REDUCING THE CARBON FOOTPRINT OF FREIGHT MOVEMENT THROUGH ECO-DRIVING
TRANSFORMING THE TRANSPORTATION SYSTEM

- **RESEARCH** — Producing “state of knowledge” white papers and interdisciplinary research projects

- **EDUCATION** — Developing model curricula for graduate programs and advanced training programs

- **ENGAGEMENT** — Informing the policy-making process at the local, state, and federal level
Introduction

Eco-driving practices for trucks

Elements and effectiveness of truck eco-driving programs

Challenges/barriers and research needs

Findings and recommendations
U.S. GREENHOUSE GAS EMISSIONS 1990-2011 BY TRANSPORTATION SOURCES

- Passenger Cars, 43%
- Light-Duty Trucks, 18%
- Medium- and Heavy-Duty Trucks, 22%
- Aircraft, 8%
- Ships and Boats, 3%
- All Other Transportation Sources, 6%
EFFORTS TO IMPROVE FLEET FUEL EFFICIENCY OF HEAVY-DUTY TRUCKS

- NHTSA/EPA’s greenhouse gas & fuel efficiency standards for heavy-duty trucks
- EPA’s SmartWay program
- DOE’s SuperTruck program

By 2027, fuel consumption and CO2 emissions lowered by up to:

- 24%
- 16%
- 16%
REASONS FOR FUEL WASTE FOR A TYPICAL FREIGHT TRUCK

- Speeding, 33%
- Hard Acceleration, 25%
- Hard Braking, 6%
- Hard Turns, 16%
- Idling, 20%

Photo credits: http://cdllife.com/2013/video/video-homer-simpson-truck-driver-stereotypes/
“The practice of driving in such a way as to minimize fuel consumption and the emission of carbon dioxide” — Oxford Dictionaries

- while not compromising the safety of oneself and other road users

In a broader sense, may also include non-driving activities:
- Pre-trip planning (of route and schedule)
- Vehicle maintenance

Core principles are similar across different vehicle types.
- Some are specific to heavy-duty trucks due to certain unique aspects of truck engine’s operation.
Pre-trip planning

- Route
  - Avoid winding roads, hilly routes, and mountainous terrain
  - Stay away from heavy snow, low temperature, and strong head wind and cross wind

- Schedule
  - Organize pickup and delivery sequence in a logical order
  - Plan a rest during the time when temperature is mild in order to minimize cab heating and cooling

Photo credit: http://www.nextraq.com/fleet-tracking-solutions/dispatching/
ECO-DRIVING PRACTICES FOR TRUCKS (2)

- **Driving**
  - **Engine**
    - Start the engine at zero throttle
    - Warm up and cool down the engine per the owner’s manual
  - **Shifting**
    - Apply progressive shifting
    - Use double-clutching technique
  - **Speed**
    - Use moderate highway speed
    - Maintaining constant speed
  - **Traffic**
    - Anticipate traffic ahead
    - Accelerating and braking mildly
    - Avoid unnecessary idling

Photo credit: http://blog.gordontrucking.com/bid/85580/Being-a-Professional-Truck-Driver
Vehicle maintenance

Service
- Change engine oil and air filters at regular intervals
- Inflate tires to manufacturer-recommended level
- Check axle alignment

Performance
- Tune electronic control module settings to improve fuel efficiency
- Retrofit truck with fuel saving technologies
A limited number of studies have been conducted in Europe, Asia, Australia, and North America.

Reported improvements in fuel economy vary greatly.
- 5% to 40% for all studies reviewed
- 5% to 15% for large-scale studies (> 300 drivers)

Results depend on a number of factors:
- Number of truck driver samples
- Baseline driving performance prior to receiving eco-driving intervention
- Method of eco-driving intervention
- Setting for evaluating fuel economy improvement
- Provision of incentives
## EXAMPLES OF TRUCK ECO-DRIVING EVALUATION STUDIES

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Training Method</th>
<th>Evaluation Setting</th>
<th>No. of Drivers</th>
<th>Fuel Economy Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>U.K.</td>
<td>Driving simulator</td>
<td>Driving simulator</td>
<td>&gt;600</td>
<td>3.5% immediately after training</td>
</tr>
<tr>
<td>2007</td>
<td>U.S.</td>
<td>Class</td>
<td>Closed driving course</td>
<td>36</td>
<td>33.6% to 40.5% immediately after training</td>
</tr>
<tr>
<td>2009</td>
<td>Australia</td>
<td>Class</td>
<td>Prescribed real-world route</td>
<td>12</td>
<td>27.3% immediately after training; 26.9% after 3 months</td>
</tr>
<tr>
<td>2010</td>
<td>European countries</td>
<td>Class followed by monthly feedback and regular refreshing class</td>
<td>Actual real-world routes</td>
<td>322</td>
<td>9.4% over an unknown period</td>
</tr>
<tr>
<td>2011</td>
<td>U.S.</td>
<td>Individualized coaching and in-vehicle real-time feedback system</td>
<td>Actual real-world routes</td>
<td>695</td>
<td>13.7% after 2 months</td>
</tr>
<tr>
<td>2013</td>
<td>Japan</td>
<td>Class</td>
<td>No information available</td>
<td>~3,000</td>
<td>8.7% immediately after training</td>
</tr>
<tr>
<td>2014</td>
<td>U.S.</td>
<td>Individualized coaching and in-vehicle real-time feedback system (plus financial incentives)</td>
<td>Actual real-world routes</td>
<td>46</td>
<td>2.6% (5.4% with financial incentives) for sleeper cabs and 5.2% (9.9% with financial incentives) for day cabs after 2 months</td>
</tr>
</tbody>
</table>
ELEMENTS OF TRUCK ECO-DRIVING PROGRAMS (1)

- Driver education and training
  - Education
    - Awareness campaign
    - Course or seminar format
    - Classroom or online setting
  - Training
    - On-road or with driving simulator

Photo credits:
https://www.youtube.com/watch?v=7R-81ucUdDw
https://www.iru.org/en_policy_co2_response_ecodriving
10 Tips for a Better Eco Driving

**Before Trip**

1. Maintain your vehicle to keep it running efficiently:
   - Use proper engine oil and air filters
   - Check tires pressures
   - Check axles alignment

2. Plan your trips and enable to bypass congested routes

3. Manage your load: no overload, well position the load

**While Driving**

4. Anticipate traffic flow and driving style accordingly use the vehicle’s motion energy as much as possible

5. Shift up early: Use the highest gear possible to avoid engine strain

**After Trip**

6. Maintain a steady speed at low RPM: accelerate and brake gently to keep a steady driving, use cruise control on motorways

7. No idling: keep out of congested areas, turn engine off

8. Minimize extra energy loss that costs fuel and money

- Heating, air conditioning, electrical equipment switched off if not needed
- Close windows at high speeds
- Remove any article that impairs the vehicles streamline effect

9. Follow your fuel consumption, per truck, per trip, per driver, day after day...

10. Analyze all driving behavior with tools, indicators
    - Detect earlier drivers to be trained or coached by your eco trainer.
    - Provide feedbacks on driving behavior and reward best drivers.

Infographic credit: www.michelin-solutions.com
Vehicle maintenance and technology support

- Provide free access to air pumps for tire inflation at rest areas
- Accelerate the availability, adoption, and market penetration of advanced fuel saving technologies
  - Research & development
  - Technology demonstration
  - Technology verification
- Streamline preventive maintenance routines
- Invest in fuel saving technologies

Photo credit:
ELEMENTS OF TRUCK ECO-DRIVING PROGRAMS (3)

- Policy support
  - Conduct educational eco-driving campaigns
  - Include eco-driving as part of commercial driver licensing process
  - Provide financial subsidies for retrofitting existing trucks with fuel saving technologies
  - Encourage or mandate eco-driving technologies in new trucks
  - Build culture of fuel-efficient driving
  - Include eco-driving metrics in driver performance review
  - Recognize or reward truck drivers for embracing eco-driving
Driver

- Habits are hard to break.
- Eco-driving performance may fade over time without proper incentive or reinforcement mechanisms, e.g.,
  - Financial reward schemes based on driving performance or fuel saved
  - On-board driving feedback and telematics systems
Industry

- High turnover rates of truck drivers make trucking companies reluctant to invest in eco-driving training and technology.
- Trucking companies need to balance fuel efficiency with other goals including productivity and safety.
- Fuel prices dictate internal rate of return on eco-driving programs.

CHALLENGES AND BARRIERS (2)
Government

- Incorporating eco-driving training or exam as part of commercial driver licensing process would involve substantial institutional change by government agencies.
- Mandating inclusion of eco-driving technologies in new model year trucks would require working closely with truck manufacturers and other stakeholders.

Funding

- Educational eco-driving campaigns
- Financial subsidies for the truck retrofits
Co-benefits of truck eco-driving

- Emissions (of criteria pollutants, especially NO\textsubscript{x} and PM)
  - How much criteria pollutant emissions can be reduced?
- Safety-related implications
  - Is there positive correlation between eco-driving and safe driving?
  - Any potential for driver distraction?
Impacts of truck eco-driving on traffic flow

- Roadway capacity
  - Would roadway capacity be reduced and by how much?
- Unintended consequences
  - Would that increase overall travel time, fuel consumption, and emissions of the traffic system?
RESEARCH NEEDS (3)

- Truck eco-driving technologies
  - On-board device and instrumentation
    - Customized feedback
    - Seamless integration
  - Connected Vehicles
    - New applications enabled by vehicle-to-vehicle and vehicle-to-infrastructure communications

Credit: www.michelin-solutions.com
Truck eco-driving policy impact analyses

- Sustainability
- Economic
- Political
- Institutional

**Truck Eco-Driving Supporting Policies**

- Conduct educational eco-driving campaigns
- Include eco-driving as part of commercial driver licensing process
- Provide financial subsidies for retrofitting existing trucks with fuel saving technologies
- Encourage or mandate eco-driving technologies in new trucks
EXAMPLES OF ONGOING RESEARCH

- Truck eco-routing
- Real-time speed advice
- Freight signal priority
- Eco-driving traffic simulation
Truck eco-driving is a win-win-win strategy for driver, industry, and government.

Truck eco-driving programs can save fuel and reduce greenhouse gas emissions in the range of 5% to 15%.

A concerted effort to implement the three elements of truck eco-driving programs is critical to the success of the programs:

- Driver education and training
- Vehicle maintenance and technology support
- Policy support
Increase efforts in promoting eco-driving as a strategy to improve fleet fuel efficiency and reduce GHG emissions from trucking operations.

- Educational campaign
- Financial subsidy
- Public policy

Invest in research to improve our understanding of the benefits and impacts of truck eco-driving programs and to further advance truck eco-driving technologies.