Reducing Impacts of Goods Movement in the Inland Empire

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Acknowledgements
UCR: Ayla Moretti, Dr. Jill Luo, Dr. Peng Hao, Dr. George Scora, Dr. Kanok Boriboonsomsin
UCR Center for Social Innovation Colleagues
UCLA Colleagues
CLIMATE SMART TRANSPORTATION AND COMMUNITIES CONSORTIUM
(a Strategic Growth Council Project)

Inland Empire Regional Initiative

- UC Davis (ITS)
- UC Berkeley (LBNL)
- UCLA (Luskin Center)
- UCR (CE-CERT & CSI)
- UC Irvine (ITS)
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Context

There is explosive growth of warehousing in the Inland Empire, with little attention on transportation needs.

- how do these warehouses and associated truck traffic affect residential neighborhoods?
  - Roadway safety
  - Traffic congestion
  - Air quality and pollutant exposure to residents
Reducing Impacts of Goods Movement in the Inland Empire

Our Research Tools:

• Heavy Duty Electrification
  • Electric Trucks (currently being tested in pilots)
  • Vehicle charging infrastructure

• Connectivity and (partial) Automation
  • Increased efficiency and safety
  • Driving Assistance, not Driver Displacement

• Advanced Fleet Management tools, including low exposure truck routing, dynamic time-of-day scheduling, geofencing

From VolvoLights Project: https://www.lightsproject.com/
Novel Electric Truck Dispatching Algorithms

• Optimize dispatching of electric trucks considering their driving range, estimated energy consumption, state of charge (SOC), charging needs, etc.

• Route electric trucks onto “eco-routes” with estimated time of arrival (ETA) within the arrival time window, if available.

Vehicle Routing:

*fastest route, eco-route, low-exposure route*

- Most trucks use navigation based on achieving the fastest route
- “Eco-routes” can be chosen that reduce fuel consumption, with a small travel time penalty

Low-exposure routes can be chosen that reduce exposure of pollutants to local residents ← this is what we are doing as part of this grant
Case Study: San Bernardino Airport Area

Expanded to a major cargo air hub

Population
- 0 - 2
- 3 - 48
- 49 - 96
- 97 - 1309

Cargo to/from LA via I-10
Cargo to/from LA via 60
Cargo to/from LA/OC/ports via 215 then 91
Cargo to/from US via I-10
Cargo to/from US via I-10 then 15
Cargo to/from LA via I-10

Amazon
San Bernardino Airport at 10am of a typical weekday

Wind Direction @ 10am

Facility Population
- 70 - 283
- 284 - 512
- 513 - 664
- 665 - 2732

Sensitive receptors (schools, assist. living, etc.)

Census Block 2018 Population
Working Hour
- 1
- 2 - 28
- 29 - 57
- 58 - 3505

General population density

Road Network PM2.5
IM of total population (µg/kg mass)
- 0.000
- 0.001 - 0.003
- 0.004 - 0.009
- 0.010 - 5.277

Roadway exposure rating

2 Kilometers
San Bernardino Airport at 10am of a typical weekday

Example Route Analysis

• Starting Point: Freeway I-215 South & 210
• Ending Point (warehouse(s)) = Star
• Baseline Route = A → Coral Route
• Alternative Route = B → Green Route

<table>
<thead>
<tr>
<th>Route</th>
<th>Driving distance (mile)</th>
<th>Driving duration (min)</th>
<th>PM$_{2.5}$ (µg)</th>
<th>CO$_2$ (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral, fastest route</td>
<td>11.45</td>
<td>12.99</td>
<td>101.77</td>
<td>18.65</td>
</tr>
<tr>
<td>Green, LER</td>
<td>8.16</td>
<td>13.32</td>
<td>97.45</td>
<td>13.73</td>
</tr>
</tbody>
</table>
Truck Volume Analysis

- Caltrans PeMS Truck Flow at mainline loop detector stations (LDS)
- Truck volume loading into the hub from four corners of the area is estimated

San Bernardino Airport at 10am of a typical weekday

PeMS Truck volume estimation reference: Kwon et al.
San Bernardino Airport at 10am of a typical weekday

Summary of Low-Exposure Routing (in progress)

**General Conclusion:** we can achieve a 28% reduction in pollutant exposure and reduce fuel consumption by 5%, but will increase travel time by 13%
Refined Analysis with Traffic Signals

- Previous analysis assumed roughly constant speeds, with no stopping
- This analysis examines the effect of stopping at stop lights (~40 second lost per stop), and the pollutants they emit

- Stop lights make previous low-exposure routes less effective
- Traffic signals synchronized with vehicle traffic can improve the performance
Other Related Technology that can be Utilized

- **Eco-Approach and Departure**
- **Freight Signal Priority**

*Source: Noblis, November 2013*
Eco-Approach and Departure Speed Advice to Drivers

- Application utilizes traffic signal phase and timing (SPaT) data to provide driver recommendations that encourage “green” approaches to signalized intersections

- Example scenarios:
  - Coast down earlier to a red light;
  - Modestly speed up to make it (safely) through the intersection on green

- Energy Savings: 10% - 20%
- Smoother Traffic Flow

Source: Nobis, November 2013
Eco-Approach and Departure Truck Demonstration Event

- March 6, 2019 in Carson, CA
- 1st Eco-Drive demo in L.A. region with demo rides given to over 50 invited attendees
- Partnership between 10 public agencies, 6 technology providers, 1 trucking companies, Volvo, and UCR
Possible Adoption of Formal Policies:

- Local and regional transportation and land use departments use their authority to limit the use of certain routes by heavy-duty trucks or designate low-exposure truck routes
  - City of San Bernardino
  - San Bernardino County Transportation Authority
  - California Department of Transportation (Caltrans) District 8

- Air quality regulators adopt indirect source rules that mandate or incentivize alternative routing or geofencing technologies
  - South Coast Air Quality Management District
  - Example: SCAQMD’s Proposed Rule 2305 - Warehouse Indirect Source Rule
Implementation Scenarios - Policy and Regulatory Levels

**Possible Voluntary Actions by Firms:**

- New industry-level norms: firms adopt low-impact emissions routing guidelines
  - The logistics sector uses emerging routing technologies to divert heavy-duty truck traffic to low-impact routes, accepting a tradeoff between slightly increased delivery time/distance for reducing inhalant exposure of PM 2.5 and NOx to communities and sensitive receptors
  - Bonus: slight reduction in fleet average fuel consumption

- Industry- or firm-specific leaders adopt new standards in the Inland Empire
  - Amazon, the region’s largest private-sector employer, pilots innovative alternative routing and geofencing technologies for their delivery fleets in the IE
Thank You!