Key Questions

(1) How can we efficiently and flexibly measure real-world, on-road vehicle emissions along a route?

(2) What are the on-road vehicle emissions during each driving mode (deceleration, acceleration, idle, cruise)?

(3) How are on-road vehicle emissions affected by delay caused by traffic signals?
(1) On-Board Emission Measurement (OEM 2100)

OEM 2100
Installed in Passenger Seat

OEM 2100 Internal Connections

Cigarette Lighter Connection

Engine Diagnostics Connection
On-Board Emission Measurement (OEM 2100)

Emissions Sampling Probe Inserted into Tailpipe

Vehicle Fully Equipped and Ready for Testing
Description of OEM 2100

• Equipment can be set up in 15 minutes.

• Connections are fully reversible, with no modification to the vehicle.

• Measures HC, NO, CO, and CO₂ concentrations from tailpipe exhaust.

• Measures engine diagnostics, such as vehicle speed and engine RPM, from On-Board Diagnostic (OBD) link.
Example Speed and Emission Profile


Speed Profile

Carbon Monoxide (CO)

- Passed center of signalized intersection.
- Midblock delay.
Emissions Occur in Short Episodes Concurrent with Acceleration Events During This Run.

(2) CO Emissions by Driving Mode

Mean CO (mg/sec)

1999 Ford Taurus (n = 23)
1996 Oldsmobile Cutlass (n = 48)
1998 Ford Club Wagon (n = 10)

95% Confidence Interval for Mean
HC Emissions by Driving Mode

1999 Ford Taurus (n = 23)
1996 Oldsmobile Cutlass (n = 48)
1998 Ford Club Wagon (n = 10)
NO Emissions by Driving Mode

- 1999 Ford Taurus (n = 23)
- 1996 Oldsmobile Cutlass (n = 48)
- 1998 Ford Club Wagon (n = 10)

![Bar chart showing mean NO emissions for different driving modes and vehicle models.]
(3) Effect of Traffic Signal on Intersection Delay

Sample vehicle trajectory as it stops at a traffic signal.
CO Emissions by Delay Status

During Delay
During Non-Delay

1999 Ford Taurus (n = 23)
1996 Oldsmobile Cutlass (n = 48)
1998 Ford Club Wagon (n = 10)

Mean CO (mg/sec)

95% Confidence Interval for Mean

During Delay
During Non-Delay
HC Emissions by Delay Status

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Ford Taurus</td>
<td>23</td>
</tr>
<tr>
<td>1996</td>
<td>Oldsmobile Cutlass</td>
<td>48</td>
</tr>
<tr>
<td>1998</td>
<td>Ford Club Wagon</td>
<td>10</td>
</tr>
</tbody>
</table>

Mean HC (mg/sec)
NO Emissions by Delay Status

1999 Ford Taurus (n = 23)
1996 Oldsmobile Cutlass (n = 48)
1998 Ford Club Wagon (n = 10)

Mean NO (mg/sec)

During Delay
During Non-Delay
Answer to Question 1

• OEM 2100 allows real-world, on-road vehicle emissions measurements on any route.

• OEM 2100 yields simultaneous measurement of vehicle emissions and engine data on a second-by-second basis.

• Data from OEM-2100 allow direct investigation between emissions and traffic control.
Answer to Question 2

• Vehicle emissions are highest during the acceleration mode for all vehicles studied.

• Therefore, emissions are more sensitive to the number of stops than to the duration of each stop.

• Vehicle emissions are lowest during the idling mode for all vehicles studied.
Answer to Question 3

• Vehicle emissions are higher during delay than during other portions of an arterial trip.

• Higher emissions during delay are because of accelerations not idling.

• Signal systems should be designed to minimize stops to reduce vehicle emissions.

• Reducing number of stops will also reduce number of accelerations, thereby reducing emissions.
Future Work

• Investigate effect of other traffic measures (e.g., number of stops) on vehicle emissions.

• Investigate effect of signal coordination on vehicle emissions.

• Test additional vehicles on signalized arterials during different congestion levels.
Acknowledgements

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• Clean Air Technologies, International - Developer of OEM 2100

• For more information, visit: www4.ncsu.edu/~frey/emissions/