

Evaluating Regional Traffic Signal Performance Measures Using Crowd-Sourced Data in 2021 Urban Mobility Report

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BACKGROUND AND OBJECTIVES

Arterial street delay accounts for approximately 60% (roughly 50% in large urban areas and about 75% in small urban areas) of delay in United States urban areas. A significant portion of delay on arterial streets occurs at traffic signals. Improving the efficiency of traffic signal operations is critical in both reducing delay and improving air quality. The Environmental Protection Agency (EPA) estimates that transportation accounts for approximately 29% of greenhouse gas (GHG) emissions in the United States. A vital component in addressing these issues is to improve traffic signal performance measurement, which provides essential information to traffic management personnel when making necessary adjustments to improve traffic signal operations. Optimizing arterial signal systems can help better utilize existing roadway capacity and be more cost-effective than adding new lane capacity and/or new interchanges to address congestion.

Traffic signal performance measurement has historically been constrained with agencies relying on limited data collection and citizen complaints to gauge the performance of traffic signal systems. Signal performance measures have been more difficult to quantify than other mobility measures, but new datasets obtained from crowdsourced data have improved the ability of users to enumerate traffic signal performance measures at statewide, urban area, and corridor levels without the installation and maintenance costs of detection and enhanced signal system equipment beyond what is needed to operate the intersection. The objective of this study is to examine the current applicability of probe-based travel data at signalized intersections for congestion and signal efficiency performance monitoring, and identify use-cases, challenges, and opportunities for improvement.

METHODOLOGY

The Urban Mobility Report (UMR) has been providing information on urban congestion levels in the U.S. for more than three decades. The UMR uses private-sector crowdsourced travel speed data from INRIX® combined with traditional public-agency roadway inventory data to measure mobility conditions. The current UMR statistics describe overall congestion levels, but do not categorize causes of congestion. With the advent of improvements in the third-party provider data streams, it is now possible to quantify at least some aspects of the mobility contribution provided by enhanced traffic signal systems.

This evaluation used detailed crowdsourced intersection traffic data collected by INRIX® to report on the performance of traffic signal systems. One week of October 2020 data for approximately 210,000 traffic signals in the United States was used for this study. INRIX has continued to exponentially expand their probe vehicle coverage and data quality. The use of this data allows agencies to leverage existing probe data for the measurement of traffic signal performance and improve traffic signal operations. This dataset is useful for evaluation of signal operations using traditional metrics such as average delay and level of service, in addition to newer metrics such as arrivals on green and traffic signal efficiency index.

Urban areas were reviewed and ranked for signal operations by evaluating metrics obtained from crowdsourced data, including arrivals on green and split failures. These metrics enhanced the evaluations that can be performed using traditional metrics like arterial street delay. Urban areas were also categorized using factors including congestion levels, population and signal density to ensure that any comparisons include contextual elements which are key to decision-maker understanding and messaging strategies.

The INRIX traffic signal analytics data was used to both summarize data provided for each urban area, and to calculate additional traffic signal performance measures. When choosing traffic signal performance measures, it is important to use multiple measures to gain a full understanding of traffic signal operations of an urban area.

RESEARCH FINDINGS

The following are some key takeaways from this evaluation:

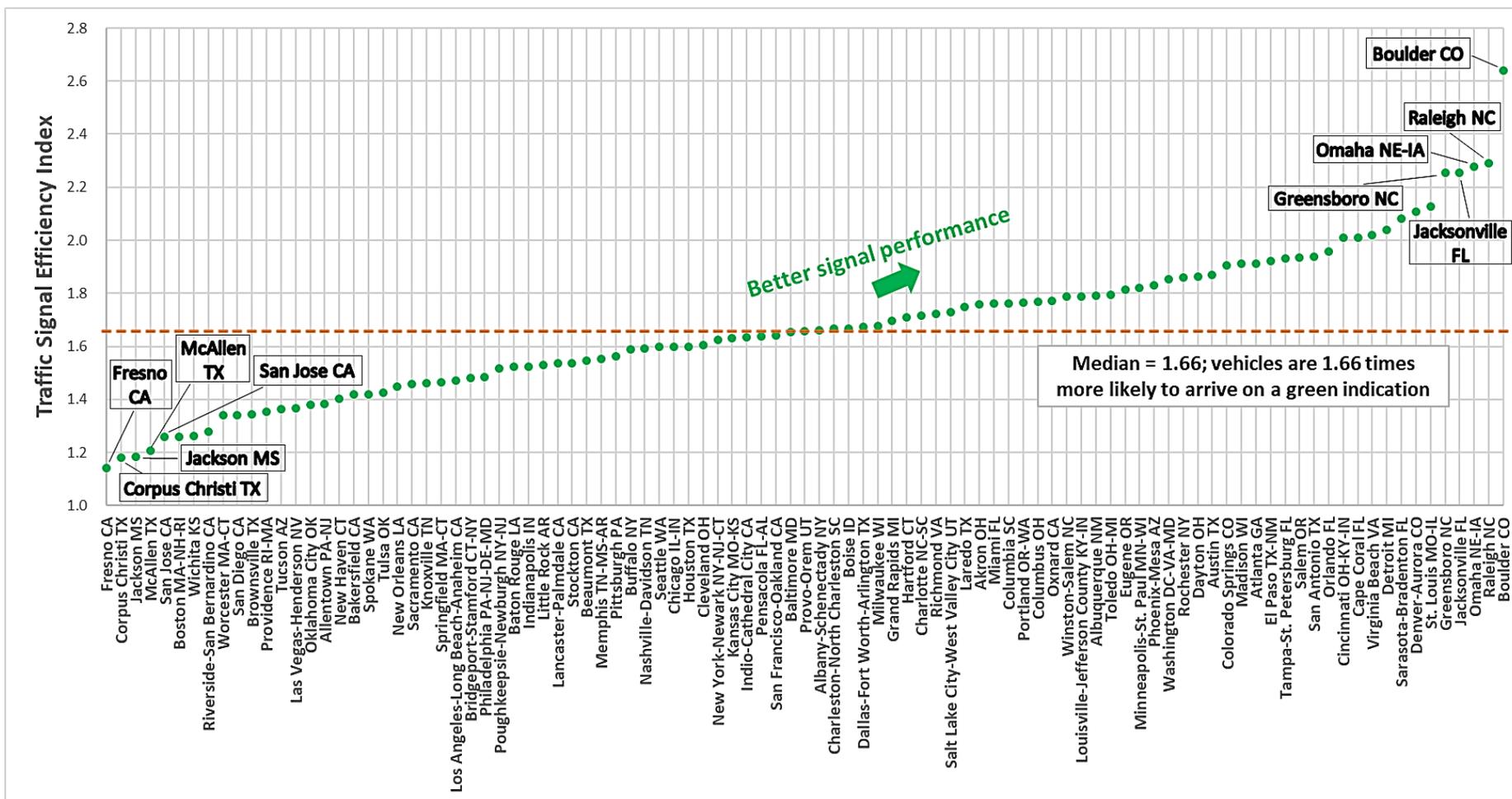
- 2020 was a unique year, and some of the unique circumstances are reflected in signal efficiency metrics as well. The chart on the next page shows urban areas' overall signal performance in 2020. It is easy to see the effects of COVID (virtual classes resulting in great signal performance in small college towns) as well as local weather conditions, special events, etc., resulting in contextual values of signal operational metrics.
- A vehicle is 1.7 times more likely to arrive at an intersection on green than red, based on the national average value of traffic signal efficiency index. The value of this index varies in the range of 1.0 to 2.7 considering all US urban areas.
- Calculation of these metrics at the statewide and urban area levels is useful for tracking performance and trends, and at the corridor level the metrics can be used for both performance tracking and traffic signal operations from a planning perspective.
- Performance measures were validated by outliers at both at the higher and lower ends of the traffic signal efficiency spectrum by events occurring during the week that data was collected:
 - Less delay due to virtual classes in university-centric communities
 - More delay in areas in Louisiana affected by a hurricane
 - Possibly more delay in New England region due to fall foliage visitors in more urbanized areas
- Level-of-Service (LOS) is a traditional measure to help tell the story on how a signal is operating, but because the letters cover a range of delay values, performance measures like the traffic signal efficiency index (TSEI) provide more detailed insight for both traffic engineers and the public on how the signal is operating.
- The range of traffic signal efficiency was broader in smaller urban areas than larger urban areas.
- Traffic signals in urban areas with higher traffic signal density generally performed at a higher efficiency than urban areas with less traffic signal density. This is likely due to how signals are operated and resources dedicated to traffic signal timing and routine maintenance in areas with more signals and more traffic. The observation on effect of signal density can be different depending on whether the analysis is performed at the corridor level or the urban area level. In the latter case, other confounding factors such as resources (funds, personnel), maintenance routine, equipment, etc., may impact results. A comparison between different corridors with different signal densities in the same urban area might give us a more granular perspective and may result in a different inference.
- This dataset provides useful information at the urban area level for comparison to peer urban areas and to track performance over time. Aggregating data to the statewide level might not be the best suited use of signal data in its current state, but it still provides some context to operational metrics, which can be investigated further at a more granular level depending on use case and scope of application.
- Community goals vary between urban areas, as some urban areas promote non-motorized transportation more than other communities, while some utilize traffic calming techniques to achieve other goals over optimizing signal systems to maximize vehicular throughput. These are important considerations when comparing urban areas to each other.

POLICY AND PRACTICE RECOMMENDATIONS

This dataset provides actionable information from a planning perspective for local traffic engineers at the corridor level by providing granular information on operations of individual traffic signals. This approach of using probe-based travel data reduces the burden on agency traffic engineering staff and infrastructure, while improving reporting on traffic signal performance to elected officials and the public. The dataset is useful for understanding traffic signal performance for intersections along a corridor to alert traffic engineers of potential areas that need closer evaluation. Examination of time-of-day patterns at individual intersections and at the corridor level can be another practical application of this data.

While this dataset cannot replace the need for detection equipment to serve as the “eyes” of the traffic signal controller, it can serve as a tool for traffic engineers to easily aggregate data and calculate easy to understand performance measures. One challenge for traffic engineers developing signal timing plans is when corridors cross jurisdictional boundaries. This dataset can provide the ability to measure performances for a corridor in multiple jurisdictions, regardless of equipment used by each agency along the corridor.

Traffic Signal Efficiency Index (TSEI) for Top 101 Urban Areas by Population Size



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