG



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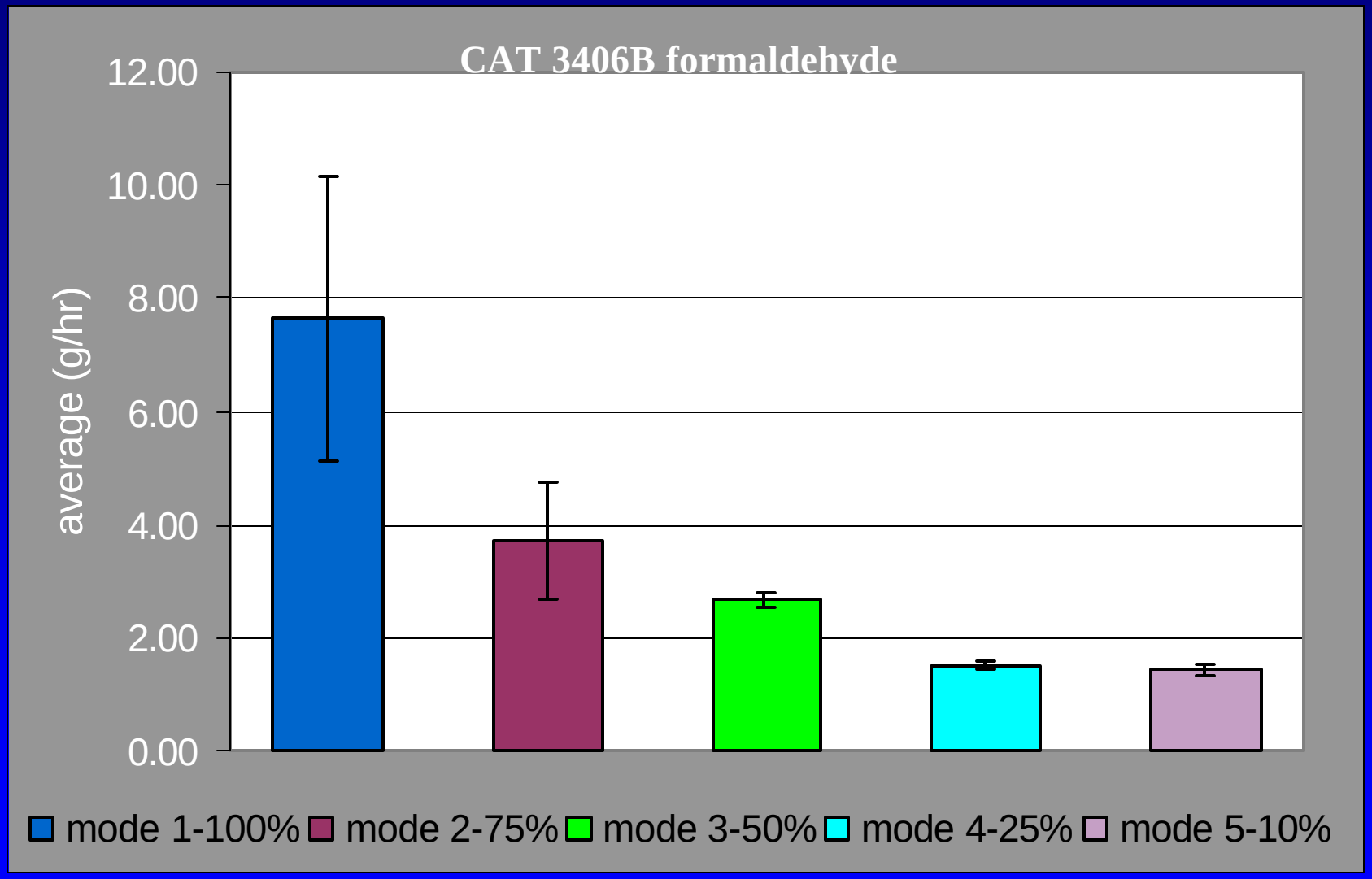

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Adaptation of Certification Cycles to On-road Testing

(Same speed profile, varying loads)

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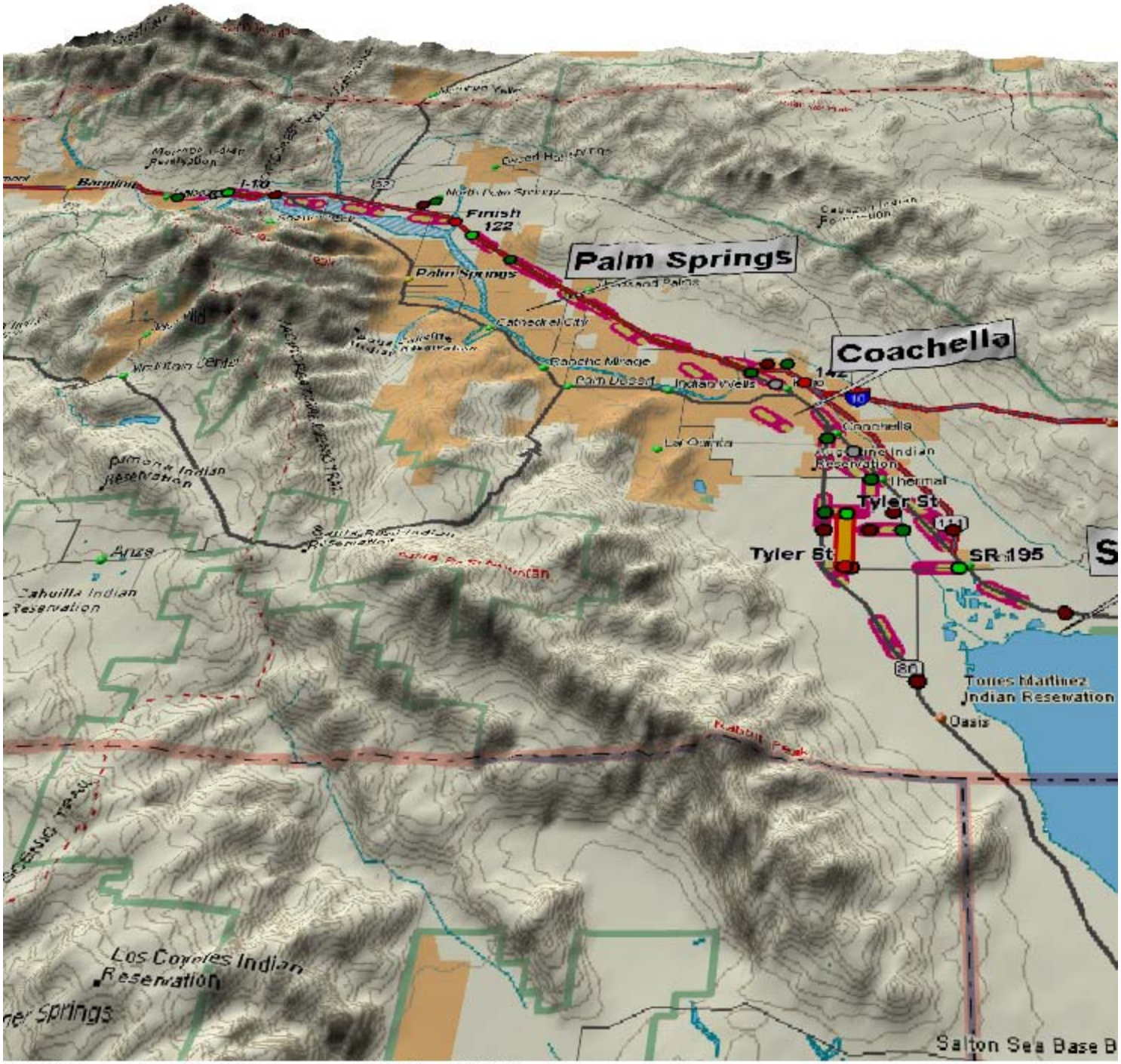

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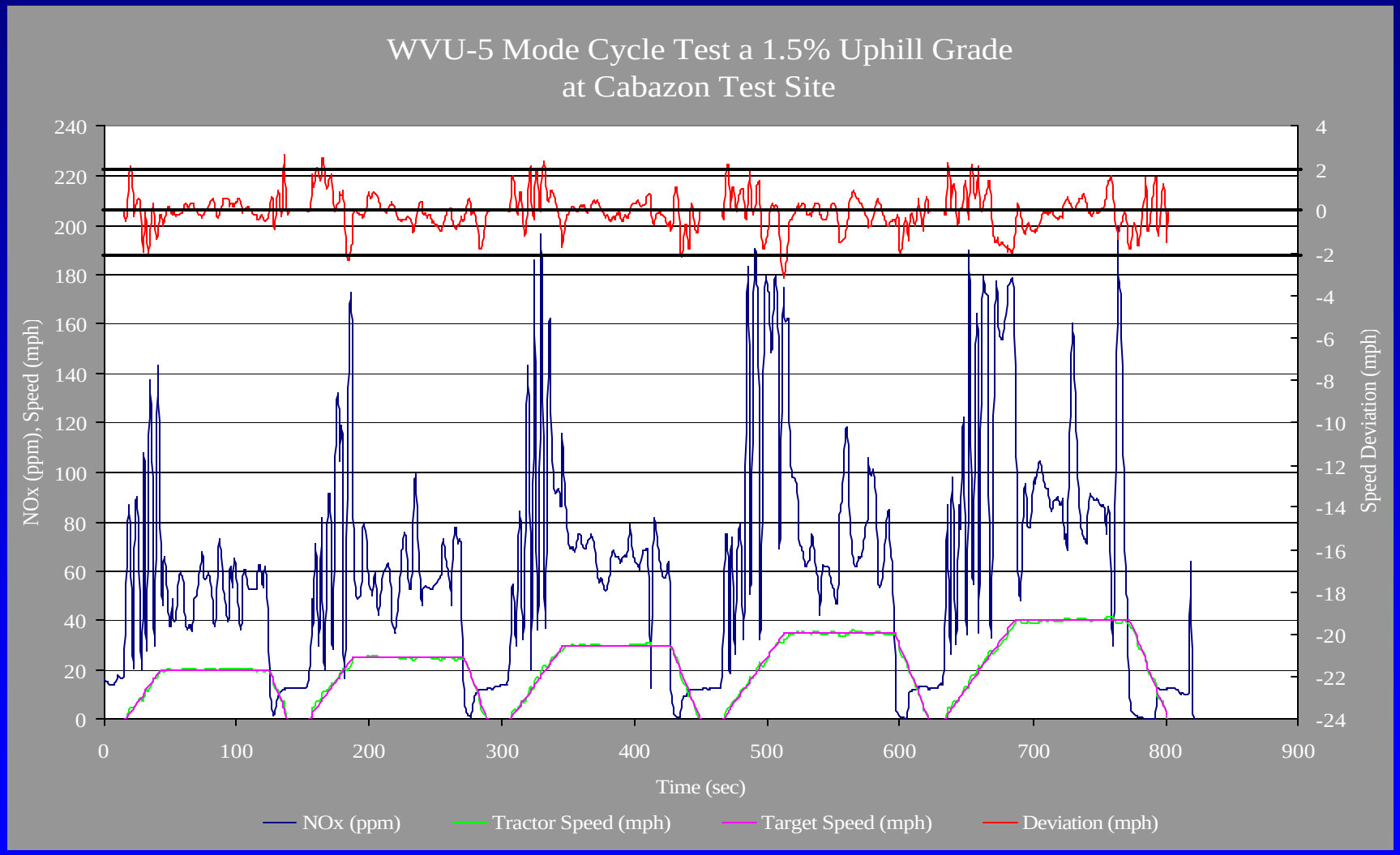
Driver’s Aid

On-Road WVU-5 Mode Cycle



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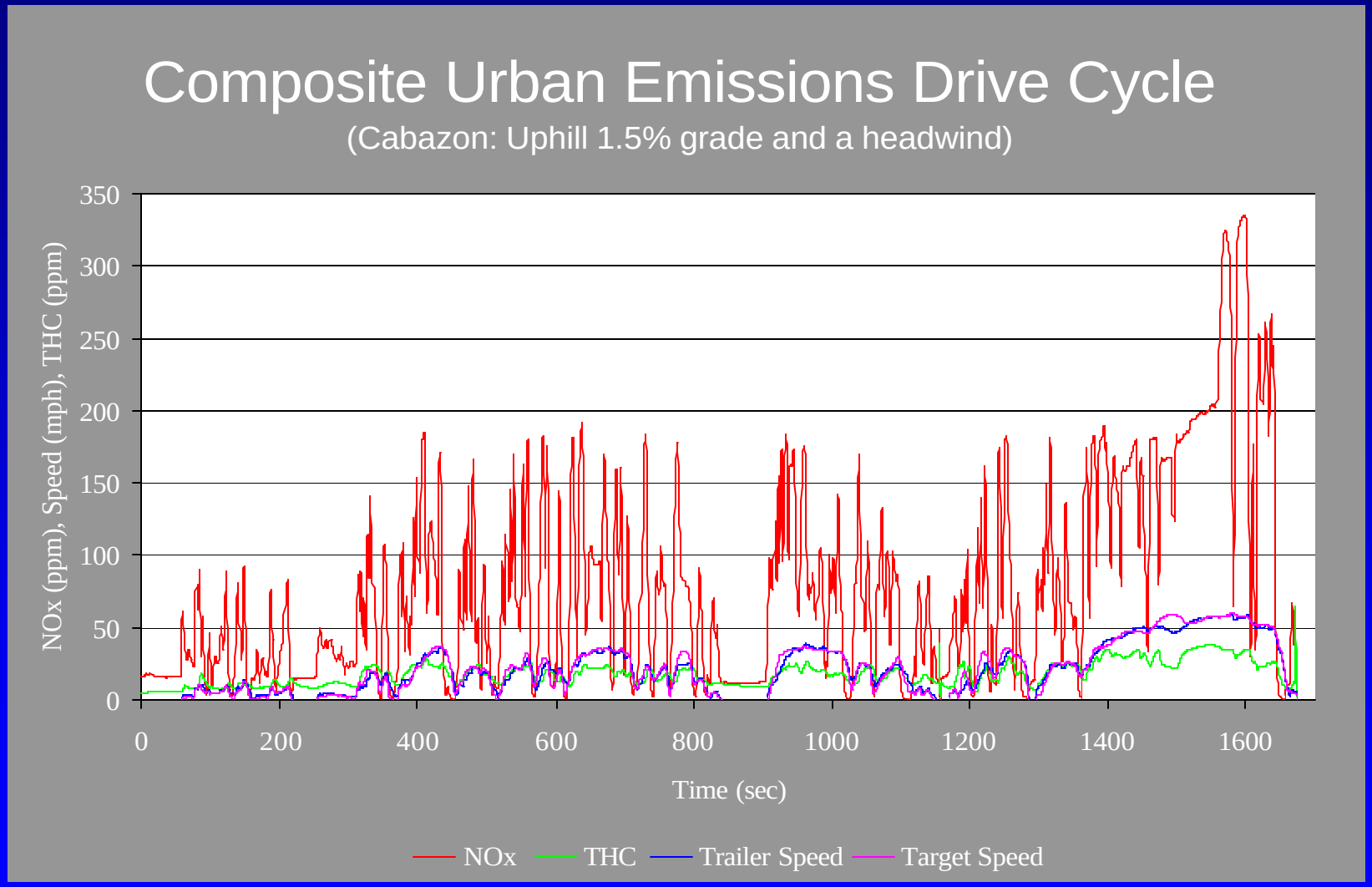
On-Road Repeatability of WVU 5-Mode Cycle

- Relative error at 95% confidence limits after eight runs

Fuel used	1.0%
Engine power	1.2%
Traction work	1.2%
Driver deviations	5.9%

Australian Multi-mode Cycle



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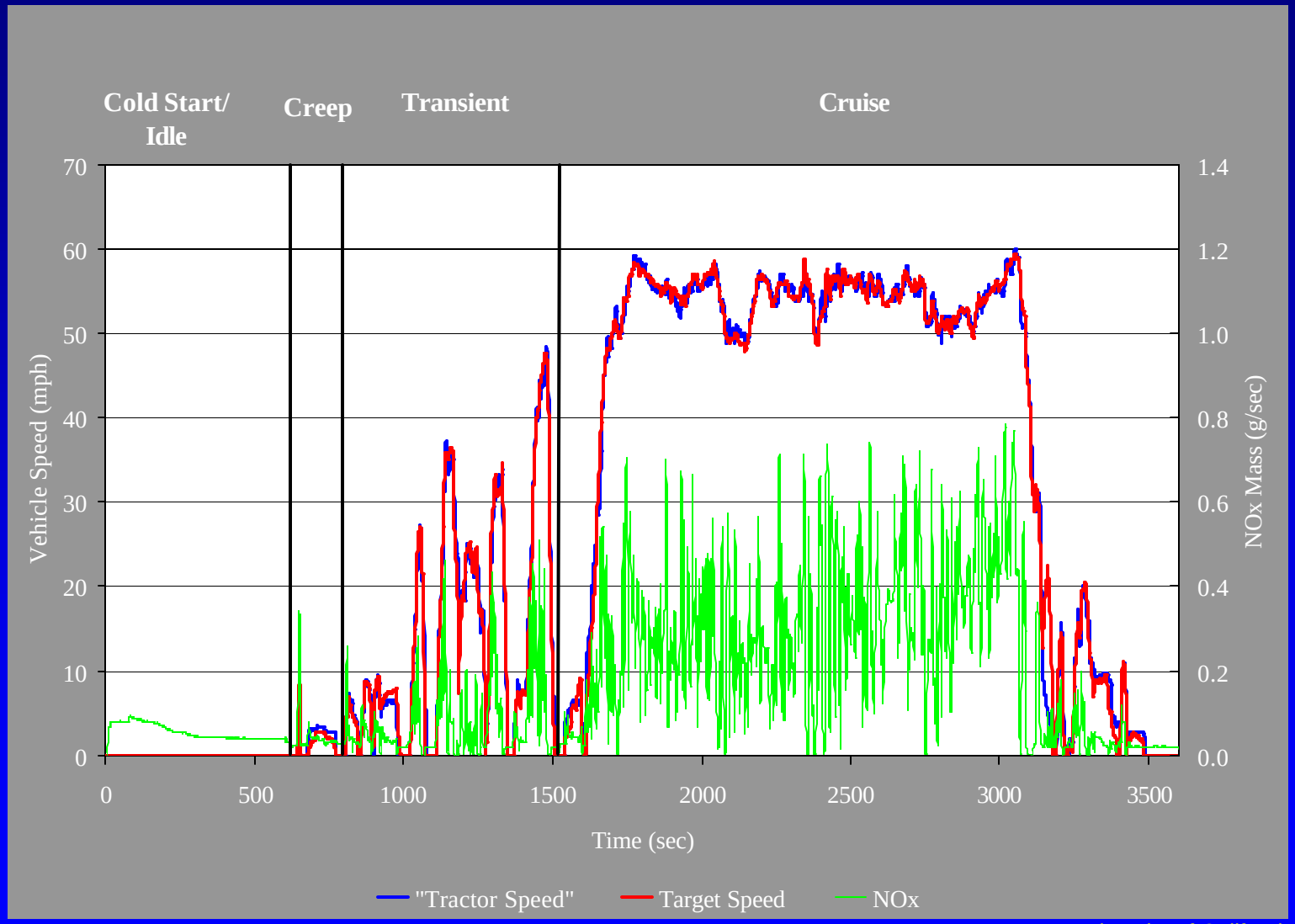
CARB's Combined Cycle for HHDDT



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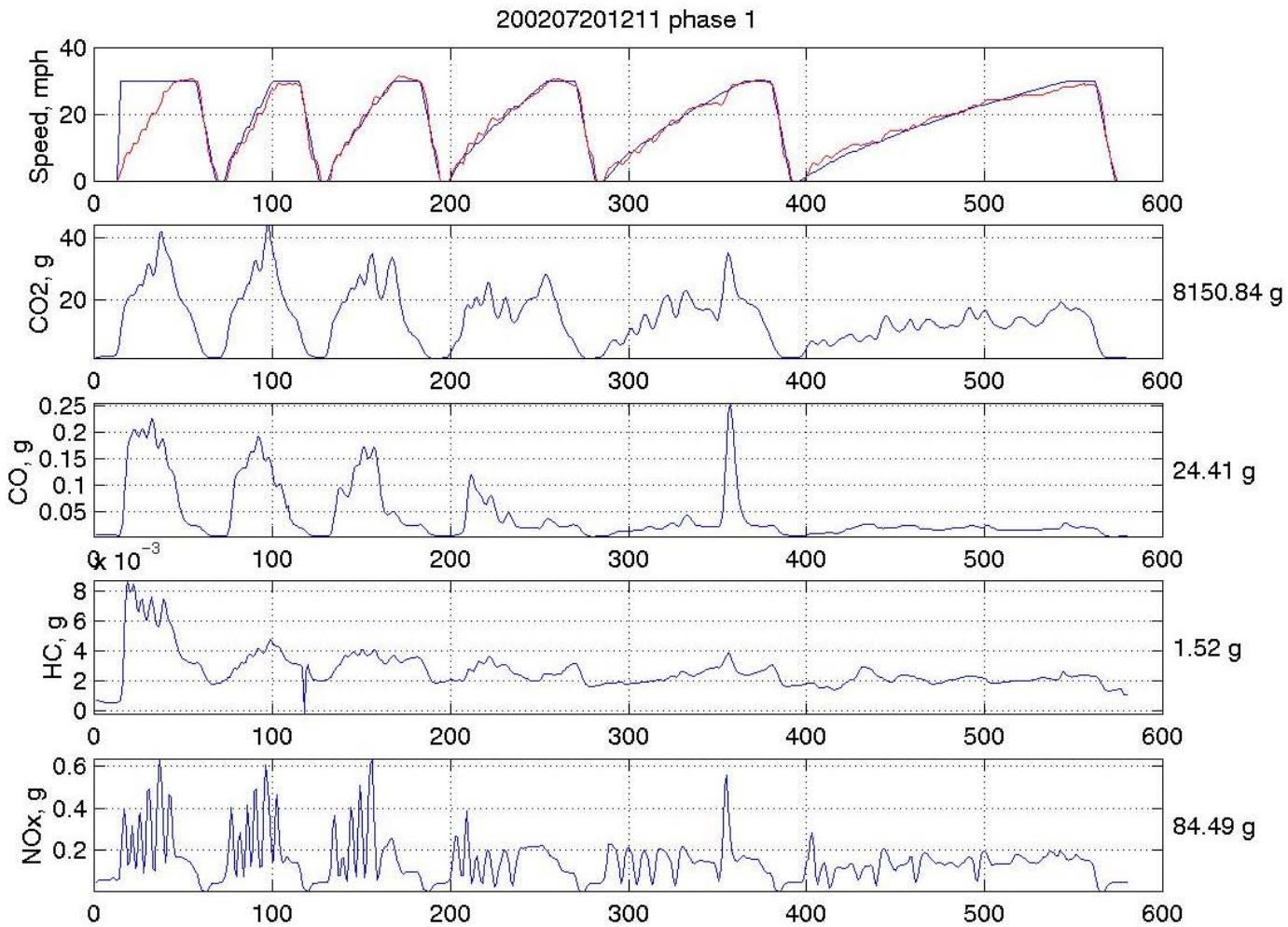
Emissions during CARB's Combined Cycle for HHDDT

	NO_x (gm)	CO_2 (kg)	PM (gm)	Formaldehyde (mg)
Cold Start/Idle	30.2	1.7	1.13	220
Creep (0.124miles)	8.0	0.7	0.19	50
Transient (2.78mi)	57.7	8.4	1.22	320
Cruise (23.1mi)	494	43.5	3.00	595

Model Development Cycles

Model Building Cycle



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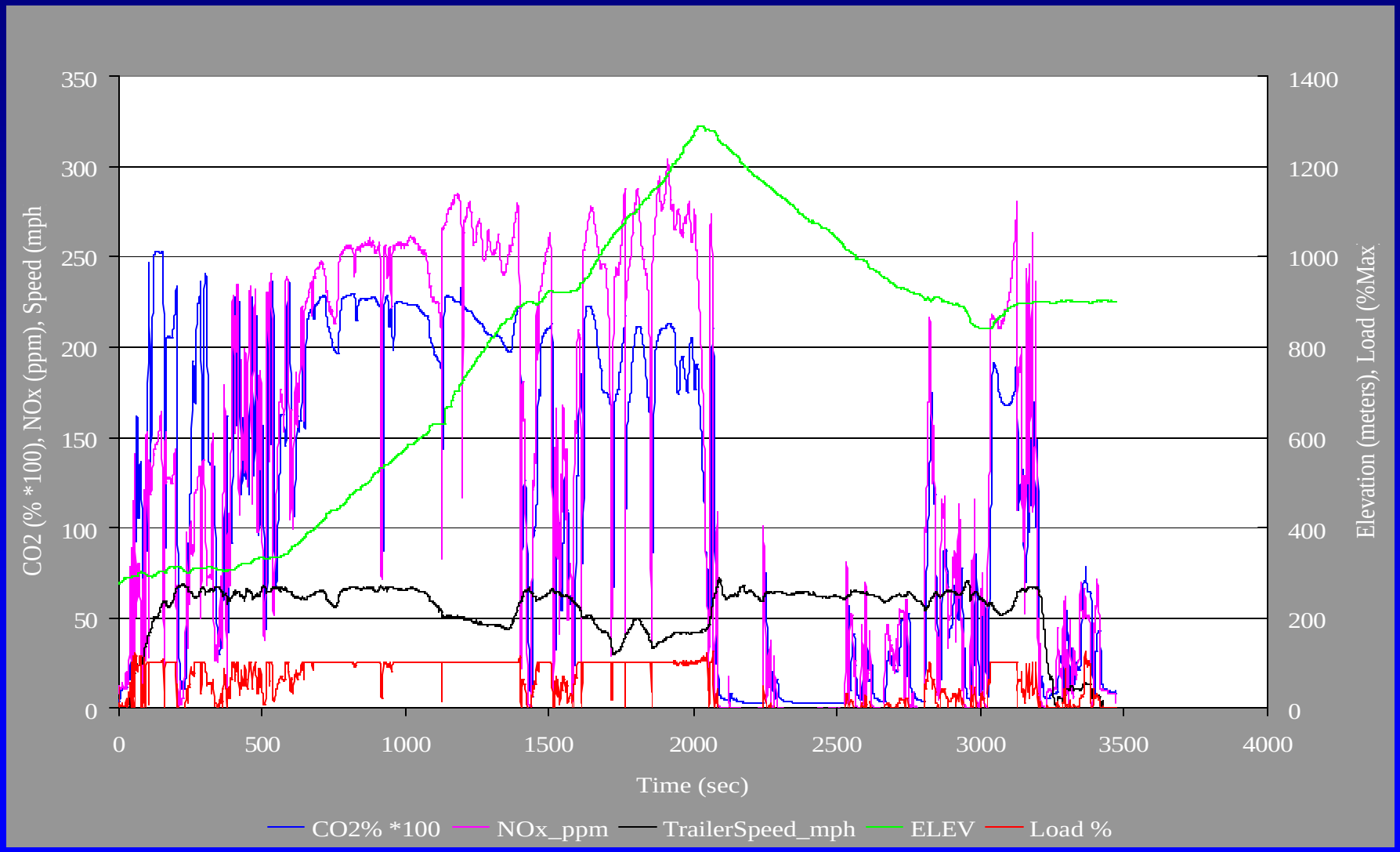
Real World Driving

On-Road Emissions
Riverside to Victorville



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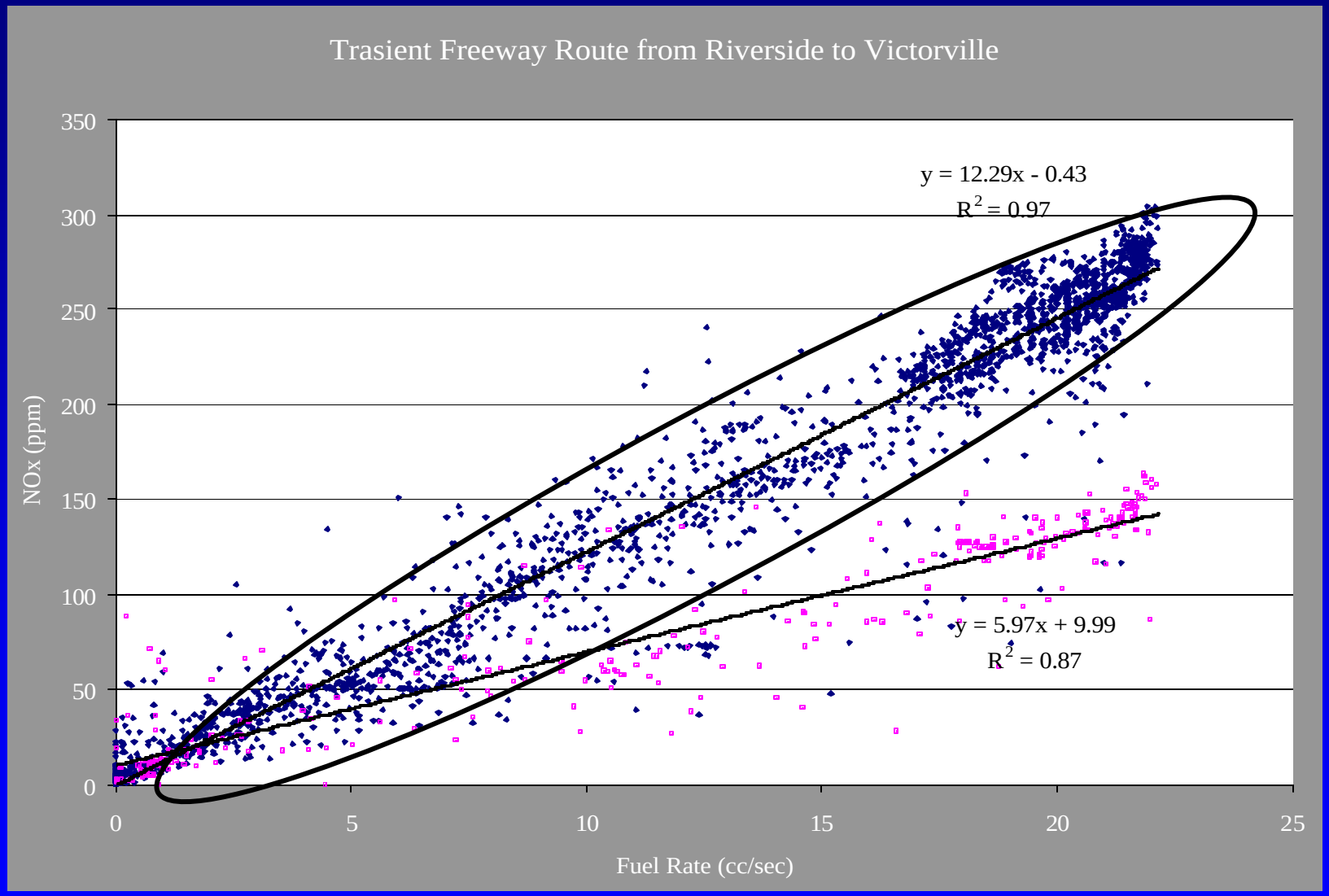
NO_x vs. Fuel Consumption



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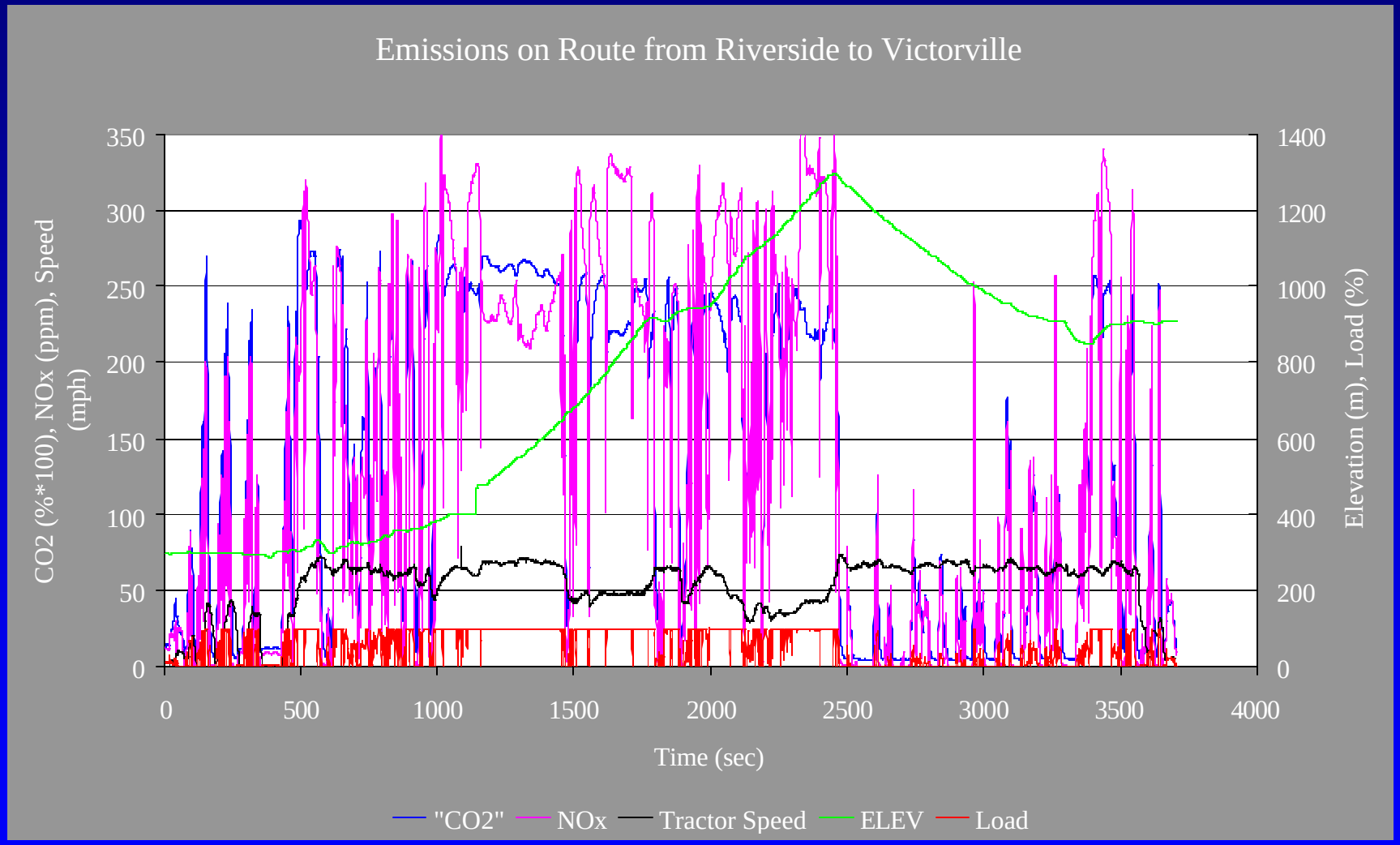
Real World Driving



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“Real World” Emissions

	NO_x (gm)	CO_2 (kg)	CO (gm)	PM 1 (gm)	PM 2 (gm)	Fuel (cc/sec)
Riverside to Victorville	1224	130.2	111	9.30	9.37	12.3
	1213	133.4	101	8.99	8.88	12.4
Victorville to Riverside	869	87.0	96	8.73	8.75	8.4
	973	96.5	93	6.53	6.37	9.4

- **Summary**
  - Mobile HDD lab is measuring regulated and toxic emissions at CFR quality from:
    - Stationary cycles
    - Certification-like cycles
    - Model development cycles
    - “Real world”/ in-use cycles
- **Current Work**
  - Testing a fleet of vehicles to develop the data needed to model emissions from HDD trucks
  - Testing a number of diesel back-up generators
    - 750-2400 hp
    - With and without controls

Sponsors and Funding Agencies

- US Environmental Protection Agency (US EPA)
- California Air Resources Board (CARB)
- California Energy Commission (CEC)
- South Coast Air Quality Management District
- Detroit Diesel Corporation
- International Truck & Engine
- Caterpillar
- Volvo
- Cummins
- Mack