Traffic Analysis of Medium- and Heavy-Duty Vehicles in the Inland Empire

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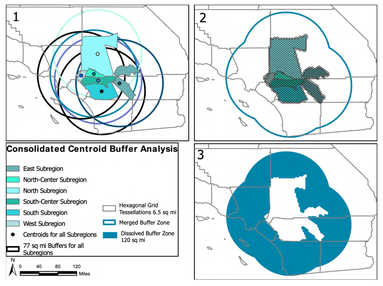
Abstract

This study investigates medium- and heavy-duty vehicle (MDHDV) operations in the Inland Empire, emphasizing potential pathways for electrification. Through detailed examinations of vehicle movement, parking availability, vehicle fuel distribution type, and infrastructure capacities, it provides an initial work for sustainable transportation planning and policy formulation in the region.

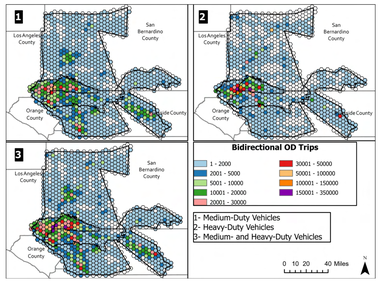
Introduction

In the Inland Empire, managing medium- and heavy-duty vehicle (MHDV) traffic is crucial amid its bustling industrial landscape and growing population. Leveraging big data analytics, this study offers insights into traffic patterns to optimize infrastructure and transition towards Zero Emission Vehicles (ZEVs). By understanding MHDV movement and infrastructure demands, decision-makers can strategically plan for sustainable transportation in the region, aligning with environmental goals.

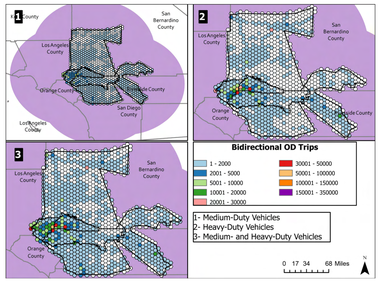
Methodologies



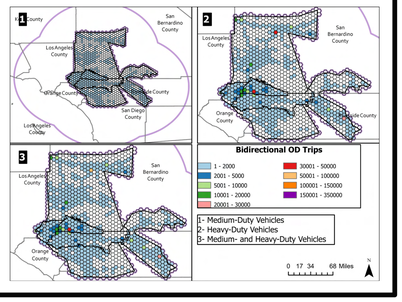
The analysis visually examines internal traffic, regional/short-haul traffic and long-haul traffic in the Inland Empire, depicting subregions and operational ranges. Integration of Streetlight Data with ArcGIS Pro aids mapping, with validation ensuring accuracy.



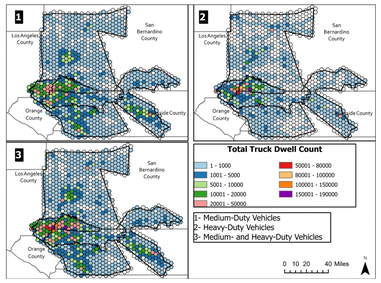
Vehicle movement within and from the Inland Empire (IE) across subregions reveals concentrated bidirectional trips in the W, NC, and SC areas, some exceeding 150,000 trips, while HDV trips are mainly in the W and NC subregions with limited activity in the N subregion. The W, NC, and SC subregions exhibit the highest truck activity, alongside significant activity in the N subregion.



This depiction shows inter-regional flows between the IE and its 77-mile buffer zone, highlighting short-haul trips within Southern California. MDV trips peak in the W, NC, and SC subregions, while the NC subregion records the highest HDV traffic at 50,000 trips, followed by the W subregion. Notably, Barstow in the N subregion sees significantly higher HDV traffic, averaging up to 30,000 trips.

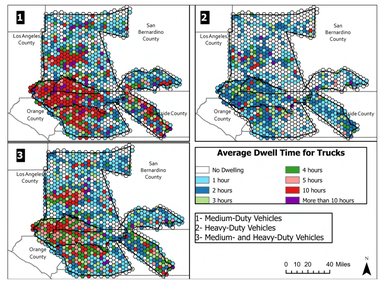


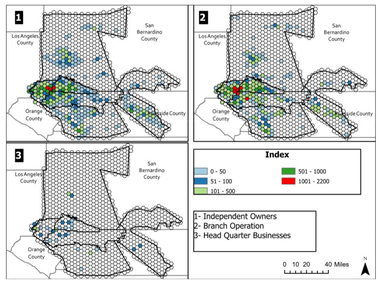
This figure illustrates HDV traffic dominance in LH trips, as expected due to the need for trucks in transporting large quantities over long distances. Map 1 indicates low MDV traffic across all regions. Map 2 highlights higher HDV traffic in the NC and some parts of the E subregion, with Barstow in the N subregion reaching up to 50,000 trips. This trend is also evident in the total MDV and HDV trips shown in Map 3.



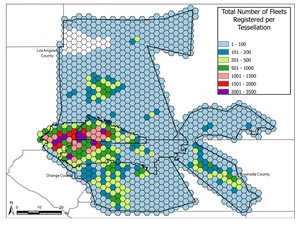
MDV counts peak in the W and NC subregions, with some areas exceeding 50,000 trucks, while HDV counts are highest in the W and NC, with some areas exceeding 150,000 HDVs in the NC. Notably, Barstow in the N subregion records over 20,000 HDVs. Total MDHDVs dwelled in 2021 reveal the highest counts in the NC and E subregions, offering valuable insights into vehicle distribution within the Inland Empire.

Analyzing MDHDV operations in the Inland Empire, the average dwell times for these vehicles in 2021 are detailed. MDV average dwell times are 10 hours in the E, NC, SC, and S subregions, while HDVs show significantly lower times. Overall, dwell times exceed three hours in most E, NC, SC, and S subregions when MDVs and HDVs are aggregated.



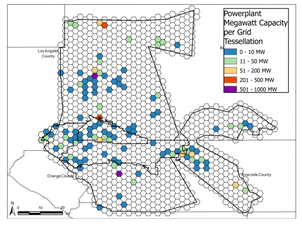


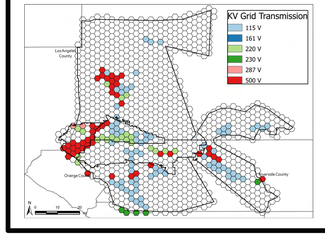
In a unified frame, three maps depict transportation business density across the IE, ranging from blue (0-50) to red (1001-2200). Map 1 emphasizes a concentration of independent owners in the E, NC, and SC subregions, with notable density in the N, E, and S. Map 2 mirrors this trend for branch operations, while Map 3 indicates fewer headquarters businesses, providing insights into regional business distribution.



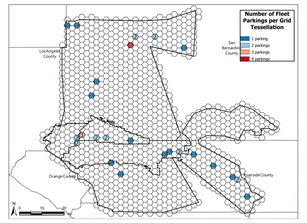
This section assesses MDHDV fuel distribution in the IE for electrification potential. Mapping diesel, gasoline, natural gas, and electric fleets offers insights into intervention areas. The distribution of MDHDVs, ranging from light blue (0-100 vehicles) to purple (2001-3500 vehicles) per tessellation, reveals concentrations in the W, NC, and SC subregions, with notable numbers in the N, S, and E subregions.

Across the IE's subregions, power plant capacities are categorized by MW output. Hexagons represent areas colored to indicate total MW capacity, from light blue (0-10 MW) to dark red (501-1000 MW). Higher-capacity plants, notably in the 501-1000 MW range, are mostly in the N subregion, with one in the S. Plants generating 0 to 200 MW are spread across the SC, NC, W, and E, with higher concentrations in the W and NC.



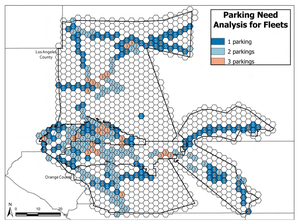


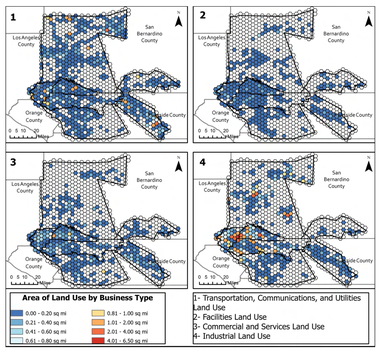
The visualization illustrates grid transmission capacities across subregions, categorized by voltage levels. Dark red hexagons (500 V) indicate high capacities mainly in the N and W. Isolated high-capacity hexagons are found in the E and S. NC and SC exhibit lower voltage levels, suggesting diminished capacities.



Utilizing a hexagonal grid, the map illustrates fleet parking availability, with color-coding indicating the number of spots in each cell: blue (1), light blue (2), orange (3), and red (4). Parking is dispersed, with single spots predominating across all six subregions. Additionally, the subsequent figure presents a parking need analysis for fleet vehicles within the IE, using a similar grid approach to depict estimated demand across different sectors of the region (Caltrans, 2022).

Parking needs for fleets are analyzed in the map, with color-coded legend indicating spots per hexagonal grid cell: blue (1), light blue (2), and orange (3). Substantial demand is seen across the W, NC, and SC subregions, with the NC and SC exhibiting the highest need for 3 spots. The N subregion also shows significant demand, while the S and E subregions have lower requirements.





In the visualization, the color legend denotes land use area in square miles, ranging from dark blue (0.00 - 0.20 sq mi) to dark red (4.01 - 6.50 sq mi). The maps depict dispersed distribution of "Transportation, Communications, and Utilities Land Use," denser concentration of "Facilities Land Use" in W, NC, and SC, heightened "Commercial and Services Land Use" in NC, and dominant "Industrial Land Use" in W, NC, and SC.

Conclusion

Through an extensive analysis of transportation and urban systems in the Inland Empire, this study sheds light on the potential transition of medium- and heavy-duty vehicles (MDHDVs) to electrification. By examining traffic patterns, fleet counts, and charging infrastructure readiness across the region's subregions, valuable insights have been uncovered. For instance, the study reveals concentrations of MDHDVs in the W, NC, and SC subregions, with some areas recording over 50,000 truck trips per day. Additionally, insights into charging infrastructure needs and land use distribution have been provided, informing tailored recommendations for MDHDV electrification. These findings pave the way for collaborative efforts to accelerate the deployment of electric trucks, optimize charging infrastructure, and drive sustainability in the transportation sector, ultimately enhancing the region's economic and environmental outlook.

Future Works

Future work for this research can be done by incorporating additional variables such as meteorological conditions, traffic flow, and infrastructural attributes to enhance analysis depth and accuracy, and vertically through the development of advanced models and predictive systems for optimizing opportunity charging stations, forecasting electric infrastructure demands and opportunity charging scenarios.

California State University Transportation Consortium

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