Performance Ranking of Arterial Corridors Using Travel Time and Travel Time Reliability Metrics

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ABSTRACT

Performance measures are important for managing transportation systems and demonstrating accountability. Probe vehicle data has emerged as a means of gathering vast amounts of information about highway networks. This paper presents a scalable methodology for analyzing arterial travel times, taking into account both the central tendency of the travel time and its reliability. A pilot analysis is carried out for 28 arterials with a total of 341 signalized intersections across the state of Indiana. Starting from individual minute-by-minute speed records, the data are converted into travel times and aggregated into time series cohorts that correspond to typical traffic signal time-of-day periods, reflecting different time-of-day behavior characteristics of traffic control in arterials. The data is normalized with respect to the ideal travel time (based on the speed limits on each route) to account for individual route lengths and speeds. Data is compiled for all Wednesdays from January through July 2014 to investigate arterial characteristics. The data shows that a greater density of traffic signals on a route loosely corresponds to higher average travel times and less reliability. A composite index incorporating both the average values and reliability characteristics of travel time is developed, and used to rank the arterials according to their performance.

SURVEY OF ARTERIALS

Arterial Routes Selected for Study

DATA QUALITY

Freeway versus Arterial Data Coverage

Arterial Section: Northbound SR 8, Greenfield, IN

PERFORMANCE MEASURE

- Data must be normalized because routes are of different length.
- Travel Rate method expresses travel time as amount of time per mile.
- Normalization To Ideal Travel Time expresses travel time as percentage of the ideal travel time
- This analysis uses speed limit travel time as surrogate for ideal travel time.
- This analysis uses normalization to speed limit travel time in order to compare multiple roadways with different travel speed expectations.

RANKING METHODOLOGY

Normalization of Central Tendency

1. Convert minute by minute speed data into travel time data for 15 minute intervals
   \[ T_{i} = \frac{1}{N} \sum_{j=1}^{N} \left( \frac{V_{j}}{S_{j}} \right) \]

2. Compute measures of central tendency and variability for each time series
   \[ s_{x} = \frac{1}{N} \sum_{j=1}^{N} x_{j} \]
   \[ m_{x} = \frac{1}{N} \sum_{j=1}^{N} x_{j} \]

3. Normalize according to the “ideal” travel time (in this study, the speed limit is used)
   \[ T_{x} = \frac{1}{N} \sum_{j=1}^{N} \left( \frac{V_{j}}{S_{j}} \right) \]

Normalization of Variability (Reliability)

Before

After
Performance Ranking of Arterial Corridors Using Travel Time and Travel Time Reliability Metrics

Overall corridor ranking based on:
- The worst performance of the two directions
- Averaged across three time-of-day periods

Index

\[ \text{Index}_{\text{Overall}} = \frac{1}{N} \sum_{i=1}^{N} \text{Index}_{i} \]

Composite Index

Composite index developed based on Euclidean distance from ideal conditions

\[ \text{Index}_{i} = 100 \sqrt{(\text{Central tendency of travel time} - \text{speed limit travel time})^2 + (\text{Standard deviation of observed travel times})^2} \]

ARS

Spacing of Signals on the Arterial Segment

- > 1.5 mile
- 1.0 mi – 1.5 mi
- 0.5 mi – 1.0 mi
- 0.33 mi – 0.5 mi
- < 0.33 mi

Variability tends to increase as the central tendency increases.

Systems with greater spacing (lower density) of traffic signals tend to have lower variability and shorter travel times.

Systems with smaller spacing (higher density) of traffic signals tend to have higher variability and longer travel times.

PARTIAL RANKING BY TIME OF DAY

AM Peak (0600-0900)

Midday

PM Peak (1500-1900)

Top 10 Arterial Corridors

 Composite Index

Overall corridor ranking based on:
- The worst performance of the two directions
- Averaged across three time-of-day periods

Index

\[ \text{Index}_{\text{Overall}} = \frac{1}{N} \sum_{i=1}^{N} \text{Index}_{i} \]