

2013–2014 Indiana Mobility Report

Summary Version



Christopher Day, Stephen Remias, Howell Li, Michelle Mekker, Margaret McNamara, Edward Cox, Deborah Horton, Darcy Bullock







Ryan Gallagher
Deputy Commissioner
Operations



Jay Wasson
Deputy Commissioner
Engineering & Asset Management

FOREWORD

Located at the crossroads of America, Indiana's highways are vital to the national transportation network and the Indiana economy. Over \$500 billion of freight moves from, to, or within the state on our highway system each year. The Indiana Interstate Highway System includes more than 1,100 centerline miles. This mileage represents about 10% of the Indiana Department of Transportation (INDOT) roadway system, but the system carries over 35% of the total vehicle miles traveled (approximately 16 billion vehicle miles in 2011).

Since 2006, INDOT has invested more than \$7 billion in hundreds of roadway and bridge projects statewide. National studies indicate that congestion in Indiana has substantially decreased during this period, and the data contained in this report substantiate those observations. However, opportunities still exist to improve our Interstate and surface street systems, and it is essential that we use the best data possible to maximize the impact of our infrastructure investments.

In collaboration with our partners from the Joint Transportation Research Program (JTRP) at Purdue University, we have defined a series of innovative mobility performance measures that leverage commercial probe vehicle data to shape our highway infrastructure investment priorities. The performance measures and presentation formats described in this report build upon the 2011 and 2012 Indiana Mobility Reports. We believe that these performance measures advance the frontier in best practices for transportation planning and provide unprecedented opportunities to greatly improve how we prioritize competing investment decisions. We can use these same measures to assess the impacts of completed capital projects, work zone management, and other day-to-day operational strategies.

CONTENTS

INTRODUCTION	1
INCREASING MOBILITY DATA UTILIZATION	1
<i>INTERSTATE SYSTEM PERFORMANCE</i>	2
INDIANA INTERSTATE SYSTEM OVERVIEW	2
INTERSTATE SYSTEM PERFORMANCE MEASURES.....	2
15-Minute Speed.....	2
Congestion Hours.....	3
Distance-Weighted Congestion Hours	6
Interstate Speed Profiles	7
45 mph Delay (Delay ₄₅)	11
Annual Average Daily Traffic (AADT) Volumes.....	12
Total Delay	13
Delta Speed.....	14
SUMMARY OF INDIANA'S INTERSTATE HIGHWAY SYSTEM PERFORMANCE	18
Monthly Performance Comparison: January 2011–June 2014	18
Indiana Interstate Segment Rankings	24
Monthly Performance Summary.....	27

2013–2014 INDIANA INTERSTATE PERFORMANCE HIGHLIGHTS	28
South Split Project.....	28
Borman Expressway (I-94) Update.....	30
Impacts of Winter Weather.....	39
<i>ARTERIAL SYSTEM PERFORMANCE</i>	41
ARTERIAL MOBILITY DATA OVERVIEW.....	41
ARTERIAL MOBILITY PERFORMANCE MEASURES	44
Average Travel Time	44
Normalized Travel Time	45
Normalized Travel Time Unreliability	45
Binning by Time of Day and Roadway	46
Composite Travel Time Index	46
SUMMARY OF ARTERIAL PERFORMANCE	47
Arterial Rankings by Travel Time and Travel Time Unreliability	47
Composite Arterial Rankings.....	51
<i>CONCLUSIONS AND FUTURE OUTLOOK</i>	52

INTRODUCTION

This report focuses on the mobility performance of critical components of the Indiana state highway network: the Interstate system (Figure 1) and selected arterial routes operated by the Indiana Department of Transportation (INDOT). The report is the third in a series of Indiana Mobility Reports that have made use of crowdsourced highway speed data measured from the time-stamped positions of mobile devices, including GPS devices used by commercial vehicles and mobile phones running apps where users have chosen to share location data. The speed data received by INDOT are anonymous, having been distilled into average segment speeds by a commercial third-party traffic data vendor. The data set has proven to be a powerful tool for assessing conditions on the highway network.

The operational performance of Indiana's state highway system was assessed using a variety of metrics based on observed speeds and, new in this edition, traffic volume data. This report provides an overview of the performance measure methodology, presents an overview of overall system performance, and introduces a real-time incident detection tool based on the data. Details are presented in the appendices (available with the full version).

INCREASING MOBILITY DATA UTILIZATION

This edition of the Mobility Report shifts the focus from a 12-month perspective to an 18-month perspective, covering 2013 and the first 6 months of 2014. This perspective aligns the report with the publication timeline and ensures that the most up-to-date information is included. We anticipate that in the future the mobility reporting tool will transition into a live dashboard where reports from the latest travel time information will be available.



Figure 1. Interstate map of Indiana.

Traffic volumes, new to this edition of the report, have been integrated into the performance measures framework based on the previously established INDOT annual average daily traffic (AADT) counts. This enables the speed- and travel time-based performance measures to be scaled according to the traffic demand on the individual roadway segments, adding another dimension to the analysis.

In 2014 the data provider began including access to travel time data with improved spatial resolution characteristics. This enhanced spatial resolution provides travel time data along 1-mile segments instead of the interchange-to-interchange segmentation used in previous Mobility Reports. This has enabled us to develop new tools for detecting queue formation on the Interstate system, leading to a new performance measure that can be applied to data starting in 2014.

INTERSTATE SYSTEM PERFORMANCE

INDIANA INTERSTATE SYSTEM OVERVIEW

This report focuses on Interstates 64, 65, 69, 70, 74, 94, and 465 (Figure 1), which are the Interstate routes operated by INDOT. These routes are the backbone of the state highway system, connecting major population centers and providing access for commuters, travelers, and freight within and through the state. The following section explains the performance measures used to characterize the mobility performance of these roadways. A full set of detailed performance measure graphics is provided for each roadway in the full version of this report.

INTERSTATE SYSTEM PERFORMANCE MEASURES

15-Minute Speed

The performance measures used in this report are based on minute-by-minute speed measurements that represent the average speed on a given segment during that minute. For the purpose of analyzing performance over long periods of time, the individual measurements are aggregated into 15-minute intervals.

The 15-minute speed (\tilde{v}_{ij}) for roadway segment i and 15-minute interval j is found by taking the median of the individual speed samples (v_k) within j :

$$\tilde{v}_{ij} = \text{Median} \{v_{k \in j}\} \quad \text{Equation 1}$$

Usually, all 15 minutes are available, although there are some occasions where 1 or 2 minutes do not have an average speed reported.

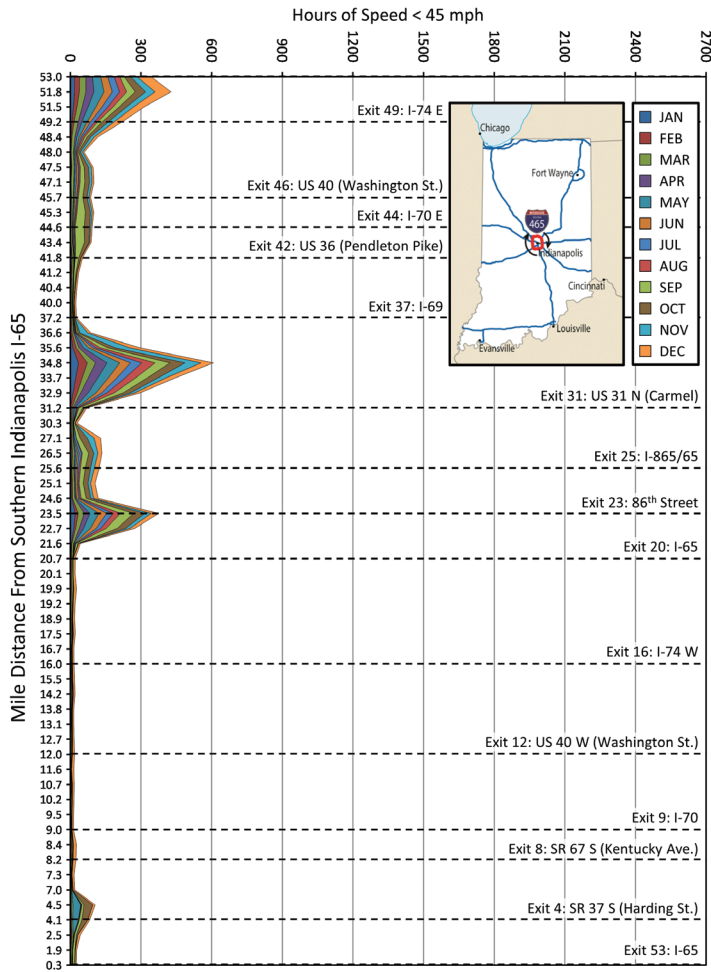
Congestion Hours

Congestion hours (CH) are defined in this report series as the number of hours for which the average speed on a segment fell below a critical threshold speed (v_c). The metric is computed from

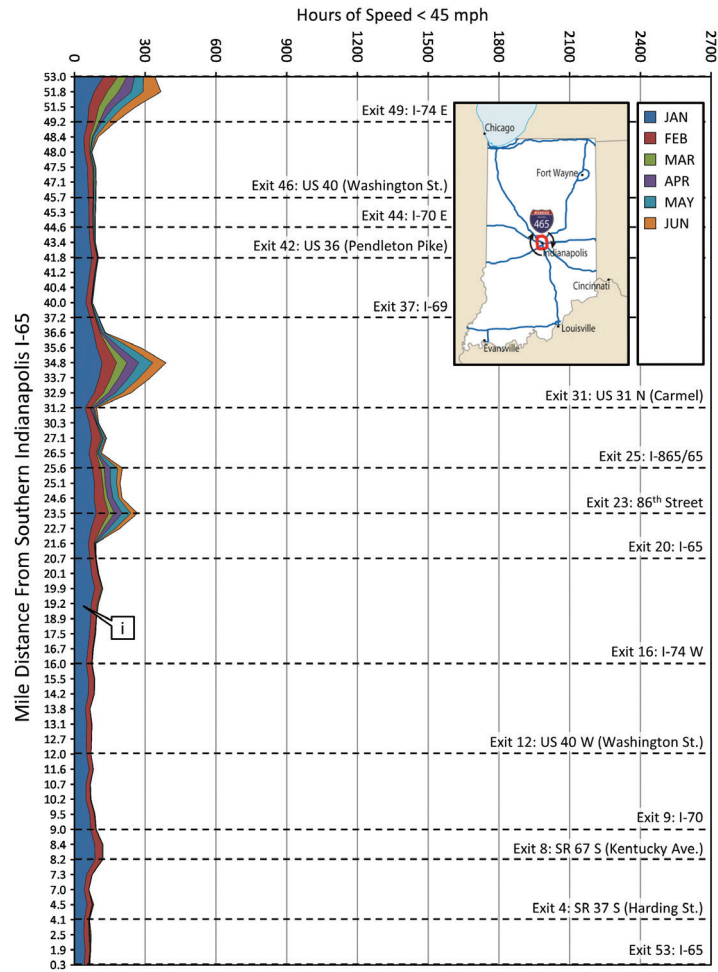
$$CH = \sum_{i \in S} \sum_{j \in T} \begin{cases} 0.25, & \tilde{v}_{ij} < v_c \\ 0, & \tilde{v}_{ij} > v_c \end{cases} \quad \text{Equation 2}$$

where \tilde{v}_{ij} is the median speed. The range is defined according to segment i belonging to roadway section S and interval j belonging to analysis period T . The factor 0.25 converts the count of 15-minute intervals into the equivalent number of hours. In this study, $v_c = 45$ mph was selected.

Congestion hours are convenient for quickly viewing the overall performance of a roadway and identifying congestion hot spots. Figure 2 shows a plot of the total number of congestion hours on the inner loop (clockwise direction) of I-465 in Indianapolis, with Figure 2a showing data from 2013 and Figure 2b from the first 6 months of 2014. Certain sections of the roadway clearly have a greater concentration of congestion hours than others—particularly the section between mile marker (MM) 31.2 and MM 37.2, which is the section on the north side that includes exits at Keystone Avenue, Allisonville Road, and the approach to the I-69 exit.



(a) January–December 2013



(b) January–June 2014

Figure 2. Congestion hours by month along I-465 (clockwise inner loop).

Figure 2b shows the impact of winter weather in January 2014, when all segments of I-465 experienced a relatively high number of congestion hours (exceeding any other individual month in the 18-month span). January 2014 (callout “i”) was the second-snowiest January on record in Indianapolis, while the entire winter season broke the record for being the snowiest.

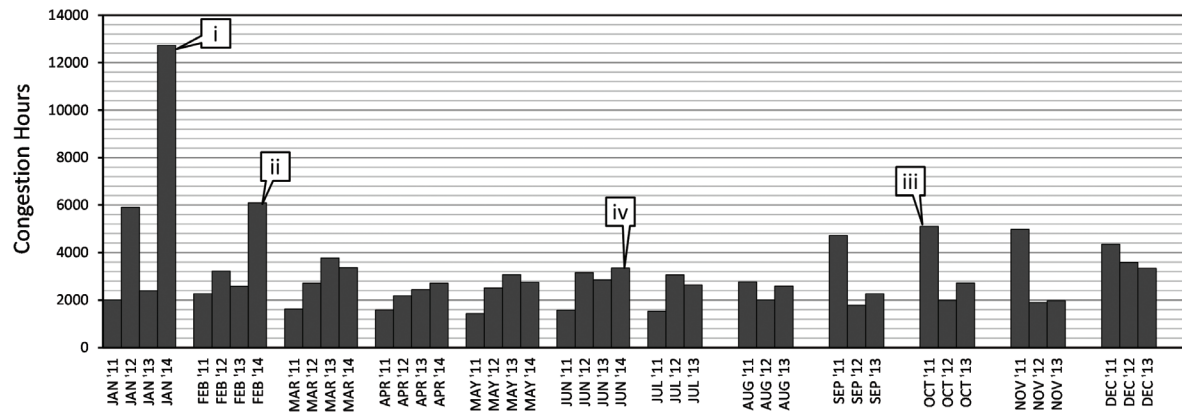


Figure 3. Congestion hours by month for I-65 (both directions).

The congestion hours by month from January 2011 through June 2014 for I-65 are shown in Figure 3. The impact of severe weather in 2014 can be seen in January (callout “i”), which had the highest number of congestion hours, and February (callout “ii”), which had the second-highest number. Another significant increase can be seen in September 2011 through January 2012 (callout “iii” shows October 2011). This is the result of severe speed reductions on the I-65 segments approaching the Kennedy Bridge across the Ohio River near Louisville. During these months the I-64 Sherman Minton Bridge was closed for repairs, with its traffic diverted to I-65. The number of congestion hours on I-65 for each of these months was approximately twice that of similar autumn months, and higher than summer months with more typical construction activities, such as June 2014 (callout “iv”).

Distance-Weighted Congestion Hours

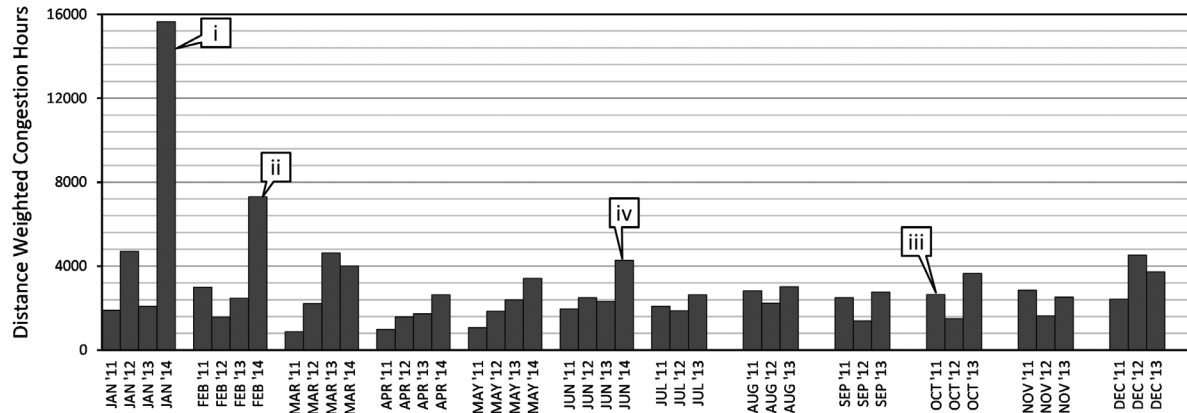
Distance-weighted congestion hours (DWCH) are calculated using the same concept as congestion hours, but also include the distance of each segment as a weighting factor:

$$DWCH = \sum_{i \in S} \sum_{j \in T} \begin{cases} 0.25x_i, & \tilde{v}_{ij} \leq v_c \\ 0, & \tilde{v}_{ij} > v_c \end{cases} \quad \text{Equation 3}$$

Here, x_i is the length of segment i , and the other quantities are the same as in Equation 2. Each segment is weighted by its length. This performance measure equates 1 hour of congestion on a 10-mile segment with 10 hours of congestion on a 1-mile segment. This emphasizes longer segments in the overall results.

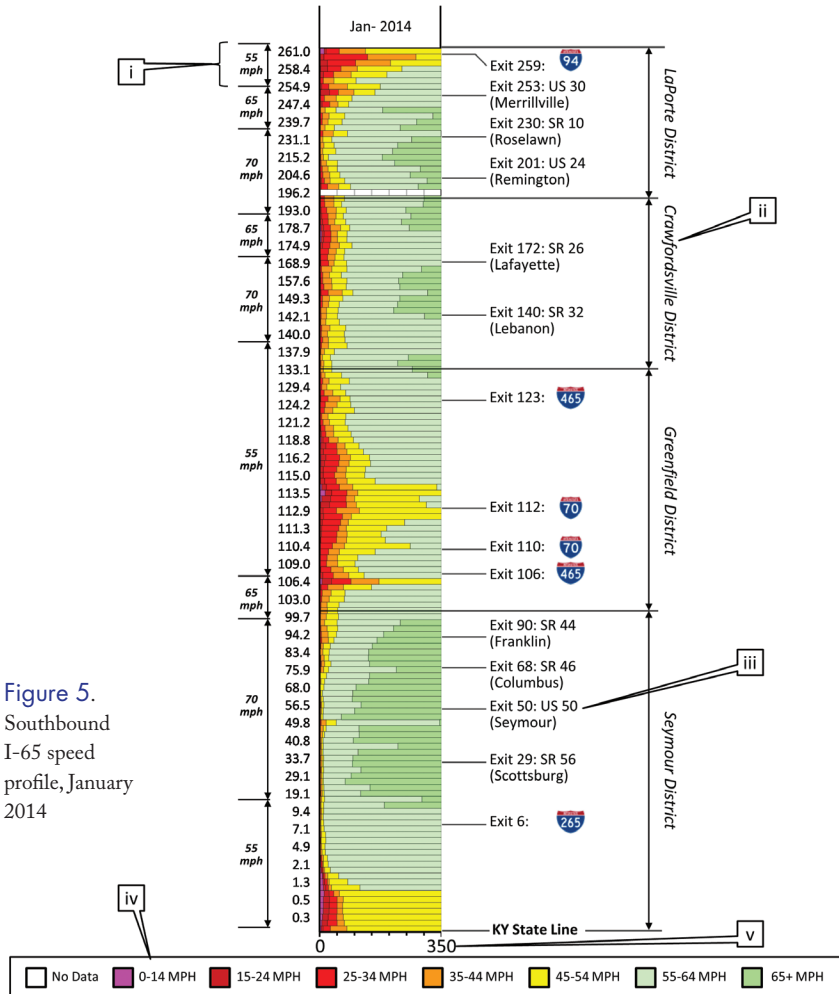
Figure 4. Distance-weighted congestion hours by month for I-65 (both directions).

Figure 4 shows the total monthly distance-weighted congestion hours for I-65 from January 2011 through June 2014. As with Figure 3, which shows the congestion hours, the impact of winter weather dominates, with January 2014 (callout “i”) and February 2014 (callout “ii”) being the highest and second-highest months in terms of total distance-weighted congestion hours. However, the impact of the I-64 Sherman Minton



Bridge closure is markedly less prominent. Note that October 2011 (callout “iii”), which had the fourth highest total number of congestion hours, has a more typical number of distance-weighted congestion hours. This is because the area impacted by congestion consisted of only a few miles on the approach to the I-65 Kennedy Bridge. The typical summer construction month,

Figure 5. Southbound I-65 speed profile, January 2014



June 2014 (callout “iv”), which was highlighted earlier, has a higher number of distance-weighted congestion hours. Although there were fewer congestion hours, these affected more miles of I-65.

Interstate Speed Profiles

A speed profile is a visualization tool that shows both the frequency and severity of congestion for each segment of a roadway. It is based on the total number of hours during which speeds belong to a particular congestion category defined by speed bins. The number of hours in each speed bin is calculated by

$$H_{ib} = \sum_{j \in T} \begin{cases} 0.25, & v_b \leq \tilde{v}_{ij} < v_{b+1} \\ 0, & \text{otherwise} \end{cases} \quad \text{Equation 4}$$

where H_{ib} is the number of hours on segment i that are in bin b , v_b and v_{b+1} are the upper and lower threshold speeds of the bin, \tilde{v}_{ij} is the median speed for segment i and interval j , T is the analysis period, and 0.25 converts the count of 15-minute intervals into the equivalent number of hours. Eight speed bins are defined by speed thresholds of 0, 15, 25, 35, 45, 55, and 65 mph. Typically, the analysis period is defined for each month, with a panel of speed profiles showing month-to-month variation.

Figure 5 shows a speed profile for January 2014 for southbound I-65. The vertical axis represents distances along the route. Speed limit zones are indicated on the left side (callout “i”),

while the right side shows INDOT districts (callout “ii”) and important interchanges (callout “iii”). Each horizontal bar represents an individual segment. The coloring of the bar indicates the number of hours within the month for which the speed fell within a certain range, as indicated by the legend (callout “iv”). The scale is capped at 350 hours (callout “v”), which is about half the number of hours in a month. Figure 6 shows each segment scaled according to its distance. As mentioned, January 2014 was quite exceptional in terms of the number of congestion hours. These figures reveal that the most severe congestion occurred north of MM 100 during that month. For example, around MM 112 (in downtown Indianapolis) there were approximately 100 hours with speeds of 35 mph or less observed during the month (Figure 6, callout “i”).

The speed profile is a useful tool to assess the current state of mobility on an entire Interstate route. It can also be used to assess the conditions before, during, and after construction activities. Figure 7 (top) is an example of a construction zone on I-65 near Lebanon, Indiana. The project construction took place throughout the summer months of 2013 and was completed prior to the winter of 2013–2014. Figure 7 (bottom) shows an image after the construction was completed in 2014. Speed profiles can provide an easy assessment tool for looking at Interstate operations over time. Figure 8 shows a panel of monthly speed profiles for I-65 for the 18-month period of January 2013 through June 2014.

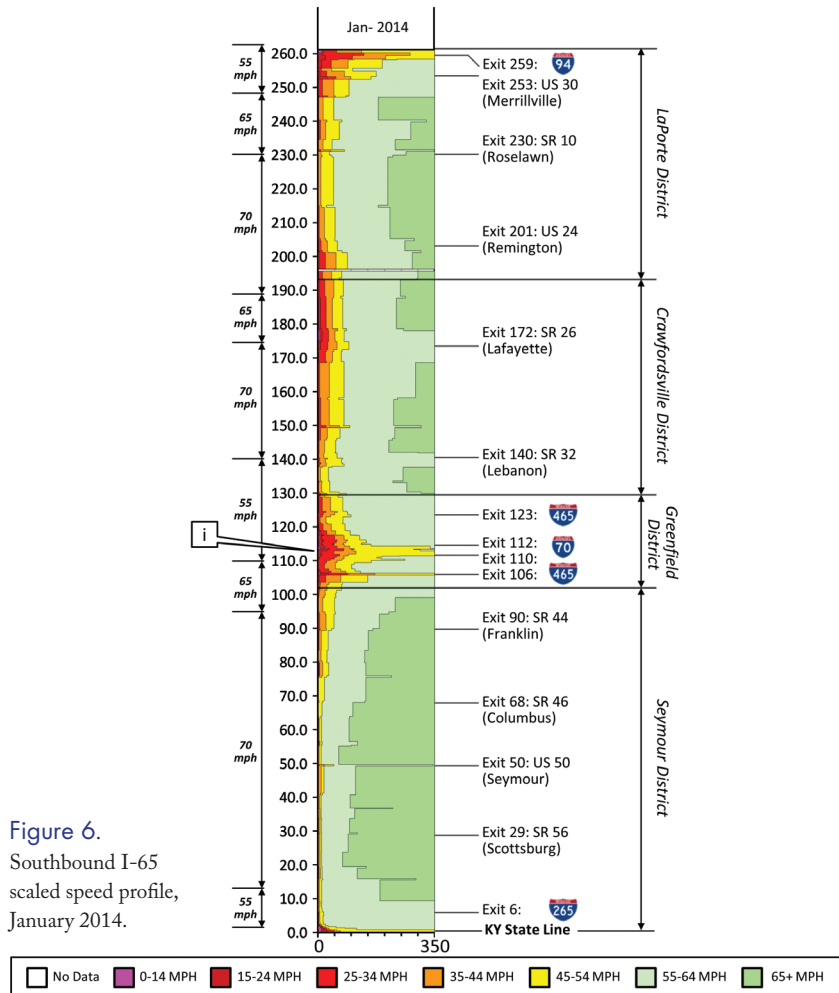


Figure 6. Southbound I-65 scaled speed profile, January 2014.



Figure 7. Construction zone on I-65 in Lebanon, Indiana.

Areas of recurring congestion are apparent in the expected locations of Indianapolis (callout “i”), Louisville (callout “ii”), and northwest Indiana (callout “iii”). Work zones near Lebanon in 2013 (around MM 140, callout “iv”) and Seymour in 2014 (around MM 50, callout “v”) also reveal themselves in the plot. The impact of winter weather in January 2014 can be seen in the increased congestion severity relative to the other months (callout “vi”). Another interesting feature is the lack of data in September 2013 around MM 110 (callout “vii”). During this time this stretch of freeway was completely closed to reconstruct the travel lanes. The before and after comparison of the Lebanon work zone (Figure 7) can be visualized with the reduced occurrence of slow speeds when comparing callouts “iv” and “viii.”

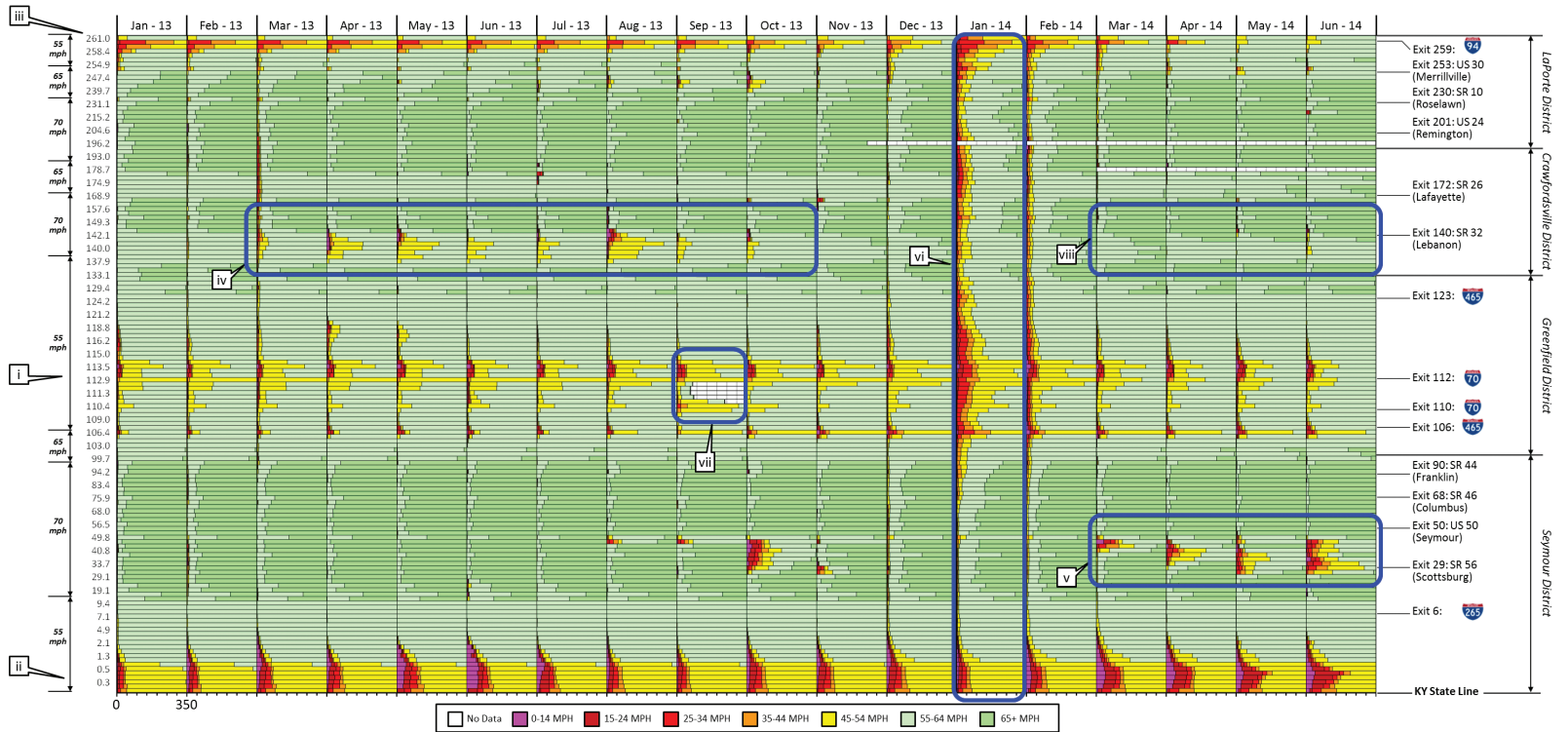


Figure 8. Speed profiles for southbound I-65, January 2013-June 2014.

45 mph Delay (Delay₄₅)

The performance measures and visualizations shown to this point are useful for assessing performance from the perspective of a system operator. The impacts on system users can be quantified by measuring the increase in travel times (or the delay) that would be expected to result from the average speeds reported on the segments. This performance measure was termed “travel time deficit” in earlier reports, but it is representative of the component of delay associated with a speed reduction under 45 mph.

The 45 mph delay (d_{45}) is calculated from

$$d_{45} = \sum_{i \in S} \sum_{j \in T} \begin{cases} x_i \left(\frac{1}{\tilde{v}_{ij}} - \frac{1}{v_c} \right), & \tilde{v}_{ij} \leq v_c \\ 0, & \tilde{v}_{ij} > v_c \end{cases} \quad \text{Equation 5}$$

where \tilde{v}_{ij} is the median speed of segment i during 15-minute interval j , x_i is the length of the segment, and v_c is the congestion threshold speed (45 mph). The 45 mph delay is expressed in units of hours.

This metric is representative of an average delay (increase in travel time) that might be experienced by a motorist on a segment during a given 15-minute interval. This incorporates both the length of the segment and the severity of the congestion. When summed up over an analysis period, it forms an index reflecting length, severity, and frequency of congestion, and it quantifies the relative impact of congestion on users.

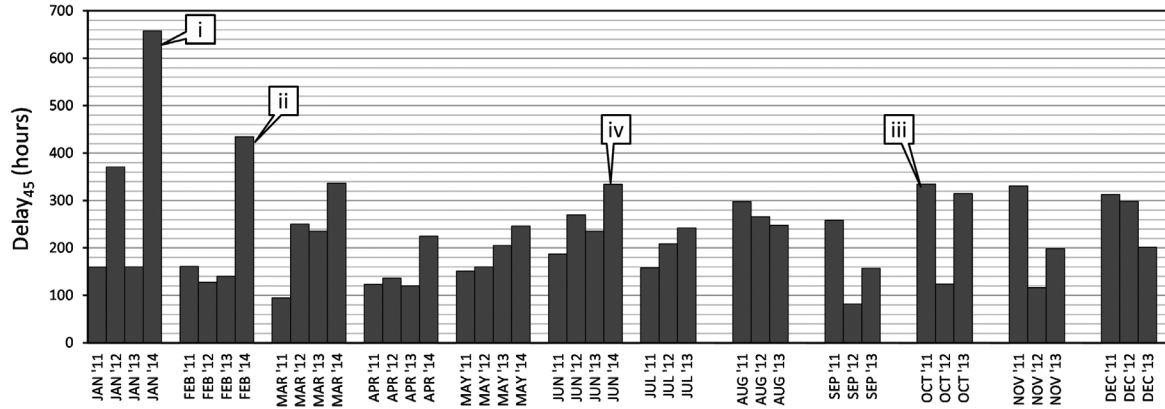


Figure 9. Delay₄₅ by month for I-65 (both directions).

(callout “iii”). Although it affected only a few miles on I-65, the speed reductions were quite severe, with speeds regularly falling below 20 mph. Although delay₄₅ effectively incorporates a distance weight, it also considers congestion severity. The total amount of delay₄₅ during October 2011 is comparable to that of a typical summer month, such as June 2014 (callout “iv”).

Annual Average Daily Traffic (AADT) Volumes

This edition of the Indiana Mobility Report introduces traffic volume as a component of the delay performance measure. Figure 10 shows the AADT for the Interstate system in July 2013, with the volumes color coded.

The volume V_{ij} for segment i over time series j is given by
$$V_{ij} = A_i f_M f_D f_H f_G \quad \text{Equation 6}$$

where A_i is the “base” AADT value of segment i , f_M is a monthly adjustment factor, f_D is a day-of-week adjustment factor, f_H is an hourly adjustment factor, and f_G is a growth factor (accounting for increases in volume since the time that the base AADT was measured). Each factor is a function of the current time (j) for which the volume V_{ij} is to be calculated.

Figure 9 shows monthly totals of delay₄₅ for I-65 from January 2011 through June 2014. As seen previously in congestion hours (Figure 3) and distance-weighted congestion hours (Figure 4), January 2014 (callout “i”) and February 2014 (callout “ii”) remain the 2 months with the greatest amount of congestion. The impact of the I-64 Sherman Minton Bridge closure in this case is shown to be rather high

Total Delay

The delay₄₅ metric (d_{45}) discussed earlier provides a measure of the amount of average delay incurred by speed reductions falling below a threshold. This allows the relative impact on roadway users to be quantified. To better understand the cumulative impacts of congestion, this estimate can be multiplied by the volume to estimate the total delay (d), as follows:

$$d = V_{ij} d_{45} = \sum_{i \in S} \sum_{j \in T} \begin{cases} V_{ij} x_i \left(\frac{1}{\tilde{v}_{ij}} - \frac{1}{v_c} \right), & \tilde{v}_{ij} \leq v_c \\ 0, & \tilde{v}_{ij} > v_c \end{cases} \quad \text{Equation 7}$$

where V_{ij} is the volume of the segment as defined by Equation 6 and the other terms are the same as in Equation 5. The units of delay are vehicle hours.

As with delay₄₅, this estimate considers only that component of the total delay resulting from speed reductions beyond the critical threshold speed (v_c) and is equivalent to a delay calculation using v_c as the “free flow” speed. Consequently, this makes it a lower bound on the total delay, since the actual free flow speed is higher (but varies from segment to segment).

Figure 11 presents a plot of the monthly total delays for I-65 from January 2011 through June 2014. This plot reveals that the total delay metric provides a different perspective than the other performance measures: congestion hours (Figure 3), distance-weighted congestion hours (Figure 4), and delay₄₅ (Figure 9). January 2014 is still identified as the most congested month with the highest amount of delay (callout “i”), but the delay was not that much more than in some of the other months on record. Figure 11 shows that February 2014 (callout “ii”), which was

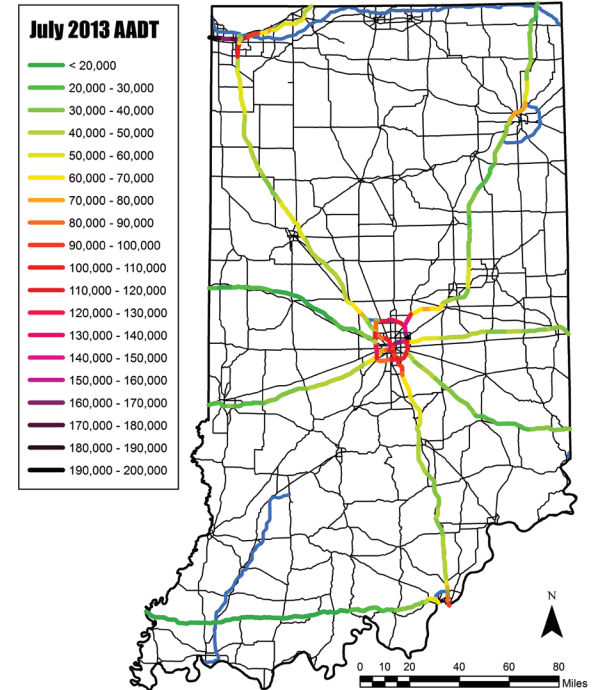


Figure 10. Overview of Indiana Interstate AADT values used in this report.

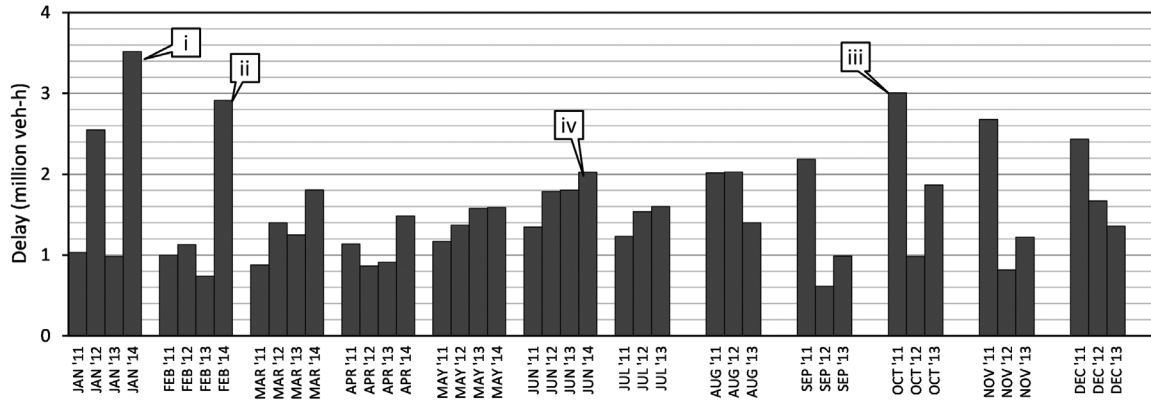


Figure 11. Delay by month for I-65 (both directions).

Minton Bridge closure were high-volume segments, and that congestion caused severe speed reductions. The segments affected by the June 2014 construction were mostly lower-volume segments and the speed reductions were less severe. Finally, winter weather affected many segments for more hours, which led to very high numbers of congestion hours (Figure 3) and distance-weighted congestion hours (Figure 4) in January 2014.

Delta Speed

In 2014, INDOT increased its investment in crowdsourced speed data and began purchasing real-time data. As mentioned, new data at a higher spatial resolution also became available in 2014. This investment facilitated the production of real-time back-of-queue detection for improving incident response.

Incidents are associated with a reduction in speed. This reduction occurs both in time (one time interval relative to the next) and space (one segment relative to the next). By the nature of the spatial segmentation of the data, speed reductions propagate rather gradually over time, but they tend to become severe within one segment before cascading into the next. This makes it

identified as the second-most congested month in the other performance measures, actually was not as congested as October 2011 (callout “iii”), which represents the middle of the I-64 Sherman Minton Bridge closure that diverted traffic to I-65. Summer construction activity in June 2014 (callout “iv”) caused considerably less total delay. This is because the segments affected by congestion during the Sherman

possible to detect incidents by calculating the difference in speeds, or “delta speeds” from one segment relative to a neighboring segment:

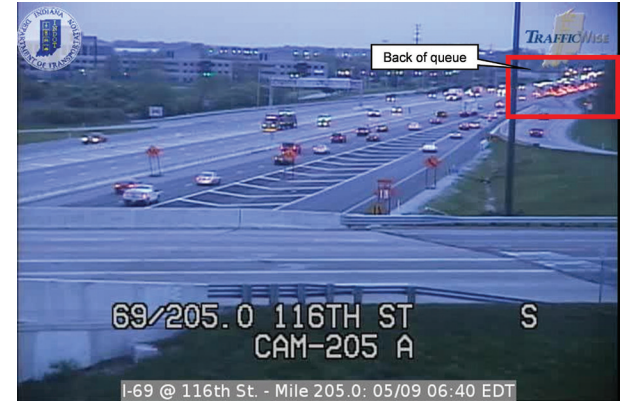
$$\Delta v_{ik} = v_{(i+1)k} - v_{ik} \quad \text{Equation 8}$$

Here, Δv_{ik} represents the delta speed for time segment i and time k . Speed reductions yield a negative value. The minute-by-minute data is used for this real-time application. Segment $i+1$ represents the neighboring segment, when the segments are ordered along the direction of travel.

This performance measure can be used for real-time incident and back-of-queue detection. In the first 6 months of 2014, a web application was developed by JTRP researchers to implement the performance measure for incident detection and to assist operations at the INDOT Traffic Management Center. This application uses the higher spatial resolution data that became available in 2014.

An example incident is illustrated by Figure 12, which presents images taken by a traffic camera of a growing queue caused by a crash on May 9, 2014, on I-69. Figure 12a shows the queue at 6:40, while Figure 12b shows an image from 5 minutes later, during which time the queue has grown to fill up the entire segment.

Figure 13 shows screen captures from the real-time analysis tool for tracking the back of the queue. The figure follows the timeline over an hour after the beginning of the incident. In each graphic, excessive delta speeds are represented with circles, the size of which indicates how

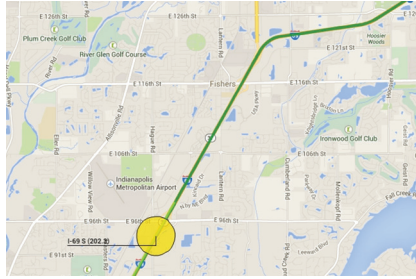


(a) Back of the queue at 6:40 AM

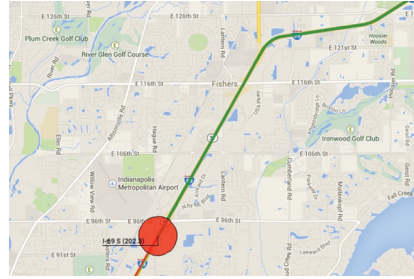


(b) Back of the queue at 6:45 AM

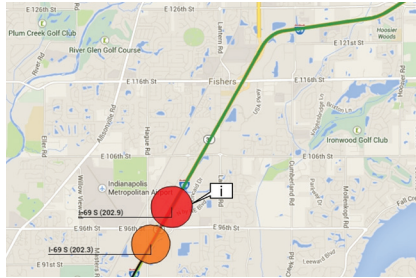
Figure 12. Camera views facing south on Interstate 69 at mile 205.



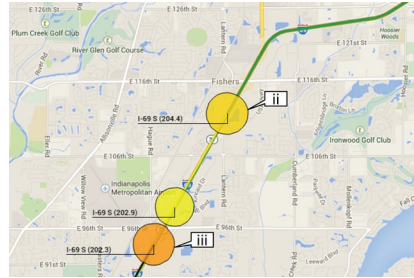
(a) Initial detection at 5:50 AM



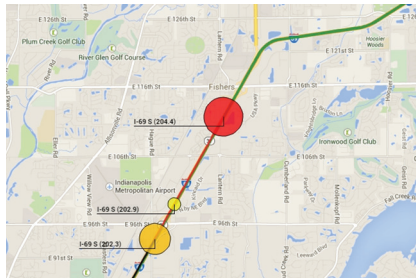
(b) Incident at 6:00 AM



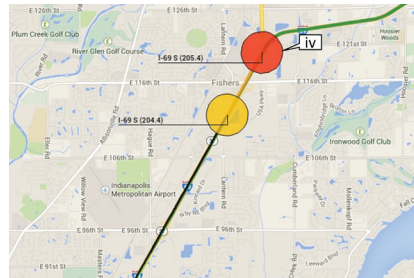
(c) Incident at 6:10 AM



(d) Incident at 6:20 AM



(e) Incident at 6:30 AM



(f) Incident at 6:40 AM

recent the incident was, while the color represents the degree of speed reduction.

The first detection of the incident occurs at 5:50 in Figure 13a and appears as a large yellow-shaded circle on the map, indicating the beginning of a queue formation with a delta speed of -20 mph. At 6:00 the delta speed intensifies to -42 mph in Figure 13b. In callout “i” in Figure 13c, the queue grows northward at 6:10, triggering a second indication on the map. At 6:20 the queue extends further to a third location (callout “ii” in Figure 13d), with the original queue location indicated by callout “iii.” The delta speed at the back of the queue further intensifies at 6:30 in Figure 13e. Finally, at 6:40 the back of the queue extends further to a fourth location (callout “iv” in Figure 13f). The back-of-queue indication in Figure 13f corroborates the ground truth imagery in Figure 12.

In addition to real-time applications, the frequency in which delta speeds occur can also be used to identify locations of recurring congestion or where back-of-queue crashes may be more likely to occur within a

Figure 13. Developing incident on southbound Interstate 69 on May 9, 2014, visualized by web application.

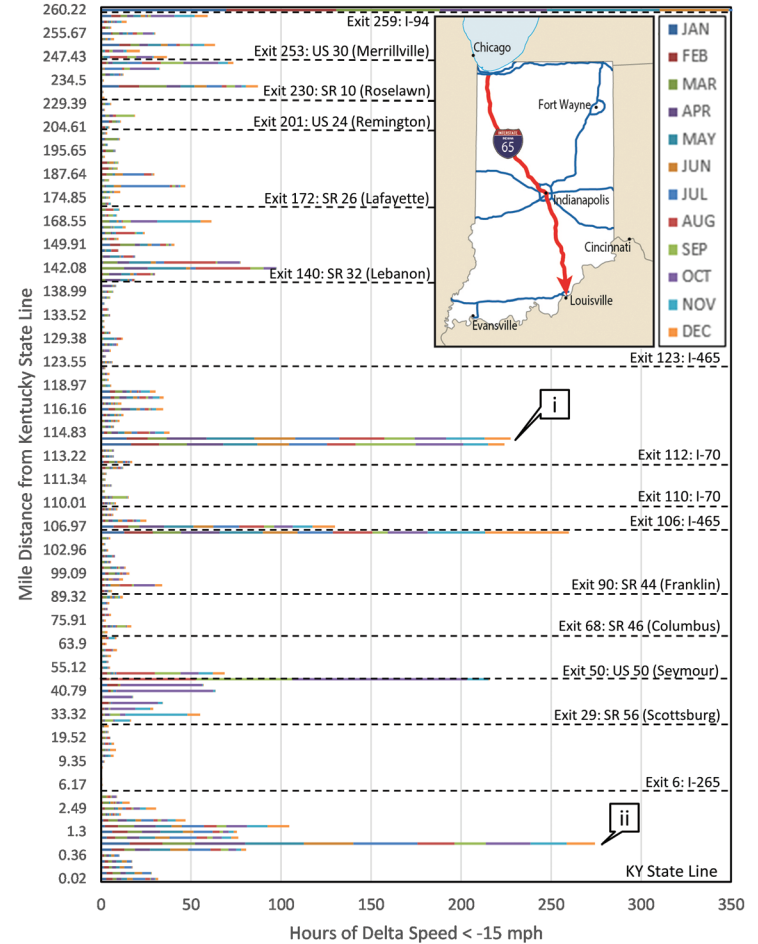
system because of speed reductions. The number of hours in which high delta speeds occur, or “high delta speed hours,” (HDSH) can be tabulated by

$$HDSH = \sum_{i \in S} \sum_{k \in T} \begin{cases} \frac{1}{60}, & \Delta v_{ik} \geq \Delta v_c \\ 0, & \Delta v_{ik} < \Delta v_c \end{cases} \quad \text{Equation 9}$$

where Δv_{ik} is defined by Equation 8, Δv_c is the threshold delta speed, and $1/60$ is a conversion factor from minutes to hours. In this report, a threshold of -15 mph was used.

Figure 14 shows a plot of the number of high delta speed hours occurring in each month of 2013 along southbound I-65. This is based on an analysis of archived data. The analysis illustrates that while nearly all segments along I-65 experienced some occurrences where the delta speeds were less than -15 mph, there were some locations where this was recurrent. For example, two segments around MM 114 in downtown Indianapolis experienced large delta speeds on a recurring basis (callout “i”). Another example location with recurring high delta speeds was around MM 1 near Louisville (callout “ii”), at the approach to the Kennedy Bridge.

Figure 14. High delta speed hours by month, southbound I-65.



SUMMARY OF INDIANA'S INTERSTATE HIGHWAY SYSTEM PERFORMANCE

This section provides an overview of the performance of the Interstate system in Indiana using the performance measures described in the previous section. Data are presented for the entire Interstate system operated by INDOT from January 2011 through June 2014.

Monthly Performance Comparison: January 2011–June 2014

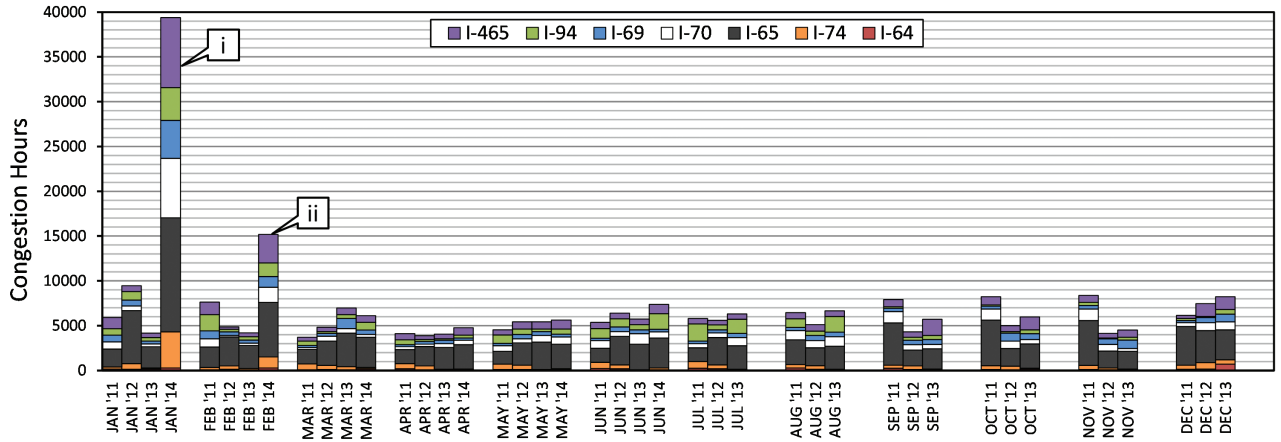
The next four figures show the monthly totals of the performance measures for the extent of the Interstate system operated by INDOT. Figure 15 shows congestion hours, Figure 16 shows distance-weighted congestion hours, Figure 17 shows delay_{45'}, and Figure 18 shows the estimated total delay. Each figure is separated into two parts, with part (a) showing the full scale so that the impact of winter weather in 2014 can be seen, and part (b) showing a partial scale so that other months can be considered. All bars are segmented to show the contribution of each individual Interstate to the system total of each performance measure.

As mentioned, 2014 was a record-breaking winter season, and heavy snowfall affected nearly every Interstate highway in Indiana, with the exception of I-64 in the southern portion of the state. All four performance measures identified January 2014 and February 2014 as having the highest and second-highest amounts of congestion, as

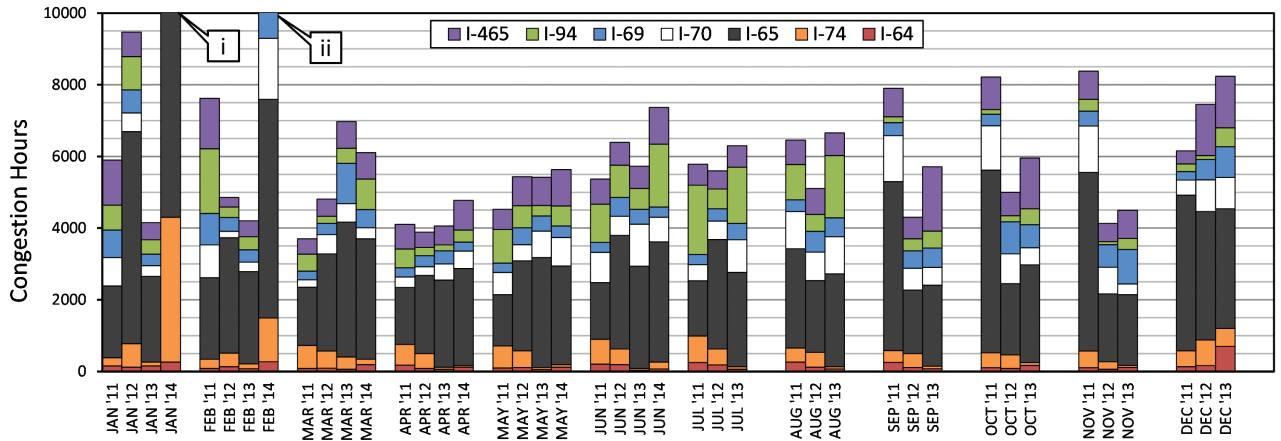
shown by callouts “i” and “ii” in Figure 15a, Figure 16a, Figure 17a, and Figure 18a. The relative amount of congestion varies somewhat with the performance measure because of how each one calculates congestion.

- In terms of congestion hours, January 2014 had approximately 4 times the congestion of a typical month (Figure 15a), because winter weather affected a large number of segments over many hours across the state.
- The difference is even greater when the congestion hours are weighted by distance (Figure 16b), because many long rural segments were impacted during winter storms for long periods of time.
- From the viewpoint of delay₄₅ (Figure 17a), system performance during January 2014 was proportionate to a typical month, following roughly the same trends as in the number of congestion hours.
- Finally, with the estimated total delay performance measure (Figure 18a), winter weather impacts are still identified as severe, but they are shown to be only about twice as bad as any other month. Also, January and February 2014 are shown to be more comparable with this measure.

Another interesting finding revealed in all four figures is that throughout the entire analysis period, March and April have been the months with the smallest amounts of congestion. This is after the winter weather season has drawn to a close, but before the start of the heaviest periods of roadwork that occur during the summer months. Also, there were no major incidents during these months from 2011 through 2014.

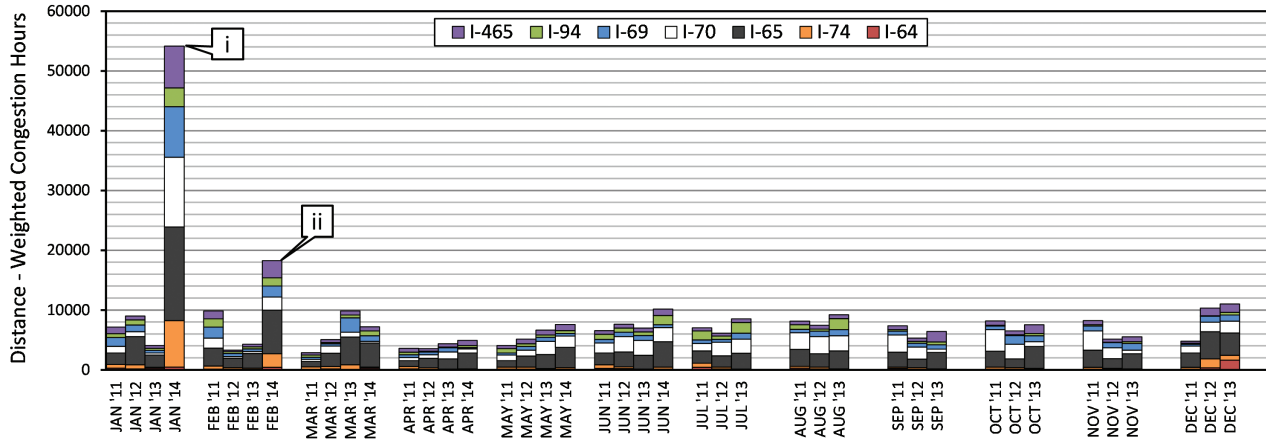


(a) Full scale to show January/February 2014

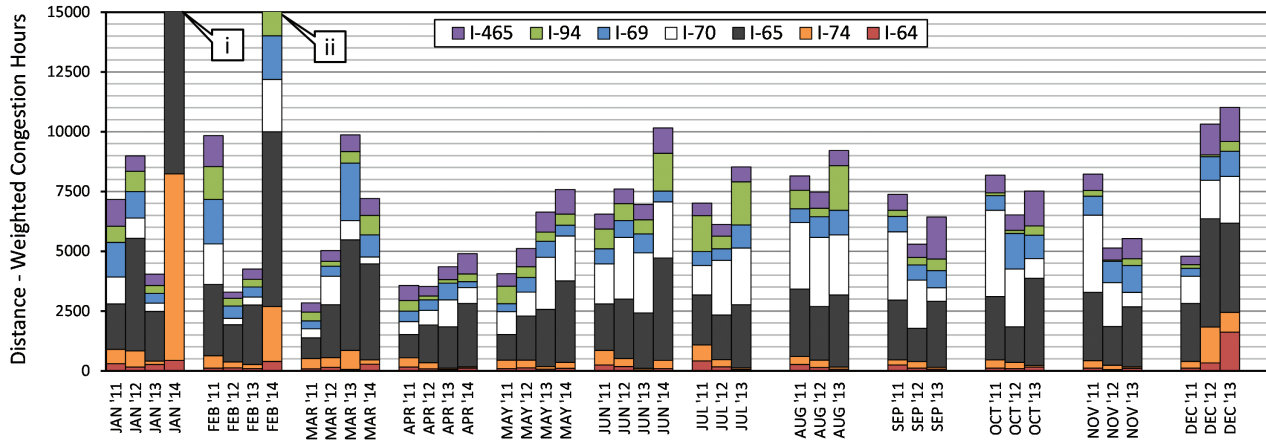


(b) Partial scale to show detail of other months

Figure 15. Month-by-month Interstate system performance, January 2011–June 2014: congestion hours.

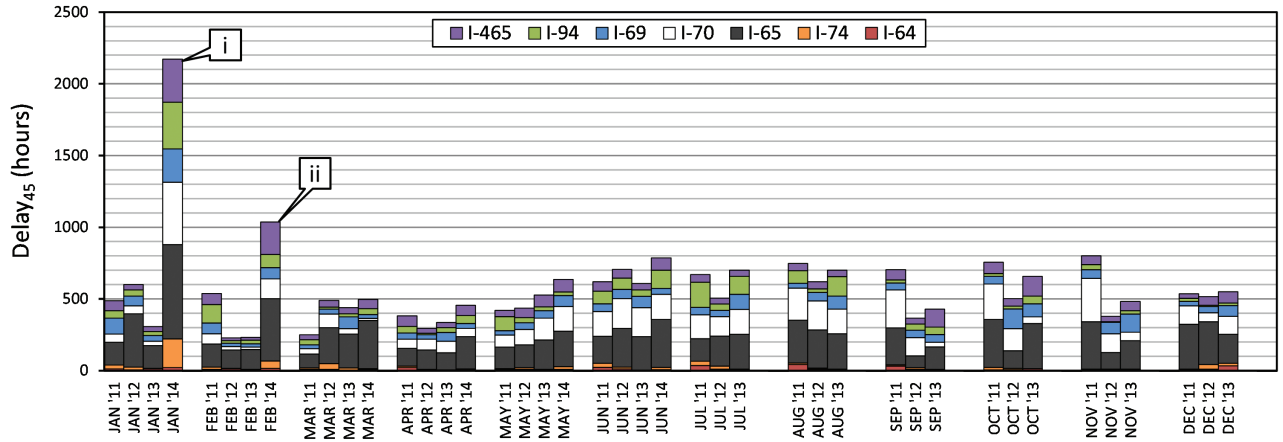


(a) Full scale to show January/February 2014

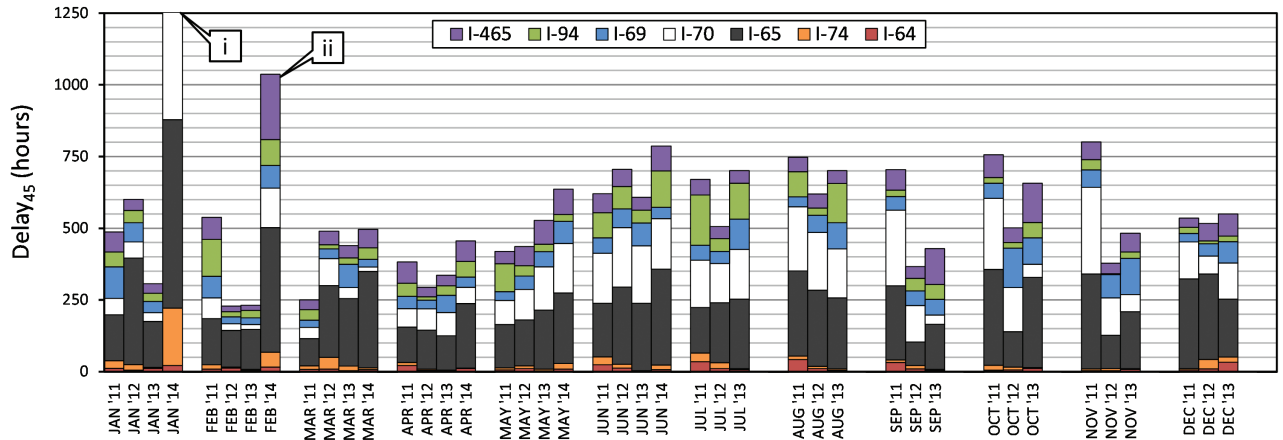


(b) Partial scale to show detail of other months

Figure 16. Month-by-month Interstate system performance, January 2011–June 2014: distance-weighted congestion hours.

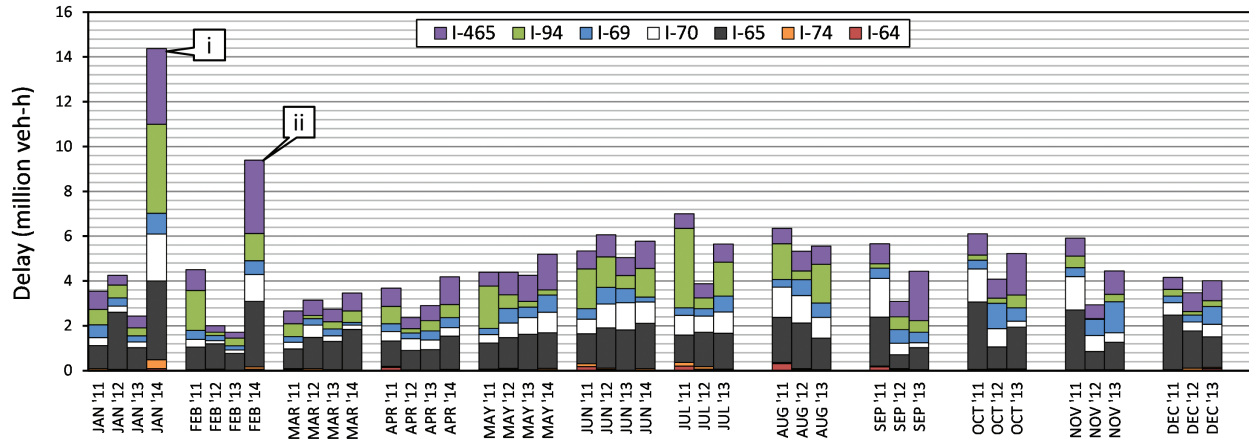


(a) Full scale to show January/February 2014

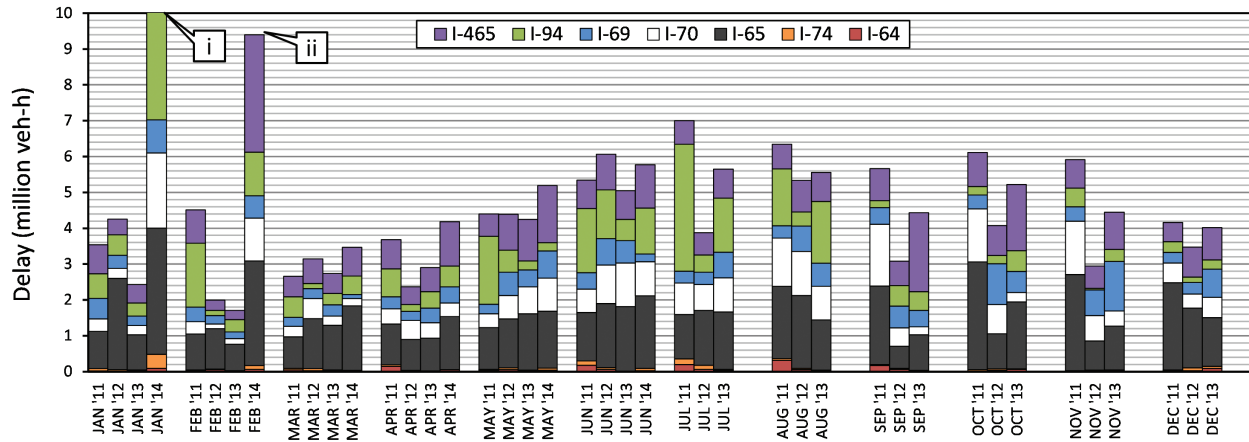


(b) Partial scale to show detail of other months

Figure 17. Month-by-month Interstate system performance, January 2011–June 2014: delay₄₅.



(a) Full scale to show January/February 2014



(b) Partial scale to show detail of other months

Figure 18. Month-by-month Interstate system performance, January 2011–June 2014: total delay.

Indiana Interstate Segment Rankings

This section presents rankings of the most congested corridors in the Indiana Interstate Highway System. Two performance measures were selected to provide two alternative perspectives. Delay_{45} incorporates distance and tends to identify longer segments where congestion has a greater impact on travel times. Total delay, on the other hand, weights these periods of congestion by the affected volumes, and therefore identifies areas of congestion that affected the most roadway users.

Figure 19 presents the 20 most congested Interstate segments in 2013, using delay_{45} (Figure 19a) and total delay (Figure 19b).

- Delay_{45} (Figure 19a) tends to identify several long sections, predominantly in rural areas, which show regions affected by work zones during 2013. These longer segments had speed reductions that led to particularly large increases in travel time. Examples include several work zones along I-65 and I-70. Several urban segments with more severe speed reductions over shorter distances are also included. The highest amount of delay_{45} occurred on southbound I-65 through a work zone near Seymour.
- Total delay (Figure 19b) identifies segments where substantial congestion occurred and where higher traffic volumes were affected. Consequently, many of the segments are located on I-465 and I-69 in the Indianapolis area. The worst performing segment was the inner loop of I-465 between Meridian Street and Keystone Avenue.



(a) Delay_{45} (hours)



(b) Total delay (vehicle hours)

Figure 19.

The 20 most congested segments in 2013 using delay_{45} and total delay criteria.

- Some segments show a heavy impact in both performance measures. These include part of southbound I-69 near Marion, northbound I-65 on the approach to the I-94 interchange near Gary, and northbound I-65 approaching I-465 in Indianapolis. I-69 on the north side of Indianapolis is also represented in both listings of the worst-performing segments.

One interesting result is that the Borman Expressway (I-94) does not appear in the 2013 list for either performance measure, despite carrying the heaviest volumes of all the Interstate segments in Indiana.

The 20 most improved segments from 2012 to 2013 are shown in Figure 20, with the segments having the greatest decrease in delay₄₅ represented in Figure 20a and the segments having the greatest decrease in total delay represented in Figure 20b.

- Delay₄₅ identifies many segments that experienced roadwork at various times in 2012. For example, most of I-70 from Indianapolis to Terre Haute is covered by segments where the performance was improved. Other noted locations include I-65 near Lebanon and Columbus. Also, several segments of I-65 near Louisville are included, which reflects a higher amount of delay experienced in 2012 as a result of the Sherman Minton Bridge closure that continued until February 2012.
- Using total delay as the performance measure identifies segments that are in the same locations. Volume was not a critical factor for determining the most improved segments when comparing 2012 to 2013. This

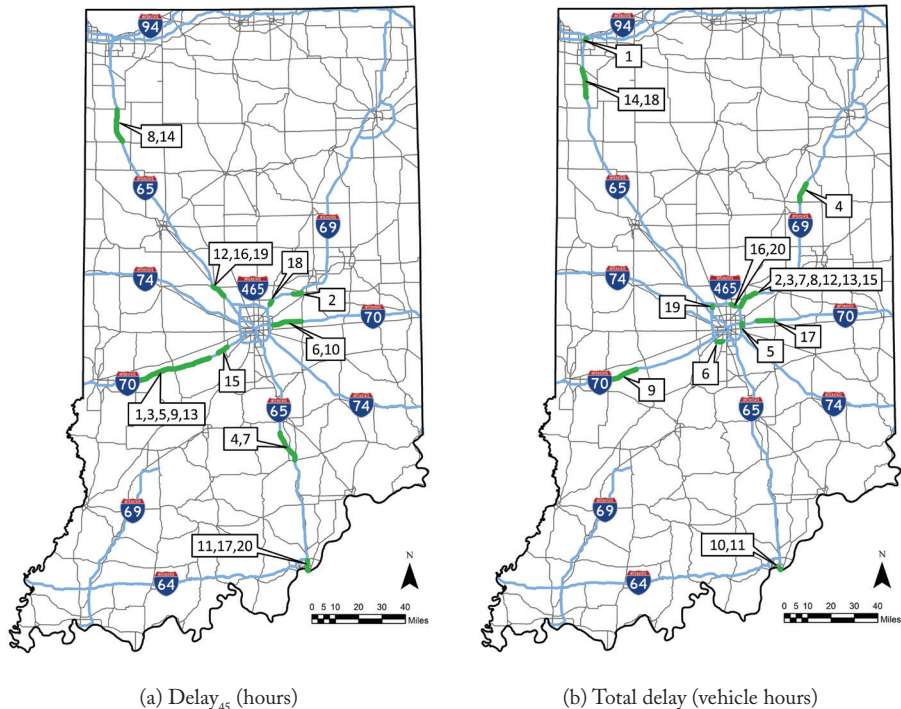
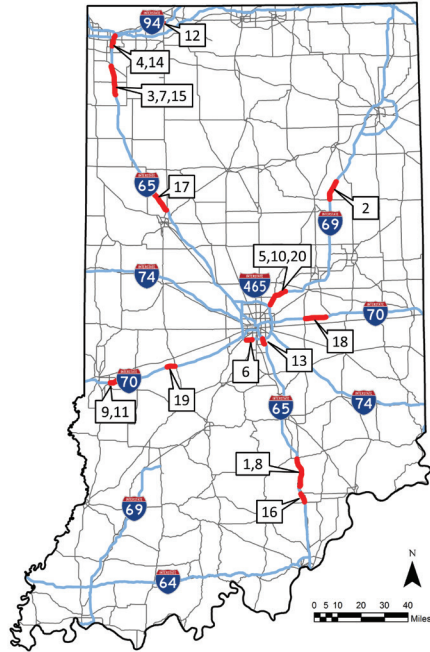


Figure 20.

The 20 most improved segments from 2012 to 2013 using delay₄₅ and total delay criteria.



(a) Delay₄₅ (hours)



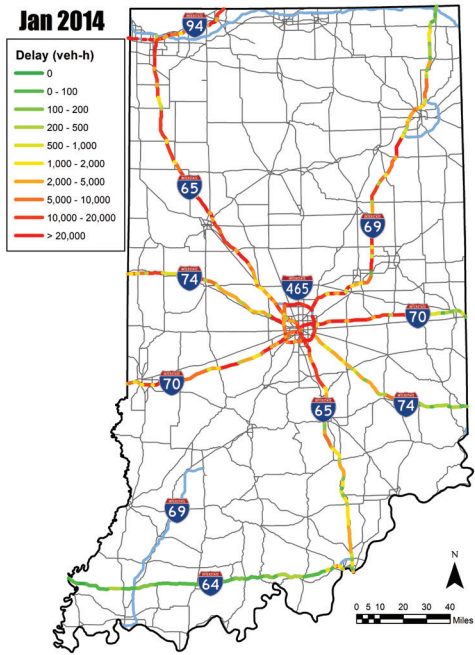
(b) Total delay (vehicle hours)

Figure 21. The 20 most degraded segments from 2012 to 2013 using delay₄₅ and total delay criteria.

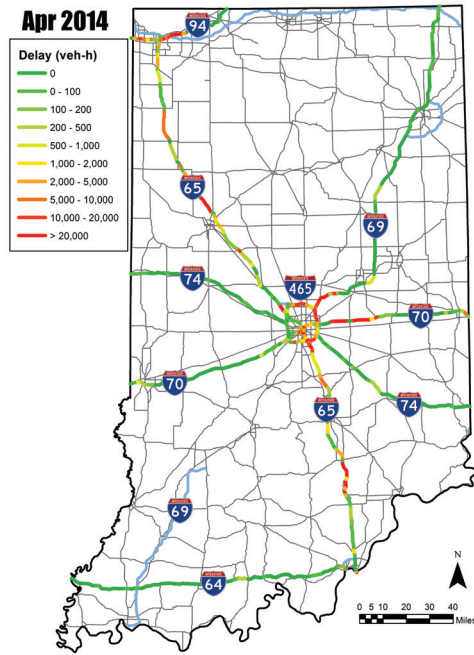
may be because most sections in heavier traffic areas did not see a change in performance between the 2 years.

Finally, Figure 21 presents the most degraded segments from 2012 to 2013. As before, delay₄₅ is represented in Figure 21a while total delay is represented in Figure 21b.

- Delay₄₅ identifies a variety of locations throughout the state. Most of the segments are located in more rural areas, with a few exceptions. These changes mainly reflect work zones that became active in 2013 that were not active in 2012.
- A somewhat different collection of segments is identified by total delay. These are mostly concentrated in areas with heavier traffic volumes, such as I-465 and I-69, and I-65 and I-94 in Lake County. The only rural segments appearing in the list are along I-69 near Marion and on I-65 near Seymour.



(a) January 2014



(b) April 2014

Figure 22. Summary of monthly percentile rank of delay (veh-h). (A summary from January 2011 through June 2014 can be found at <http://dx.doi.org/10.4231/R76D5QXB>.)



Monthly Performance Summary

The previous section highlighted the worst 20 segments in the state of Indiana per year using multiple performance measures. Another visual performance measure that has been developed to identify congestion issues is the monthly performance summary. These graphics are maps of the Interstate Highway System in which each segment has been colorized according to the amount of congestion observed over a month. In Figure 22, the Interstate segments are colorized relative to the total delay in vehicle hours. This visualization allows the comparison of Indiana Interstate performance from month to month for all segments. The example in Figure 22 compares the months of January 2014 (Figure 22a) and April 2014 (Figure 22b).



2013–2014 INDIANA INTERSTATE PERFORMANCE HIGHLIGHTS

South Split Project

During September and October 2013, part of the stretch of freeway carrying both I-65 and I-70 through downtown Indianapolis known as the “South Split” was completely closed for 44 days. The official detour map (Figure 23) shows that I-465 on the south side of Indianapolis was the detour route for both I-65 and I-70.

The closure was necessary to reconstruct much of the freeway to increase the clearance under several bridges along the section. From 1999 to 2013, more than 400 strikes to the bridge occurred on this section of roadway (Figure 24), leading to numerous substantial closures for cleanup and emergency repair. The South Split project simultaneously reconstructed both directions of travel to lower the pavement and provide greater clearance. Figure 25 shows a section of northbound I-65/I-70 passing under Virginia Avenue, with all of the original pavement removed.

Figure 23.
South Split project work area and official detour routes on I-465 (www.southsplit.in.gov).



Figure 24.

A tractor-trailer striking a bridge on I-65/I-70. (Screen capture from video available at <http://dx.doi.org/10.4231/R7PC308C>.)



Figure 25.

Reconstruction of I-65/I-70 in the South Split to increase bridge clearance. (South Split construction time-lapse available at <http://dx.doi.org/10.4231/R7XW4GQQ> and <http://dx.doi.org/10.4231/R7T43R0Q>.)



Because of the detours, the work had substantial negative impacts on I-465. Figure 26 shows monthly speed profiles for the outer loop of I-465 (counterclockwise movement), while Figure 27 shows monthly speed profiles for the inner loop (clockwise movement). September and October were the 2 months during which the South Split area was closed. An increased number of congestion hours can be observed in these months around a few different locations on the loop. The outer loop was most affected on the south side from the southern I-65 interchange and the eastern I-70 interchange (Figure 26 , callout “i”), while the inner loop saw an increase in congestion starting from the southern I-65 interchange to the western I-70 interchange (Figure 27, callout “i”). The impact was more severe on the outer loop. After the project ended, the congestion levels on these sections reverted to existing conditions (November 2013, callout “ii”). An increased amount of slower traffic conditions can be observed in December 2013 due to winter weather (callout “iii”).

Borman Expressway (I-94) Update

The Borman Expressway (Figure 28) is the only freeway linking Chicago to points eastward, and the sections closest to the state border carry the heaviest traffic volumes of the entire Interstate system within Indiana (Figure 10). The year 2011 saw the conclusion of 7 years of construction efforts aimed at adding lanes to the roadway and improving its interchanges. The 2012 Mobility Report showed the reductions in congestion associated with the conclusion of these construction projects in 2011. Here, the analysis is extended through June 2014 to see how this roadway has performed since then.

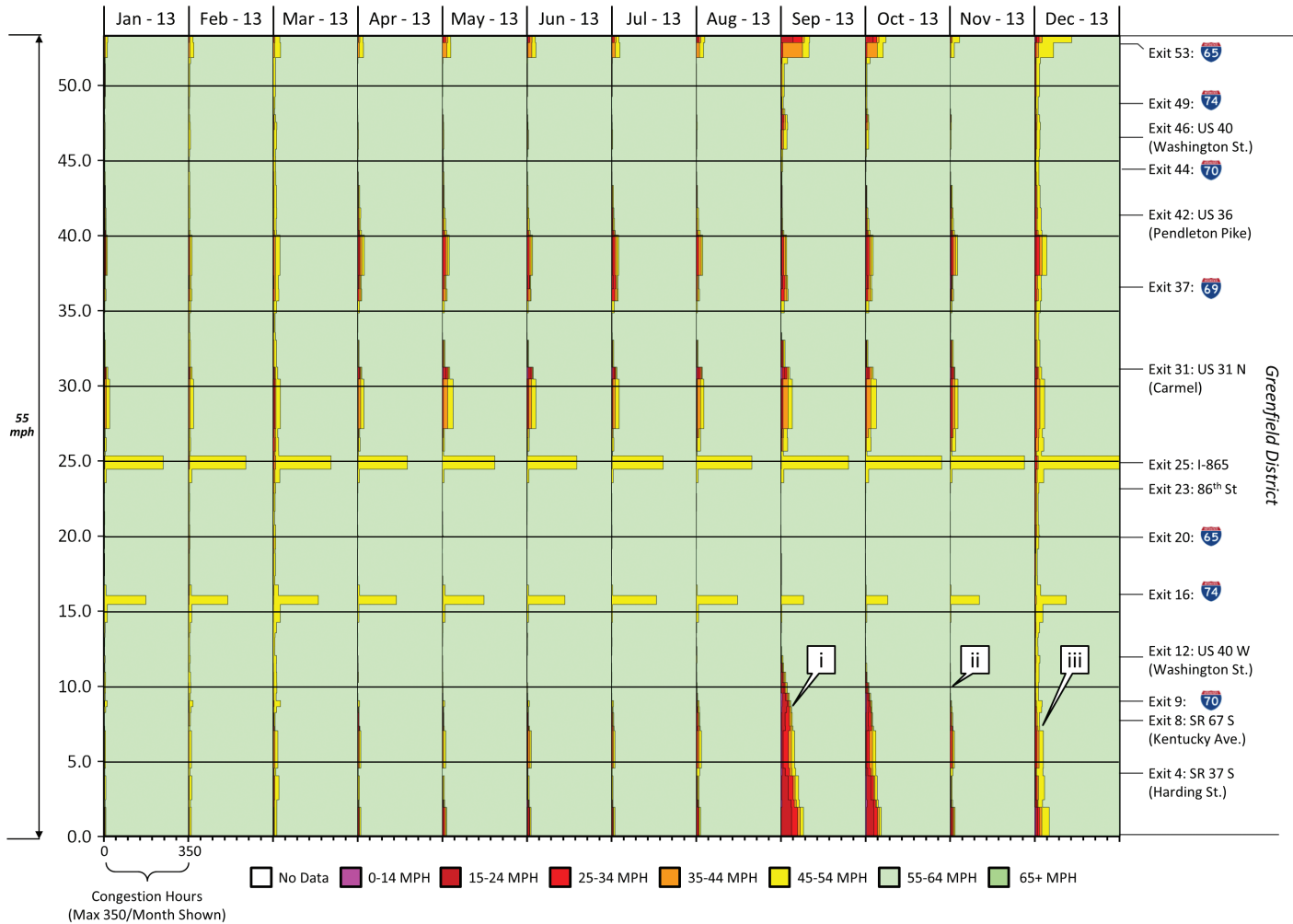


Figure 26. Monthly speed profiles for I-465, outer loop, 2013.

Figure 27.
Monthly speed profiles for I-465, inner loop, 2013.

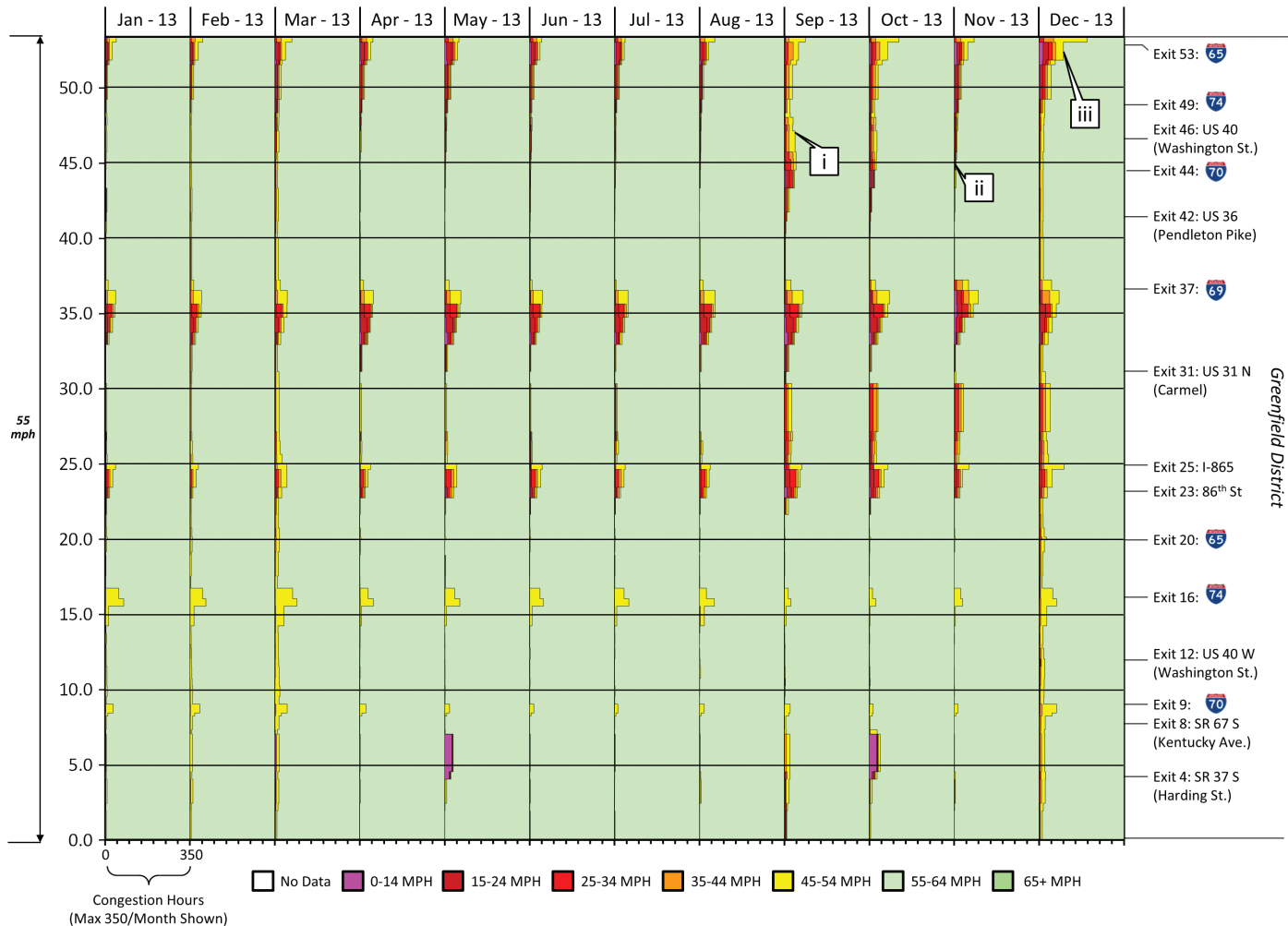


Figure 29 and Figure 30 respectively show the eastbound and westbound monthly speed profiles for I-94 from the Illinois border to the Michigan border. The Borman Expressway is the section between the Illinois border and the interchange with I-65 at MM 10 (callouts “i”).

The impact of the construction projects can be seen from January 2011 through August 2011, especially in the eastbound direction, with the most severe congestion occurring in July 2011 (Figure 29 and Figure 30, callout “ii”). Starting in August 2011, however, the speeds improve substantially (Figure 29 and Figure 30, callout “iii”), and there are very few occurrences of congestion occurring on the roadway for most of the subsequent months. Roadwork in the summers of 2012 and 2013 caused some speed reductions in the eastbound direction (Figure 29 and Figure 30, callouts “iv” and “v”). The impact of winter weather can be seen in January 2014, with substantial speed reductions visible in both directions during that month (Figure 29 and Figure 30, callout “vi”). The impact of 2014 summer roadwork in southern Indiana can also be seen in both directions (Figure 29 and Figure 30, callout “vii”).”

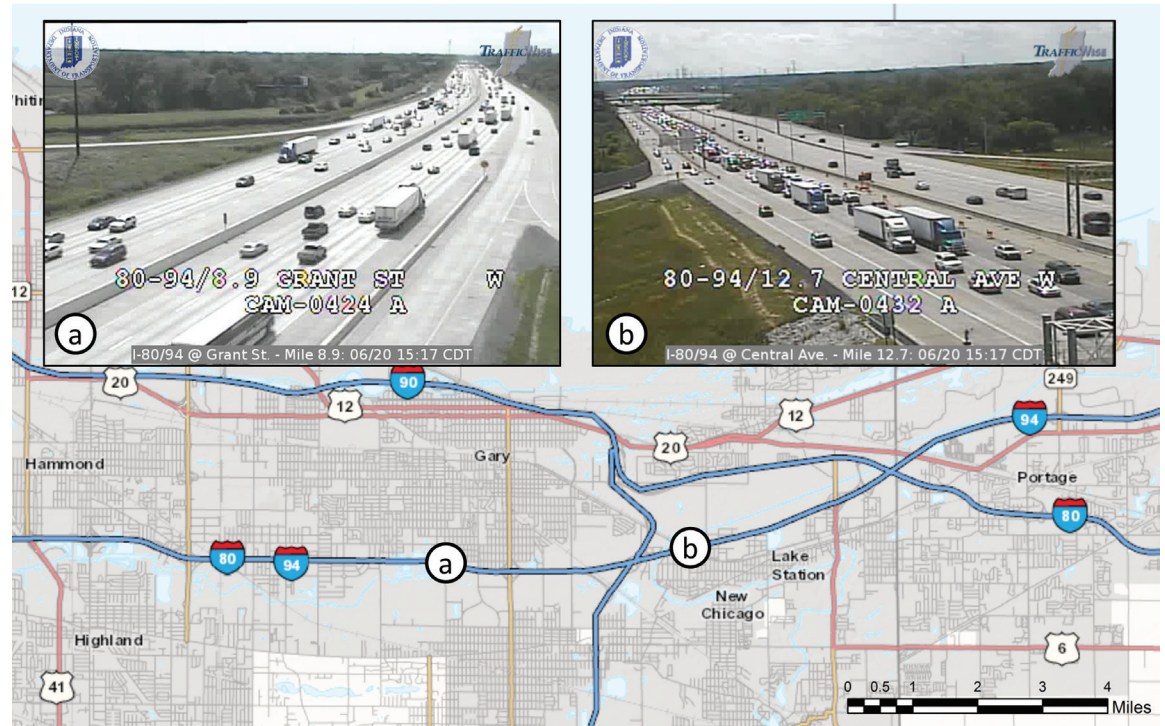


Figure 28. I-80/I-94 near Gary, IN.

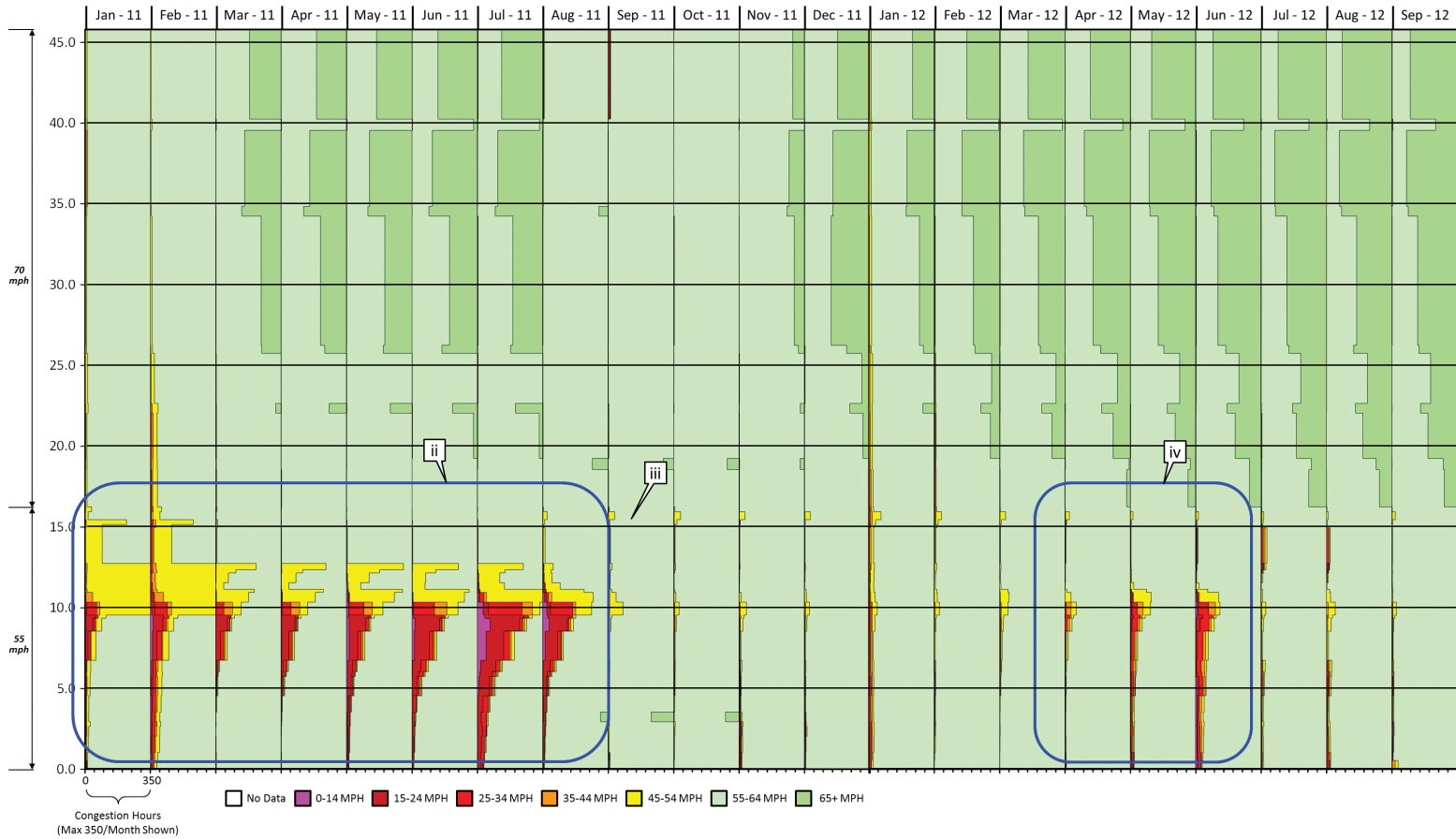
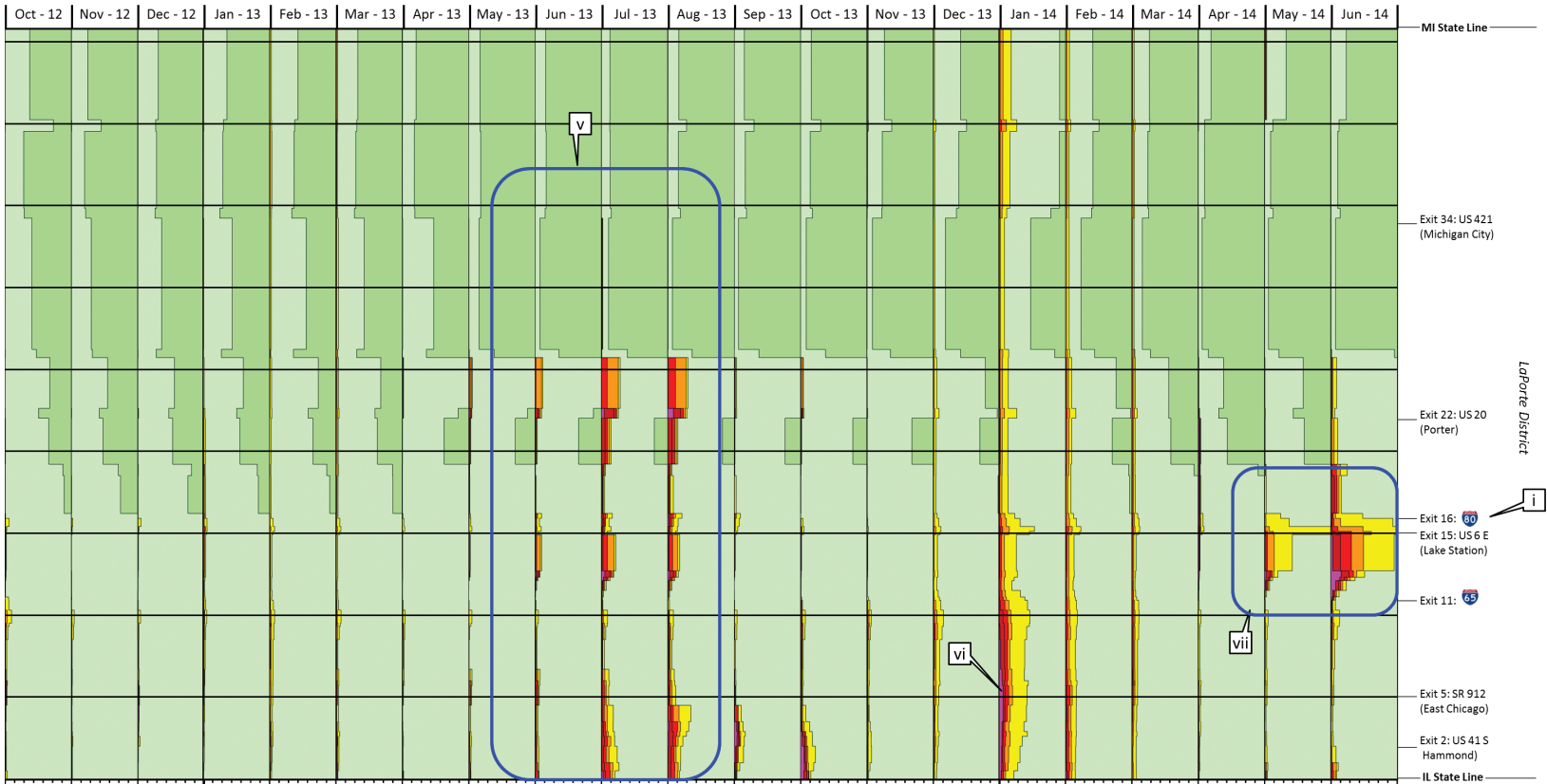


Figure 29. Pages 34–35: Monthly speed profiles, eastbound I-94, January 2011–June 2014.



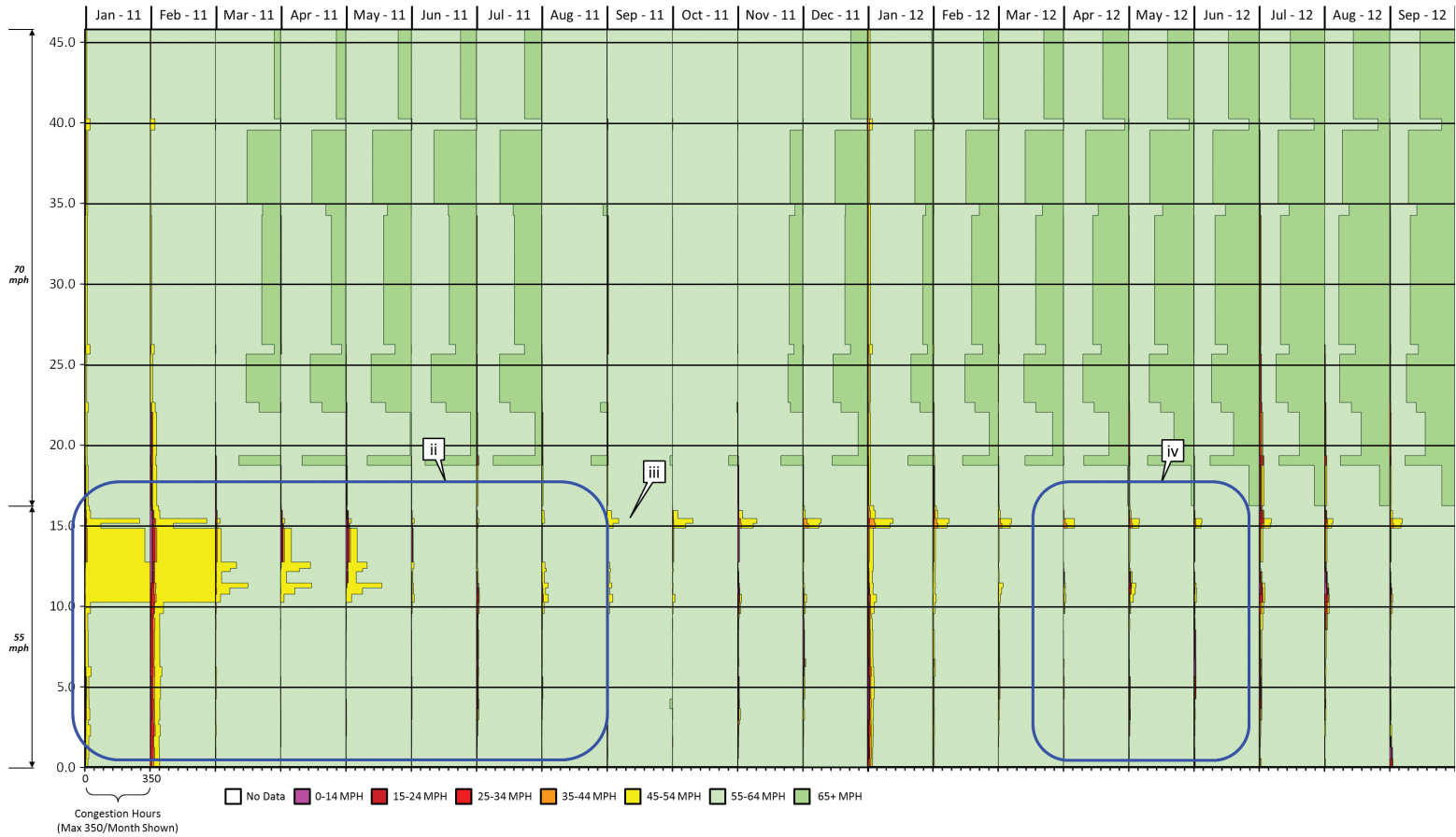
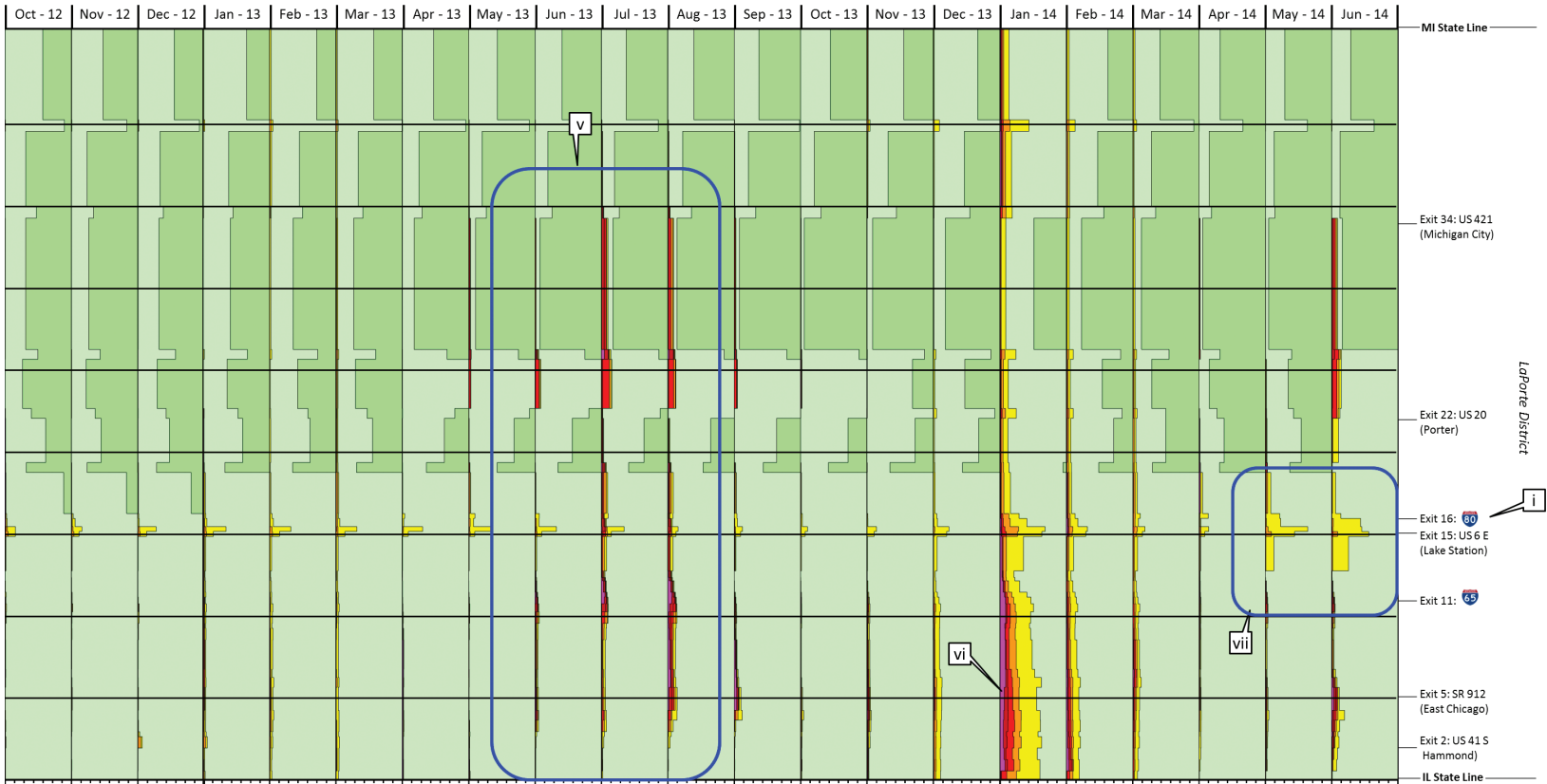


Figure 30. Pages 36–37: Monthly speed profiles, westbound I-94, January 2011–June 2014.



LaPorte District

i

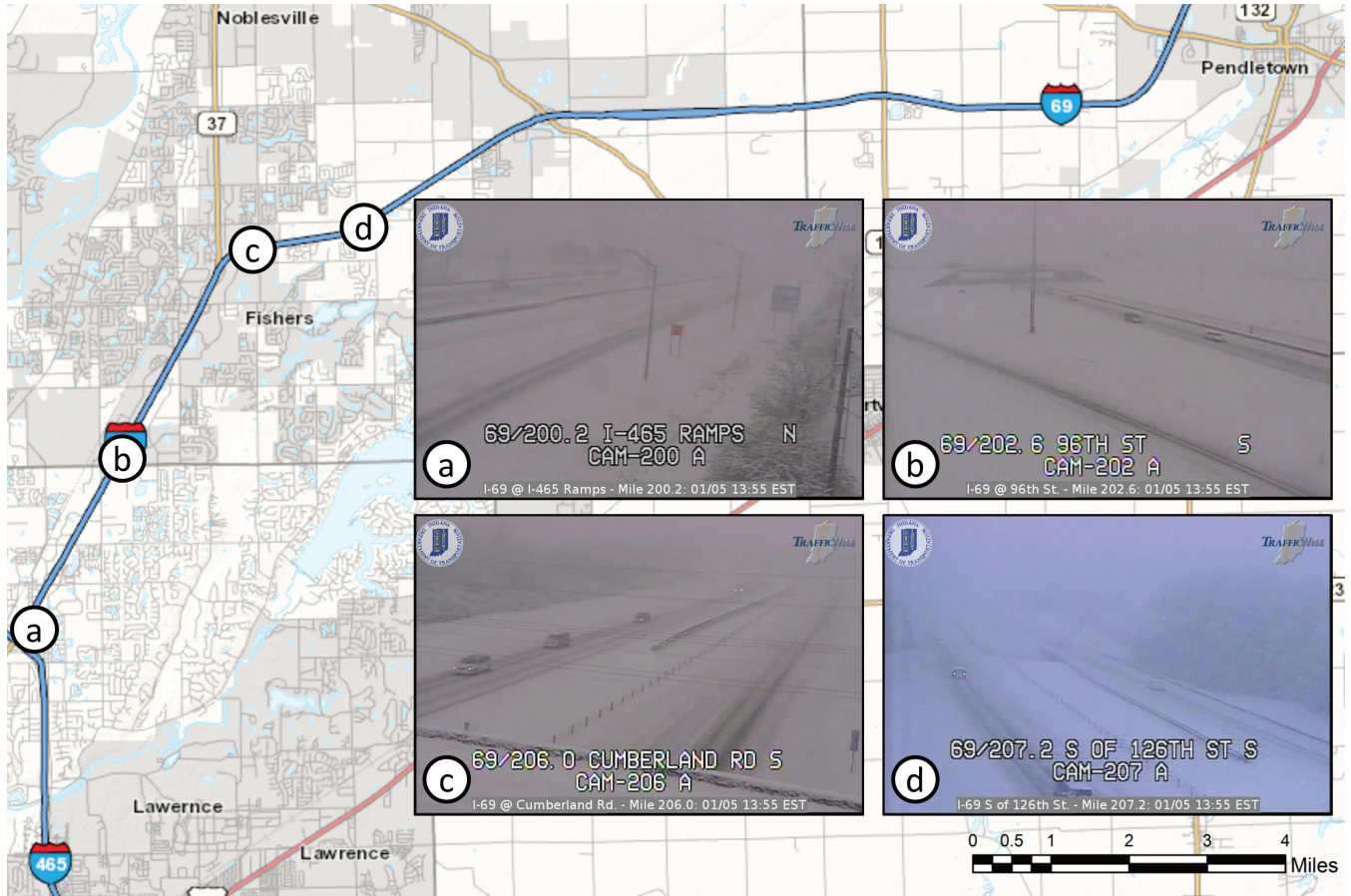
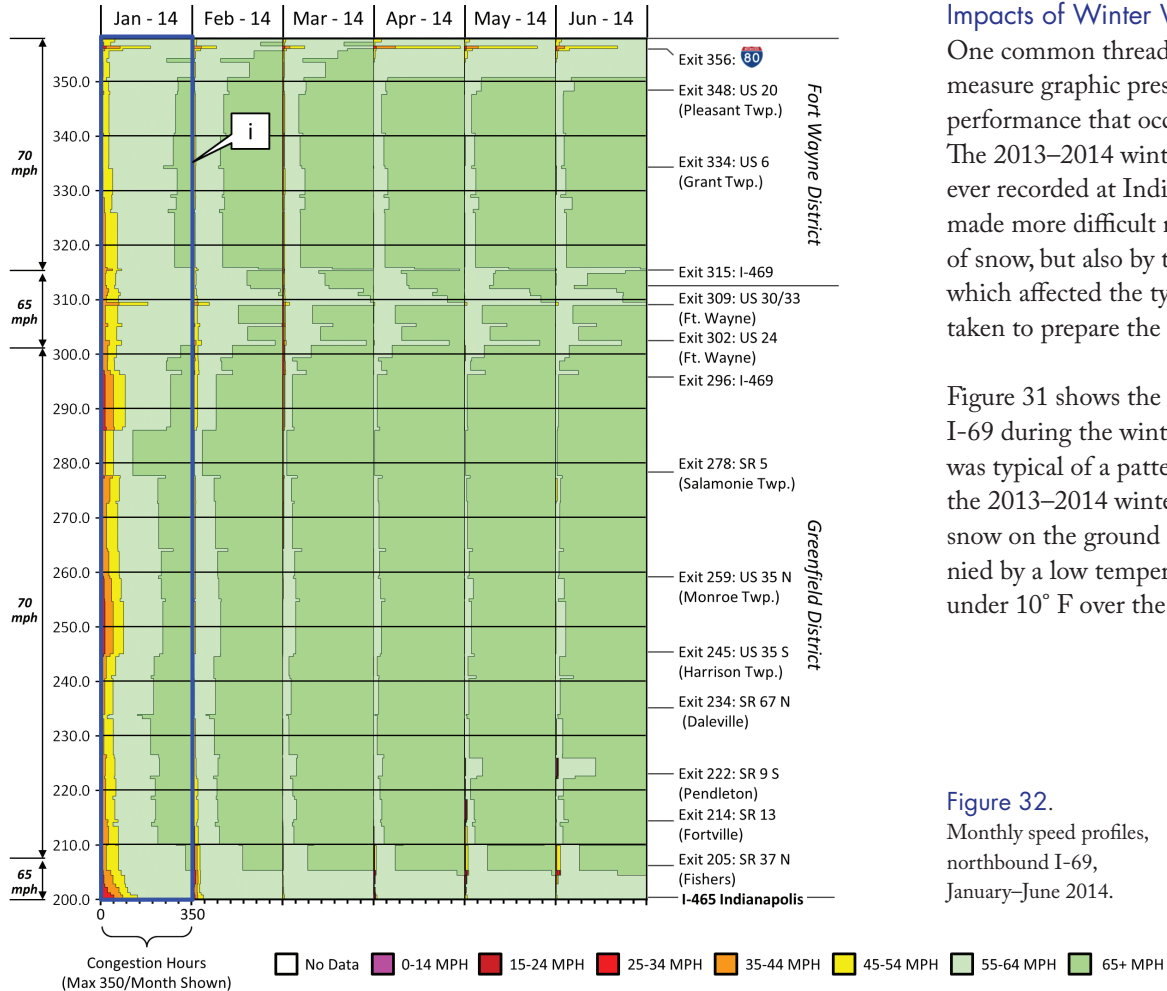


Figure 31. Views from multiple traffic cameras on I-69 during the winter storm on January 5, 2014. (Time-lapse of January 5 snow event on I-69 available at <http://dx.doi.org/10.4231/R72N506D>.)



Impacts of Winter Weather

One common thread that can be seen in every performance measure graphic presented in this report is a degradation of performance that occurred in January and February of 2014. The 2013–2014 winter season had the heaviest snowfall ever recorded at Indianapolis. Snow removal efforts were made more difficult not only by the record-breaking amount of snow, but also by the colder than normal temperatures, which affected the type of countermeasures that could be taken to prepare the roadways for snow and ice.

Figure 31 shows the views from multiple traffic cameras on I-69 during the winter storm on January 5, 2014. This storm was typical of a pattern that repeated several times during the 2013–2014 winter season. The storm left 11 inches of snow on the ground at Indianapolis but was also accompanied by a low temperature of -15° F and high temperatures under 10° F over the next 48 hours.

Figure 32.

Monthly speed profiles, northbound I-69, January–June 2014.

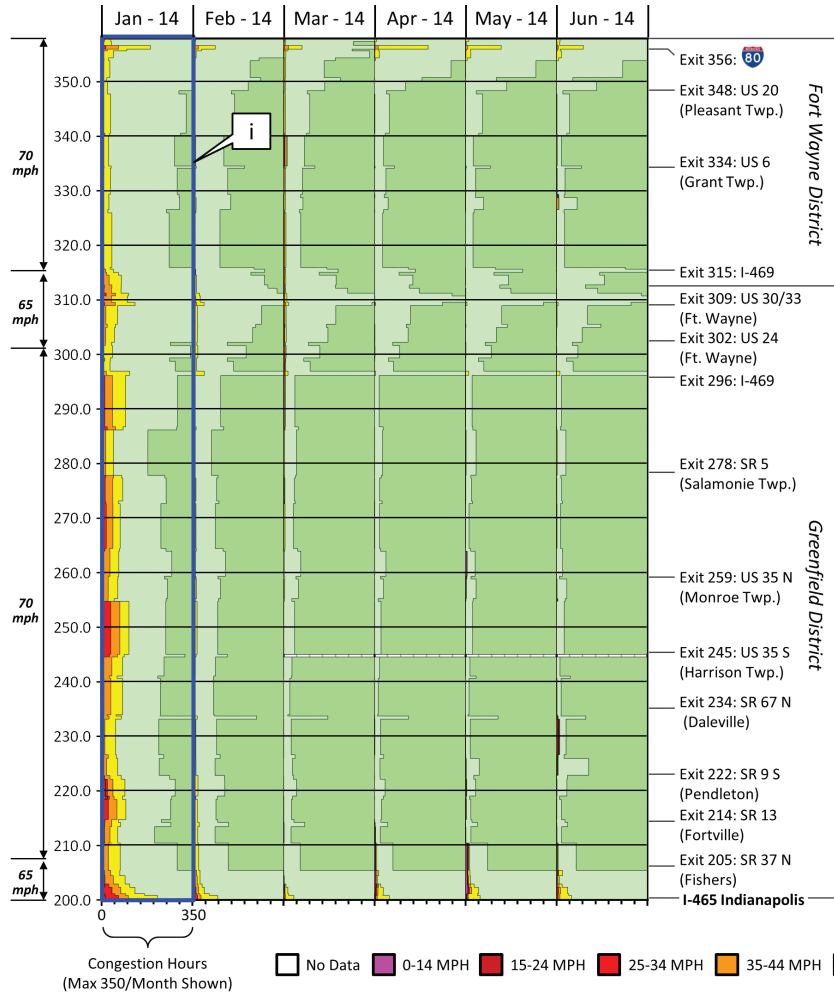


Figure 32 and Figure 33 show monthly speed profiles for the northbound and southbound directions on I-69 respectively for the first 6 months of 2014. In both directions, January 2014 stands out as clearly having the most substantial speed reductions (callouts “i”). These occurred in both directions along the entire extent of I-69 from I-465 to Michigan. Notably, these speed reductions are much greater than those occurring during more typical conditions prevailing through the following months.

Figure 33. Monthly speed profiles, southbound I-69, January–June 2014.

ARTERIAL SYSTEM PERFORMANCE

ARTERIAL MOBILITY DATA OVERVIEW

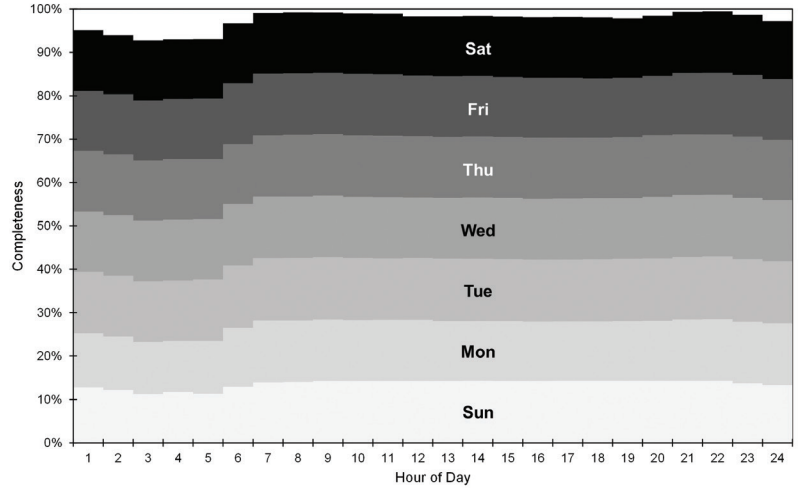
Previous editions of the Indiana Mobility Report have included an analysis of arterial travel times, but because of increased interest and a new analysis methodology, this edition separates the discussion of arterial performance into a new section.

Arterial travel time characteristics are fundamentally different from those of freeways because of the presence of traffic control devices, particularly traffic signals. These increase the variability in the travel time and, along with the congestion, roadwork, and incidents that occur in both environments, are a factor in delay. Traffic control tends to introduce some constraints on the distributions of travel time even in the absence of these other conditions.

The data quality for arterials is somewhat different from that for freeways, by virtue of the fact that there are generally somewhat fewer commercial vehicles present on most arterial routes, and the data source relies heavily on the commercial vehicle fleet. Consequently, the data set is somewhat less complete for arterial routes. Figure 34 compares the number of 1-minute speed data records per hour throughout 2013 for a representative freeway section (Figure 34a) and an arterial section (Figure 34b) that are in the same geographic area. Figure 34a shows that the freeway section has nearly complete data coverage for all hours of the day. In contrast, Figure 34b reveals that the level of arterial coverage is generally lower. In particular, there is sporadic data coverage during the overnight hours, with less than 15% of the available minutes reporting data during the early morning hours (Figure 34b, callout “i”). However, the data set is over 90% complete for most of the busier daytime hours, making it feasible to analyze arterial performance during those hours. Also, there is no substantial difference between different days of the week.

To initiate a pilot analysis of the arterial sections, INDOT engineers compiled a list of the highest priority corridors to be analyzed. Figure 35 shows a map of the selected corridors, and Table 1 provides a list, along with summary information about the arterial characteristics and the number and density of traffic signals. Most of the arterial routes are considerably shorter in length than the Interstate sections.

(a) Data coverage for a typical Interstate section (westbound I-70, MM 103 to MM 95.9)



(b) Data coverage for a typical arterial section (northbound SR 9, Greenfield, IN)

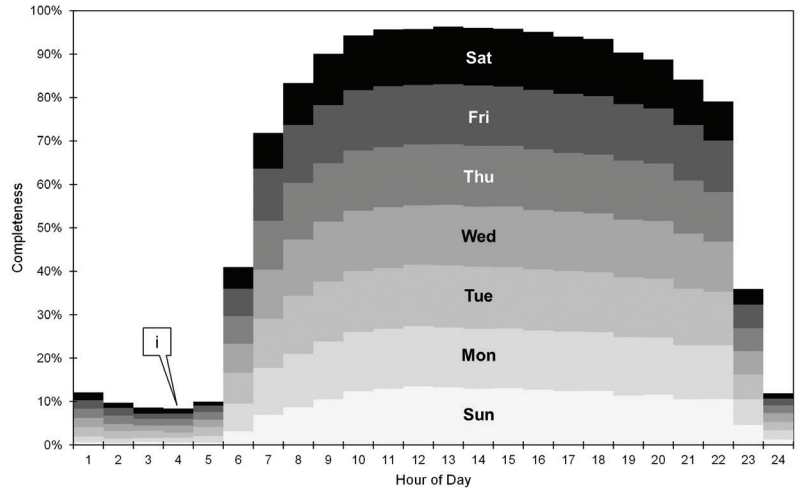


Figure 34.
Comparison of Interstate
and arterial data coverage
in 2013.

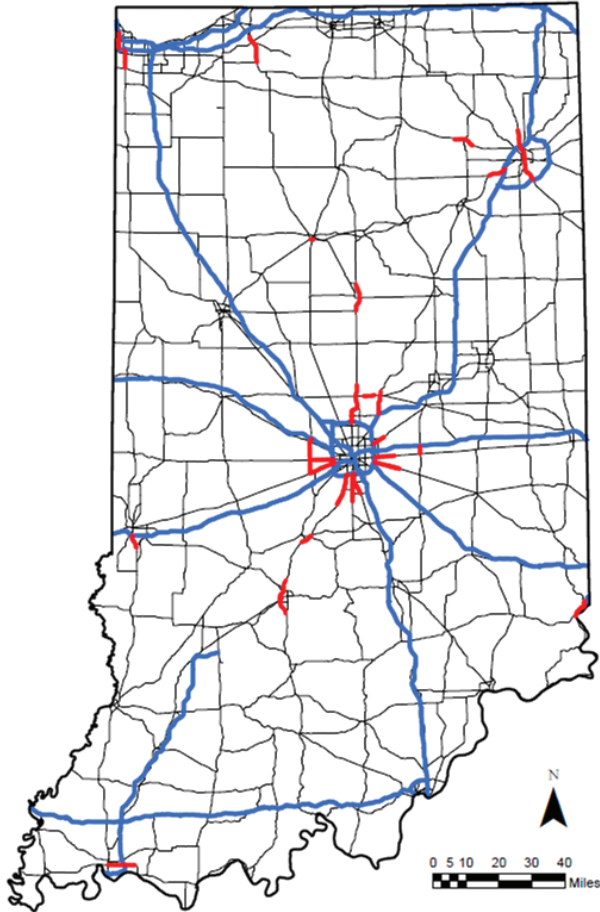


Figure 35. Indiana arterial sections selected for analysis in this report.

TABLE 1. List of arterial sections defined for the 2013–2014 Mobility Report

Arterial Section	Number of Traffic Signals	Total Distance (mi)	Number of Traffic Signals per Mile	Average Spacing Between Traffic Signals (ft)
US 30 Lake County	44	24.3	1.8	2,919
US 31 Carmel	13	9.0	1.4	3,648
US 36 Indianapolis West	17	7.1	2.4	2,219
US 40 Indianapolis West	16	8.2	2.0	2,690
US 52 Indianapolis East	5	11.2	0.4	11,791
SR 37 Indianapolis South	14	9.9	1.4	3,730
US 31 Indianapolis South	14	6.4	2.2	2,412
SR 66 Evansville	15	8.4	1.8	2,961
US 50 Lawrenceburg	13	5.9	2.2	2,397
SR 135 Indianapolis South	15	8.0	1.9	2,809
SR 37 Bloomington	3	8.8	0.3	15,475
SR 37 Martinsville	8	3.8	2.1	2,491
US 41 Terre Haute	9	4.2	2.1	2,481
SR 267 Hendricks County	8	10.8	0.7	7,100
US 40 Indianapolis East	14	6.1	2.3	2,291
US 31 Westfield	2	3.6	0.6	9,532
US 24 Fort Wayne	5	5.6	0.9	5,964
US 27 Fort Wayne	27	11.0	2.5	2,147
SR 3 Fort Wayne	11	5.1	2.1	2,471
US 30 Columbia City	7	6.4	1.1	4,800
US 35 La Porte	8	8.6	0.9	5,678
US 41 Hammond	17	5.7	3.0	1,766
US 41 Schererville	18	4.6	3.9	1,352
SR 32 Westfield	3	3.5	0.9	6,188
SR 37 Indianapolis North	10	7.0	1.4	3,709
SR 9 Greenfield	9	2.3	3.9	1,368
US 36 Indianapolis East	10	2.5	4.1	1,302
SR 931 Kokomo	6	4.0	1.5	3,496

The functional purpose of most arterial routes selected in this analysis is to provide access to commuters, rather than intercity connections. For this pilot overview, the analysis focuses on the performance of the busier sections in order to rank arterials by the degree of congestion and unreliability. Future analysis would seek to expand the network to include more sections and intercity routes where appropriate and where the data coverage is adequate.

ARTERIAL MOBILITY PERFORMANCE MEASURES

A set of performance measures was devised for arterials for the purpose of comparing different sections with different lengths and speed characteristics. This was accomplished by normalizing measures of the central tendency and the variability in travel times according to the speed limit travel time, which is the amount of time for a motorist to traverse the section if operating at the speed limit on each segment comprising the section. The speed limit travel time is an ideal condition not always achieved on an arterial section because of the presence of traffic control. However, it provides a means of comparing one section to another and of ranking sections according to performance.

Average Travel Time

The arterials analysis relies on the computation of average speed data. Speeds were calculated for 15-minute intervals, as was done for the Interstate analysis. From this, the average travel time during interval j can be calculated from

$$t_j = \sum_{i \in S} \frac{x_i}{\tilde{v}_{ij}} \quad \text{Equation 10}$$

where \tilde{v}_{ij} is the average speed on segment i during interval j and x_i is the length of segment i . Summing over all the segments in an arterial section yields the travel time for the arterial during time interval j .

Similarly, the speed limit travel time is calculated from

$$t_L = \sum_{i \in S} \frac{x_i}{v_{iL}} \quad \text{Equation 11}$$

where v_{iL} is the speed limit of each segment i .

Normalized Travel Time

The normalized travel time is computed by taking the average of the travel times over the analysis period and dividing this average by the speed limit travel time. The average travel time for analysis period T is found from

$$\tilde{t}_T = \frac{1}{N_T} \sum_{j \in T} t_j \quad \text{Equation 12}$$

where N_T is the number of samples. Next, the average is normalized by dividing by the speed limit travel time (t_L):

$$t'_T = \frac{\tilde{t}_T}{t_L} \quad \text{Equation 13}$$

The result is a number that represents the central tendency of the travel time as a percentage of the speed limit travel time. The larger the number, the higher the amount of delay experienced on the section. Percentages less than 100 represent cases where the travel times based on measured speeds were actually lower than the speed limit travel times (meaning the observed speeds tended to be higher than the posted speed limits). There were very few sections where this was the case.

Normalized Travel Time Unreliability

The normalized travel time unreliability is computed by taking the standard deviation of the travel times over the analysis period and dividing by the speed limit travel time. The standard deviation is calculated for the analysis period T by

$$s_T = \frac{1}{N_T} \sum_{j \in T} (\tilde{t}_T - t_j)^2 \quad \text{Equation 14}$$

Here, N_T is the number of samples, t_j is the average travel time for each sample (Equation 10), and \tilde{t}_T is the average for the analysis period T (Equation 12).

The standard deviation is then normalized by dividing by the speed limit travel time (t_L):

$$s'_T = \frac{s_T}{t_L} \quad \text{Equation 15}$$

This provides a relative measure of the variation in the travel times as a percentage of the speed limit travel time. A value of zero would indicate a travel time that is always perfectly constant. The higher the value, the greater the spread in the travel times.

Binning by Time of Day and Roadway

The previous performance measures were described in terms of an analysis period, T . To come up with meaningful indices for each arterial section, travel time data from the 18-month period during 2013–2014 were separated into different time-of-day (TOD) cohorts where similar operating conditions prevailed. The separate TOD categories included the AM peak (6:00–9:00), midday (9:00–15:00), and PM peak (15:00–19:00).

Next, within each of these TOD cohorts, the travel time characteristics were aggregated across the two directions by taking the maximum value of these directions. The reason for this approach was to avoid masking an unfavorable condition in one direction by taking an average with a favorable condition in the opposing direction.

Composite Travel Time Index

The normalized travel time and the normalized travel time unreliability provide two separate dimensions of performance. A composite travel time index was developed to take both of these into account. The formula is based on the concept of finding a “distance” from an ideal condition with infinitesimally small variation and average travel time equal to the nominal ideal speed. It is modified by adding a weighting factor to the unreliability element, and ignoring any component where the normalized travel time was observed to be less than 100% of the speed limit travel time. The travel time index for analysis period T is found from

$$\text{Index}_T = 100 \cdot \sqrt{\max\{0, t'_T - 1\}^2 + (\omega \cdot s'_T)^2} \quad \text{Equation 16}$$

Here, t'_T is the average normalized travel time, s'_T is the normalized standard deviation of the travel times, and ω is a weighting function that is intended to weight the component of the standard deviation. A value of $\omega = 1$ was used in this study.

A composite value of the travel time index for all times of day was obtained by taking the average value for the AM, midday, and PM time periods. A simple average of the three values was used because each time of day was considered to be equally important in developing the composite value.

SUMMARY OF ARTERIAL PERFORMANCE

Arterial Rankings by Travel Time and Travel Time Unreliability

Figure 36 shows ranked lists of the arterials according to normalized average travel time (Figure 36a) and normalized standard deviation of travel time (Figure 36b) for the AM peak, while Figure 37 repeats this view of the data for the PM peak. All of the arterials, with one exception, have normalized travel times above 100%. SR 37 in Bloomington has a value under 100%, indicating that speeds tend to be above the speed limit on this roadway. Notably, this route has the fewest number of traffic signals per mile of all the arterials in this study. Actually, much of the route is grade separated, and it is part of the future I-69 corridor from Indianapolis to Evansville.

A relatively small portion of the entire group experienced large travel times or unreliability. The same routes tend to appear in the same spots in the distribution. For example, SR 9 in Greenfield tends to have consistently high normalized average and standard deviations of travel time and appears near the bottom of the list.

Figure 38 combines the two metrics together by plotting the unreliability measure (normalized standard deviation of travel time) against the measure of central tendency (normalized average travel time). Figure 38a shows this plot for the AM peak cohort while Figure 38b shows the PM peak. Each data point represents the value for one arterial route. In terms of performance, it is more desirable for the points to be near the bottom left side of the plot, which indicates average travel time closer to the speed limit and more reliability.

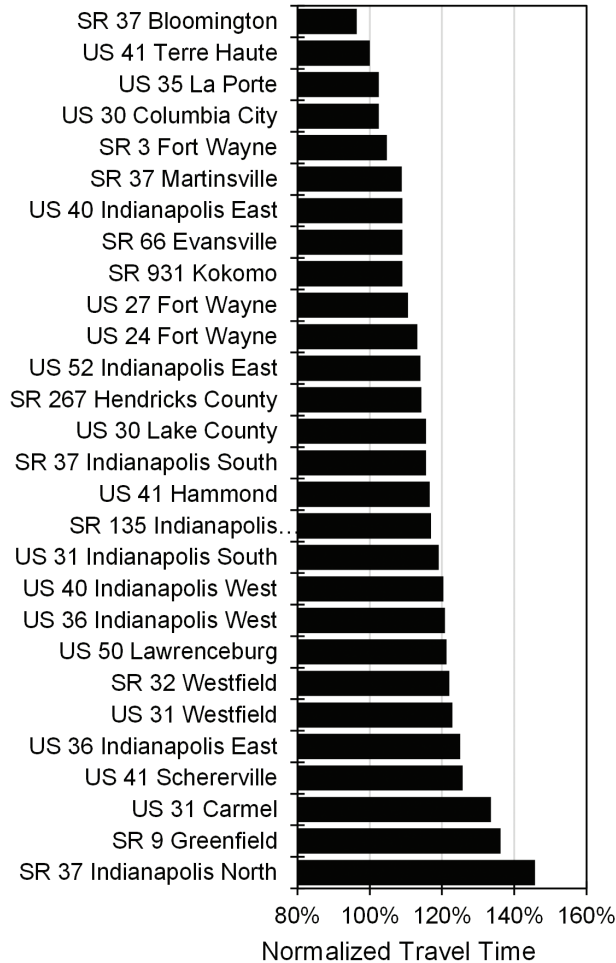
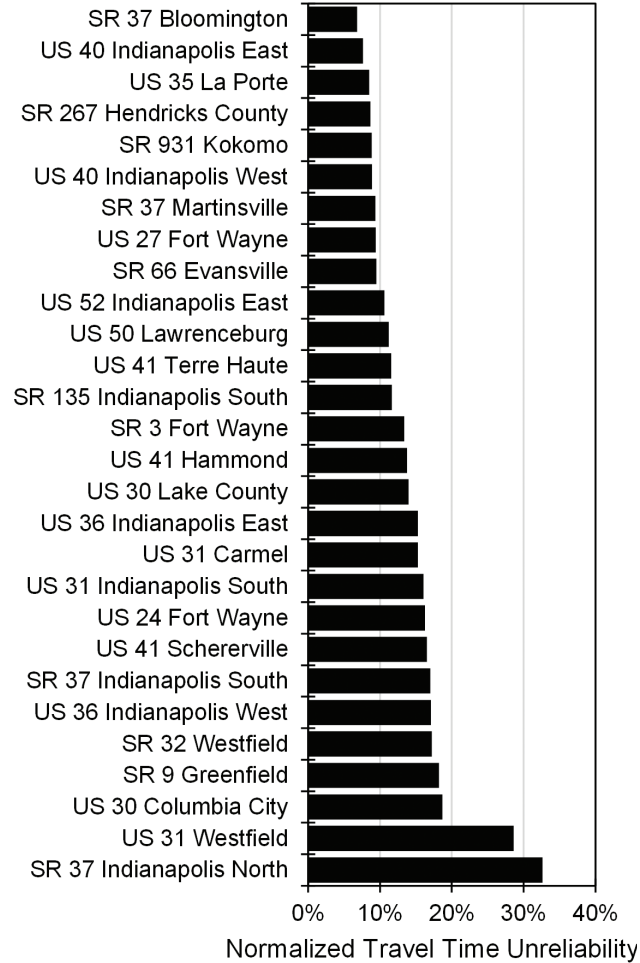
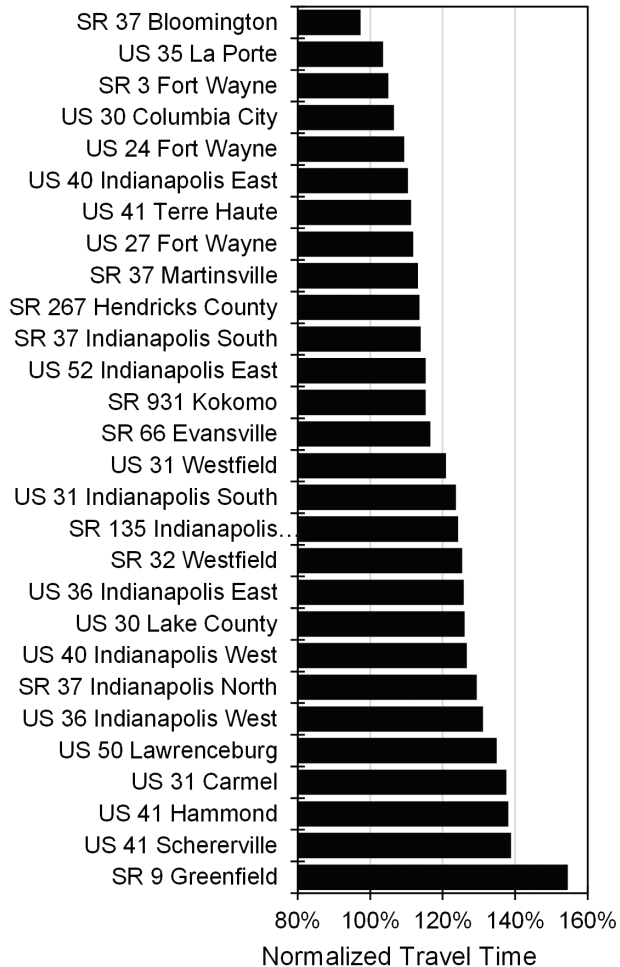


Figure 36.
 Arterial ranking:
 AM Peak (6:00–
 9:00). Data shown
 for all Wednesdays,
 January 2013–
 June 2014.

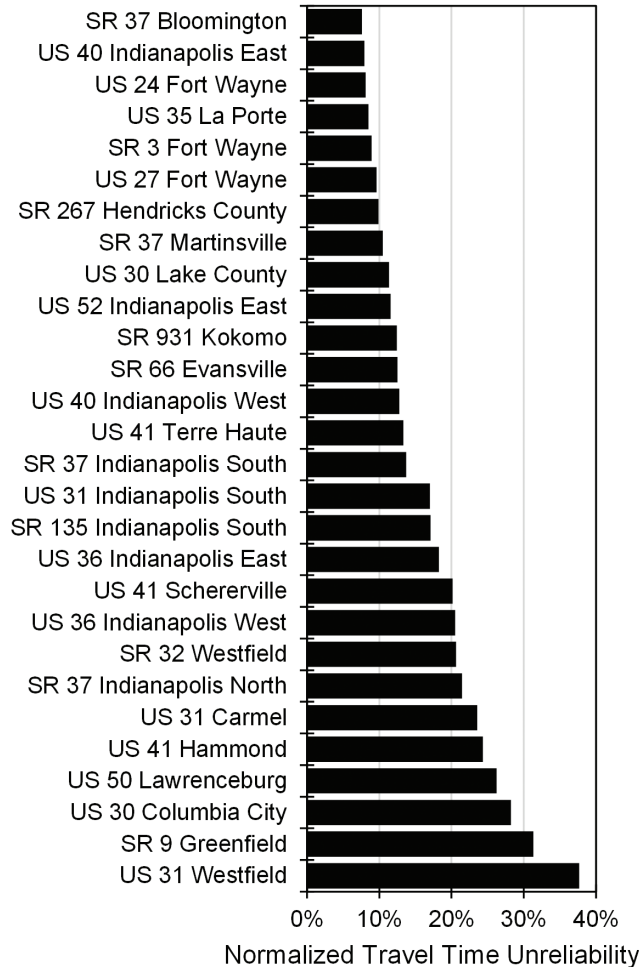
(a) Sorted by normalized average travel time



(b) Sorted by normalized standard deviation of travel time



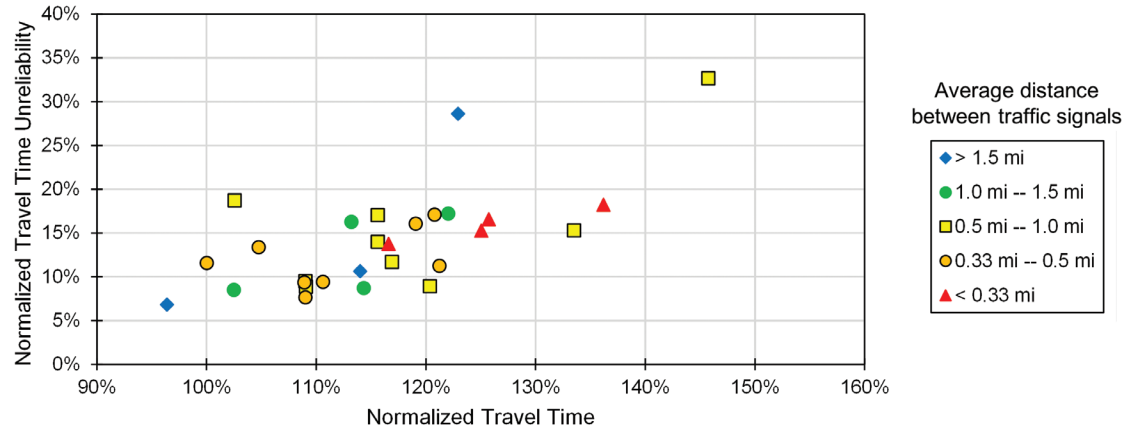
(a) Sorted by normalized average travel time



(b) Sorted by normalized standard deviation of travel time

Figure 37.
Arterial ranking:
PM Peak (15:00–
19:00). Data shown
for all Wednesdays,
January 2013–
June 2014.

(a) AM Peak (6:00–9:00)



(b) PM Peak (15:00–19:00)

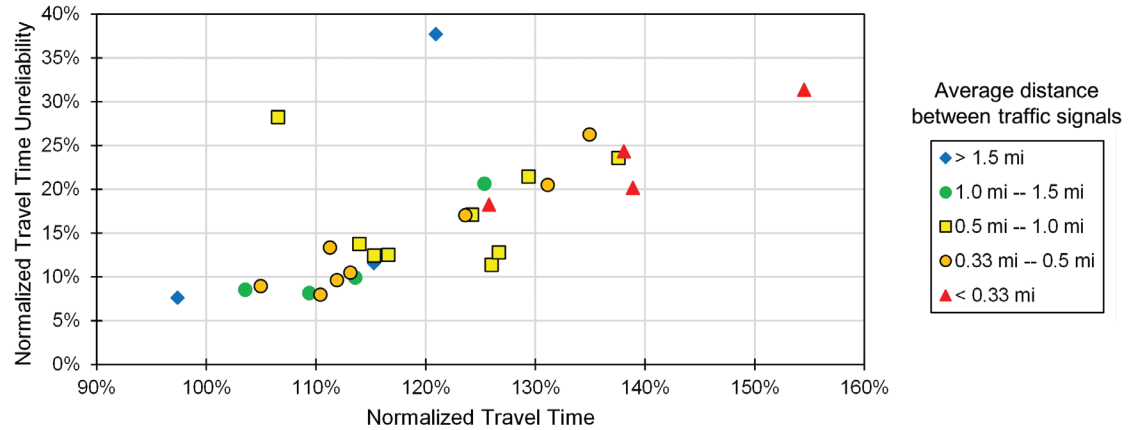


Figure 38.

Unreliability versus central tendency. Legend shows average distance between traffic signals. Data shown for all Wednesdays, January 2013–June 2014.

The arterials are divided into five groups according to the density of traffic signals occurring on the route. The plots show that there is a tendency for arterial routes with a higher density of traffic signals to have higher travel times and less reliability than those with fewer traffic signals.

Composite Arterial Rankings

Table 2 shows the overall results for all of the arterial routes considered in the study, sorted from highest to lowest values of the composite index. The composite index is found by taking the average of the individual indices of the AM, midday, and PM peaks. The individual values are also shown for each arterial. This metric makes it possible to rank routes according to their travel characteristics, with those at the top of the list having the most need for improvement. Many of those routes consist of major commuter arterials, such as SR 37 on the north side of Indianapolis, or US 31 in Carmel. However, the worst-performing arterial, SR 9 in Greenfield, is not only a commuter thoroughfare but also the principal street in the city of Greenfield, providing the only real route from Interstate 70 to the center of town. While its operational characteristics may be well-known to those who travel it daily, they are less likely to be understood at the agency-wide level. Even if they were, there is no immediate reason to suspect that this particular roadway would have worse

TABLE 2. List of arterial sections ordered by travel time index

Arterial Section	AM Index	Midday Index	PM Index	Composite Index
SR 9 Greenfield	40.5	62.2	62.9	55.2
SR 37 Indianapolis North	56.2	37.4	36.4	43.3
US 31 Carmel	36.8	37.5	44.4	39.6
US 31 Westfield	36.7	38.5	43.1	39.4
US 41 Schererville	30.6	35.4	43.8	36.6
US 41 Hammond	21.6	33.5	45.2	33.4
US 50 Lawrenceburg	24.0	29.4	43.7	32.4
US 36 Indianapolis West	26.9	30.5	37.3	31.5
US 36 Indianapolis East	29.3	30.0	31.6	30.3
SR 32 Westfield	28.0	29.6	32.7	30.1
US 30 Columbia City	18.9	38.2	29.0	28.7
US 31 Indianapolis South	24.9	29.3	29.1	27.8
US 40 Indianapolis West	22.2	24.7	29.6	25.5
US 30 Lake County	21.0	26.1	28.4	25.1
SR 135 Indianapolis South	20.6	24.4	29.7	24.9
SR 37 Indianapolis South	23.1	15.9	19.6	19.5
US 52 Indianapolis East	17.6	17.2	19.2	18.0
SR 931 Kokomo	12.7	18.3	19.7	16.9
SR 66 Evansville	13.1	16.5	20.8	16.8
SR 267 Hendricks County	16.8	16.3	16.8	16.6
US 24 Fort Wayne	20.9	13.9	12.4	15.8
SR 37 Martinsville	12.9	17.5	16.8	15.8
US 41 Terre Haute	11.6	18.2	17.5	15.7
US 27 Fort Wayne	14.2	15.8	15.3	15.1
US 40 Indianapolis East	11.8	15.7	13.1	13.5
SR 3 Fort Wayne	14.2	10.5	10.2	11.6
US 35 La Porte	8.9	7.8	9.2	8.6
SR 37 Bloomington	6.8	6.0	7.6	6.8

performance than what would seem to be busier routes in denser urban areas. This demonstrates the potential value in using speed data to assist operational staff to make better-informed decisions.

CONCLUSIONS AND FUTURE OUTLOOK

This report presents an overview of the mobility performance of the Indiana state highway network, covering the full extent of the Interstate system operated by INDOT and selected arterial highway sections. A variety of performance measures have been developed for visualizing these characteristics and for ranking different roadway segments according to the level of congestion from different perspectives.

INDOT continues to invest in the improvement of the data methodology and system-wide monitoring capabilities. In the first 6 months of 2014, a new research project was engaged to further innovate and expand the analysis of the system performance. Simultaneously the quality of the data improved, and data with improved spatial resolution became available at the same time. This has enabled us to develop real-time monitoring tools capable of detecting the presence of queues on the Interstate system.

We anticipate that in the future, data fusion efforts will expand the analysis, not only to include measured speeds and estimated traffic volumes but also to take into account the safety characteristics of roadways and integrate real-time information from INDOT's work zone management tools and existing ITS infrastructure. These will add new dimensions to the system performance analysis. Our goals are to migrate the performance tools from a static report format into a dynamic online dashboard and to support the mission of INDOT planners and engineers to provide an optimally performing highway system.

INDIANA MOBILITY REPORT HISTORY AND AWARDS

In July 2012, the Indiana Department of Transportation (INDOT) published the *2011 Indiana Interstate Mobility Report*, its first statewide mobility report using private sector probe data. In August 2013, INDOT received the Institute of Transportation Engineers 2013 Management & Operations/ITS Council Project Achievement Award for that inaugural report.

PUBLICATION INFORMATION

The Indiana Mobility Report collection on e-Pubs (<http://docs.lib.purdue.edu/imr/>) was established as a repository for annual mobility reports jointly produced by INDOT and Purdue University. The tools and data described in the annual reports provide a quantitative evaluation of how the Indiana highway system is performing and where opportunities lie for future infrastructure investments, and assessment of mobility when new infrastructure investments are completed.

Summary and full versions of the *2011 Indiana Interstate Mobility Report* and the *2012* and *2013–2014 Indiana Mobility Report* are archived on Purdue e-Pubs and are available for electronic download free of charge. Print versions of these reports are also available to purchase via a link on the download page or through major booksellers.

Recommended Citations

Day, C., Remias, S., Li, H., Mekker, M., McNamara, M., Cox, E., Horton, D., & Bullock, D. (2014). *2013–2014 Indiana Mobility Report: Summary Version* (Joint Transportation Research Program Indiana Mobility Reports). West Lafayette, IN: Purdue University. <http://dx.doi.org/10.5703/1288284315507>

Day, C., Remias, S., Li, H., Mekker, M., McNamara, M., Cox, E., Horton, D., & Bullock, D. (2014). *2013–2014 Indiana Mobility Report: Full Version* (Joint Transportation Research Program Indiana Mobility Reports). West Lafayette, IN: Purdue University. <http://dx.doi.org/10.5703/1288284315508>

CONTACT INFORMATION

The following e-mail address has been established to provide a structured mechanism for submitting questions and improvement suggestions: mobilityreport@purdue.edu.

About the Joint Transportation Research Program (JTRP)

Over 77 years ago, on March 2, 1937, the Indiana General Assembly passed a resolution that the motto for Indiana would be “The Crossroads of America.” Nine days later, on March 11, 1937, the Indiana General Assembly passed enabling legislation that led to the formation of the Joint Highway Research Project (JHRP) to facilitate collaboration between Purdue University and what was then known as the Indiana State Highway

Commission. The Joint Highway Research Program was renamed the Joint Transportation Research Program (JTRP) in 1997 to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports on a diverse portfolio of transportation-related research projects.

Over 1,500 technical reports are currently available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation. Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at <http://docs.lib.purdue.edu/jtrp>. Since 2006, there have been over 950,000 downloads of these reports worldwide.

Further information about JTRP and its current research program is available at <http://www.purdue.edu/jtrp>.

Photographs taken in Indianapolis near I-69 mile marker 110.

Top. September 2013: under construction.

Bottom. September 2014: open to traffic.

