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Kentucky Transportation Center

Research Report
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Analysis of Historical Travel Time Data

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KTC-15-12/SPR12-444-1F

ANALYSIS OF HISTORICAL TRAVEL TIME DATA

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16. Abstract
Travel speed is a critical piece of information for many applications. The Moving Ahead for Progress in the 21st Century Act (MAP-21) states that calculating travel speeds illuminates the performance of the nation's highway system. New technologies make the collection of speed data more straightforward than ever. Private vendors collect and sell this data, and KTC purchased speed data for 2010-2013 from NAVTEQ (now HERE). The main objectives of the research were to:

- Evaluate private sector speed data and its use in generating travel time based performance measures
- Create a mechanism to integrate this speed data with networks maintained by KYTC and Kentucky Metropolitan Planning Organizations (MPOs) to facilitate congestion management and travel model improvement
- Generate performance measures, including travel time index, planning time index, buffer index, annual hours of delay, and percentage travel under congested conditions

This study assessed private sector speed data, its potential as a robust data source, and its limitations. Evaluation of the data indicated that link-referenced ATP data offered the best value for a wide range of applications. It offered details on speed distribution and provided critical insights into the dynamics of congestion and the variability of travel times. Among the three types of data, the link-referenced ATP data should be the first choice when future purchases of private sector speed data are made. These data provided critical support to develop the performance measures required by MAP-21. These data need to be linked with traffic volumes to generate the full range of performance measures. Data remain sparse for roads with lower functional classifications, especially collectors and local streets. When sample size is a concern, the research team recommends that data from other sources (such as Bluetooth, radar, and others) be used to supplement the private sector speed data. A range of congestion and reliability performance measures have been generated from these data and were provided to KYTC and MPO stakeholders in the form of geodatabases. Other applications can benefit from these data, including: the calibration and validation of simulation models, travel demand models, and air quality analyses.

17. Key Words
Traffic volume, congestion, travel times, time-based performance measures, private sector speed data, link-referenced ATP data, MAP-21

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EXECUTIVE SUMMARY

Travel speed is a critical piece of information for many applications. It is a measure that is often used to calculate the performance of the nation's highway networks. In 2011, the Kentucky Transportation Cabinet (KYTC), in collaboration with the Kentucky Transportation Center (KTC) at University of Kentucky, purchased speed data for 2010 and 2011 from NAVTEQ (now HERE). In 2013, speed data for the year 2012 were acquired from the same vendor. The specific data items included:

- 2010 Analytical Traffic Pattern (ATP)
- 2010 Traffic Pattern (TP)
- 2011 Link-Referenced ATP
- 2012 Link-Referenced ATP

The main objectives of this research were to:

- Evaluate the private sector speed data with regard to its use in generating travel time based performance measures
- Create a mechanism to integrate this speed data with networks maintained by KYTC and Kentucky Metropolitan Planning Organizations (MPOs) to facilitate congestion management and travel model improvement
- Generate performance measures including travel time index, planning time index, buffer index, annual hours of delay, and percentage travel under congested conditions

Evaluation of the data indicated that link-referenced ATP data offered the best value for a wide range of applications. It can be used to generate performance measures on many Kentucky roadways, including many minor arterial and collectors that are not typically included in the TMC network. Link-referenced ATP had finer spatial resolution, which allowed for the identification of bottlenecks on longer corridors. The calibration and validation of travel demand models and simulation models may also benefit from the data because they reflected measured and unedited speeds across different times of day. Among the three types of data evaluated, the link-referenced ATP data should be the first choice when future purchases of private sector speed data are made.

The analyses performed as part of this study demonstrated the robustness of the link-reference ATP data, and these findings will support KYTC's and MPOs' needs for performance tracking. Since probe vehicle data were not available on all segments for all time intervals, private sector speed data remained sparse on many roadways, especially low volume rural roads. Nevertheless, probe vehicle sample size and coverage has improved over recent years.

For segments with adequate sample coverage, performance measures were generally reliable. When sample size is a concern, the research team suggests that data from other sources (such as Bluetooth, radar, and others) supplement private sector speed data. A range of congestion and reliability performance measures were generated from these data after they had been conflated with the KYTC's highway inventory network. Results were sent to KYTC and MPO stakeholders in the form of geodatabases. Other applications can benefit from these

data, including: the calibration and validation of simulation models, travel demand models, and air quality analyses.

CHAPTER 1 BACKGROUND

Travel speed is a critical piece of information for many applications, such as congestion management, air quality conformity analysis, and travel demand model calibration and validation. The Moving Ahead for Progress in the 21st Century (MAP-21) states that travel speed is a necessary input when calculating measures that evaluate the nation's highway performance. Traditional speed data collection methods such as floating cars require significant effort and resources to achieve desirable accuracy. With the advances in GPS and communication technologies, speed data have become increasingly available through private data vendors.

In 2011, the Kentucky Transportation Cabinet (KYTC), in collaboration with the Kentucky Transportation Center (KTC) at the University of Kentucky, purchased speed data for 2010 and 2011 from NAVTEQ (now HERE). In 2013, KTC acquired speed data for 2012 from the same vendor. The data obtained included:

- 2010 Analytical Traffic Pattern (ATP)
- 2010 Traffic Pattern
- 2011 Link-Referenced ATP
- 2012 Link-Referenced ATP

The main objectives of the research were to:

- Evaluate the private sector speed data and its use in generating travel time based performance measures
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- Generate performance measures including travel time index, planning time index, buffer index, annual hours of delay, and percentage travel under congested conditions

The comprehensive research was divided into several major projects, which were funded through different sources. Planning Study 20 (PL-20) funded the tasks of purchase, quality control, and network conflation with KYTC's roadway system. SPR12-444 and PL-24 funded the data analyses and the generation of performance measures. This report documents the research carried out under SPR12-444 and PL-24.

1.1 2010 Network and Data

The 2010 ATP data is Traffic Message Channel (TMC)-based, which means that the probe data was only available on the TMC network. TMC protocol was developed decades ago to deliver travel information to motorists via conventional FM radio broadcasts. The TMC network largely coincides with the National Highway System (NHS). As a result, the TMC-based speed data have very limited coverage. Figure 1-1 shows the TMC-based network for the 2010 ATP data.

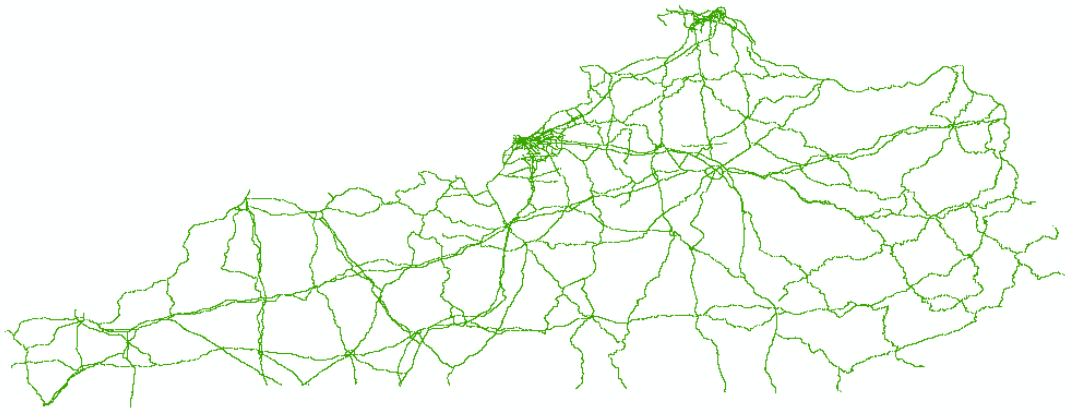


Figure 1-1 2010 TMC-based network

The 2010 ATP data were reported at 15-minute intervals and aggregated by day of the week and by month. When a highway segment on the TMC-network did not have sufficient probe vehicle coverage, the vendor used other information such as historical data and/or data on similar roadways in the area to estimate average speeds. The algorithm to estimate these data is proprietary and not available to the research team. Therefore, the application of these data on generating performance measures is limited.

1.2 2011 Network and Data

The 2011 link-referenced ATP data were attached to the links of the massive NAVTEQ street network. The speeds were reported at 5-minute intervals and grouped by day of the week and by month. Speeds were not reported on a link for the periods when probe data were not available. In addition to the average speeds, probe speed sample size and speed standard deviation were also reported for each link and for each time interval.

Examination of the 2011 link-referenced ATP data showed that many lower functionally classified roads (mostly in NAVTEQ functional class 5, which roughly corresponds to FHWA's local roads classification) had very small sample sizes. When performance measures for 2011 were generated, those roads were excluded. Figure 1-2 shows the 2011 link-referenced ATP data coverage on NAVTEQ roadways (classes 1–4). The high resolution of the 2011 link-referenced ATP data allowed for performance analysis to be conducted on every link and at 5-minute intervals. For the purpose of maintaining consistency with the 2010 measures, it was decided that measures would be generated for 15-minute intervals.

Figure 1-2 2011 Link-referenced network

MAP-21 also requires that performance measures be generated for all roads in the National Highway System (NHS). The NHS roads for which speed data were available for 2011 are shown in Figure 1-3.

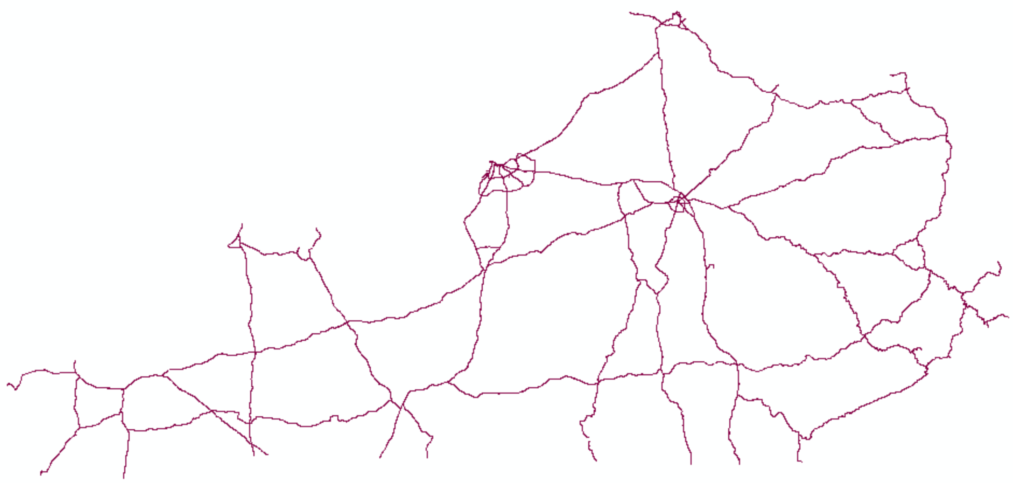


Figure 1-3 2011 National highway system network

The 2011 NAVTEQ network was conflated with KYTC's Highway Performance Monitoring System (HPMS) network. One drawback of this practice is that many attributes in the HPMS network have been aggregated from multiple links, and therefore, using the HPMS network sacrificed granularity. At the advice of the advisory panel, this approach will not be used in the future conflation amid changes to the data management process at KYTC.

1.3 2012 Network and Data

The 2012 data have the same format as the 2011 ATP data. Noticeable differences included the addition of new roads and changes in roadway segmentation. Both of these changes resulted in added links and therefore an increased number of link IDs.

Network conflation was performed using the NAVTEQ street network and KYTC's HIS network extract of traffic flow (TF), speed limit (SL), type of operation (OP), and functional classification (FS). These asset types were chosen because they contained information needed for performance calculations after the conflation was completed. Conflation involved spatially joining the two networks to link their attributes together. But since the definition of travel direction differed between the NAVTEQ network and the HIS network, complications arose. Further, for divided highway segments, NAVTEQ's network may use two lines, one for each travel direction, to represent that segment, whereas there may be a single line in the HIS network. A manual check was necessary to identify mismatches and to align the direction of travel between the two systems.

Through discussions with KYTC, it was concluded that the following steps would be the most advantageous to link the performance measures generated by this study to KYTC's Transportation Enterprise Database (TED):

- Perform spatial join between the NAVTEQ and HIS layers to assign NAVTEQ links with rid (i.e., RT_NE_UNIQ), fmeas (i.e., BEGIN_MP) and tmeas (i.e., END_MP) to their end points. The detailed procedure has been developed at KYTC (*1*).
- Find the coordinates of the end points for each link, and follow the NAVTEQ "direction of travel" defined in the bullets below to assign From_Node or To_Node to each end point. This will require the creation of additional fields that would be appended to the attribute table.
  - The end point with lower latitude would be From_Node and the other would be To_Node.
  - If both end points have the same latitude, the one with lower longitude would be the From_Node and the other would be To_Node.
- Add a cardinality field to the HIS attribute table, and assign direction code. This will align the "DIR_TRAVEL" (i.e., direction of travel) in NAVTEQ street (with the entry of "T" or "F") attribute with the cardinal direction.
  - If the milepoint increases from From_Node to To_Node, then let cardinality = Y;
  - Otherwise, let cardinality = N
- For two-way operation, as defined in asset OP (Type of Operation) or as "B" (i.e., both ways) in NAVTEQ field DIR_TRAVEL, duplicate each link ID in the data table. Change DIR_TRAVEL from "B" to "T" in the original records and from "B" to "F" in duplicated records (or vice versa) based on the NAVTEQ "direction of travel" logic mentioned above.
- In the duplicated records, change the cardinality of the duplicated record to the opposite of the original.
- Perform manual check to identify and correct mismatches.

1.4 Data Quality Screening

1.4.1 Conflation Check

To generate performance measures, it was necessary to conflate the NAVTEQ links, (which contained speeds) with KYTC's highway network, (which contained volume and other important inventory data). The conflation task is part of Planning Study 20. The final report for that study will contain the description of the concept and methodology developed by the research team for the 2010 TMC-based network. The conflation technique evolved over time. The 2011 data were conflated to KYTC's HPMS network, while the 2012 data were conflated to KYTC's HIS network. A description of the latest technique was provided in Section 1.3.

While the parameters used in the automated conflation process can be adjusted to find the optimum match between the two networks, mismatches were inevitable due to the networks' complexities. For example, when conflating the 2011 networks, a mismatch occurred at the interchange of the Watterson Expressway and Newburg Road in the Louisville metro area, shown in Figure 1-4. Because of the extremely short length of the Watterson Expressway link (highlighted in the figure), the algorithm assigned the state's HIS attributes from the intersecting segment of Newburg Road to the expressway segment. This was the most typical type of mismatch observed during the manual check.

Figure 1-4 Example of mismatched link

While there is no systematic way to identify where mismatches happen and correct them at one time, a set of screening rules was developed to facilitate the quality assurance process.

For 2010 and 2011 data, the team observed that mismatches at interchanges could be identified by comparing the original NAVTEQ roadway class of a segment with its assigned FHWA functional class (from the state's inventory database) following conflation. This involved three steps. First, a rough mapping between the NAVTEQ roadway class and FHWA functional classification was created (see Table 1-1). Then, for a given segment, if its original NAVTEQ roadway class differed from the FHWA functional classification by two or more levels, the record was flagged as a possible mismatch. For example, the NAVTEQ roadway class of the segment of Watterson Expressway is 1. If conflated correctly, the FHWA functional classification should be 11. However, if the assigned FHWA functional classification is 14, 16, 17, or 19, a mismatch most likely occurred. Manual checks of the flagged segments were conducted to fix the errors.

Table 1-1 Roadway class mapping

FHWA Functional Classification	NAVTEQ Class
1,11	1
2,12	2
6,14,16	3
7,8,17	4
9,19	5

During analysis of the 2012 data, an additional rule (based on network connectivity) was adopted to find potentially incorrect integration that could not be identified by class mapping. The rule used the ending mile point of the upstream link and the beginning mile point of the downstream link when the combination of NAVTEQ link ID and direction were the same for those two links. For a possible mismatch, such as the example above, the link ID and direction combination was the same for the links on Watterson Expressway and Newburg Road. The mile points of those two links were not continuous. Therefore, those two links were flagged for further examination. It should be noted that when a route enters another county the milepoint may reset. Caution should be used when applying this milepoint-based quality-screening rule. Despite being labor intensive, milepoint-based screening is quite useful at identifying mismatched segments.

1.4.2 Sample Adequacy

The speeds in the 2011 and 2012 ATP data sets came directly from the probe vehicle speeds recorded at each link during a specified period. Since the number of probes sampled for a time interval determined the collected data's accuracy, the limited sample size of probe vehicle speeds in some time intervals cast doubt on the usability of these data. In practice, the floating car or probe vehicle technique has been widely used to collect traffic information, and the data from sampled probes can be used as a trusted estimate of population characteristics when sample size is deemed adequate. A previous study by Chen and Chien (2), who used a calibrated freeway traffic simulation model, demonstrated that a 3% sampling rate was adequate to produce statistically accurate estimates of travel time at the 95% confidence level. In a similar study, Turner and Holdener (*3*) analyzed the data collected from the Houston traffic monitoring system, and they indicated that the minimum number of samples was determined by the variation of travel time. For a 15-minute analysis period, 2-4 samples would be sufficient to achieve a 95% confidence level. Since the number of samples required to derive accurate information would vary, depending on facility type and traffic characteristics, it would be difficult to set a specific threshold for adequate sample size.

The research team developed a series of indicators to better understand the distribution of sample size on a link over time. They are shown in Table 1-2.

Table 1-2 Sample adequacy measures

Measure	**Description**
TotalIntervals_Ideal	Number of 15-min intervals of the time period of interest. For example, 8064 in the whole year.
TotalIntervals_Sampled	Number of 15-min intervals with probe data during the time period of interest.
PcntInterval_Sampled	Percentage of 15-min intervals with probe data during the time period of interest. It is calculated as 100*TotalIntervals_Sampled/TotalIntervals_Ideal
TotalSamples	Total number of probe samples collected during the time period of interest
AvgSamplePerInterval	Average number of samples per 15-min interval that has probe speed data during the time period of interest. It is calculated as TotalSamples/TotalIntervals_Sampled.
AggStdDev	The standard deviation of all 15-min speeds during the time period of interest. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N}n_i)X^2}{(\sum_{i=1}^{N}n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples	The maximum number of samples in an interval during the time period of interest. It can be used to find potentially erroneous records which have excessively large numbers of probe vehicles.
PIF	Peak interval factor for the time period of interest. It is calculated as TotalSamples/(TotalIntervals_Sampled*MaxSamples). The concept is similar to peak hour factor and is proposed as an indicator of the concentration of samples.

TotalIntervals_Sampled and PcntIntervals_Sampled were calculated for 2011 and 2012 data, while the rest of the measures were only available for 2012 data. Additional time periods, such as mid-day period, weekdays, and weekends were also calculated for 2012 data.

The following example illustrates the temporal and spatial coverage of samples. Figure 1-5 shows the 2011 statewide network with probe data. The cyan-highlighted roads are those with probe speeds available less than 0.5% of the time during the year. That is, no more than 40 periods out of 8064 (i.e., 96 15-minute intervals a day and 7 days of a week for each of 12 months) total 15-minute periods in a year have probe vehicle speeds recorded for these roads. Most of the highlighted roadways are rural facilities or urban facilities with low functional classification. Larger sample sizes are most readily available from heavily traveled urban interstates and a small number of roads that are frequently traveled by commercial vehicles.

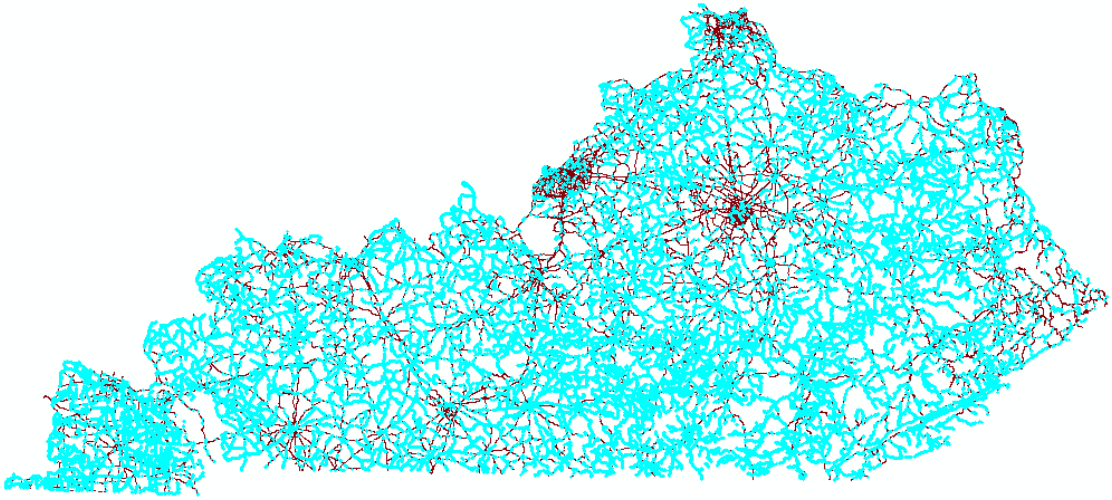


Figure 1-5 2011 Probe sample coverage

As the percentage of time intervals that have probe data decreases, confidence in the data diminishes. A minimum threshold of 1% probe coverage was chosen as the adequate sample size. This is equivalent to requiring a minimum of 80 15-minute intervals to have probe speeds in a year. Reasonable confidence can be gained for the time period being analyzed, including all days in the year, all weekdays, weekday AM periods, weekday PM periods, and so forth. Table 1-3 lists the smallest level of temporal coverage that should be satisfied for different time periods in this study. When the sample percentage of a link was less than 1%, the link was flagged in the record.

Table 1-3 Minimum sample size desired

Time Period	Total Intervals	1% Threshold
All days	8064	81
Weekdays	5760	58
Weekends	2304	24
Weekday daytime(6am-8pm)	3360	34
Weekday AM period (6am-9am)	720	8
Weekday mid-day period (9am-3pm)	1440	15
Weekday PM period (3pm-6pm)	720	8

1.4.3 Data Anomaly

Occasionally, the average speed on a segment was unreasonably low, such as less than 1 mph for a number of periods in a day across the entire year. Review of the original data did not find reasonable explanation for this anomaly. These segments were often low-volume rural roads that were not prone to recurring congestion. The probe sample sizes were usually quite limited for those segments. With a large portion of the data in very slow speed range, the performance measures generated would be skewed. In this study, segments with their yearly 85th percentile speed below a specified threshold (such as one half of the speed limit) were flagged in the database. The criteria used to flag such outliers are listed in Appendix A for 2011 data and in Appendix B for 2012 data. For some short segments at signalized intersections, a large number of vehicles may travel at very low speeds because many of them may need to wait for a green light. Therefore, this rule was more suitable for corridor-level analysis, and applications at the link level required special caution.

The cyan-highlighted roads Figure 1-6 indicate 85th percentile speeds of all days in 2011 that were not flagged as suspicious by these quality-screening rules.

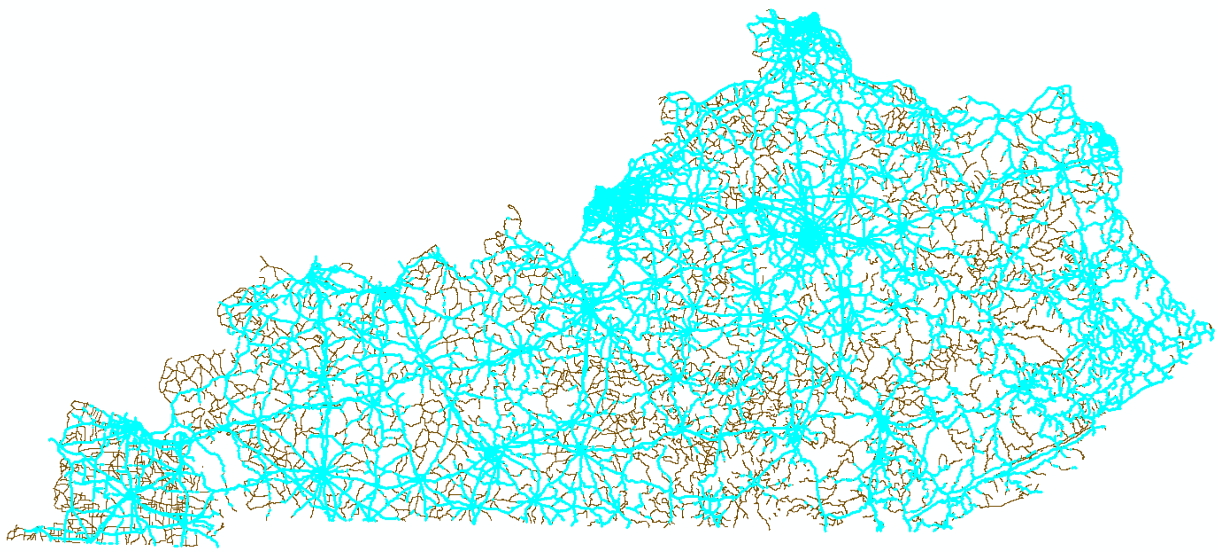


Figure 1-6 2011 Network with highlighted routes satisfying sample adequacy requirement

CHAPTER 2 PERFORMANCE MEASURES

This chapter discusses the analyses involved in developing performance measures based on travel times. Drawing from various studies at the national and state levels (4, 5), we developed the following performance measures based on the speed data:

(1) Average AM peak speeds for (6-9am) and PM (3-6pm) periods
(2) Travel time index for AM and PM periods by direction
(3) Planning time index for AM and PM periods by direction
(4) Buffer index for AM and PM periods by direction
(5) Annual vehicle miles traveled (VMT) under congested condition
(6) Annual vehicle hours traveled (VHT) VHT under congested condition
(7) Annual vehicle hours of delay

For 2011 data, measures 1–4 were calculated based on all days of data for the entire year. For 2012 data, they were calculated separately for weekdays, weekends, and all days.

For many of these performance measures (e.g. travel time index), it was necessary to define the uncongested benchmark condition. The speed value that separates congested from uncongested conditions is defined as reference speed in this report. Section 2.1 discusses ways to determine reference speeds.

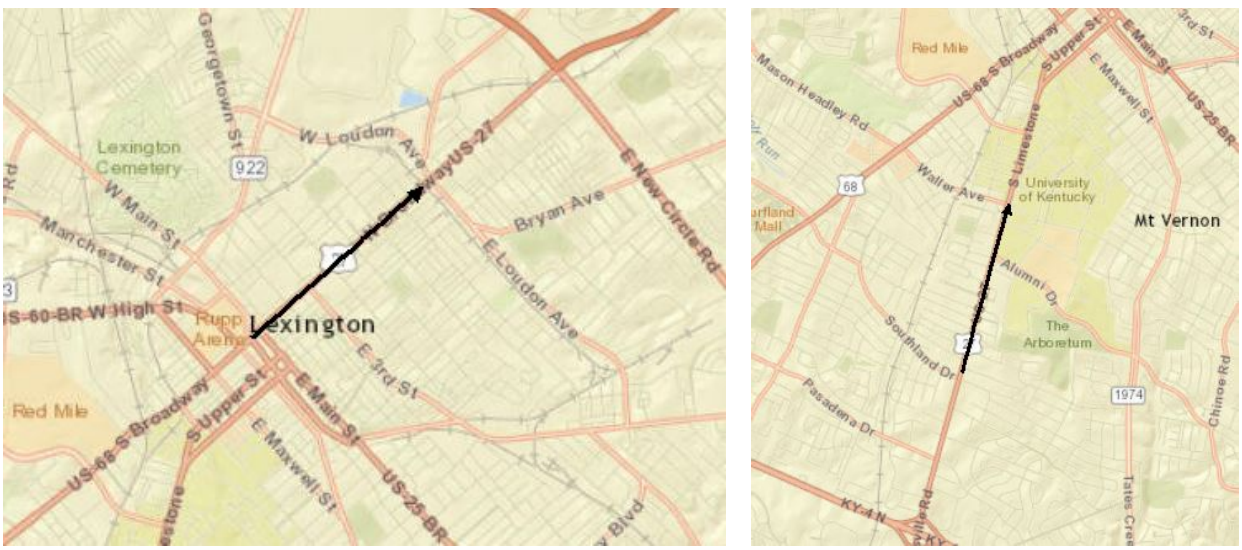
2.1 Determine Reference Speed

A benchmark condition should be defined before measuring congestion. Free-flow speed has been used widely as such a benchmark. However, for facilities on which the free flow speed conditions are rarely achieved during the day time, using free-flow speed may overestimate level of congestion. In this study, the term "reference speed" is used to confer more flexibility to agencies when setting the benchmark condition and the performance target. A typical reference speed used for performance measurement is the 85th percentile speed, which is measured using all time intervals throughout a year (*4;* 6). Variations of this measure have also been used (7, 8).

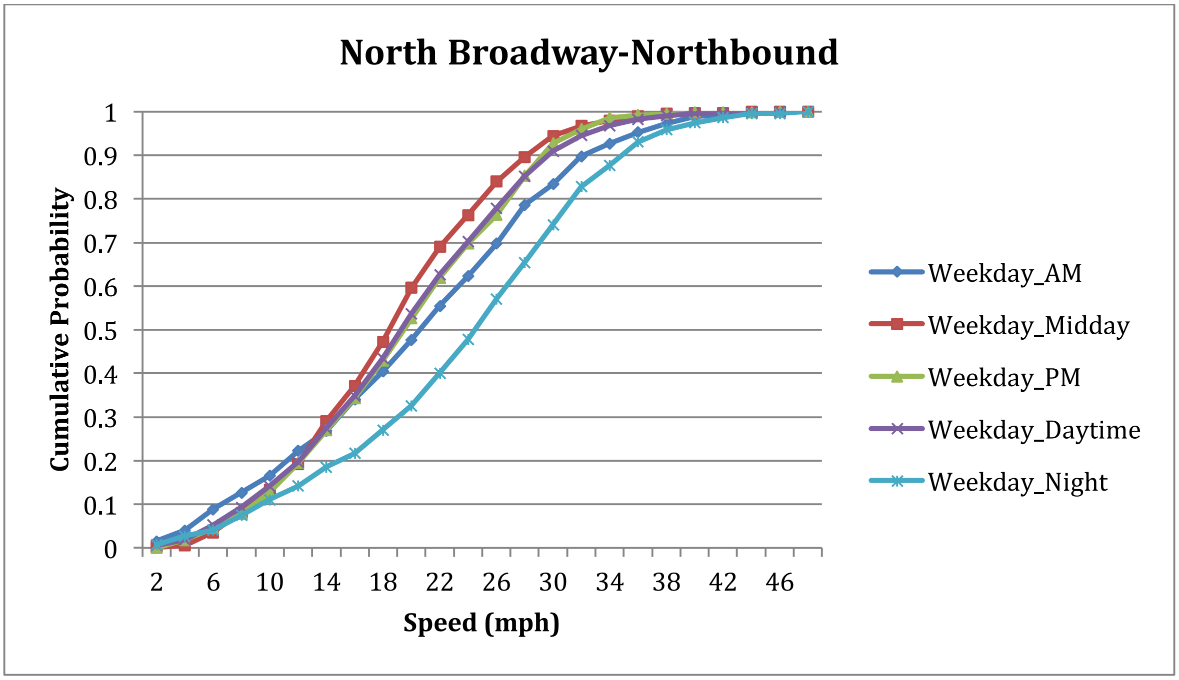
2.1.1 The 85th Percentile Speed

The 85th percentile speed is the speed value at the 85th percentile point of the cumulative speed distribution of a road segment for all time periods. For 2010 and 2011 data sets, the 85th percentile speed was selected based on all data from that year. There were few samples available from 2010, so only instances where there were at least two sample speeds per 30-minute interval were used to determine the 85th percentile speed. For 2012 data, the 85th percentile speed was determined for each of the three time periods: weekdays, weekends, and all days.

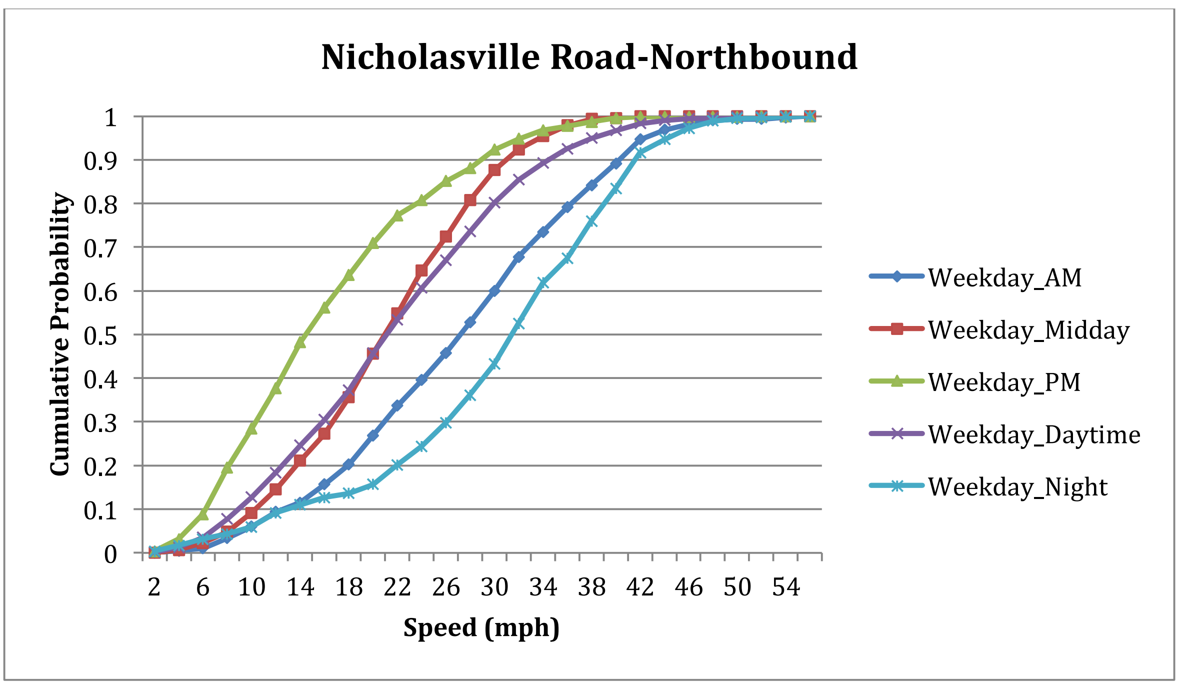
The 85th percentile speed worked well for uninterrupted facilities since traffic can potentially achieve that speed while traversing a road segment. On urban arterials, flow will be periodically interrupted by traffic signals – even when traffic volume is very light. Furthermore, signal timing plans may change throughout the day, especially in large urban areas. During peak periods on heavily traveled corridors, a longer green time or wider green band was often established. As a result, peak hour speeds on roads or directions accorded preferential treatment may be higher than the speeds recorded on the same facilities during other periods of the day. The research team examined speed distributions on sample arterials, including the North Broadway and Nicholasville Road corridors in Lexington (see Figure 2-1(a)&(b) for specific locations). For the northbound travel direction on North Broadway, the cumulative distribution functions in Figure 2-1(c) showed that mid-day period speeds were often lower than the speeds during both the AM and PM peaks. 80% of the speeds during the mid-day were less than 25 mph, while only 60% of the AM peak speeds were less than 25 mph. An evaluation of the traffic flow indicated that the mid-day volume was 840 vehicles/hour while the AM peak hourly volume was 1433 vehicles/hour.



(a) (b)



(c)



(d)

Figure 2-1 (a) North Broadway location map; (b) Nicholasville Road location map; (c) cumulative distributions of speeds on North Broadway; (d) cumulative distributions of speeds on Nicholasville Road

Similarly, for the northbound travel direction on the Nicholasville Road segment, the AM peak speed was generally higher than speeds observed during any other period except for the nighttime. Although this section's AADT was 44600 vehicles, vehicles moving north during the AM peak encountered significantly better conditions due to the extra lane added under the reversible lane operation. During the PM peak only one northbound through lane remained open, with the southbound direction having three operational through lanes. As a result, the PM peak speeds were the lowest in a day, as shown in Figure 2-1(d).

Data from these two sites revealed that on an urban arterial, low flow conditions may not always correlate with higher speeds, and peak period speeds are not always the slowest. This is often observed on urban arterials with signal timings that grant preferential treatment to specific lanes or to traffic moving in a particular direction. Nighttime speeds are most likely the highest compared to speeds during daytime periods. Therefore, using nighttime speed as the reference speed tended to inflate the level of congestion.

To determine an appropriate reference speed for the special characteristics of urban interrupted facilities, various percentile values were derived and compared to the speed curve (sorted by time of day). The 85^{th} percentile speed during weekday daytimes was the preferred choice since it was derived from the daytime (6am–8pm) speed profile and it more accurately reflected the impact of traffic signals on speed. Therefore, this finding was added to the bundle of reference speeds produced for 2012 data.

2.1.2 The 60th Percentile Speed

For interrupted urban facilities, there has not been a strong consensus on how to select a proper reference speed for performance measurement. Many continue to use the 85^{th} percentile speed as the reference speed, while others have tested different percentile values. A study conducted by the Texas A&M Transportation Institute explored using the use of 60^{th} percentile speed during the daytime as the benchmark to measure congestion on urban arterials (9). This was to account for the fact that flow may be impeded by traffic control devices even when the intersections are operating at light traffic conditions. Such delay should not be viewed as the result of congestion. Tests conducted on sample road segments indicated that the 60^{th} percentile speed was very similar to the average speed during the midday period and therefore, was selected as a candidate for the reference speed for urban interrupted facilities, i.e., FC14 or below.

For 2011, the 60^{th} percentile speed was determined by using daytime data. This encompassed the period between 6am and 7pm for all days. At the request of the advisory committee, for 2012 data, the 60^{th} percentile speed was based on weekday daytime data between 6am and 8pm. It should be noted that the 85th percentile speed was still used as the reference speed for other periods.

2.1.3 Speed Limit as Reference Speed

Speed limit, as indicated in the HIS data, can be used as a reference speed. Speed limit based performance measures are computed for the years of 2011 and 2012.

2.2 Other Performance Measures

Several metrics were applied to different aspects of traffic congestion in the Kentucky roadway system. Those measures included travel delay, VMT and VHT under congested conditions, travel time index, planning time index, and buffer index.

2.2.1 Travel Delay

Travel delay refers to the additional time spent traveling because of congestion. Due to fluctuating demand, traffic incidents, adverse weather and many other factors, it is unrealistic to suggest that transportation systems operate under ideal conditions all the time. Transportation agencies and MPOs have widely used total vehicle hours of delay to monitor the transportation system and trends in congestion. Annual hours of delay (AHD) can be calculated with the following equations. Formulas differ depending on the data format.

2010 data:

$$AHD = \sum_{n}\sum_{m}\sum_{w}\sum_{h} VMT_{m,w,h} * \left(\frac{1}{V_{m,w,h}} - \frac{1}{RS}\right)$$

Where:
n denotes the number of specific weekdays in each month, for example, there are 5 Fridays in January in 2010;
m denotes the month of year;
w denotes the day of week;
h denotes the hour of the day;
$VMT_{m,w,h}$ denotes the vehicle miles traveled in hour of day h, day of week w, and month of year m;
$V_{m,w,h}$ denotes the hourly average speed in this time period; and
RS denotes the reference speed.

2011 and 2012 data:

$$AHD = 52 * \sum_{w}\sum_{h} VMT_{w,h} * \left(\frac{1}{V_{w,h}} - \frac{1}{RS}\right)$$

Where:
w denotes the day of week;
h denote the hour of the day;
$VMT_{w,h}$ denotes the total vehicle miles traveled during hour of day h, day of week w in a year;
$V_{w,h}$ denotes the hourly average speed during hour of day h, day of week w in a year; and
RS denotes the reference speed.

For 2011 and 2012 data, the delay measure should be used with caution, because data was not available for all time intervals. For intervals lacking data, delays could not be estimated. This is not to suggest that delay did not occur during those periods.

2.2.2 VMT and VHT under Congested Condition

In addition to delay, both vehicle miles traveled (VMT) and vehicle hours traveled (VHT) under congested conditions were calculated. These metrics reflect the number of vehicle miles and vehicle hours traveled when observed traffic speed was less than the reference speed.

2010 data:

$$VMT_{Congested} = \sum_{n}\sum_{m}\sum_{w}\sum_{h} VMT_{m,w,h} * \Delta_{m,w,h}$$

$$VHT_{Congested} = \sum_{n}\sum_{m}\sum_{w}\sum_{h} \frac{VMT_{m,w,h}}{V_{m,w,h}} * \Delta_{m,w,h}$$

Where $\Delta_{m,w,h}$ is a binary indicator and $\Delta_{m,w,h} = \begin{cases} \mathbf{1}, & \boldsymbol{if\ V_{m,w,h} > 0\ and\ V_{m,w,h} < RS} \\ \mathbf{0}, & \boldsymbol{otherwise} \end{cases}$

Other terms are the same as in 2010 delay calculation formula.

2011 and 2012 data:

$$VMT_{Congested} = 52 * \sum_{w}\sum_{h} VMT_{w,h} * \Delta_{w,h}$$

$$VHT_{Congested} = 52 * \sum_{w}\sum_{h} \frac{VMT_{w,h}}{V_{w,h}} * \Delta_{w,h}$$

Where $\Delta_{w,h}$is a binary indicator and $\Delta_{w,h} = \begin{cases} \mathbf{1}, & \boldsymbol{if\ V_{w,h} > 0\ and\ V_{w,h} < RS} \\ \mathbf{0}, & \boldsymbol{otherwise} \end{cases}$

Other terms are the same as in 2011 and 2011 delay calculation formula.

2.2.3 Travel Time Index

The travel time index (TTI) measures the severity of congestion during the peak period. It is defined as the ratio between travel time during the peak period and the reference travel time. TTI is also unit-less and therefore can be used to compare the congestion conditions across facilities with different geometric characteristics. The calculation formula is:

$$\boldsymbol{TTI = \frac{Average\ Travel\ Time}{Reference\ Travel\ Time}}$$

The above formula can be rewritten equivalently to the following formula:

$$TTI = \frac{Reference\ Speed}{Average\ Speed}$$

At the suggestion of the study advisory committee, 6-9am was designated as the AM peak period while 3-6pm was designated as the PM peak period.

2.2.4 Planning Time Index

The planning time index (PTI) is a measure for travel time reliability and is often computed as the ratio of the 95th percentile travel time (the 5th longest travel time) to the reference travel time. It reflects the travel time needed to ensure an on-time arrival at a destination on 19 days out of 20. Note that the PTI's definition is not restricted to the 95th percentile travel time. For example, an agency may choose to use PTI(80), i.e., the ratio the of 80th percentile travel time to the reference travel time, to measure the amount of time needed to ensure an on-time arrival 4 out of 5 trips. PTI is calculated using the following formula:

$$PTI = \frac{\text{The } 95th\ Percentile\ Travel\ Time}{Reference\ Travel\ Time}$$

The above formula can be rewritten equivalently into following formula:

$$PTI = \frac{Reference\ Speed}{\text{The } 5th\ percentile\ speed}$$

2.2.5 Buffer Index

The buffer index (BI) is closely related to the travel time index and the planning time index. It is the percentage time that a traveler needs to plan, relative to his/her own average travel time, to ensure a 95% chance of on time arrival. It indicates the extra effort a traveler needs to ensure an on-time arrival at a destination. It is calculated using this formula:

$$BI = \frac{\text{The } 95th\ Percentile\ Travel\ Time - Average\ Travel\ Time}{Average\ Travel\ Time}$$

The above formula can be rewritten equivalently into following formula:

$$BI = \frac{Average\ speed}{\text{The } 5th\ percentile\ speed} - 1$$

2.3 Results and Analysis

Since the 2010 TMC based data was considered less useful, this report focused mainly on the performance results for the 2011 and 2012 data. Performance measures were calculated using the 2011 and 2012 data, and were included in the attribute tables of the 2011 and 2012 geodatabases. These files have been delivered to KYTC and the MPO stakeholders. The complete lists of measures and methodology used in their calculation are in Appendices A and B.

2.3.1 Sample Sizes

Travel speeds were aggregated to the 15-min level by day of the week and by month. This resulted in 8,064 time intervals per year. Probe vehicle speeds were not available for all of these periods. The temporal coverage of the probe speeds was measured as the proportion of 15-min intervals in a year for which probe data were available. Table 2-1 shows the direction-miles of Kentucky roadways according to the ranges of temporal coverage. For example, a temporal coverage range of (1, 2) indicates probe speeds were available for 1% –2% of the 8064 intervals. This would equate to approximately 80-161 fifteen-minute periods. 16.097% of the 2012 total direction-miles have speed data at this temporal coverage range. The total direction-miles of the conflated network in 2011 and 2012 were 59,091.85 miles and 57,332.31 miles, respectively.

Table 2-1 Sample coverage of link-referenced ATP data

Temporal Coverage Range	Year		AM		PM	
	2011	2012	2011	2012	2011	2012
0	1.0	0.5	18.9	13.5	6.4	4.3
(0,0.012]	1.1	0.6	0.0	0.0	0.0	0.0
(0.012,0.5]	33.3	27.7	21.2	19.6	15.5	12.8
(0.5,1]	15.9	15.6	11.5	11.8	13.9	12.8
(1,2]	14.9	16.1	10.3	10.8	14.3	14.3
(2,5]	15.0	16.8	13.7	14.8	18.9	20.0
(5,10]	7.4	8.5	8.3	9.9	11.1	12.2
(10,20]	4.8	5.8	6.4	7.5	8.1	9.2
(20,50]	3.8	4.7	5.3	6.6	6.5	7.9
(50,100]	2.9	3.7	4.5	5.6	5.3	6.6

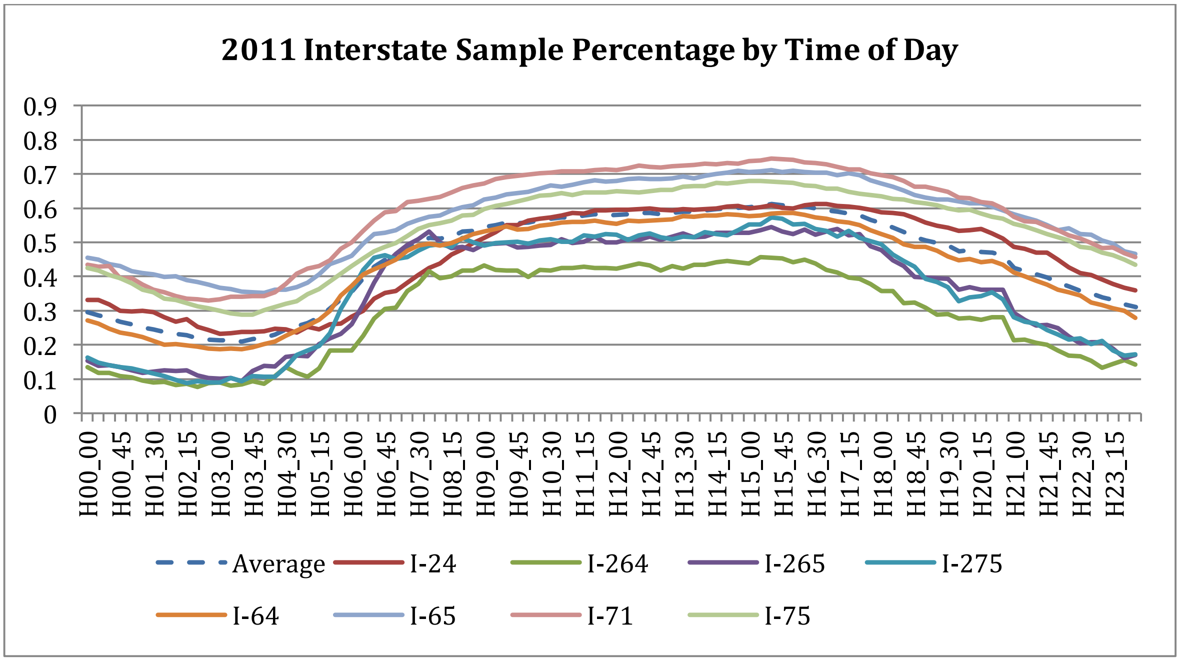
Table 2-1 indicates that data availability improved slightly between 2011 and 2012, both in terms of year-round statistics and peak-period statistics.

Table 2-2 partitions the data in Table 2-1 according to functional classification. Interstates and major arterials tend to have probe coverage at the high end, while lower functionally classified roadways, especially those in rural areas, have very limited data. The improvement in probe data coverage is mostly concentrated in higher functionally classified roads, such as interstates and major arterials.

Table 2-2 Sample size by functional classification (FC)

2011												
Range	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
0.0	0.0	0.0	0.0	0.1	0.9	3.2	0.0	0.0	0.0	0.0	0.1	0.8
(0,0.012]	0.0	0.0	0.1	0.2	1.2	3.1	0.0	0.0	0.0	0.0	0.1	0.6
(0.012,0.5]	0.0	0.5	7.8	19.6	47.6	63.0	0.0	0.0	0.4	3.0	12.1	32.0
(0.5,1]	0.0	1.5	9.7	19.1	21.8	17.0	0.0	0.1	0.5	6.0	14.6	23.2
(1,2]	0.0	4.4	17.7	23.7	16.8	9.2	0.0	0.6	2.2	13.2	23.1	21.3
(2,5]	0.1	15.2	32.0	25.6	9.9	3.9	0.1	2.9	12.9	32.8	30.8	15.6
(5,10]	0.4	21.7	21.1	8.3	1.5	0.4	0.6	6.1	24.0	27.1	14.4	5.0
(10,20]	1.3	23.5	9.2	2.8	0.3	0.1	2.6	14.4	32.9	14.7	3.9	1.4
(20,50]	10.3	26.9	2.2	0.6	0.1	0.1	18.3	44.7	25.9	3.2	0.8	0.3
(50,100]	87.9	6.4	0.0	0.0	0.0	0.0	78.3	31.2	1.2	0.0	0.0	0.0
2012												
Range	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
0.0	0.0	0.0	0.0	0.0	0.5	1.8	0.0	0.0	0.1	0.0	0.1	0.2
(0,0.012]	0.0	0.0	0.0	0.1	0.7	2.0	0.0	0.0	0.0	0.0	0.1	0.4
(0.012,0.5]	0.0	0.2	3.9	14.8	41.2	57.6	0.0	0.0	0.3	1.5	10.9	27.6
(0.5,1]	0.0	0.6	5.7	16.6	22.5	19.3	0.0	0.1	0.3	3.3	12.9	20.4
(1,2]	0.0	1.9	12.6	23.9	19.7	11.6	0.0	0.2	0.9	8.6	21.4	20.8
(2,5]	0.0	8.3	28.1	28.5	12.6	6.5	0.0	1.7	6.3	25.0	32.0	19.9
(5,10]	0.2	15.3	24.8	11.4	2.2	0.9	0.3	4.6	15.5	28.8	15.1	6.5
(10,20]	0.8	24.6	17.0	3.5	0.5	0.1	1.5	10.4	31.7	22.9	6.1	2.4
(20,50]	6.0	34.1	7.9	1.2	0.1	0.1	14.0	41.2	41.6	9.8	1.4	1.6
(50,100]	92.9	15.1	0.0	0.0	0.0	0.0	84.3	41.8	3.3	0.0	0.0	0.1

The distribution of probe samples was also analyzed over a 24-hour period. Figure 2-2 shows the percentage of the time on Kentucky interstates that a particular 15-minute period had probe speeds. This was calculated based on 84 periods in a year (i.e., 12 months and 7 days of a week). For 2011 and 2012, daytime hours received better coverage than nighttime and early morning hours.



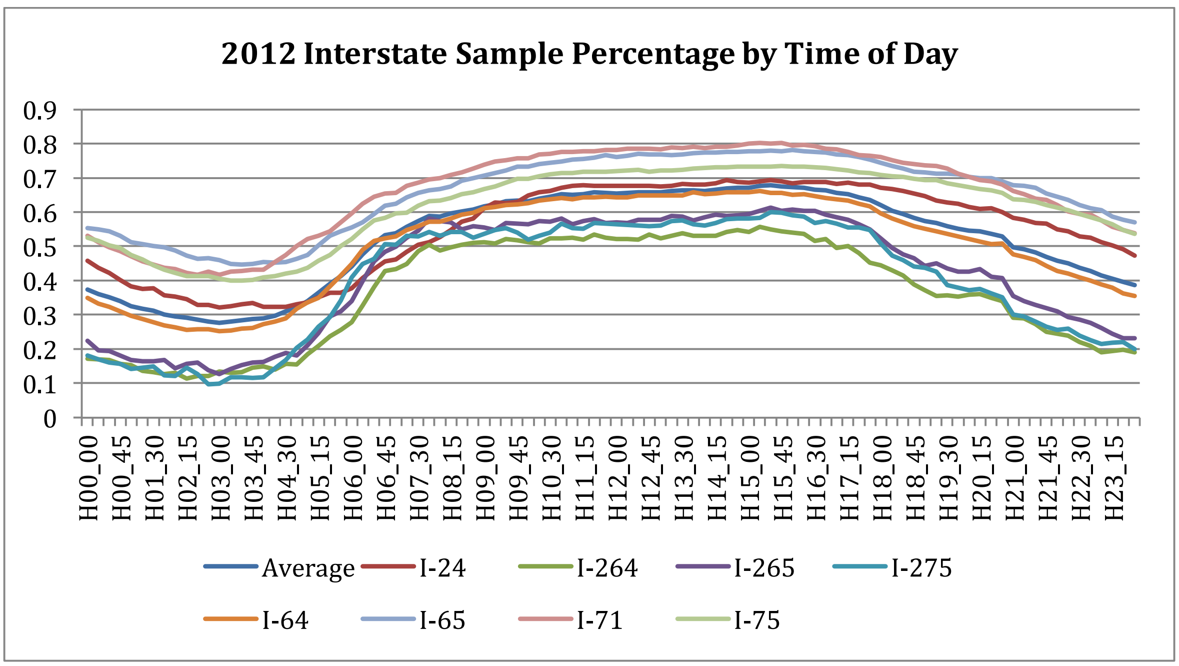


Figure 2-2 Sample coverage by time of day on interstates in KY

A set of interstate segments were selected to further evaluate the time-of-day probe coverage by area type, as shown in Figure 2-3. Comparisons were made between the rural and urban segments, differentiated by color, and the results are shown in Figure 2-4. During nighttime, probe data are more abundant on rural interstates, which is evident on the pair of I-65 segments that were evaluated.

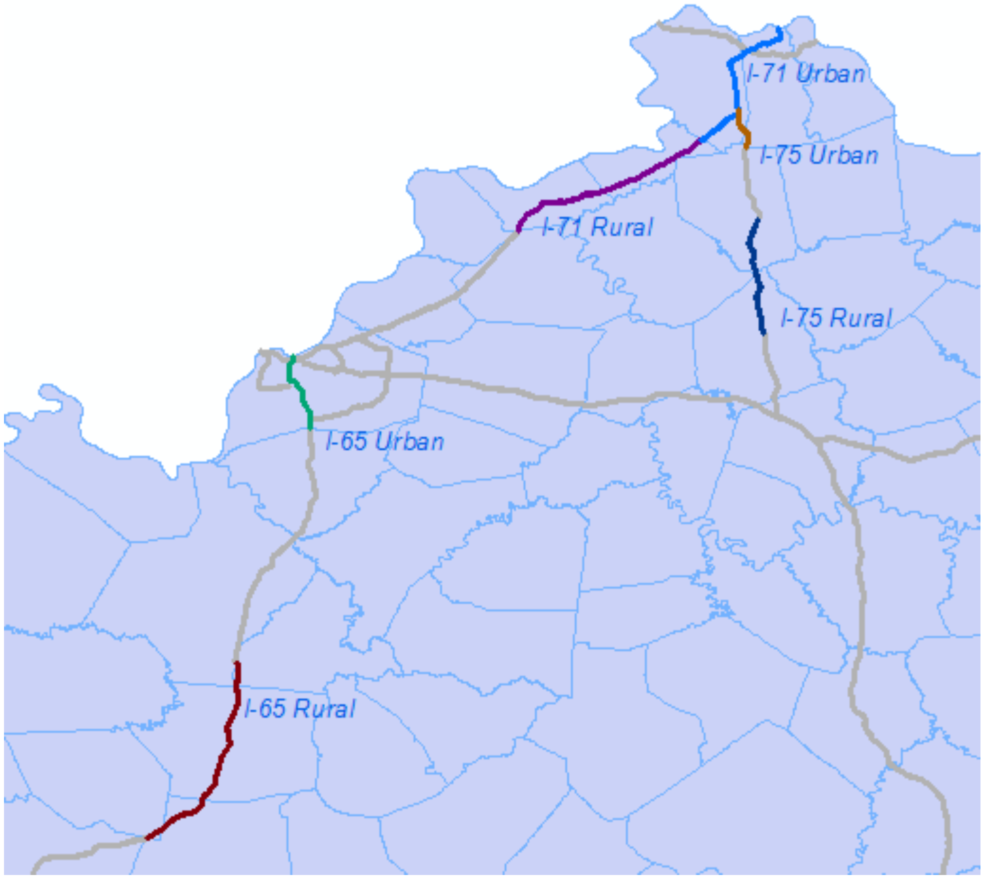
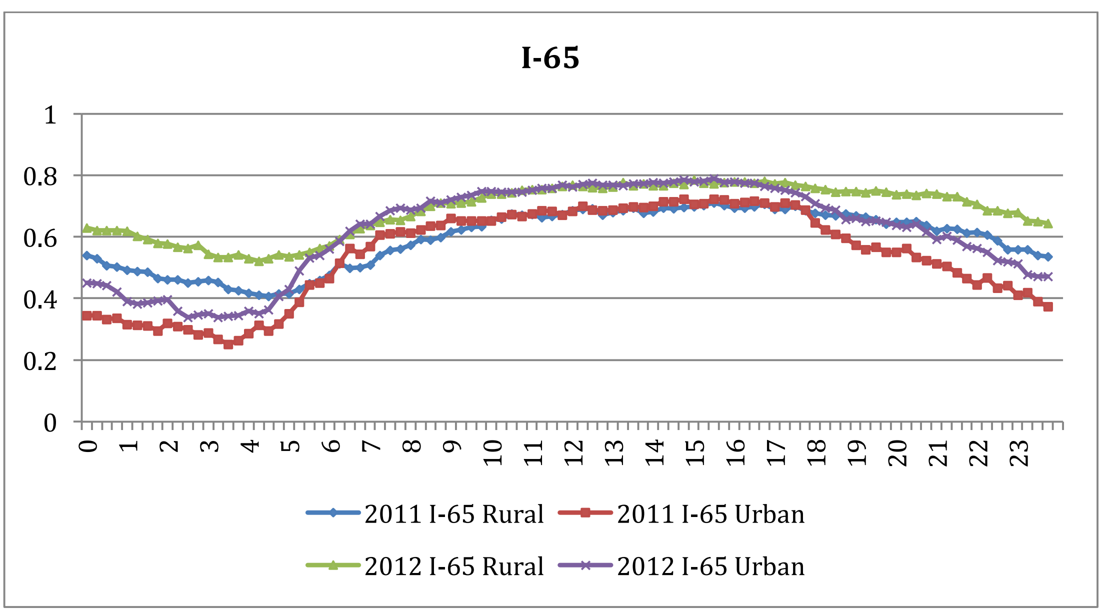
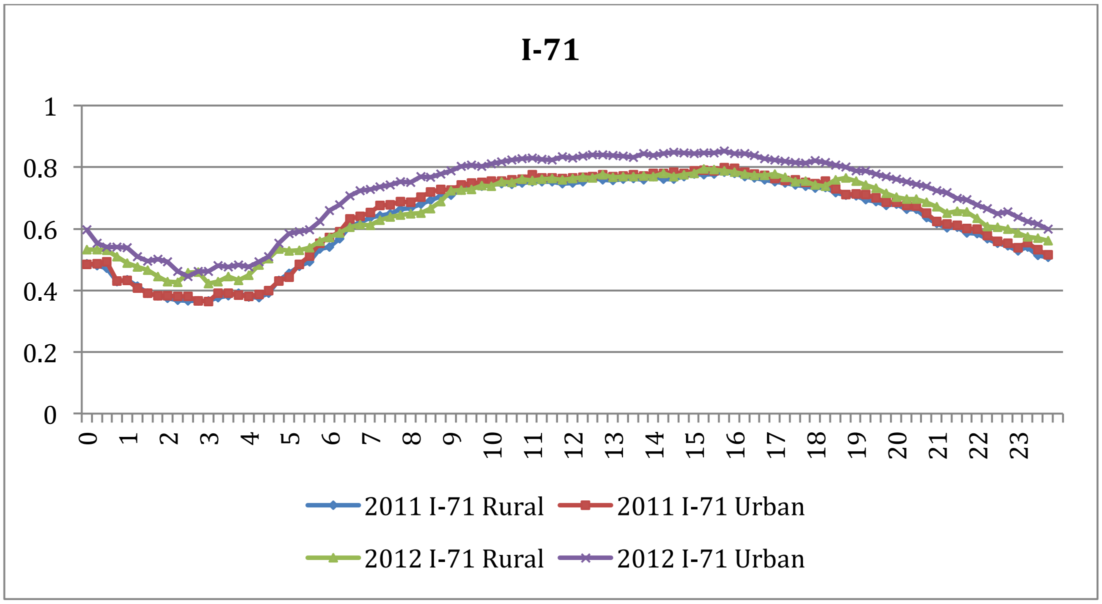


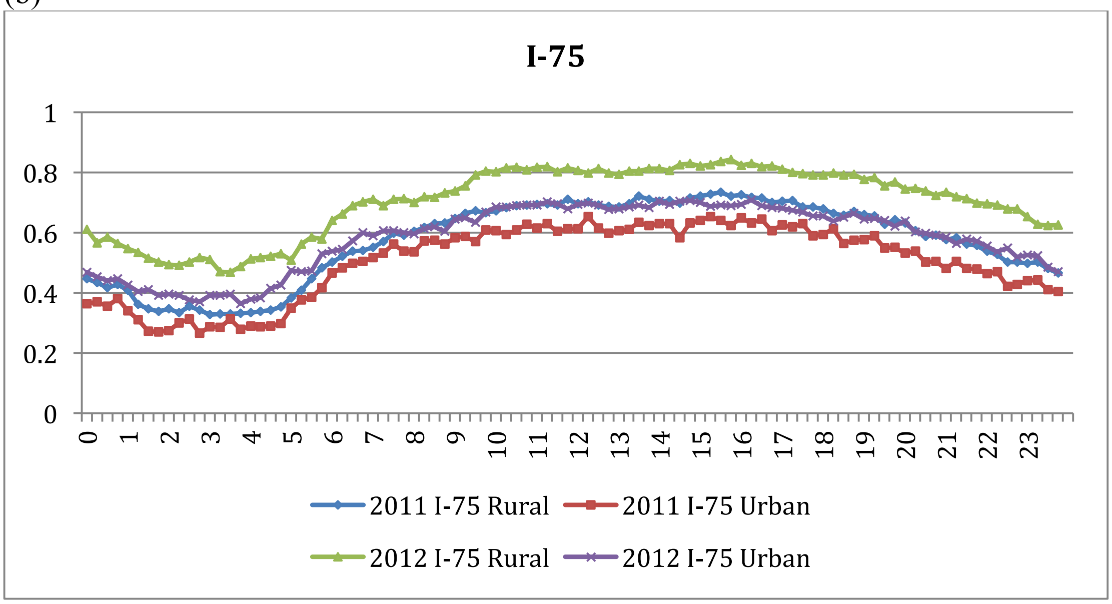
Figure 2-3 Interstate segments selected by area type



(a)



(b)



(c)

Figure 2-4 Time-of-day probe coverage on selected interstates

2.3.2 Performance Measures

Due to the high number of network links, comparing the performance measures for the two years on a link-by-link basis was challenging. Also, the segmentation of the 2012 network (HIS-based) was different from that of the 2011 network (HPMS-based). Comparisons were made at the area level by aggregating the link-based measures into regional measures. The weighting factor used was vehicle-miles traveled. Regional measures were also separated based on functional classes. Table 2-3 through Table 2-9 illustrate the comparisons between 2011 and 2012 for travel time index, planning time index, buffer index, and annual hours of delay. Note that only the measures calculated with two options for reference speed – (1) the 85th percentile speeds of all days and (2) the speed limit – are reported in these tables because they were the only reference speeds both years shared.

Table 2-3 Travel time index

Region	2011				2012			
	Reference = the 85th percentile speed		Reference = speed limit		Reference = the 85th percentile speed		Reference = speed limit	
	AM	PM	AM	PM	AM	PM	AM	PM
Ashland	1.2	1.2	1.1	1.1	1.2	1.2	1.1	1.2
Evansville	1.1	1.2	1.1	1.1	1.1	1.2	1.1	1.1
Lexington	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
KIPDA	1.2	1.2	1.1	1.1	1.2	1.2	1.1	1.1
OKI	1.2	1.2	1.1	1.1	1.2	1.2	1.2	1.2
Other	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Statewide	1.2	1.2	1.1	1.1	1.2	1.2	1.1	1.1

Congestion levels for 2011 and 2012 were comparable. Based on the values of TTI, which used speed limit as the reference speed, the 2012 data showed a slight increase in congestion. Table 2-4 revealed that this increase was mostly attributable to FC14 and FC16 roadways in large urban areas such as OKI and KIPDA.

Table 2-4 Travel time index by functional classification

(a) The 85th percentile speed as reference speed

Region	Year	Period	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
Ashland	2011	AM	1.1	1.1	1.1	1.2	1.3	1.2			1.2	1.2	1.3	1.2
		PM	1.1	1.1	1.2	1.2	1.2	1.3			1.2	1.3	1.3	1.2
	2012	AM	1.1	1.1	1.1	1.2	1.2	1.2			1.2	1.2	1.2	1.2
		PM	1.1	1.1	1.1	1.2	1.2	1.2			1.2	1.3	1.2	1.3
Evansville	2011	AM		1.1	1.1	1.1	1.2	1.2		1.1	1.2	1.2	1.2	1.4
		PM		1.1	1.1	1.1	1.2	1.3		1.1	1.2	1.2	1.2	1.3
	2012	AM		1.1	1.1	1.1	1.2	1.2		1.1	1.2	1.2	1.3	1.4
		PM		1.1	1.1	1.1	1.2	1.3		1.1	1.2	1.2	1.2	1.3
Lexington	2011	AM	1.1	1.1	1.1	1.2	1.3	1.3	1.1	1.1	1.3	1.3	1.3	1.4
		PM	1.1	1.2	1.1	1.2	1.2	1.3	1.1	1.1	1.4	1.3	1.3	1.4
	2012	AM	1.1	1.1	1.2	1.2	1.3	1.3	1.1	1.1	1.3	1.3	1.3	1.3
		PM	1.1	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.4	1.3	1.3	1.3
KIPDA	2011	AM	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.1	1.3	1.3	1.3	1.4
		PM	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.3	1.3	1.3	1.3
	2012	AM	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.1	1.3	1.3	1.3	1.4
		PM	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.3	1.3	1.3	1.3
OKI	2011	AM	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3
		PM	1.3	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.2	1.3
	2012	AM	1.1	1.1	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.3	1.3	1.4
		PM	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.2	1.3
Other	2011	AM	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.1	1.2	1.3	1.3	1.4
		PM	1.1	1.1	1.2	1.2	1.2	1.3	1.1	1.1	1.3	1.3	1.3	1.3
	2012	AM	1.1	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.2	1.2	1.3	1.3
		PM	1.1	1.1	1.1	1.2	1.2	1.2	1.1	1.1	1.3	1.3	1.3	1.3
State	2011	AM	1.1	1.1	1.2	1.2	1.2	1.3	1.2	1.1	1.3	1.3	1.3	1.4
		PM	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.3	1.3	1.3	1.3
	2012	AM	1.1	1.1	1.1	1.2	1.2	1.3	1.1	1.1	1.3	1.3	1.3	1.3
		PM	1.1	1.1	1.1	1.2	1.2	1.2	1.1	1.1	1.3	1.3	1.3	1.3

Note: blank cells mean there is no facility with designated functional class in the region.

(b) Use speed limit as reference speed

Region	Year	Period	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
Ashland	2011	AM	1.0	1.0	1.0	1.2	1.6	1.3			1.1	1.2	1.2	1.2
		PM	1.0	1.0	1.0	1.2	1.5	1.5			1.1	1.2	1.2	1.2
	2012	AM	1.1	1.1	1.0	1.2	1.5	1.2			1.2	1.2	1.2	1.3
		PM	1.0	1.0	1.0	1.2	1.5	1.5			1.2	1.2	1.2	1.3
Evansville	2011	AM		1.1	1.0	1.0	1.1	1.2		1.0	1.1	1.2	1.1	1.9
		PM		1.0	1.0	1.0	1.1	1.3		1.0	1.1	1.1	1.1	2.4
	2012	AM		1.0	1.0	1.1	1.3	1.3		1.0	1.1	1.2	1.2	2.0
		PM		1.0	1.0	1.1	1.3	1.4		1.0	1.2	1.2	1.1	2.0
Lexington	2011	AM	1.0	1.1	1.1	1.1	1.2	1.6	1.1	1.0	1.4	1.2	1.3	1.9
		PM	1.0	1.1	1.2	1.1	1.2	1.6	1.0	1.0	1.4	1.2	1.2	1.8
	2012	AM	1.0	1.1	1.2	1.3	1.4	1.6	1.1	1.0	1.4	1.3	1.3	1.9
		PM	1.0	1.1	1.2	1.2	1.3	1.6	1.0	1.0	1.5	1.3	1.3	1.5
KIPDA	2011	AM	1.0	1.0	1.0	1.1	1.3	1.4	1.0	1.0	1.2	1.2	1.2	1.4
		PM	1.0	1.0	1.0	1.1	1.2	1.4	1.1	1.0	1.3	1.2	1.2	1.3
	2012	AM	1.0	1.0	1.1	1.2	1.3	1.5	1.1	1.0	1.3	1.3	1.3	1.5
		PM	1.0	1.0	1.1	1.2	1.3	1.5	1.1	1.0	1.3	1.3	1.2	1.3
OKI	2011	AM	1.1	1.1	1.1	1.1	1.1	1.5	1.1	1.0	1.2	1.2	1.2	1.5
		PM	1.3	1.1	1.1	1.1	1.2	1.6	1.1	1.0	1.2	1.2	1.2	1.3
	2012	AM	1.0	1.0	1.1	1.2	1.4	1.4	1.2	1.1	1.3	1.3	1.3	1.5
		PM	1.0	1.0	1.1	1.2	1.4	1.5	1.1	1.1	1.3	1.3	1.2	1.3
Other	2011	AM	1.0	1.0	1.1	1.1	1.3	1.5	1.0	1.1	1.2	1.2	1.2	1.4
		PM	1.0	1.0	1.1	1.1	1.2	1.5	1.0	1.1	1.2	1.2	1.2	1.3
	2012	AM	1.0	1.0	1.1	1.2	1.3	1.5	1.0	1.1	1.2	1.3	1.3	1.5
		PM	1.0	1.0	1.1	1.2	1.3	1.5	1.0	1.1	1.3	1.3	1.3	1.4
State	2011	AM	1.0	1.0	1.1	1.1	1.3	1.5	1.1	1.0	1.2	1.2	1.2	1.4
		PM	1.0	1.0	1.1	1.1	1.2	1.5	1.1	1.0	1.2	1.2	1.2	1.3
	2012	AM	1.0	1.0	1.1	1.2	1.4	1.5	1.1	1.0	1.3	1.3	1.3	1.5
		PM	1.0	1.0	1.1	1.2	1.3	1.5	1.1	1.0	1.3	1.3	1.2	1.4

Table 2-5 Planning time index

Region	2011				2012			
	Reference = the 85th percentile		Reference = speed limit		Reference = the 85th percentile		Reference = speed limit	
	AM	PM	AM	PM	AM	PM	AM	PM
Ashland	2.0	2.0	1.7	1.8	2.0	2.1	1.9	2.0
Evansville	1.7	1.8	1.6	1.7	1.7	1.8	1.7	1.8
Lexington	2.2	2.3	2.2	2.3	2.2	2.3	2.2	2.3
KIPDA	1.9	2.1	1.8	1.9	1.9	2.1	1.8	2.0
OKI	2.1	2.2	1.9	2.0	2.0	2.0	2.0	2.0
Other	1.7	1.8	1.5	1.6	1.7	1.8	1.6	1.7
Statewide	1.8	1.9	1.7	1.8	1.8	1.9	1.8	1.9

Planning time index (PTI) gauges the reliability of travel time. It measures variations in travel time against the reference speed. It appears that travel time reliability decreased from 2011 to 2012. One noticeable increase in PTI occurred for FC12 roadways in the OKI area. Further investigation indicated that there is only one section of highway where this change occurred, which is from the interchange of I-471 and I-275 to US27 near the campus of Northern Kentucky University, classified as Functional Class 12. It is highlighted in blue in Figure 2-5.

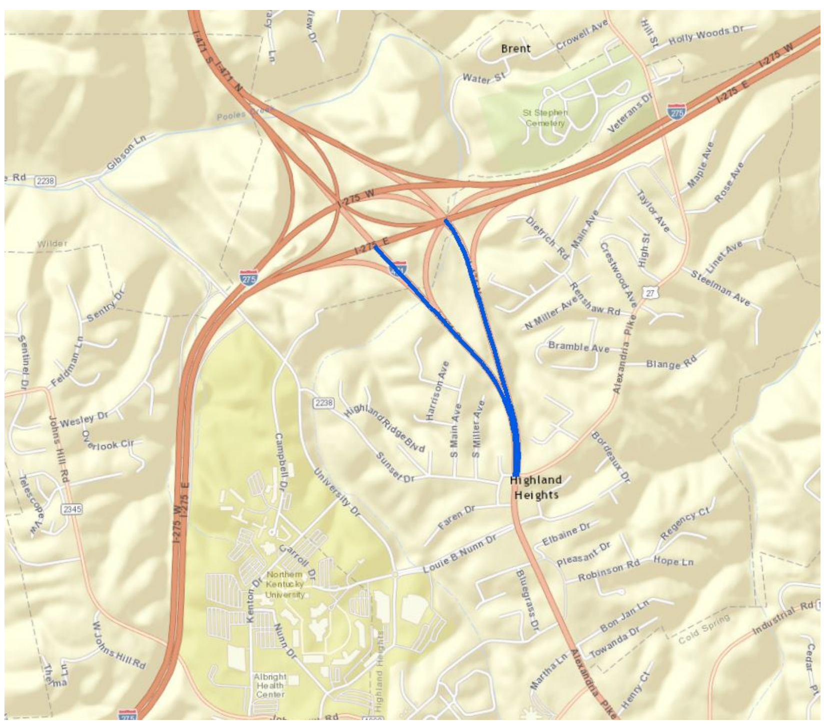


Figure 2-5 FC12 section in OKI region

In 2012 larger portions of the sample speeds were in a lower range, compared to speeds in 2011. Additionally, in 2012 the speed limit on one of the segments was increased to 55mph from 45mph. As a result, more congestion and unreliability were derived from the 2012 data.

Table 2-6 Planning time index by functional classification

(a) The 85th percentile speed as reference speed

Region	Year	Period	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
Ashland	2011	AM	1.3	1.6	1.7	1.8	2.1	2.1			2.4	2.4	2.4	1.9
		PM	1.3	1.6	2.2	1.9	2.2	2.7			2.4	2.7	2.5	2.4
	2012	AM	1.3	1.6	1.4	1.8	1.9	2.3			2.4	2.6	2.4	2.5
		PM	1.2	1.6	1.4	1.9	2.0	2.4			2.5	2.9	2.6	2.4
Evansville	2011	AM		1.3	1.5	1.5	1.9	2.0		1.3	2.2	2.2	2.1	5.4
		PM		1.3	1.6	1.7	2.3	2.3		1.3	2.3	2.4	2.6	4.0
	2012	AM		1.2	1.5	1.6	2.0	2.3		1.3	2.3	2.3	2.5	2.9
		PM		1.2	1.5	1.7	2.3	2.7		1.3	2.3	2.5	2.5	2.6
Lexington	2011	AM	1.2	1.6	1.8	2.2	2.3	2.1	1.2	1.4	3.3	3.0	2.9	3.1
		PM	1.2	1.7	1.7	2.2	2.3	2.6	1.2	1.6	3.5	3.1	2.9	3.2
	2012	AM	1.1	1.6	1.7	2.3	2.3	2.3	1.2	1.3	3.2	3.3	2.9	2.7
		PM	1.1	1.6	1.7	2.1	2.2	2.6	1.2	1.6	3.5	3.3	3.0	3.5
KIPDA	2011	AM	1.2	1.6	1.8	1.9	2.1	2.3	1.5	1.3	2.9	2.8	2.9	3.2
		PM	1.2	1.5	1.8	1.8	2.2	2.3	1.6	1.3	3.2	2.9	2.9	3.1
	2012	AM	1.2	1.5	1.7	1.8	2.1	2.4	1.5	1.3	2.9	2.9	3.1	3.3
		PM	1.2	1.5	1.7	1.8	2.2	2.3	1.7	1.2	3.4	3.1	2.9	3.1
OKI	2011	AM	1.3	1.6	1.9	1.9	1.9	2.1	1.8	2.1	2.8	2.9	2.8	3.2
		PM	1.8	1.6	2.1	1.9	2.0	2.4	1.8	2.2	2.8	3.0	2.7	2.7
	2012	AM	1.2	1.5	1.8	1.9	1.9	2.1	1.7	2.3	2.9	3.0	2.9	3.4
		PM	1.2	1.4	1.9	2.1	1.9	2.3	1.6	2.6	3.2	2.9	2.7	2.9
Other	2011	AM	1.2	1.5	1.7	1.8	2.0	2.2	1.3	1.4	2.7	2.6	2.7	2.9
		PM	1.3	1.5	1.8	1.9	2.1	2.4	1.3	1.4	2.9	2.9	2.9	3.0
	2012	AM	1.2	1.5	1.7	1.8	2.0	2.2	1.2	1.4	2.6	2.7	2.8	3.0
		PM	1.2	1.5	1.7	1.9	2.1	2.3	1.2	1.4	2.9	3.0	3.0	2.8
State	2011	AM	1.2	1.5	1.7	1.8	2.1	2.2	1.6	1.4	2.8	2.8	2.8	2.8
		PM	1.3	1.5	1.8	1.9	2.1	2.4	1.6	1.4	3.0	2.9	2.8	2.9
	2012	AM	1.2	1.5	1.7	1.8	2.0	2.3	1.5	1.3	2.8	2.9	2.9	3.1
		PM	1.2	1.5	1.7	1.9	2.1	2.4	1.6	1.4	3.1	3.0	2.9	3.0

Note: blank cells mean no facility with designated functional class in the region.

(b) The speed limit as reference speed

Region	Year	Period	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
Ashland	2011	AM	1.2	1.3	1.2	1.7	2.6	2.3			1.9	2.2	2.2	1.8
		PM	1.2	1.4	1.4	1.7	2.6	3.1			1.9	2.4	2.3	2.2
	2012	AM	1.2	1.5	1.2	1.8	2.3	2.2			2.3	2.6	2.3	2.6
		PM	1.2	1.5	1.2	1.9	2.5	2.8			2.4	2.8	2.5	2.4
Evansville	2011	AM		1.2	1.4	1.3	1.7	1.9		1.1	2.1	2.0	1.9	6.5
		PM		1.2	1.4	1.4	2.0	2.4		1.1	2.1	2.2	2.3	6.4
	2012	AM		1.2	1.4	1.5	2.1	2.3		1.1	2.2	2.3	2.1	5.0
		PM		1.2	1.4	1.6	2.4	2.7		1.2	2.3	2.4	2.1	6.2
Lexington	2011	AM	1.1	1.5	1.8	1.9	2.1	2.6	1.2	1.2	3.4	2.9	2.9	4.2
		PM	1.1	1.6	1.7	2.0	2.1	3.3	1.2	1.4	3.6	2.9	2.7	4.4
	2012	AM	1.1	1.5	1.7	2.3	2.5	3.1	1.2	1.2	3.4	3.3	2.9	3.8
		PM	1.1	1.5	1.7	2.2	2.5	3.3	1.2	1.4	3.7	3.3	2.9	3.0
KIPDA	2011	AM	1.2	1.4	1.4	1.6	2.1	2.5	1.4	1.2	2.8	2.6	2.6	3.2
		PM	1.1	1.3	1.4	1.5	2.1	2.5	1.5	1.2	3.1	2.7	2.6	2.9
	2012	AM	1.1	1.3	1.6	1.8	2.2	2.7	1.3	1.2	3.0	2.9	2.9	3.9
		PM	1.1	1.3	1.6	1.8	2.4	2.7	1.5	1.2	3.4	3.1	2.7	3.3
OKI	2011	AM	1.2	1.6	1.6	1.7	1.7	2.4	1.7	1.7	2.6	2.8	2.5	3.3
		PM	1.7	1.6	1.8	1.7	2.0	3.0	1.7	1.7	2.6	2.8	2.4	2.7
	2012	AM	1.2	1.3	1.8	2.0	2.1	2.4	1.6	2.1	3.0	3.0	2.8	3.7
		PM	1.2	1.2	1.8	2.1	2.2	2.7	1.5	2.4	3.3	2.9	2.6	3.0
Other	2011	AM	1.2	1.3	1.5	1.5	2.0	2.5	1.2	1.3	2.5	2.4	2.5	2.8
		PM	1.3	1.3	1.5	1.6	2.1	2.6	1.2	1.3	2.7	2.6	2.6	2.8
	2012	AM	1.2	1.4	1.6	1.8	2.2	2.6	1.2	1.3	2.6	2.8	2.7	3.5
		PM	1.1	1.3	1.6	1.9	2.3	2.7	1.2	1.3	2.9	3.0	2.8	3.1
State	2011	AM	1.2	1.3	1.5	1.5	2.0	2.5	1.4	1.3	2.7	2.6	2.6	2.7
		PM	1.3	1.3	1.5	1.6	2.1	2.7	1.5	1.3	2.9	2.7	2.6	2.7
	2012	AM	1.2	1.4	1.6	1.8	2.2	2.6	1.4	1.2	2.9	2.9	2.8	3.4
		PM	1.1	1.3	1.6	1.9	2.3	2.7	1.5	1.3	3.2	3.0	2.8	2.9

Buffer index indicates the variability of travel time experienced by users. Instead of choosing a fixed speed value as the reference, it uses the travelers' average speed as the "reference". The statewide buffer index was virtually unchanged between from 2011 to 2012, while the OKI and Lexington areas show slightly reduced variability. This indicates that the variability in travel time – for the average user – during peak periods decreased. Considering the slight increase in congestion (measured by TTI), we can conclude that travel time in these areas has become consistently longer.

Table 2-7 Buffer index

Region	2011		2012	
	AM	PM	AM	PM
Ashland	0.632	0.662	0.654	0.693
Evansville	0.453	0.537	0.469	0.547
Lexington	0.756	0.812	0.731	0.797
KIPDA	0.586	0.674	0.562	0.714
OKI	0.630	0.726	0.589	0.654
Other	0.426	0.517	0.430	0.496
Statewide	0.508	0.589	0.499	0.578

Table 2-8 Buffer index by functional classification

Region	Year	Period	FC1	FC2	FC6	FC7	FC8	FC9	FC11	FC12	FC14	FC16	FC17	FC19
Ashland	2011	AM	0.2	0.3	0.5	0.5	0.6	0.7			0.9	0.9	0.9	0.6
		PM	0.2	0.4	0.8	0.6	0.8	1.1			0.9	1.1	0.9	0.9
	2012	AM	0.2	0.4	0.3	0.5	0.5	0.8			0.9	1.1	0.9	0.9
		PM	0.2	0.4	0.3	0.6	0.6	0.9			0.9	1.2	1.0	0.8
Evansville	2011	AM		0.2	0.3	0.3	0.6	0.6		0.2	0.8	0.8	0.7	2.5
		PM		0.2	0.4	0.4	0.8	0.8		0.2	0.8	1.0	1.0	1.7
	2012	AM		0.1	0.3	0.4	0.6	0.8		0.2	0.8	0.8	0.8	1.1
		PM		0.2	0.3	0.5	0.8	1.0		0.2	0.8	1.0	1.0	1.0
Lexington	2011	AM	0.1	0.4	0.5	0.8	0.8	0.6	0.1	0.2	1.4	1.3	1.2	1.2
		PM	0.1	0.5	0.5	0.8	0.9	1.0	0.1	0.4	1.4	1.4	1.2	1.2
	2012	AM	0.1	0.4	0.5	0.8	0.9	0.9	0.1	0.2	1.4	1.4	1.2	1.0
		PM	0.1	0.3	0.4	0.7	0.8	1.0	0.1	0.4	1.4	1.4	1.3	1.4
KIPDA	2011	AM	0.1	0.4	0.5	0.5	0.7	0.8	0.3	0.2	1.2	1.2	1.2	1.2
		PM	0.1	0.3	0.5	0.6	0.8	0.8	0.4	0.2	1.4	1.2	1.2	1.3
	2012	AM	0.1	0.3	0.5	0.5	0.7	0.8	0.3	0.2	1.3	1.2	1.3	1.3
		PM	0.1	0.3	0.5	0.6	0.8	0.8	0.4	0.1	1.5	1.3	1.3	1.3
OKI	2011	AM	0.2	0.4	0.6	0.6	0.6	0.8	0.4	0.7	1.2	1.3	1.1	1.3
		PM	0.4	0.5	0.8	0.6	0.7	1.0	0.5	0.9	1.2	1.3	1.1	1.1
	2012	AM	0.1	0.3	0.5	0.6	0.6	0.7	0.3	0.9	1.2	1.3	1.2	1.4
		PM	0.1	0.3	0.6	0.7	0.6	0.8	0.4	1.1	1.3	1.2	1.1	1.2
Other	2011	AM	0.1	0.3	0.5	0.5	0.6	0.7	0.2	0.3	1.1	1.0	1.0	0.9
		PM	0.2	0.3	0.5	0.6	0.7	0.8	0.2	0.3	1.2	1.2	1.2	1.1
	2012	AM	0.1	0.3	0.4	0.5	0.6	0.7	0.1	0.2	1.1	1.1	1.1	1.1
		PM	0.1	0.3	0.5	0.6	0.7	0.8	0.1	0.2	1.2	1.2	1.2	1.1
State	2011	AM	0.1	0.3	0.5	0.5	0.6	0.7	0.3	0.2	1.2	1.1	1.1	1.0
		PM	0.2	0.3	0.5	0.6	0.7	0.8	0.4	0.3	1.2	1.2	1.2	1.1
	2012	AM	0.1	0.3	0.4	0.5	0.6	0.7	0.3	0.2	1.2	1.2	1.1	1.2
		PM	0.1	0.3	0.5	0.6	0.7	0.8	0.4	0.3	1.3	1.3	1.2	1.2

The annual hours of delay are shown in Table 2-9. If using the 85^{th} percentile speed as reference speed, the delay seems to have reduced from 2011 to 2012. It should be noted that the 85^{th} percentile speed was derived entirely from the data, and therefore, its value may change from year to year.

On the other hand, the speed limit can be a relatively stable reference speed for this comparison. Based on data in Table 2-9(b), the delay increased in 2012 throughout the state, especially outside the major metropolitan areas. This seemingly significant increase in delay can be partly attributed to the improved probe sample size and to probe coverage in 2012. However, the change in delay for larger metropolitan areas such as OKI and KIPDA (where samples were abundant in both years), was not very significant.

Table 2-9 Annual hours of delay (in thousands of vehicle hours)

(a) The 85th percentile speed as reference speed

Functional Class	Ashland		Evansville		Lexington		KIPDA		OKI		Other		State	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
FC1	73	71			396	341	872	793	449	248	5572	4234	7362	5687
FC2	356	311	171	98	472	384	278	81	112	74	14052	10883	15441	11831
FC6	25	73	84	111	242	267	1160	1352	84	157	8779	11800	10374	13760
FC7	310	298	85	82	452	400	595	640	486	529	17778	19168	19706	21117
FC8	149	133	111	132	397	327	726	875	247	218	11023	11220	12653	12905
FC9	77	75	44	47	28	196	213	260	73	64	4239	3702	4674	4345
FC11					202	178	6165	5616	4140	3155	743	580	11250	9529
FC12			59	57	534	580	253	241	55	58	371	335	1273	1273
FC14	1590	1297	796	665	9781	7758	21123	10331	5355	3101	17655	10973	56299	34124
FC16	655	757	340	444	3016	4165	11961	20507	4260	6003	13572	18971	33803	50847
FC17	717	673	231	203	2821	3000	5773	5438	3338	3332	7930	8364	20811	21010
FC19	165	216	4	111	189	357	383	2075	133	294	630	1246	1504	4299
Total	4117	3903	1923	1950	18530	17954	49502	48210	18732	17233	102344	101477	195149	190727

(b) The speed limit as reference speed

Functional Class	Ashland		Evansville		Lexington		KIPDA		OKI		Other		State	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
FC1	36	39			113	132	524	502	345	143	2465	2172	3481	2988
FC2	168	189	97	51	321	275	151	31	90	30	7420	6520	8245	7097
FC6	13	36	49	56	250	277	658	1072	56	150	6426	10292	7453	11882
FC7	285	338	49	63	345	448	469	677	401	589	14336	19609	15885	21725
FC8	196	182	94	146	361	386	737	997	248	268	11446	13015	13082	14995
FC9	93	92	44	39	36	210	226	295	73	78	4137	4457	4609	5170
FC11					107	108	2398	2419	2713	2017	292	306	5511	4851
FC12			8	18	138	164	74	98	30	44	247	234	498	557
FC14	969	1142	650	599	10505	8988	21382	10994	5052	3320	16325	11317	54883	36359
FC16	507	725	297	408	2388	4137	11364	20551	4126	6315	12640	20265	31321	52400
FC17	567	670	157	161	2093	2703	5093	4421	2862	3240	7164	7881	17936	19076
FC19	171	205	6	8	89	12	210	304	136	154	494	630	1106	1313
Total	3003	3619	1451	1548	16747	17841	43285	42361	16132	16348	83392	96699	164011	178415

CHAPTER 3 NATIONAL HIGHWAY SYSTEM

In response to MAP-21 requirements, the AASHTO Standing Committee on Performance Management (SCOPM) formed a Task Force on performance measure development, coordination, and reporting charged to "assist SCOPM and AASHTO in developing a limited number of national performance measures and to help prepare AASHTO members to meet the new federal performance management requirements" (10). The performance measures for the National Highway System (NHS) in Kentucky were calculated following the procedures recommended in a report by the Task Force of SCOPM (10). Annual hours of delay and the reliability index were suggested as the indicators of congestion and reliability of the NHS.

3.1 SCOPM Measures

3.1.1 Reliability Index

The Reliability Index (RI_{80}) is defined as the ratio of the 80^{th} percentile (the 80^{th} worst) travel time during weekday periods to the reference travel time. Similar to the planning time index, RI_{80} estimates the travel time needed to ensure an on-time arrival at a destination 4 out of 5 times during peak congestion periods. The reliability index can be calculated using the following:

$$RI_{80} = \frac{\text{80th Percentile Travel Time}}{\text{Free-flow Travel Time}}$$

3.1.2 Annual Hours of Delay

As defined in the Task Force document, Annual Hours of Delay(AHD) is the amount of travel time above a congestion threshold (defined by State DOTs or MPOs), measured in units of vehicle-hours of delay, on Interstates and on NHS corridors.

Due to the limitation of the data source, an alternative approach outlined in the SCOPM report (10) was used to calculate AHD. This approach involved the same equations as those used in the statewide roadway system for 2011 and 2012 data. As stated in Section 2.2.1, AHD should be used with caution because it is estimated from probe data, which is not available for all time periods.

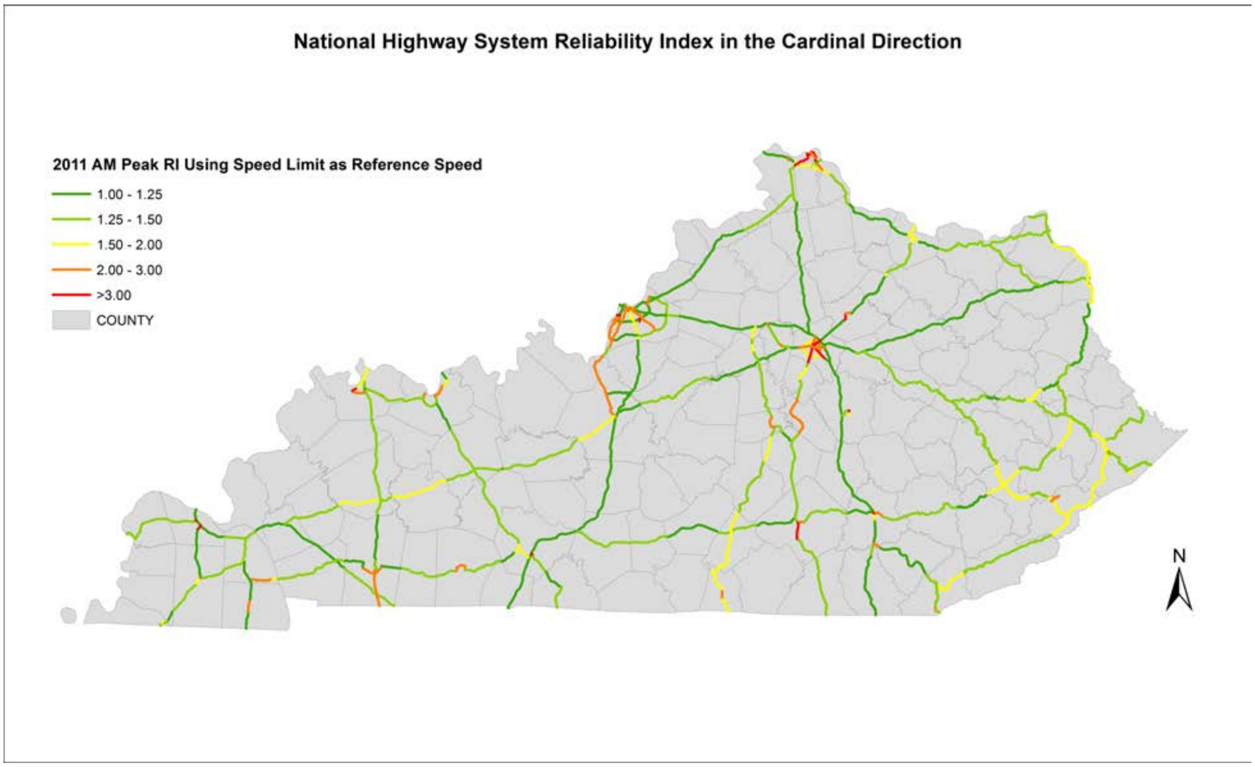
3.2 Corridor Performance

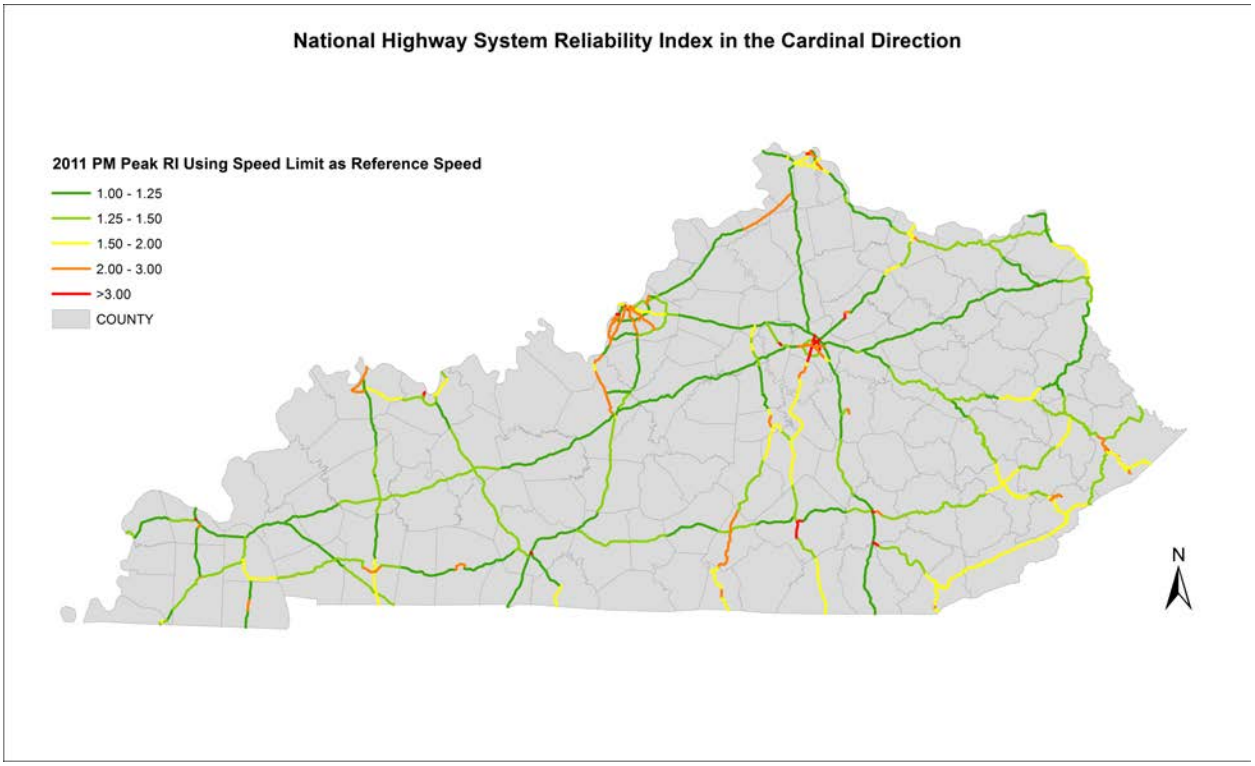
Corridor level performance measures help transportation agencies and MPOs evaluate congestion and prioritize projects. For the purpose of this report, corridor level performance measures were derived by aggregating performance metrics calculated at the link level.

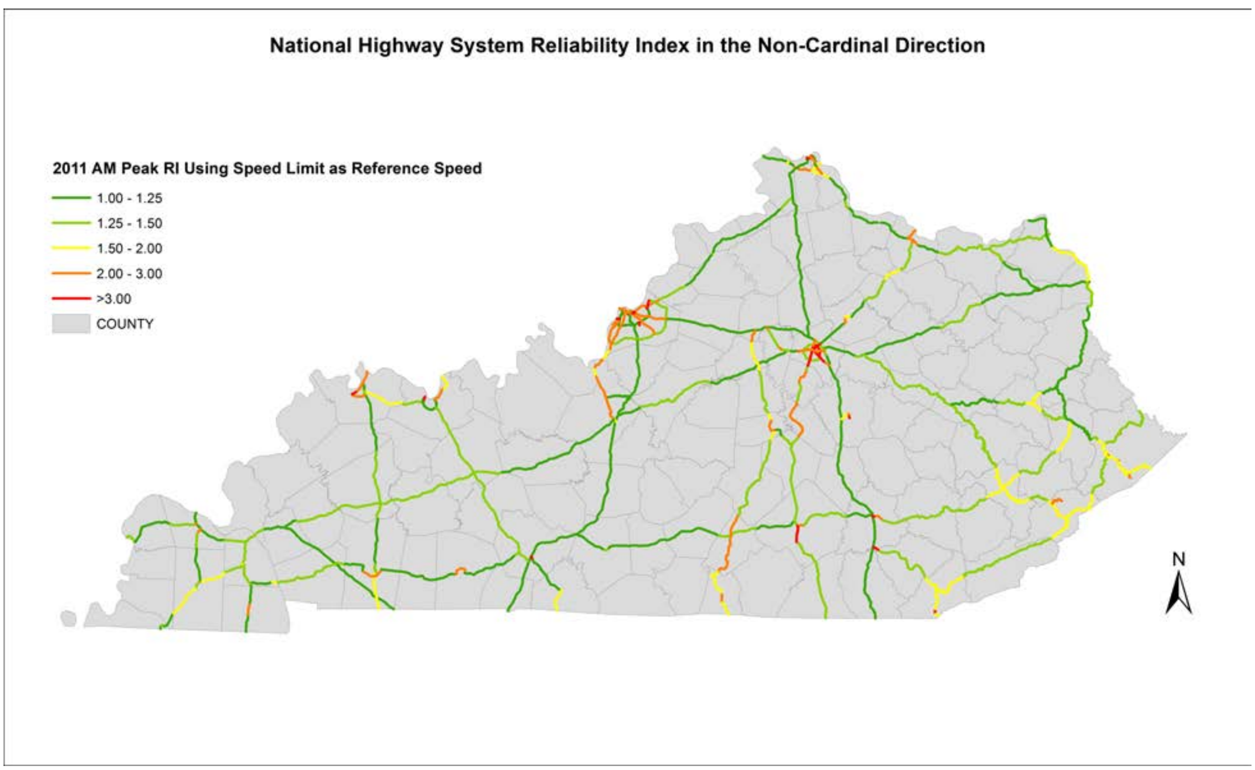
Without a specific segmentation scheme, a simple approach was adopted to automatically define corridors and to generate performance measures for NHS roads. Corridors were formed by combining links with the same route number, functional classification, and county code. This report contains this calculation for the 2011 and 2012 data. The results have been integrated into geodatabases and delivered to KYTC and MPO stakeholders. The list of attributes and their descriptions are shown in Appendix C.

3.2.1 Reliability Index

The reliability index at the corridor level is shown in Figure 3-1 and Figure 3-2. Comparing data from 2011 and 2012, it is apparent that more roadway segments are included in the NHS system in 2012. The reliability index was developed based on available data, and its value should only be used when the sample size and coverage are verified as being adequate.




National Highway System Reliability Index in the Cardinal Direction
2011 PM Peak RI Using Speed Limit as Reference Speed
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
>3.00
COUNTY
N


National Highway System Reliability Index in the Non-Cardinal Direction
2011 AM Peak RI Using Speed Limit as Reference Speed
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
>3.00
COUNTY
N

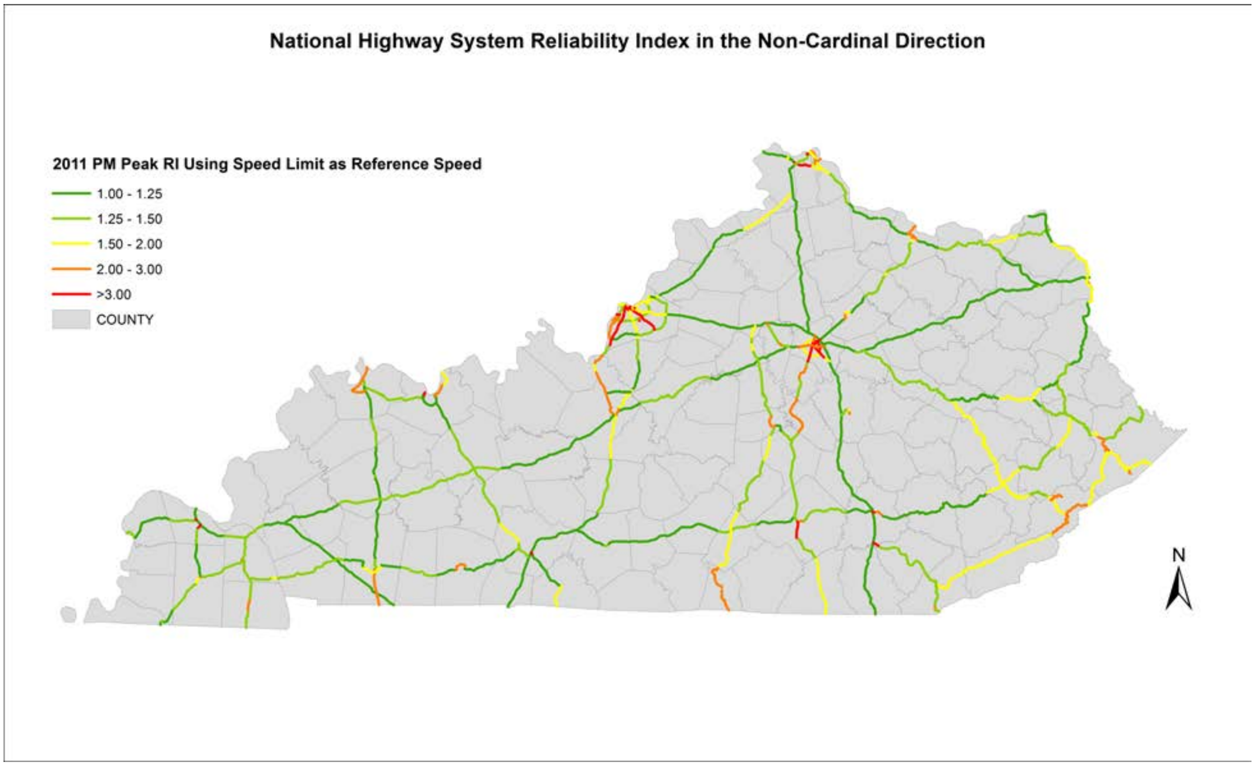
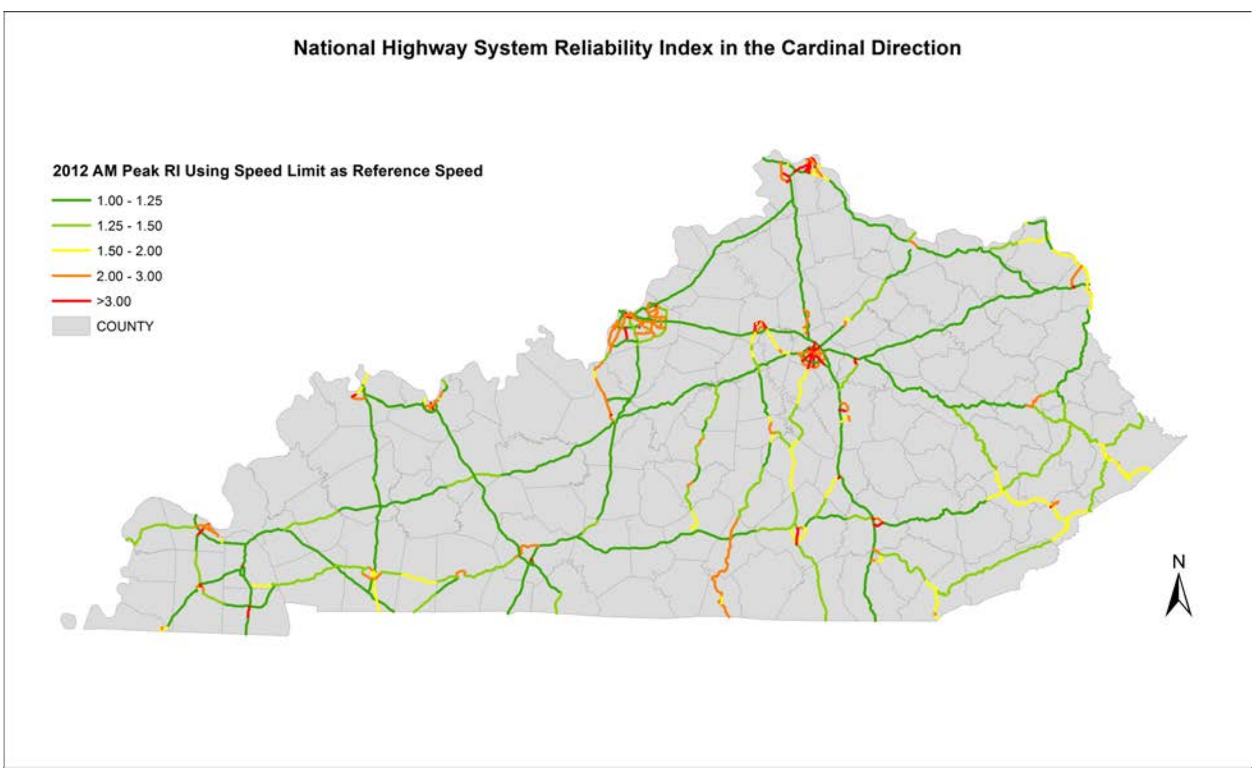
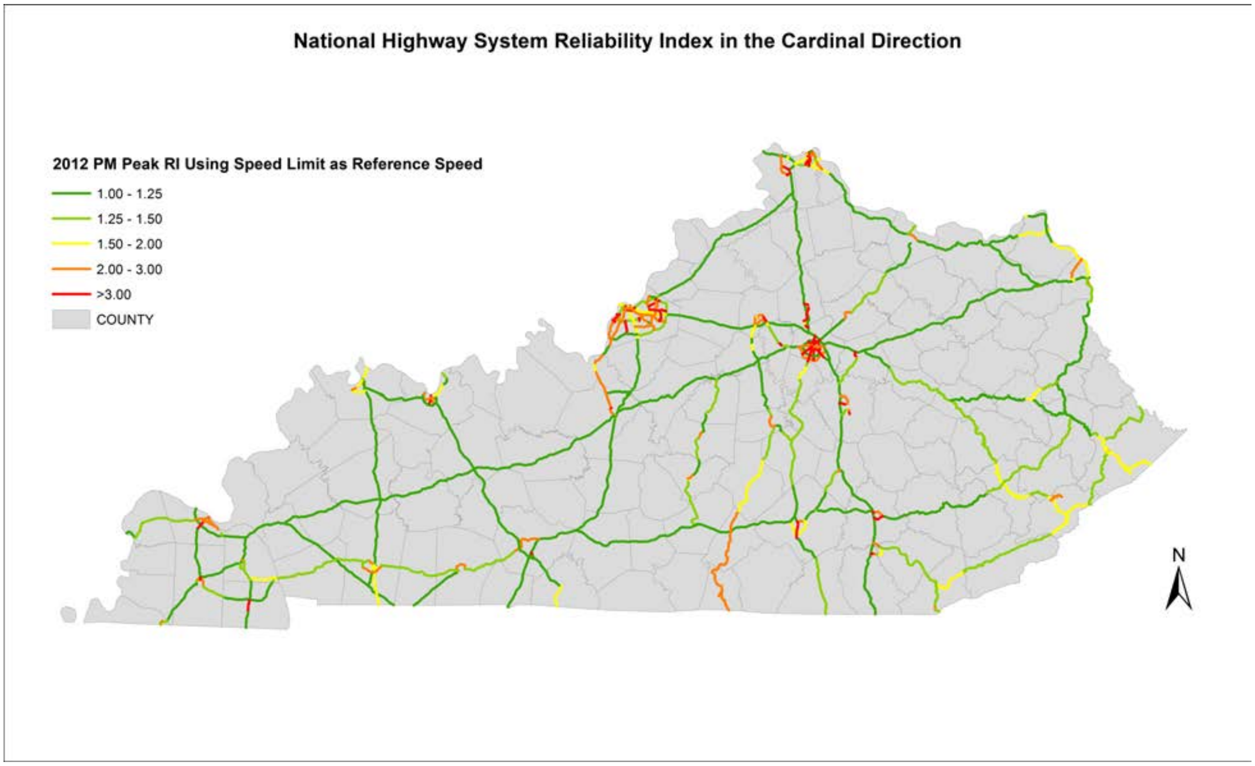
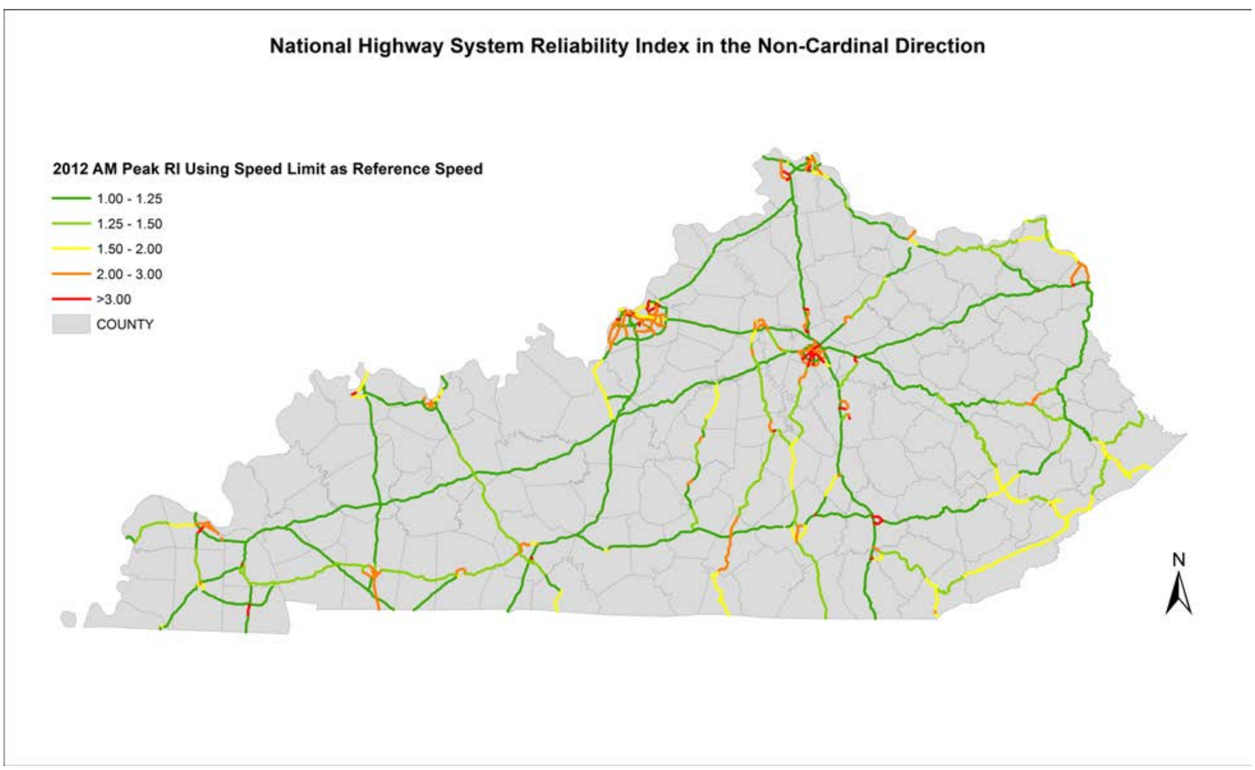


Figure 3-1 2011 NHS corridor reliability index




National Highway System Reliability Index in the Cardinal Direction
2012 PM Peak RI Using Speed Limit as Reference Speed
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
>3.00
COUNTY
N


National Highway System Reliability Index in the Non-Cardinal Direction
2012 AM Peak RI Using Speed Limit as Reference Speed
1.00 - 1.25
1.25 - 1.50
1.50 - 2.00
2.00 - 3.00
>3.00
COUNTY
N

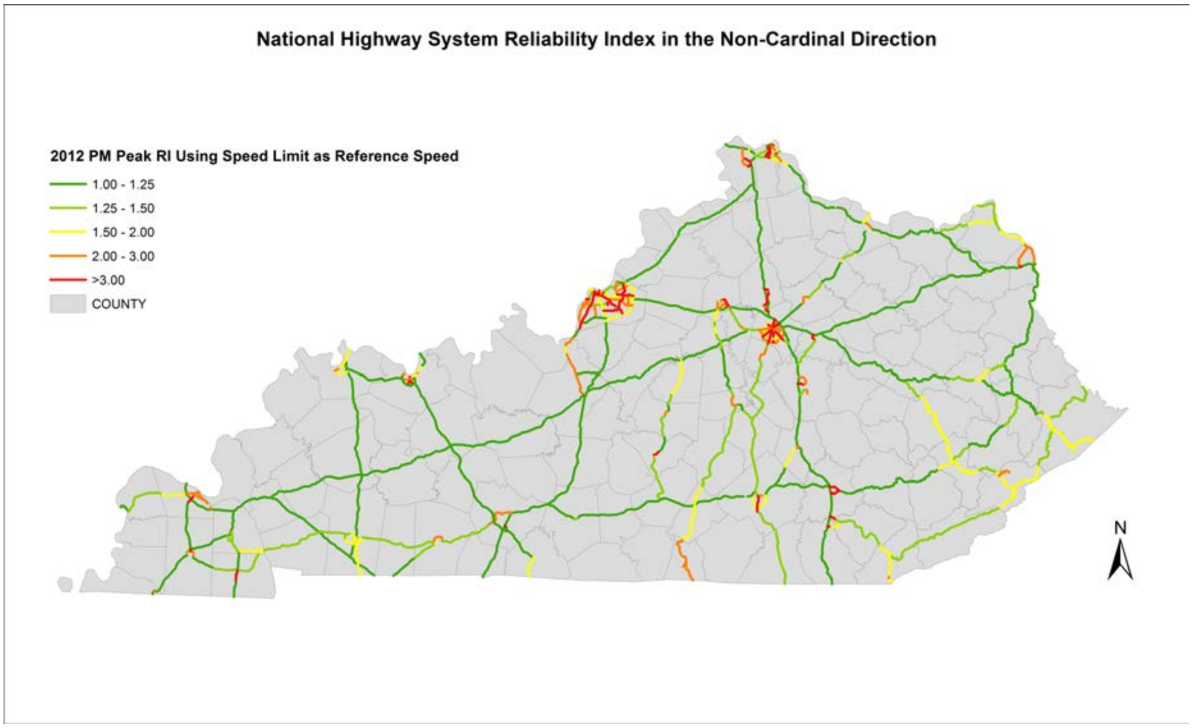


Figure 3-2 2012 NHS corridor reliability index

3.2.2 Annual Hours of Delay

The AHD calculated at the NHS corridor level is shown in Table 3-1.

Table 3-1 Annual hours of delay on NHS corridor by functional classification (in thousands of hours)

Functional Class	Length (mile)		Delay based Speed Limit		Delay based on 85th Percentile	
	2011	2012	2011	2012	2011	2012
FC1	1190.0	1194	3481	2988	7362	5687
FC2	3348.2	3710.3	5683	7040	11127	11758
FC6	2.1	2.1	20	21	13	15
FC7	21.1	21.3	102	110	85	88
FC8	2.6	2.6	31	28	25	23
FC9	4.5	4.5	10	10	9	9
FC11	404.9	407.7	5511	4851	11250	9529
FC12	124.0	134.8	478	557	1250	1273
FC14	574.9	1008.3	19523	36297	20043	33644
FC16	7.6	7.6	87	74	98	84
FC17	11.6	11.6	106	123	113	123
FC19	2.1	2.1	12	17	10	15
Total	5693.6	6507.1	35044	52117	51387	62248

CHAPTER 4 CONCLUSION

This study provides an assessment of the purchased private sector speed data, the potential as a robust data source, and the limitations. Table 4-1 summarizes the data items evaluated. Among the three types of data, the link-reference speed data in 5-minute intervals (reported wherever probe sample was available) proved the most versatile. It offered details on speed distribution and provided critical insights into the dynamics of congestion and on the variability of travel times. These data provided crucial support to develop the performance measures required by MAP-21.

Table 4-1 Summary of travel speed data

Data Set	Roadway Coverage	Data	Speed Data Source	Measured or Blended
2010 TMC-based ATP	TMC network (interstates and most arterials)	15-min speeds by month and by day of the week	Mostly current year probe vehicle speeds; data from other sources	Proprietary algorithm used to estimate speeds when probe data is insufficient
2010 TP	All links	15-min speeds by month and by day of the week	Three-year probe speeds; data from other sources	Proprietary algorithm used to estimate speeds for all links
2011&2012 Link-Referenced ATP	All links with probe data	5-min speeds by month and by day of the week	Current year probe speeds	No blending with other data or historical average. Probe sample counts and standard deviation of sample speeds are also reported.

These data need to be linked with traffic volumes to generate the full range of performance measures. The process of linking these two pieces of information will require combining a vendor's network with KYTC's highway inventory network. This process will be labor intensive although automated batch processing can accomplish some of the required steps. While the sample size and temporal coverage was consistently adequate on interstate highways and major arterials, data are still sparse on lower functionally classified roads, especially at the levels of collectors and local streets.

A range of congestion and reliability performance measures have been generated from these data and were provided to KYTC and MPO stakeholders in the form of geodatabases. These measures were generally reliable on roadways with adequate sample coverage. When the sample size may be a concern, data from other sources (such as Bluetooth, radar, etc.) can be used to supplement the speeds obtained from the private sector. Other applications can benefit from these data, including the calibration and validation of simulation models, travel demand models, and air quality analyses.

These data were accompanied by information on sample size and sample standard deviation, which shed light on their quality. Unfortunately, the vendor plans to discontinue the production of these two data items. While it is more appropriate to evaluate performance at the corridor level, speed data at the link level measured directly by probe vehicles, without information from other sources blended in, remains the most valuable option to KYTC and MPOs.

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APPENDIX A 2011 GEODATABASES LIST OF ATTRIBUTES

Attribute	Description
rid	Unique identifier for a given roadway segment
fmeas	Beginning milepoint of a given roadway segment
tmeas	Ending milepoint of a given roadway segment
CO	County code
Pre	Roadway Prefix
RT	Roadway number
SU	Roadway Suffix
LinkID	Unique link identifier of NAVTEQ street network
Direction	Travel directions of a navigable link: F= From reference node, T= To reference node
Street_Name	Street name in NAVTEQ street network
CardinalDir	Travel directions of a link: cardinal direction or non-cardinal direction
County_Code	Numerical county code
F_System	Functional classifications in HPMS network
NHS	National highway system indicator
Type_Facility	Type of facility: one-way or two-way
AADT	Annual Average Daily Traffic
DirectionalAADT	Directional Annual Average Daily Traffic
Speed_Limit	Speed limit of roadway
RT_UNIQUE	Unique identifier for a given roadway segment
Non_Cardinal_Pair	Paired unique identifier for non-cardinal direction of a given roadway segment
NAVTEQ_FC	Functional classifications in NAVTEQ network
HPMS_ConvertedFC	Converted HPMS functional classification to match NAVTEQ functional classification
FS_Flag	Functional classification system flag, “Y” = converted HPMS FC and NAVTEQ functional classifications don’t match; “N” = otherwise
RS_Flag	Reference speed flag, “Y” = obtained 85th percentile speed from probe data is less than half of the speed limit or speed limit=0; “N” = otherwise
AM_Flag	AM peak period speed flag: “Y” = average speed <3mph, or 5th percentile speed<1mph; “N” = otherwise
PM_Flag	PM peak period speed flag, “Y” = average speed <3mph, or 5th percentile speed<1mph; “N” = otherwise
RS85th	Reference speed using 85th percentile speed of all data

Attribute	Description
RS85thCnt	Number of 15-minute intervals with probe data
RS85thPcnt	Percentage of 15-minute intervals with probe data
RS60th	Reference speed using 60th percentile speed of day-time data (6am to 7pm) on urban arterials
RS60thCnt	Number of 15-minute intervals with probe data during day-time period on urban arterials
RS60thPcnt	Percentage of 15-minute intervals with probe data during day-time period on urban arterials
AMAvgSpd	Average speed during AM peak (6-9am) period
AMCnt	Number of 15-minute intervals with probe data during AM peak period
AMPcnt	Percentage of 15-minute intervals with probe data during AM peak period
AM5thSpd	The 5th percentile speed of AM peak period
PMAvgSpd	Average speed during PM peak (3-6pm) period
PMCnt	Number of 15-minute intervals with probe data during PM peak period
PMPcnt	Percentage of 15-minute intervals with probe data during PM peak period
PM5thSpd	The 5th percentile speed of PM peak period
TTI_RS85th_AM	Travel time index using 85th percentile speed as reference speed during AM peak period
PTI_RS85th_AM	Planning time index using 85th percentile speed as reference speed during AM peak period
TTI_RS85th_PM	Travel time index using 85th percentile speed as reference speed during PM peak period
PTI_RS85th_PM	Planning time index using 85th percentile speed as reference speed during PM peak period
TTI_RS60th_AM	Travel time index using 60th percentile speed as reference speed during AM peak period
PTI_RS60th_AM	Planning time index using 60th percentile speed as reference speed during AM peak period
TTI_RS60th_PM	Travel time index using 60th percentile speed as reference speed during PM peak period
PTI_RS60th_PM	Planning time index using 60th percentile speed as reference speed during PM peak period
TTI_SpeedLimit_AM	Travel time index using speed limit as reference speed during AM peak period
PTI_SpeedLimit_AM	Planning time index using speed limit as reference speed during AM peak period

Attribute	Description
TTI_SpeedLimit_PM	Travel time index using speed limit as reference speed during PM peak period
PTI_SpeedLimit_PM	Planning time index using speed limit as reference speed during PM peak period
TTI_90PcntSL_AM	Travel time index using 90 percent of speed limit as reference speed during AM peak period
PTI_90PcntSL_AM	Planning time index using 90 percent of speed limit as reference speed during AM peak period
TTI_90PcntSL_PM	Travel time index using 90 percent of speed limit as reference speed during PM peak period
PTI_90PcntSL_PM	Planning time index using 90 percent of speed limit as reference speed during PM peak period
BTI_AM	Buffer time index during AM peak period
BTI_PM	Buffer time index during PM peak period
Delay_RS85th	Total vehicle-hours of travel delay using 85th percentile speed as reference speed
Delay_RS60th	Total vehicle-hours of travel delay using 60th percentile speed as reference speed
Delay_SpeedLimit	Total vehicle-hours of travel delay using speed limit as reference speed
Delay_90PcntSL	Total vehicle-hours of travel delay 90 percent of speed limit as reference speed
VMT	Total vehicle miles traveled
VMT_SL	Vehicle miles traveled at a speed below the speed limit
VMT_SL90	Vehicle miles traveled at a speed below 90 percent of the speed limit
VMT_RS85	Vehicle miles traveled at speed below the 85th percentile speed of all data
VMT_RS60	Vehicle miles traveled at a speed below the 60th percentile speed of day-time data - from 6am to 7pm on urban arterials
VHT	Total vehicle hours traveled
VHT_SL	Vehicle hours traveled at a speed below the speed limit
VHT_SL90	Vehicle hours traveled at a speed below 90 percent of the speed limit
VHT_RS85	Vehicle hours traveled at a speed below the 85th percentile speed of all data
VHT_RS60	Vehicle hours traveled at a speed below 60th percentile speed of day-time data on urban arterials
AMVMT	Vehicle miles traveled on a roadway segment during weekday AM peak period
PMVMT	Vehicle miles traveled on a roadway segment during weekday PM peak period

Attribute	Description
Flag_TotalSample	Flag of the sample size of all year: “Y” = the percent of intervals with speed data is less than 1%; “N” = otherwise.
Flag_RS85th	Reference speed flag for the 85^{th} percentile speed: “Y” = the percent interval is less than 1% or obtained 85^{th} percentile speed from probe data is less than half of the speed limit; “N” = otherwise
Flag_RS60th	Reference speed flag for the 60^{th} percentile speed: “Y” = the percent interval is less than 1% or obtained 60^{th} percentile speed from probe data is less than two fifth of the speed limit; “N” = otherwise
Flag_AMPeriod	AM peak period flag: For roadways with functional class less than 14: “Y” = the percent interval is less than 1% or 5th percentile speed<10mph; “N” = otherwise. For roadways with functional class equal to or larger than 14: “Y” = the percent interval is less than 1% or 5th percentile speed<5mph; “N” = otherwise.
Flag_PMPeriod	PM peak period flag, which depends on the facility type. For roadways with functional class less than 14: “Y” = the percent interval is less than 1% or 5th percentile speed<10mph; “N” = otherwise. For roadways with functional class equal to or larger than 14: “Y” = the percent interval is less than 1% or 5th percentile speed<5mph; “N” = otherwise.
Shape_Length	The length of the link

APPENDIX B 2012 GEODATABASES LIST OF ATTRIBUTES

Attribute	Description
rid	Unique identifier for a given roadway section from KYTC's HIS network
fmeas	Beginning milepoint of a given roadway section from the conflation process.
tmeas	Ending milepoint of a given roadway section from the conflation process.
ST_Name	Street name from the NAVTEQ street network
Func_Class	Functional classification from NAVTEQ network
Cardinal_Direction	Travel directions of a link: Y = cardinal, N = non-cardinal. It's generated from the conflation process
RT_Prefix	Roadway prefix from the HIS network
RT_Number	Roadway number from the HIS network
RT_Suffix	Roadway suffix from the HIS network
ADTPrior	ADT of the roadway from the HIS network
New_Class_Code	New functional classification code from the HIS network
New_Class_Description	Description of the new functional classification from the HIS network
Class_Code	Previous functional classification code from the HIS network
Class_Description	The description of the previous classification code from the HIS network
NHS_Code	National highway system code from the HIS network
Operation_Code	Operation code from the HIS network; 1 means one-way roadway, 2 means two-way roadway.
Speed limit	Speed limit from the HIS network
UniKey	Unique key of the table. It's generated to identify or join records.
County_Code	County code from the HIS network
LinkID	Unique identifier for the link from NAVTEQ street network
Direction	Travel directions of a navigable link from NAVTEQ street network, F =From reference node and T = To reference node
PcntSpeed_85thWd	The 85th percentile speed based on weekday data
TotalIntervals_85thWd	Number of 15-min intervals with probe data during weekdays
PcntInterval_85thWd	Percentage of 15-min intervals with probe data during weekdays. It is calculated as 100*TotalIntervals_85thWd/5760.
TotalSamples_85thWd	Total number of probe samples collected during weekdays

Attribute	Description
AvgSamplePerInterval_85thWd	Average number of samples per 15-min interval with probe speed data during weekdays. It is calculated as TotalSamples_85thWd/TotalIntervals_85thWd.
AggStdDev_85thWd	Standard deviation of all 15-min speeds during weekdays. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N}n_i)X^2}{(\sum_{i=1}^{N}n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_85thWd	The maximum number of samples in an interval during weekdays
PIF_85thWd	Peak interval factor for weekdays. It is calculated as TotalSamples_85thWd/(TotalIntervals_85thWd*MaxSamples_85thWd). The concept is similar to peak hour factor and is proposed to describe the concentration of samples.
PcntSpeed_85thAll	The 85th percentile speed for all days and time periods in a year
TotalIntervals_85thAll	Number of 15-min intervals with probe data in a year
PcntInterval_85thAll	Percentage of 15-min intervals with probe data in a year. It is calculated as 100*TotalIntervals_85thAll/8064.
TotalSamples_85thAll	Total number of probe samples collected in a year
AvgSamplePerInterval_85thAll	Average number of samples per interval with probe data in the year. It is calculated as TotalSamples_85thAll/TotalIntervals_85thAll.
AggStdDev_85thAll	Standard deviation of all the speeds in a year. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N}n_i)X^2}{(\sum_{i=1}^{N}n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_85thAll	The maximum number of samples in an interval during the year
PIF_85thAll	Peak interval factor for 2012. It is calculated as TotalSamples_85thAll/(TotalIntervals_85thAll*MaxSamples_85thAll).
PcntSpeed_85thWend	The 85th percentile speed for weekends
TotalIntervals_85thWend	Number of 15-min intervals with probe data during weekends
PcntInterval_85thWend	Percentage of 15-min intervals with probe data during weekends. It is calculated as 100*TotalIntervals_85thWend/2304.
TotalSamples_85thWend	Total number of samples collected during weekends

Attribute	Description
AvgSamplePerInterval_85thWend	Average number of samples per 15-min interval with probe data during weekends. It is calculated as TotalSamples_85thWend/TotalIntervals_85thWend.
AggStdDev_85thWend	Standard deviation of all the speeds during weekends. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N}n_i)X^2}{(\sum_{i=1}^{N}n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_85thWend	Maximum number of samples in an interval during weekends
PIF_85thWend	Peak interval factor for weekends. It is calculated as TotalSamples_85thWend/(TotalIntervals_85thWend*MaxSamples_85thWend).
PcntSpeed_60thWdtime	60th percentile speed during weekday daytime from 6am to 8pm on urban interrupted facilities
PcntSpeed_85thWdtime	85th percentile speed during weekday daytime from 6am to 8pm on urban interrupted facilities
TotalIntervals_Wdtime	Number of 15-min intervals with probe data during weekday daytime from 6am to 8pm
PcntInterval_Wdtime	Percentage of 15-min intervals with probe data during weekday daytime from 6am to 8pm. It is calculated as 100*TotalIntervals_Wdtime/3360.
TotalSamples_Wdtime	Total number of probe samples collected during weekday daytime from 6am to 8pm
AvgSamplePerInterval_Wdtime	Average number of samples per 15-min interval with probe speed data during weekday daytime from 6am to 8pm. It is calculated as TotalSamples_Wdtime/TotalIntervals_Wdtime
AggStdDev_Wdtime	Standard deviation of all the speeds during weekday daytime from 6am to 8pm. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N}n_i)X^2}{(\sum_{i=1}^{N}n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_Wdtime	Maximum number of samples in an interval during weekday daytime from 6am to 8pm
PIF_Wdtime	Peak interval factor for weekday daytime from 6am to 8pm. It is calculated as TotalSamples_Wdtime/(TotalIntervals_Wdtime*MaxSamples_Wdtime).
PcntSpeed_Wday5thAM	The 5th percentile speed during weekday AM peak from 6am to 9am
AvgSpeed_WdayAM	Average speed during weekday AM peak from 6am to 9am. It is calculated as $\mu = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N}n_i}$, where n_i, $\bar{x}_i$is the sample size, average speed of interval i respectively; N is the total number of

Attribute	Description
	intervals with probe data.
TotalIntervals_WdayAM	Number of 15-min intervals with probe data during weekday AM peak from 6am to 9am
PcntInterval_WdayAM	Percentage of 15-min intervals with probe data during weekday AM peak from 6am to 9am. It is calculated as 100*TotalIntervals_WdayAM/720.
TotalSamples_WdayAM	Total number of probe samples collected during weekday AM peak
AvgSamplePerInterval_WdayAM	Average number of samples per 15-min interval with probe speed data during weekday AM peak from 6am to 9am. It is calculated as TotalSamples_WdayAM/TotalIntervals_WdayAM
AggStdDev_WdayAM	Standard deviation of all the speeds during weekday AM peak from 6am to 9am. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N} n_i)X^2}{(\sum_{i=1}^{N} n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N} n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_WdayAM	Maximum number of samples in an interval during weekday AM peak.
PIF_WdayAM	Peak interval factor for weekday AM peak from 6am to 9am. It is calculated as TotalSamples_WdayAM/(TotalIntervals_WdayAM*MaxSamples_WdayAM).
PcntSpeed_Wday5thMD	The 5th percentile speed during weekday mid-day period from 9am to 3pm
AvgSpeed_WdayMD	Average speed during weekday mid-day period from 9am to 3pm. It is calculated as $\mu = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N} n_i}$, where n_i, $\bar{x}_i$is the sample size, average speed of interval i respectively; N is the total number of intervals with probe data.
TotalIntervals_WdayMD	Number of 15-min intervals with probe data during weekday mid-day period from 9am to 3pm
PcntInterval_WdayMD	Percentage of 15-min intervals with probe data during weekday mid-day period from 9am to 3pm. It is calculated as 100*TotalIntervals_WdayMD/1440.
TotalSamples_WdayMD	Total number of probe samples collected during weekday mid-day period
AvgSamplePerInterval_WdayMD	Average number of samples per 15-min interval with probe speed data during weekday mid-day period from 9am to 3pm. It is calculated as TotalSamples_WdayMD/TotalIntervals_WdayMD
AggStdDev_WdayMD	Standard deviation of all the speeds during weekday mid-day period from 9am to 3pm. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N} n_i)X^2}{(\sum_{i=1}^{N} n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i\bar{x}_i)}{\sum_{i=1}^{N} n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size,

Attribute	Description
	standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_WdayMD	Maximum number of samples in an interval during weekday mid-day period from 9am to 3pm.
PIF_WdayMD	Peak interval factor for weekday mid-day period from 9am to 3pm. It is calculated as TotalSamples_WdayMD/(TotalIntervals_WdayMD*MaxSamples_WdayMD).
PcntSpeed_Wday5thPM	5th percentile speed during weekday PM peak from 3pm to 6pm
AvgSpeed_WdayPM	Average speed during weekday PM peak from 3pm to 6pm. It is calculated as $\mu = \frac{\sum_{i=1}^{N}(n_i \bar{x}_i)}{\sum_{i=1}^{N} n_i}$, where n_i, $\bar{x}_i$is the sample size, average speed of interval i respectively; N is the total number of intervals with probe data.
TotalIntervals_WdayPM	Number of 15-min intervals with probe data during weekday PM peak from 3pm to 6pm
PcntInterval_WdayPM	Percentage of 15-min intervals with probe data during weekday PM peak from 3pm to 6pm. It is calculated as 100*TotalIntervals_WdayPM/720.
TotalSamples_WdayPM	Total number of probe samples collected during weekday PM peak period.
AvgSamplePerInterval_WdayPM	Average number of samples per 15-min interval with probe speed data during weekday PM peak from 3pm to 6pm. It is calculated as TotalSamples_WdayPM/TotalIntervals_WdayPM
AggStdDev_WdayPM	Standard deviation of all the speeds during weekday PM peak from 3pm to 6pm. It is calculated as $\sigma = \sqrt{\frac{\sum_{i=1}^{N}[(n_i-1)\sigma_i^2]+\sum_{i=1}^{N}[n_i(\bar{x}_i)^2]-(\sum_{i=1}^{N} n_i)X^2}{(\sum_{i=1}^{N} n_i)-1}}$, where $X = \frac{\sum_{i=1}^{N}(n_i \bar{x}_i)}{\sum_{i=1}^{N} n_i}$, and n_i, σ_i, $\bar{x}_i$is the sample size, standard deviation, and average speed of interval i respectively; N is the total number of intervals with probe data.
MaxSamples_WdayPM	Maximum number of samples in an interval during weekday PM peak from 3pm to 6pm.
PIF_WdayPM	Peak interval factor for weekday PM peak from 3pm to 6pm. It is calculated as TotalSamples_WdayPM/(TotalIntervals_WdayPM*MaxSamples_WdayPM).
TTI_SL_AM	Travel time index using speed limit as reference speed during AM peak period
TTI_SL_MD	Travel time index using speed limit as reference speed during mid-day period
TTI_SL_PM	Travel time index using speed limit as reference speed during PM peak period
PTI_SL_AM	Planning time index using speed limit as reference speed during AM peak period
PTI_SL_MD	Planning time index using speed limit as reference speed during mid-day period
PTI_SL_PM	Planning time index using speed limit as reference speed during PM peak period

Attribute	Description
TTI_85thAll_AM	Travel time index using 85th percentile speed of all day as reference speed during AM peak period
TTI_85thAll_MD	Travel time index using 85th percentile speed of all day as reference speed during mid-day period
TTI_85thAll_PM	Travel time index using 85th percentile speed of all day as reference speed during PM peak period
PTI_85thAll_AM	Planning time index using 85th percentile speed of all day as reference speed during AM peak period
PTI_85thAll_MD	Planning time index using 85th percentile speed of all day as reference speed during mid-day period
PTI_85thAll_PM	Planning time index using 85th percentile speed of all day as reference speed during PM peak period
TTI_85thWd_AM	Travel time index using 85th percentile speed of weekdays as reference speed during AM peak period
TTI_85thWd_MD	Travel time index using 85th percentile speed of weekdays as reference speed during mid-day period
TTI_85thWd_PM	Travel time index using 85th percentile speed of weekdays as reference speed during PM peak period
PTI_85thWd_AM	Planning time index using 85th percentile speed of weekdays as reference speed during AM peak period
PTI_85thWd_MD	Planning time index using 85th percentile speed of weekdays as reference speed during mid-day period
PTI_85thWd_PM	Planning time index using 85th percentile speed of weekdays as reference speed during PM peak period
TTI_60thWdtime_AM	Travel time index using 60th percentile speed of weekday daytime as reference speed during AM peak period
TTI_60thWdtime_MD	Travel time index using 60th percentile speed of weekday daytime as reference speed during mid-day period
TTI_60thWdtime _PM	Travel time index using 60th percentile speed of weekday daytime as reference speed during PM peak period
PTI_60thWdtime _AM	Planning time index using 60th percentile speed of weekday daytime as reference speed during AM peak period

Attribute	Description
PTI_60thWdtime _MD	Planning time index using 60th percentile speed of weekday daytime as reference speed during mid-day period
PTI_60thWdtime _PM	Planning time index using 60th percentile speed of weekday daytime as reference speed during PM peak period
TTI_85thWdtime_AM	Travel time index using 85th percentile speed of weekday daytime as reference speed during AM peak period
TTI_85thWdtime_MD	Travel time index using 85th percentile speed of weekday daytime as reference speed during mid-day period
TTI_85thWdtime _PM	Travel time index using 85th percentile speed of weekday daytime as reference speed during PM peak period
PTI_85thWdtime _AM	Planning time index using 85th percentile speed of weekday daytime as reference speed during AM peak period
PTI_85thWdtime _MD	Planning time index using 85th percentile speed of weekday daytime as reference speed during mid-day period
PTI_85thWdtime _PM	Planning time index using 85th percentile speed of weekday daytime as reference speed during PM peak period
BTI_AM	Buffer time index during AM peak period
BTI_PM	Buffer time index during PM peak period
WdayDelay_SL	Total vehicle-hours of travel delay during weekdays using speed limit as reference speed
WdayDelay_All85	Total vehicle-hours of travel delay during weekdays using 85th percentile speed of all day as reference speed
WdayDelay_Wday85	Total vehicle-hours of travel delay during weekdays using 85th percentile speed of weekday as reference speed
WdayDelay_Wdaytime85	Total vehicle-hours of travel delay during weekdays using 85th percentile speed of weekday daytime as reference speed
WdayDelay_Wdaytime60	Total vehicle-hours of travel delay during weekdays using 60th percentile speed of weekday daytime as reference speed
WendDelay_SL	Total vehicle-hours of travel delay during weekends using speed limit as reference speed
WendDelay_All85	Total vehicle-hours of travel delay during weekends using 85th percentile speed of all day as reference speed
WendDelay_Wend85	Total vehicle-hours of travel delay during weekends using 85th percentile speed of weekend as

Attribute	Description
	reference speed
YearDelay_SL	Total vehicle-hours of travel delay for a whole year using speed limit as reference speed
YearDelay_All85	Total vehicle-hours of travel delay for a whole year using 85th percentile speed of all day as reference speed
Wday_VMT	Total vehicle miles traveled during weekdays
Wday_VMT_SL	Vehicle miles traveled at speed below the speed limit during weekdays
Wday_VMT_All85	Vehicle miles traveled at a speed below the 85th percentile speed of all day during weekdays
Wday_VMT_Wd85	Vehicle miles traveled at a speed below the 85th percentile speed of weekday during weekdays
Wday_VMT_Wdaytime85	Vehicle miles traveled at a speed below the 85th percentile speed of weekday daytime during weekdays
Wday_VMT_Wdaytime60	Vehicle miles traveled at a speed below the 60th percentile speed of weekday daytime during weekdays
Wday_VHT	Total vehicle hours traveled during weekdays
Wday_VHT_SL	Vehicle hours traveled at a speed below the speed limit during weekdays
Wday_VHT_All85	Vehicle hours traveled at a speed below the 85th percentile speed of all day during weekdays
Wday_VHT_Wd85	Vehicle hours traveled at a speed below the 85th percentile speed of weekday during weekdays
Wday_VHT_Wdaytime85	Vehicle hours traveled at a speed below the 85th percentile speed of weekday daytime during weekdays
Wday_VHT_Wdaytime60	Vehicle hours traveled at a speed below the 60th percentile speed of weekday daytime during weekdays
Wend_VMT	Total vehicle miles traveled during weekends
Wend_VMT_SL	Vehicle miles traveled at a speed below the speed limit during weekends
Wend_VMT_All85	Vehicle miles traveled at a speed below the 85th percentile speed of all day during weekends
Wend_VMT_Wend85	Vehicle miles traveled at a speed below the 85th percentile speed of weekend during weekends
Wend_VHT	Total vehicle hours traveled during weekends
Wend_VHT_SL	Vehicle hours traveled at a speed below the speed limit during weekends
Wend_VHT_All85	Vehicle hours traveled at a speed below the 85th percentile speed of all day during weekends
Wend_VHT_Wend85	Vehicle hours traveled at a speed below the 85th percentile speed of weekend during weekends
All_VMT	Total vehicle miles traveled in a year
All_VMT_SL	Vehicle miles traveled at a speed below the speed limit in a year

Attribute	Description
All_VMT_All85	Vehicle miles traveled at a speed below the 85th percentile speed of all day in a year
All_VHT	Total vehicle hours traveled during the year
All_VHT_SL	Vehicle hours traveled at a speed below the speed limit in a year
All_VHT_All85	Vehicle hours traveled at a speed below the 85th percentile speed of all day in a year
Flag_TotalSample	Flag of the sample size of all year. "Y" if the percent of intervals with speed data is less than 1% out of total 8064 intervals in a year; "N" otherwise
Flag_85thAll	Reference speed flag for the 85th percentile speed: "Y" = percent interval in a year is less than 1% or obtained 85th percentile speed from probe data is less than half of the speed limit; "N" = otherwise.
Flag_85thWd	Reference speed flag for the 85th percentile speed of weekdays: "Y" = the percent interval in weekdays is less than 1% or obtained 85th percentile speed from probe data is less than half of the speed limit; "N" = otherwise.
Flag_85thWend	Reference speed flag for the 85th percentile speed of weekends: "Y" = the percent interval in weekends is less than 1% or obtained 85th percentile speed from probe data is less than half of the speed limit; "N" = otherwise.
Flag_Wdtime	Reference speed flag for the 60th and 85th percentile speed of weekday daytime period: "Y" = the percent interval in weekday daytime period is less than 1% or obtained 85th percentile speed from probe data is less than half of the speed limit; "N" = otherwise.
Flag_AMPeriod	Flag for AM peak measures. For roadways with functional class less than 14: "Y" = the percent interval in AM peak is less than 1% or 5th percentile speed<10mph; "N" = otherwise. For roadways with functional class equal to or larger than 14: "Y" = the percent interval in AM peak is less than 1% or 5th percentile speed<5mph; "N" = otherwise.
Flag_PMPeriod	Flag for PM peak measures. For roadways with functional class less than 14: "Y" = the percent interval in PM peak is less than 1% or 5th percentile speed<10mph; "N" = otherwise. For roadways with functional class equal to or larger than 14: "Y" = the percent interval in PM peak is less than 1% or 5th percentile speed<5mph; "N" = otherwise.
Shape_Length	Length of the link

APPENDIX C NHS GEODATABASES LIST OF ATTRIBUTES

Attribute	Description
CorridorID	Unique identification of the corridor
Delay_SL	Total vehicle-hours of travel delay using speed limit as reference speed
Delay_RS85	Total vehicle-hours of travel delay using 85th percentile speed as reference speed
AMAvgSpeed	AM peak average speed
PMAvgSpeed	PM peak average speed
AMRI_RS85	Reliability index using 85th percentile speed as reference speed during AM peak period
AMRI_SL	Reliability index using speed limit as reference speed during AM peak period
PMRI_RS85	Reliability index using 85th percentile speed as reference speed during PM peak period
PMRI_SL	Reliability index using speed limit as reference speed during PM peak period
County	Numerical county code
Pre	Roadway prefix
RT_Number	Roadway number
Direction	Travel directions of a link, can be either cardinal direction or non-cardinal direction
FC	Functional classification from the HIS network
Shape_Length	Length of the corridor