15-0063

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

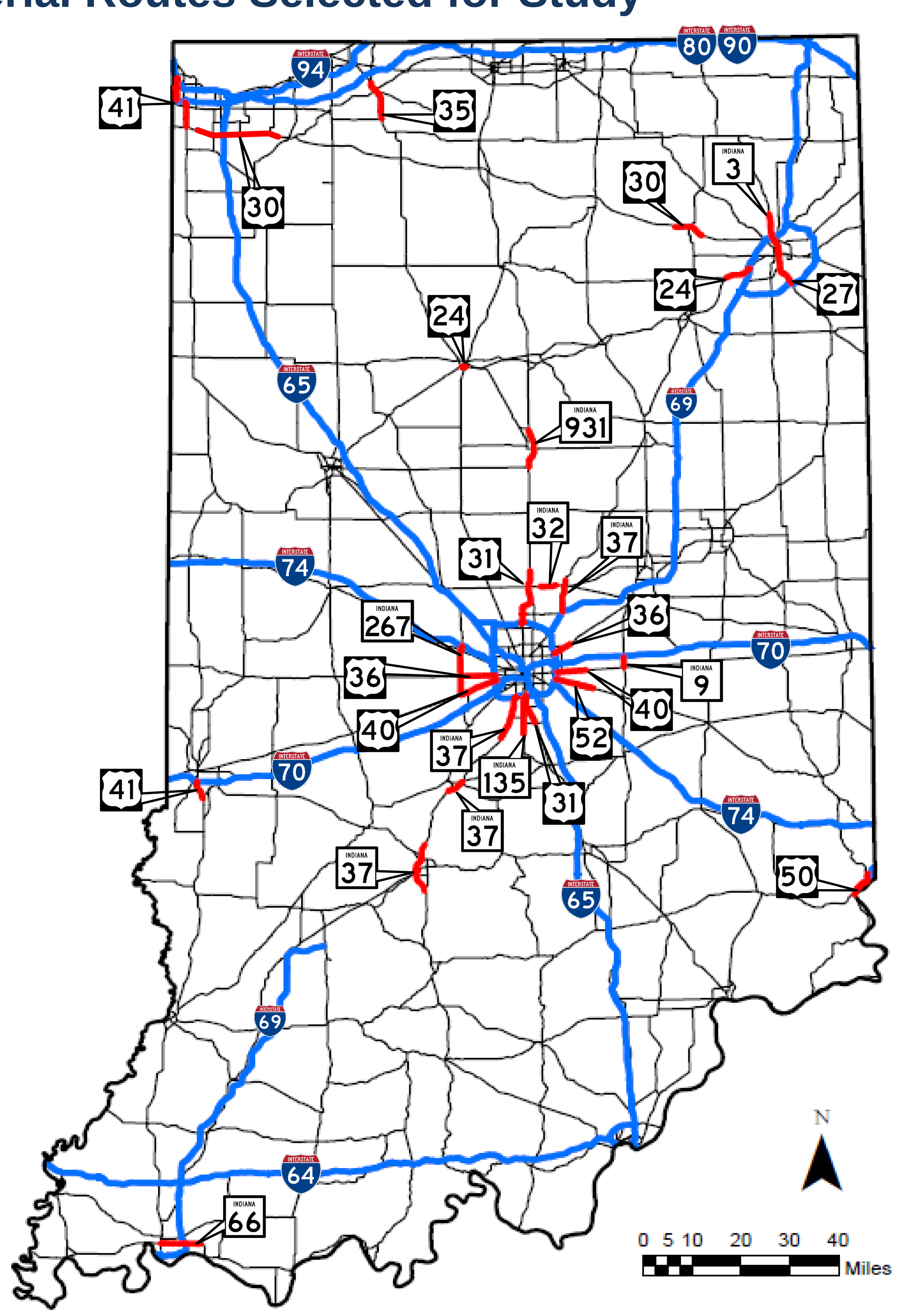
Christopher M. Day[1], Stephen M. Remias[1], Howell Li[1], Michelle M. Mekker[1], Margaret L. McNamara[1], Edward D. Cox[2], and Darcy M. Bullock[1]
1: Purdue University; 2: Indiana Department of Transportation

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.

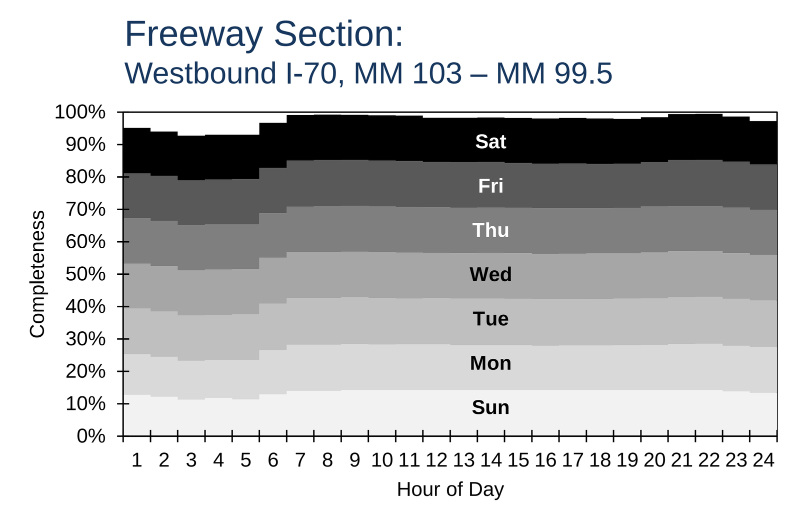
SURVEY OF ARTERIALS

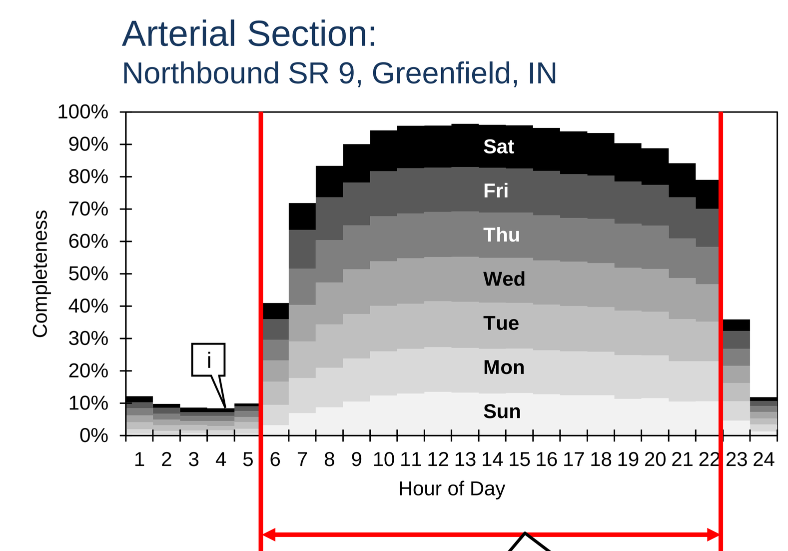
Arterial Routes Selected for Study



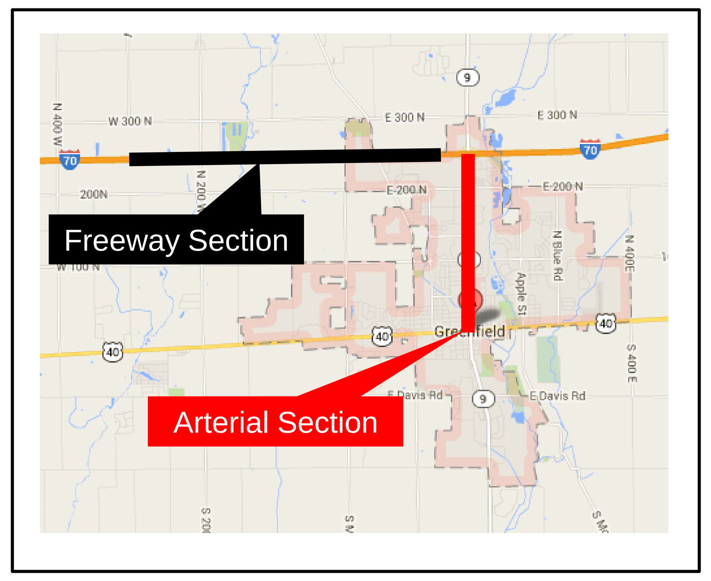
DATA QUALITY

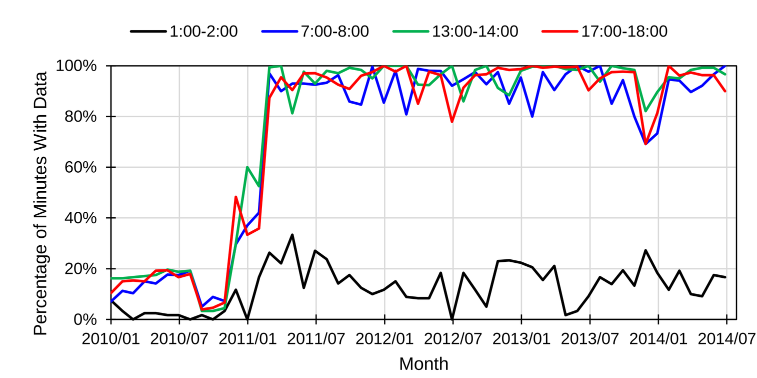
Freeway versus Arterial Data Coverage





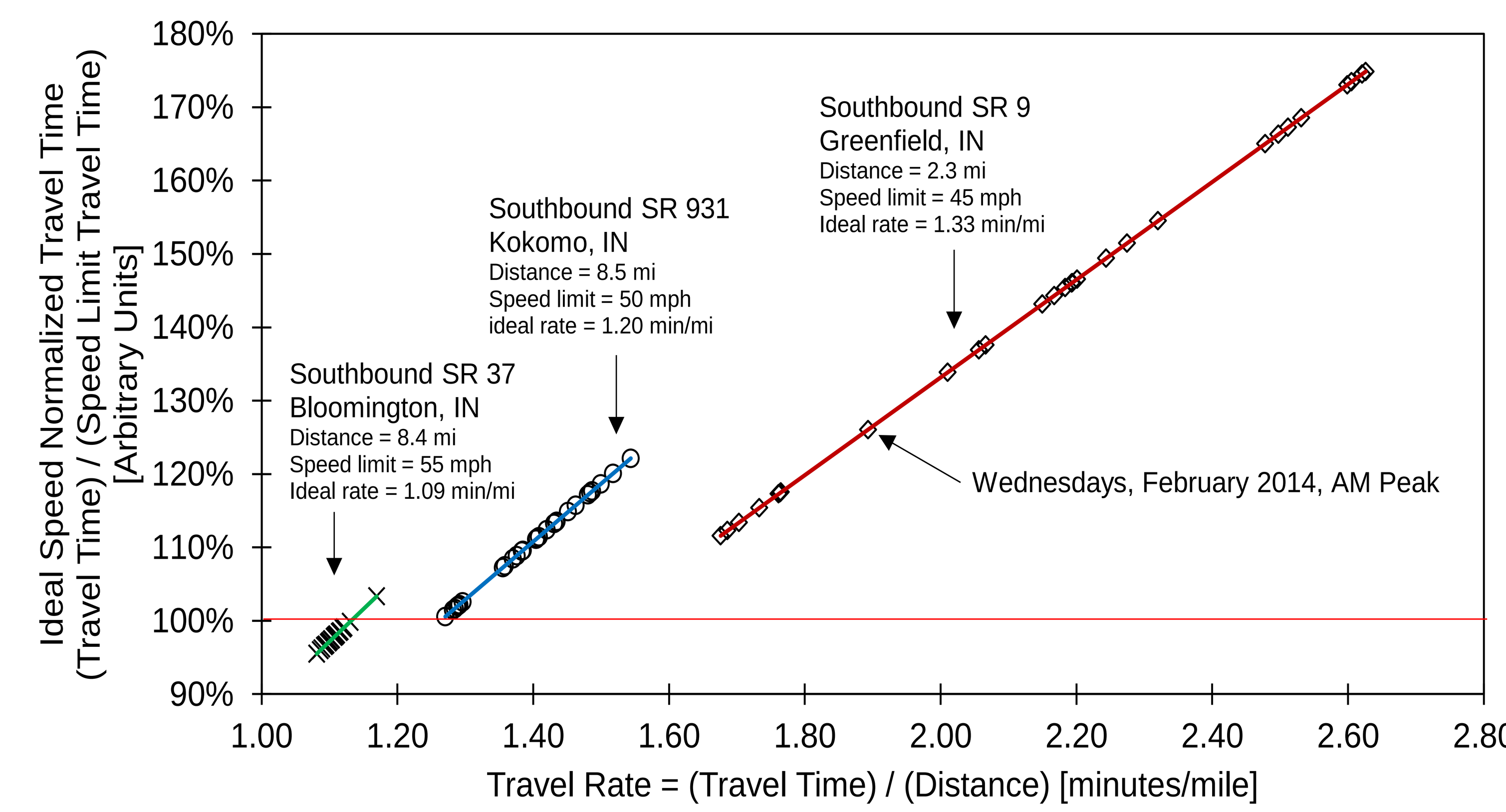
Arterial data is complete enough to analyze the busiest portion of the day spanning 6:00 through 22:00.





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

1. Convert minute-by-minute speed data into travel time data for 15-minute intervals

$$t_j = \sum_{i \in S} \frac{d_i}{v_i}$$

2. Computer measures of central tendency and variability for each time series

$$x_T = \frac{1}{N_T} \sum_{j \in T} t_j$$

$$s_T = \frac{1}{N_T} \sum_{j \in T} (t_j - x_T)^2$$

3. Normalize according to the "ideal" travel time (in this study, the speed limit is used)

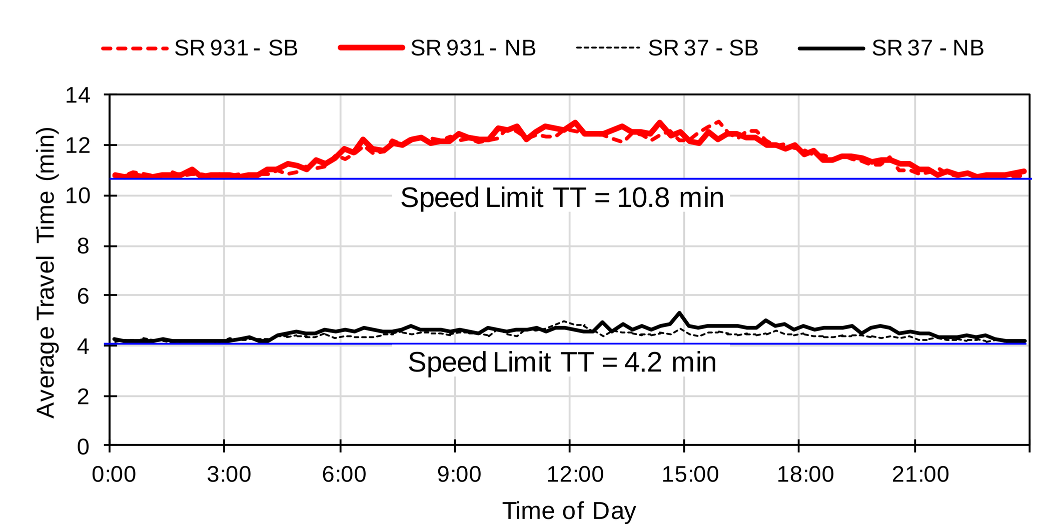
$$t_0 = \sum_i \frac{d_i}{L_i}$$

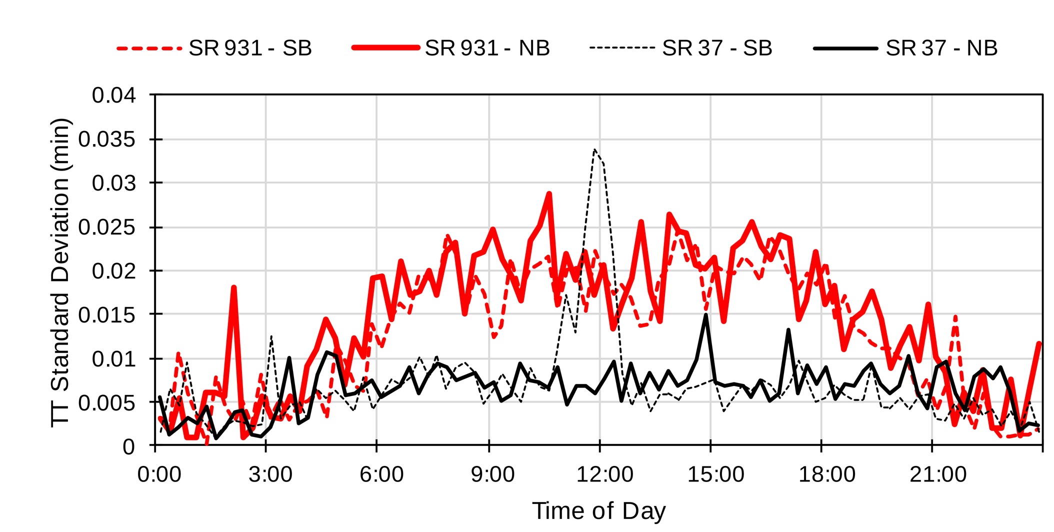
$$x'_T = \frac{x_T}{t_0} \qquad s'_T = \frac{s_T}{t_0}$$

Normalization of Central Tendency

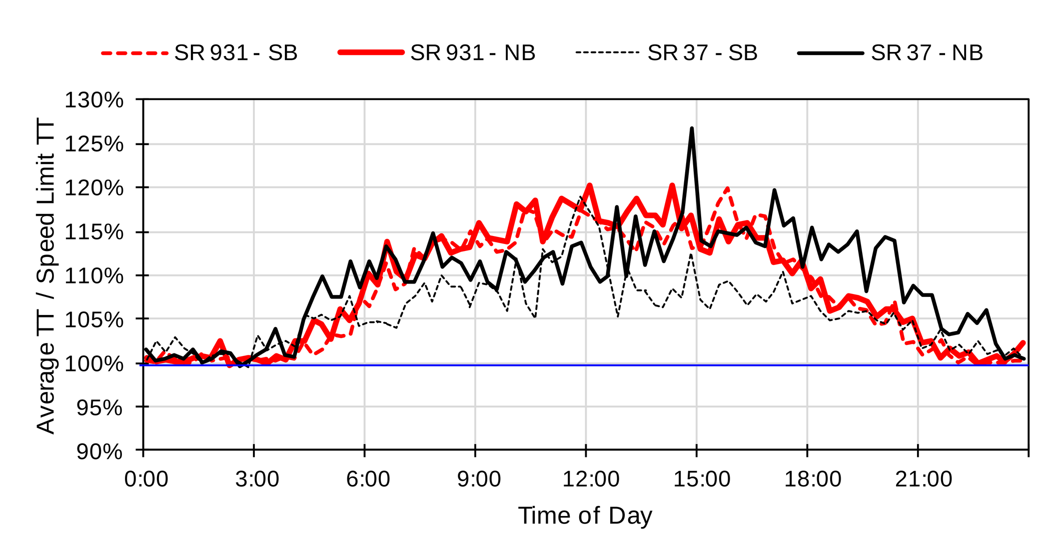
Normalization of Variability (Reliability)

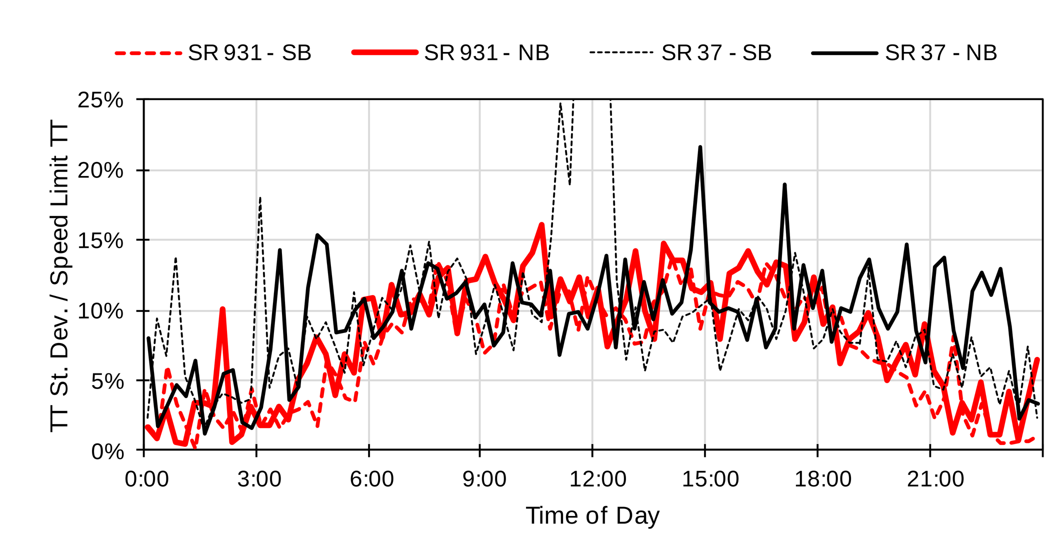
Before





After





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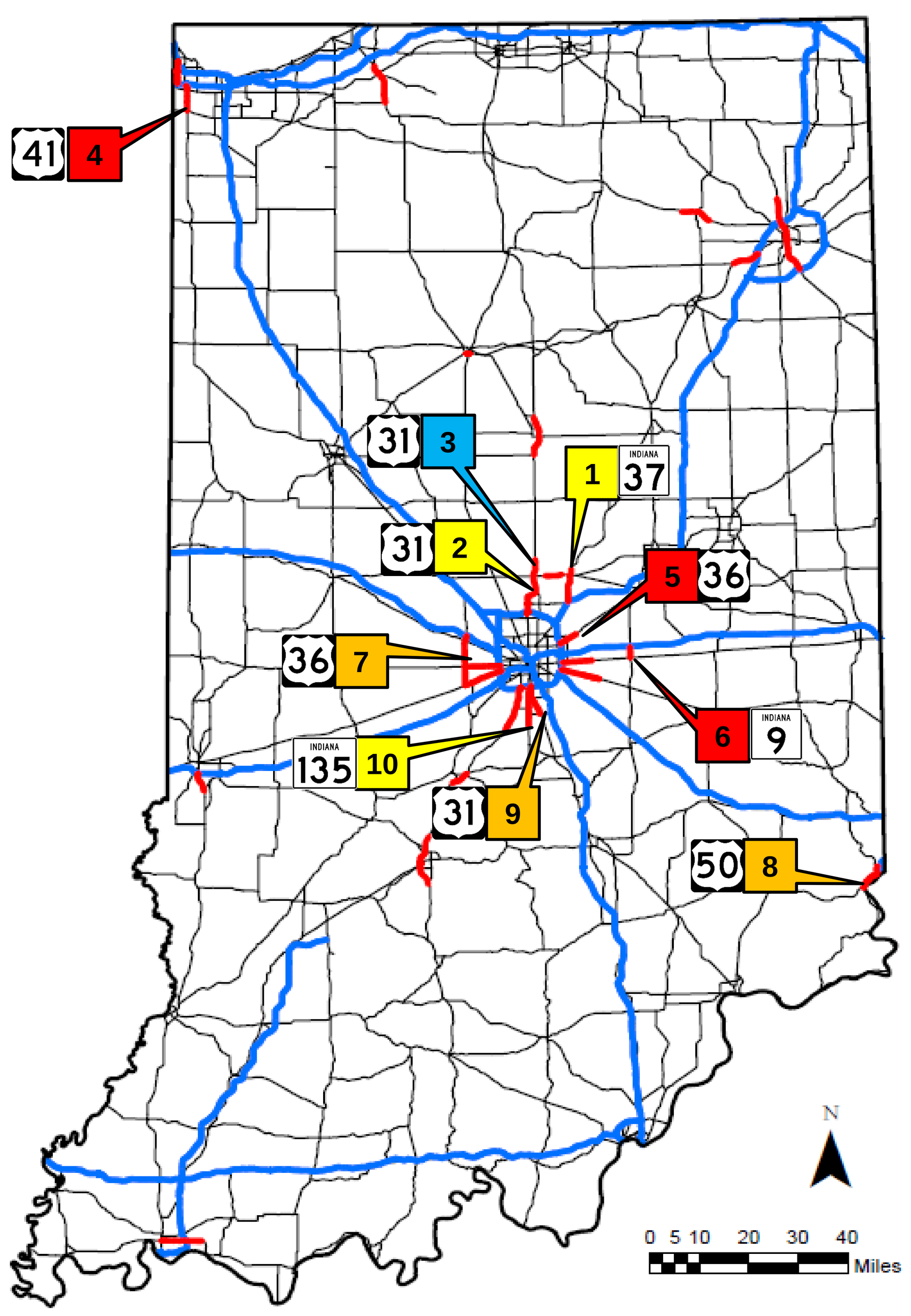
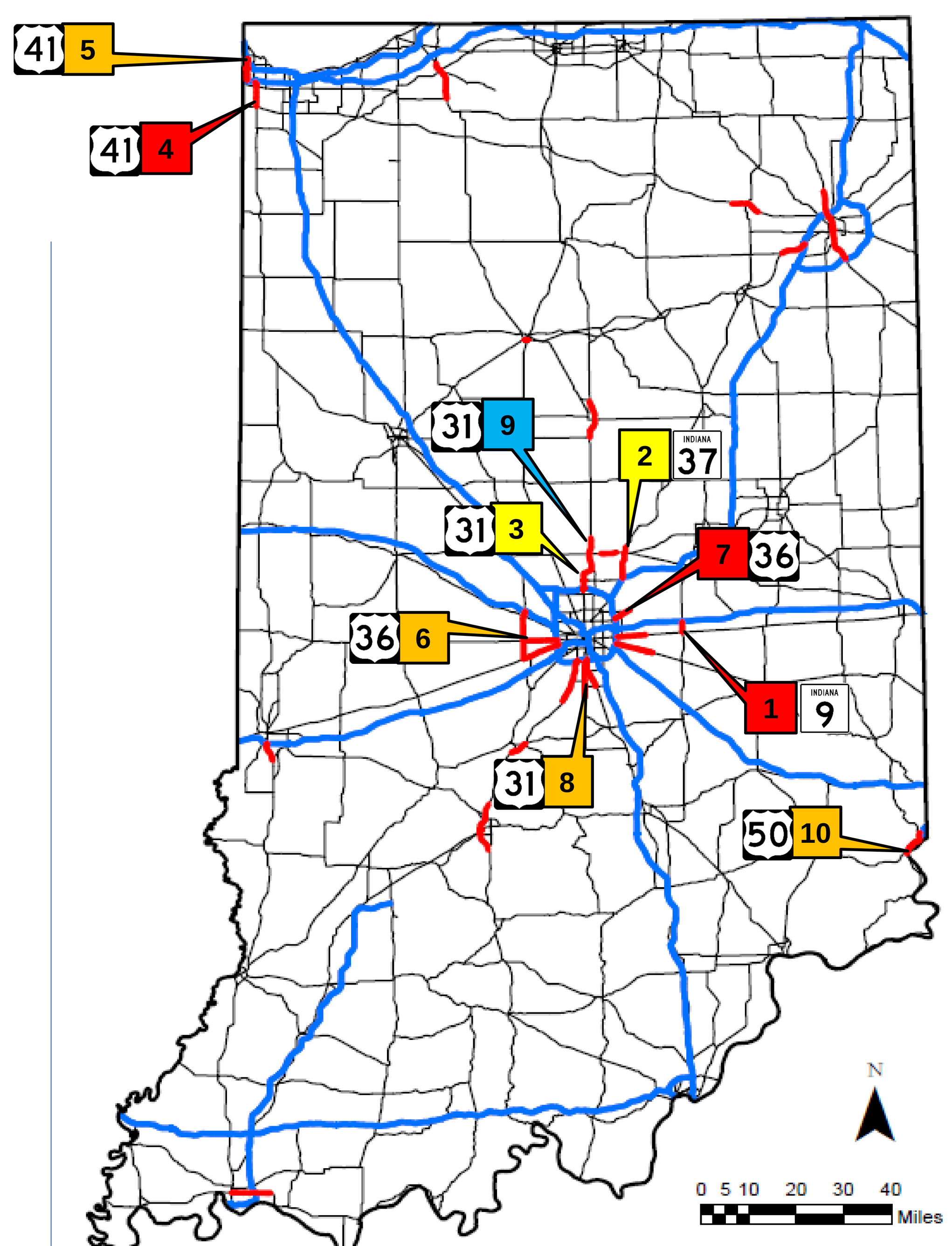
ARTERIAL RANKING BY TIME OF DAY

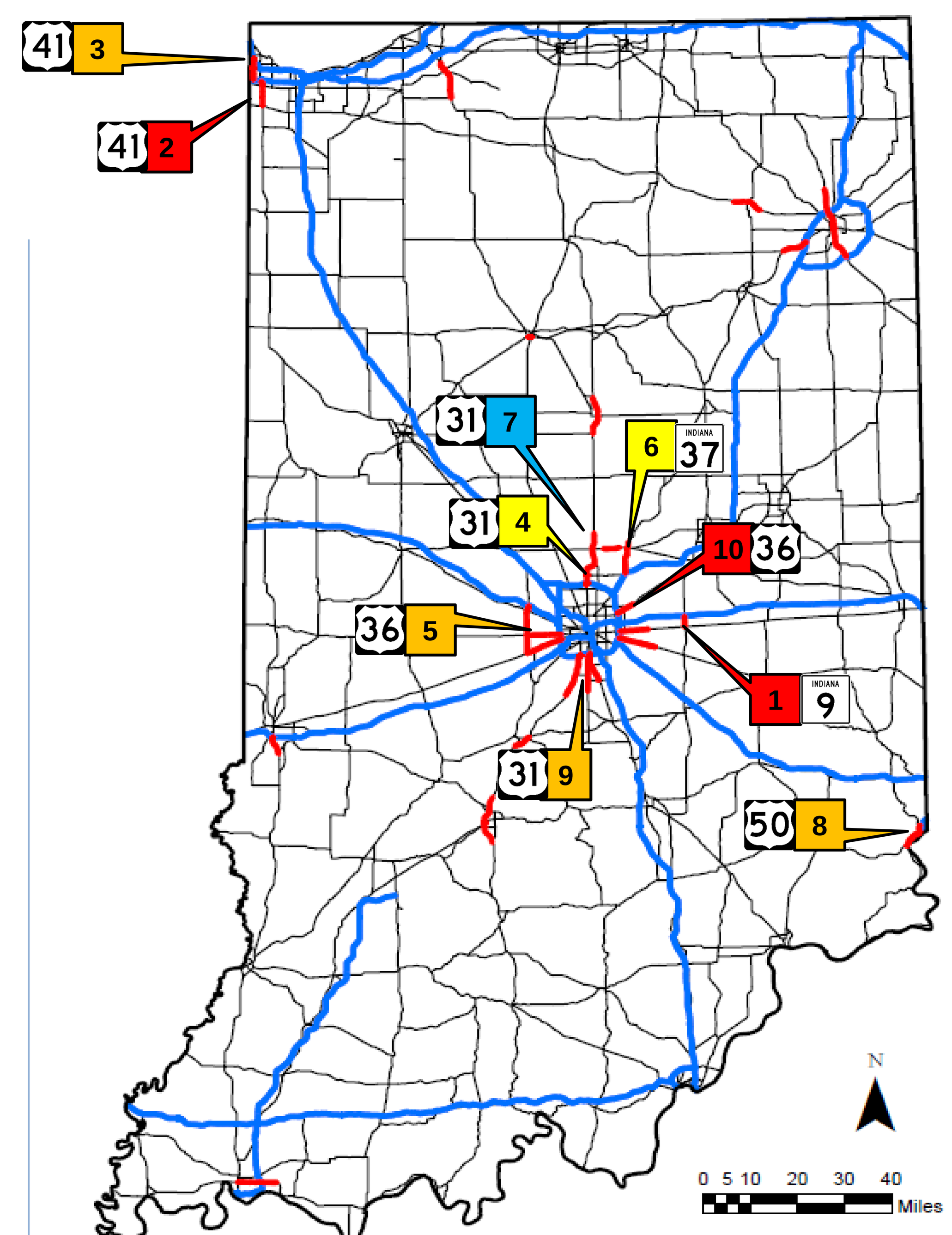
AM Peak (Top 10)



Midday (Top 10)



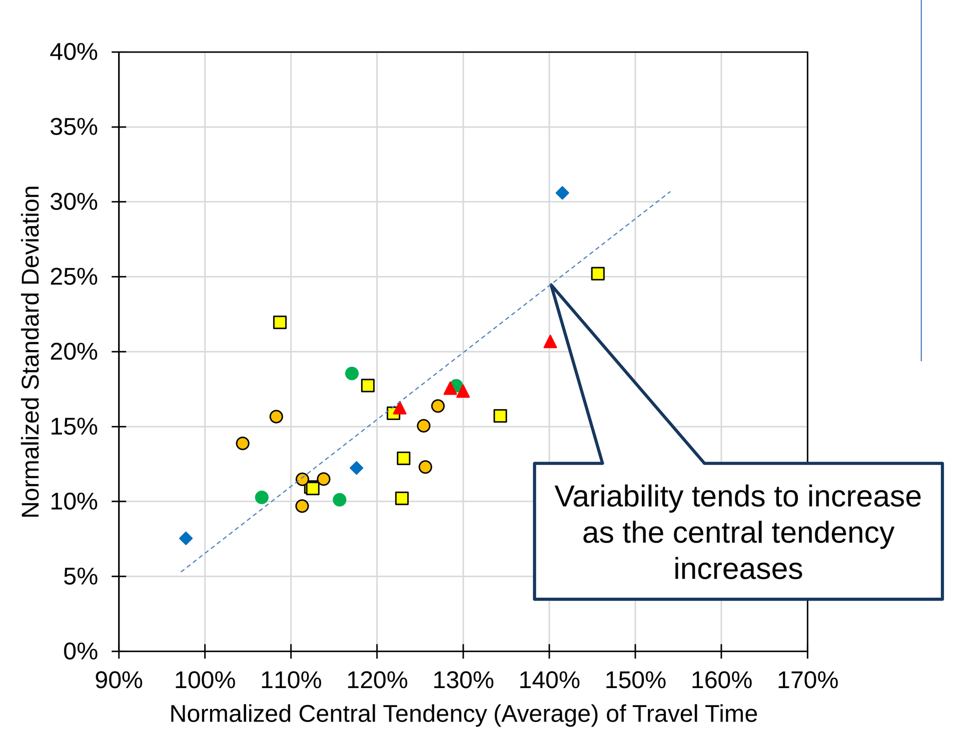
PM Peak (Top 10)



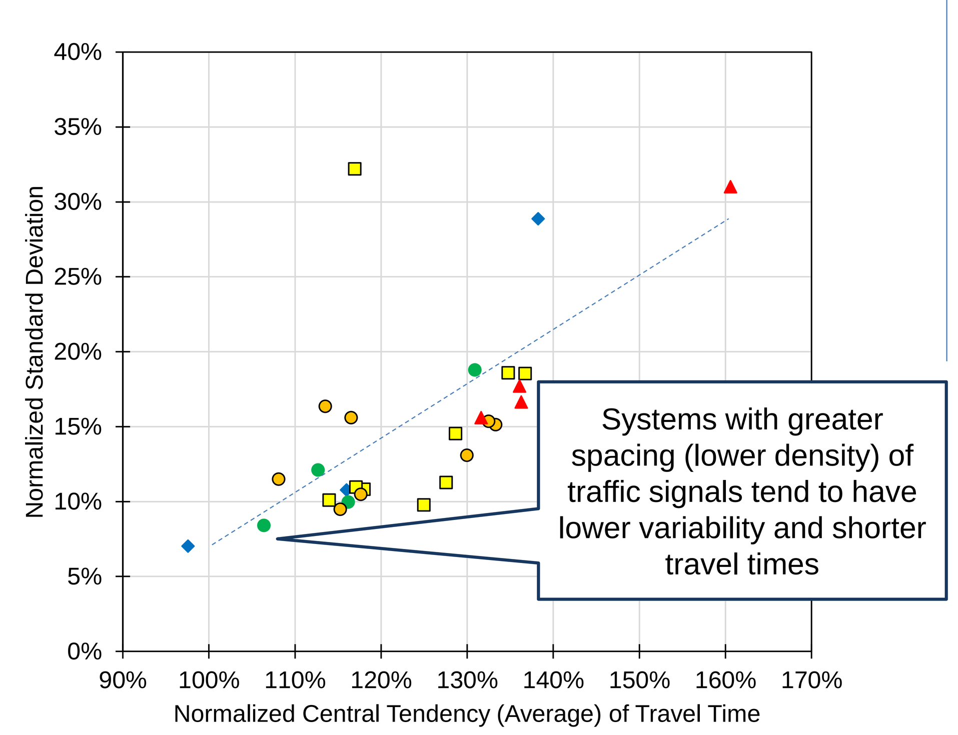
Spacing of Signals on the Arterial Segment

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

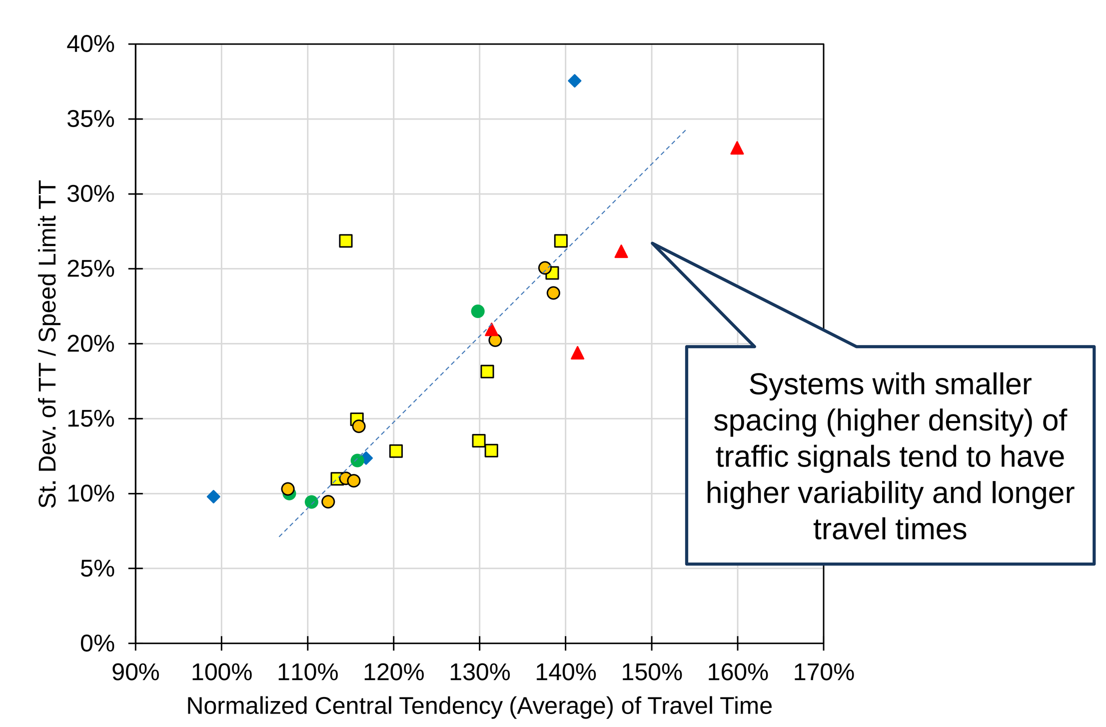
AM Peak (0600-0900)



Midday



PM Peak (1500-1900)

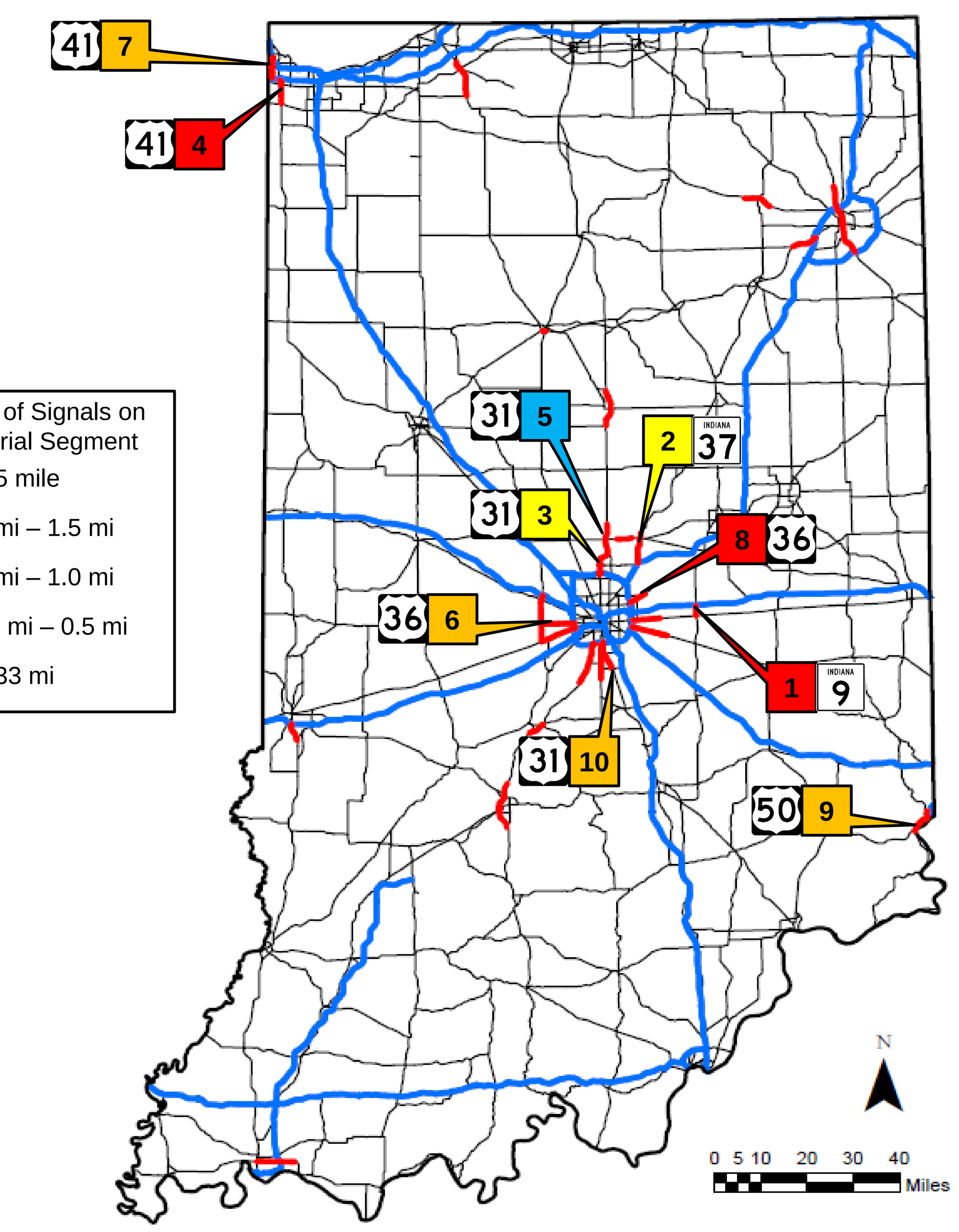


OVERALL RANKING

Top 10 Arterial Corridors

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



Composite Index

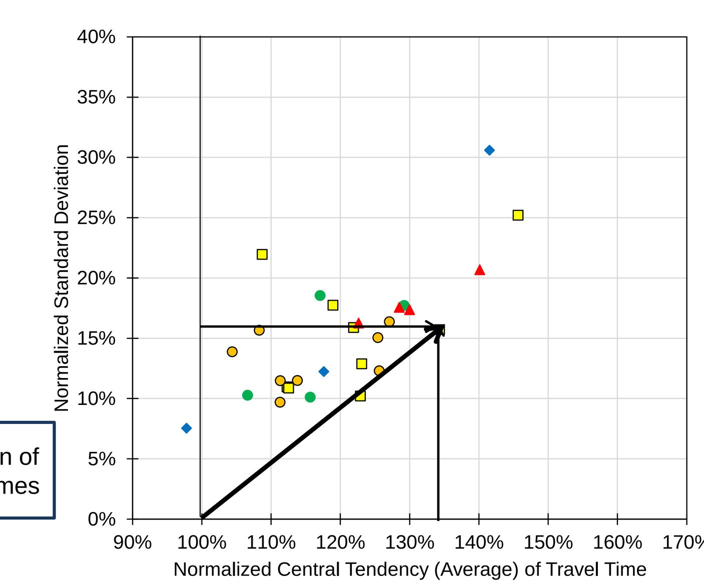
Composite index developed based on Euclidean distance from ideal conditions

$$\text{Index}_T = 100 \cdot \sqrt{\left(\max\{0, x'_T - 1\}\right)^2 + \left(w \cdot s'_T\right)^2}$$

Central tendency (when travel time > speed limit travel time)

Weighting factor (= 1)

Standard deviation of observed travel times



Overall corridor ranking based on:

- The worst performance of the two directions
- Averaged across three time-of-day periods

$$\text{Index}_T = \max\{\text{Index}_{[\text{Direction1}]}, \text{Index}_{[\text{Direction2}]}\}$$

$$\text{Index}_{\text{Corridor}} = \frac{1}{N}\sum_T Index_T$$