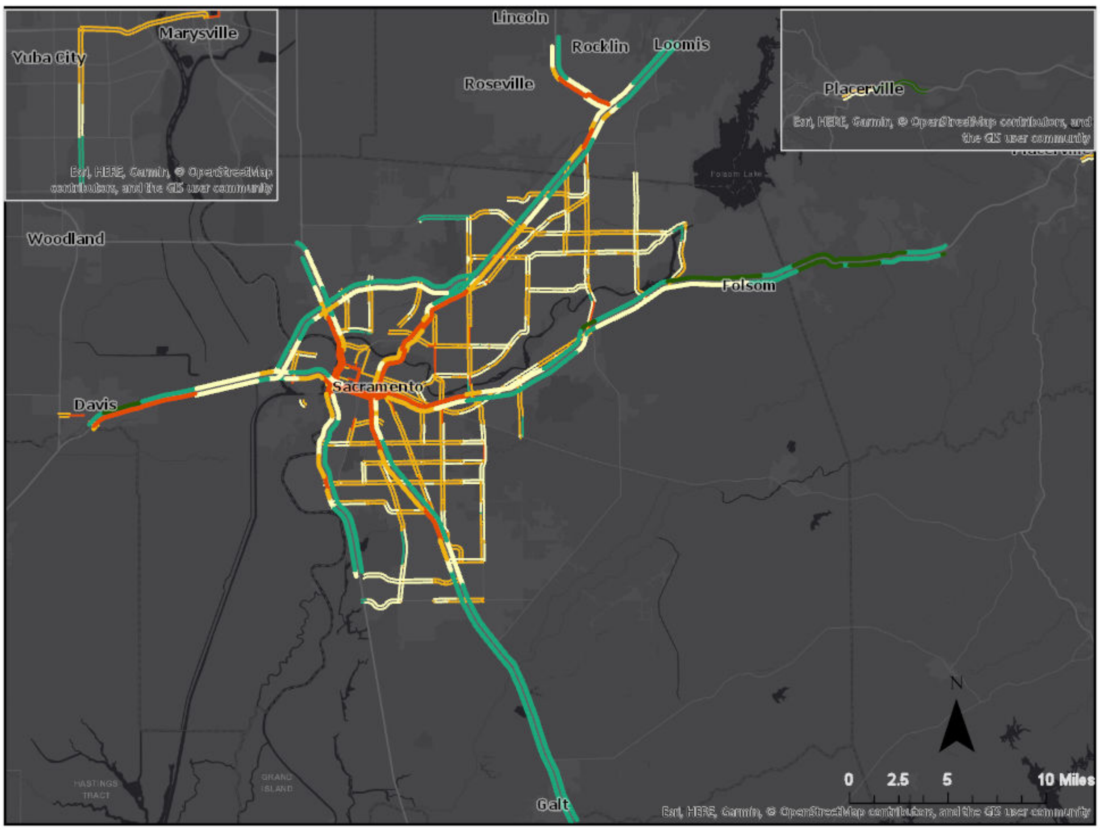
2018 Congestion Management Process Update



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July 2018

2018 CMP Update

Contents

Figures

2018 Monitoring Results

Overview

SACOG submitted its first Congestion Management Process (CMP) report in June 2017. Developed in collaboration with local jurisdictions, SACOG's first CMP defined metrics to quantify congestion and travel time reliability and identify strategies to improve performance on the CMP network.

As the CMP is an ongoing process, as opposed to a one-time plan, SACOG is responsible for periodically measuring and revising CMP metrics. This Monitoring Report describes the most recent monitoring efforts and provides updated numbers reflecting how SACOG is trending on several of its key CMP metrics, including:

- *Average peak period speed*, *all vehicles* – Average speeds for cars and trucks during the 6am-9am and 3pm-6pm peak periods.
- *Average peak period speed*, *trucks only* – Average truck speeds during the 6am-9am and 3pm-6pm peak periods. Truck average speeds were only measured for limited-access freeways.
- *Level of travel time reliability (LOTTR) for all vehicles during the AM and PM peak periods* - LOTTR is the ratio between the 80th percentile travel time and the 50th percentile travel time for a given CMP network segment. E.g., if the 80th longest travel time was three minutes and the 50th percentile travel time was two minutes, the LOTTR would be 3/2, or 1.5

  Borrowing from FHWA's MAP-21 rule, our CMP defines a road segment as unreliable if it's LOTTR is greater than or equal to 1.5.

- *Truck travel time reliability (TTTR) the AM and PM peak periods* - This is the same as the LOTTR, but only for truck speeds and for limited-access freeways[1].
- *Congestion Score* – The observed speed divided by the "unconstrained speed", or the speed corresponding to the 5-minute period whose average vehicle speed is faster than 85 percent of the other epochs in the 6pm-6am overnight period. This approximates a "free-flow" speed and allows congestion to be normalized by road type (e.g., a congested speed for a freeway will not be considered a congested speed for an arterial).
- *Share of the CMP road network that is either unreliable or congested and has transit service*.

This Monitoring Report does not change the metrics, add any new performance metrics, or change which roads are on the CMP network[2]. Similarly, as this is purely a monitoring report, it will not propose new strategies nor alter the strategies outlined in SACOG's previous CMP. SACOG will work with local jurisdictions to review and potentially update metrics and strategies during the next CMP update.

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[1] MAP-21 measures truck travel time reliability using 95th/50th percentile travel times, but in the CMP we use 80th/50th percentile in order to match the metric used for all vehicle types. We may revise this definition in the next major CMP update.
[2] CMP segments that did not come with the 2017 NPMRDS data set were removed, but otherwise we used the same segments.

Peak Period Average Speeds

Figure 1 and Figure 2 below show average all-vehicle (both truck and passenger vehicle) speeds for the AM and PM peaks during October 2017.

Like the patterns found in the 2015 data used for the 2017 CMP Report, PM peak speeds are generally slower than AM peak speeds. Slower PM peak speeds are not surprising since, in addition to the extra demand created by people commuting, there are more non-commuting trips (shopping, errands, etc.) occurring during the PM peak than the AM peak which in turn increase the total number of vehicles using the road.

Figure 1 - AM Peak Period All-Vehicle Speed, October 2017

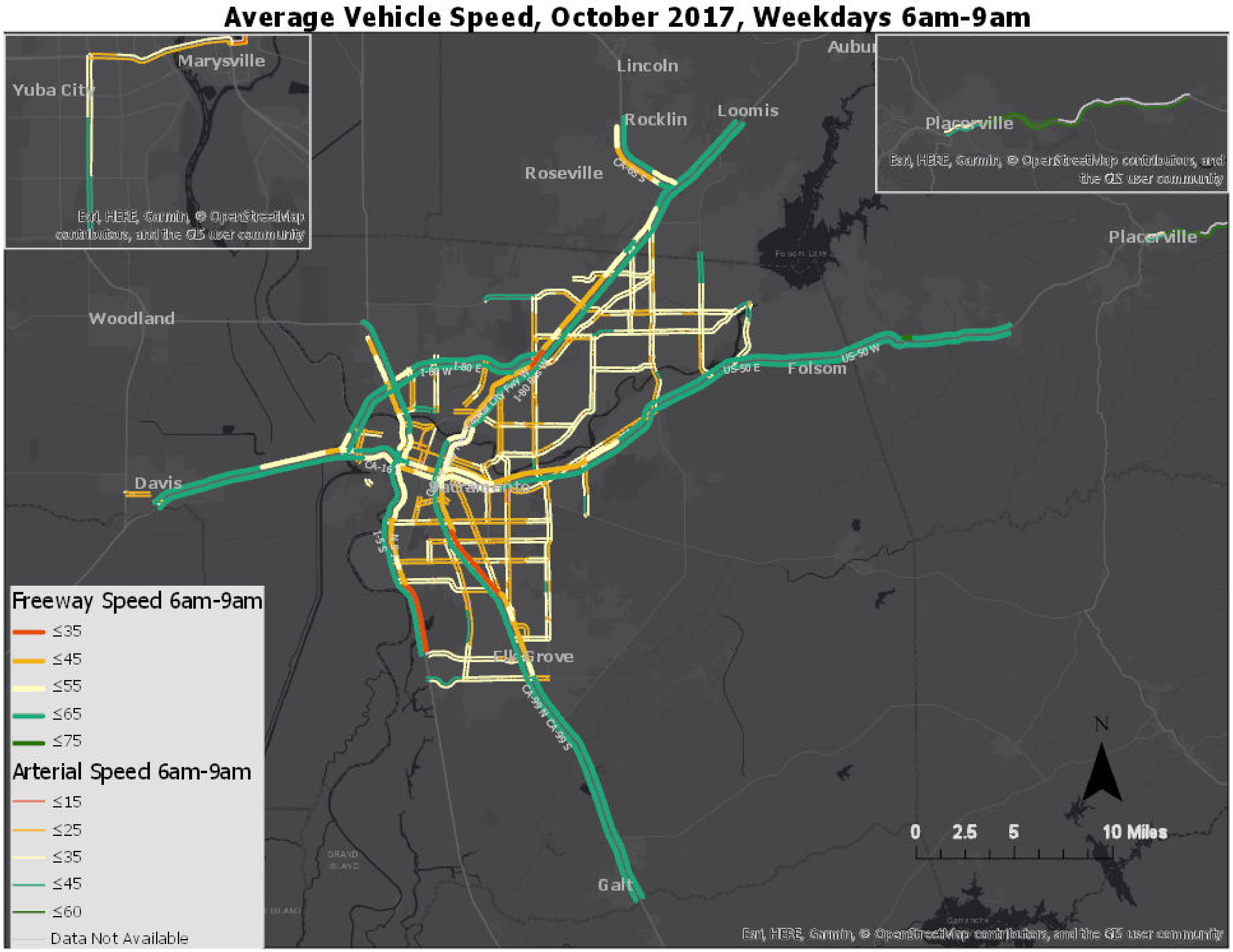
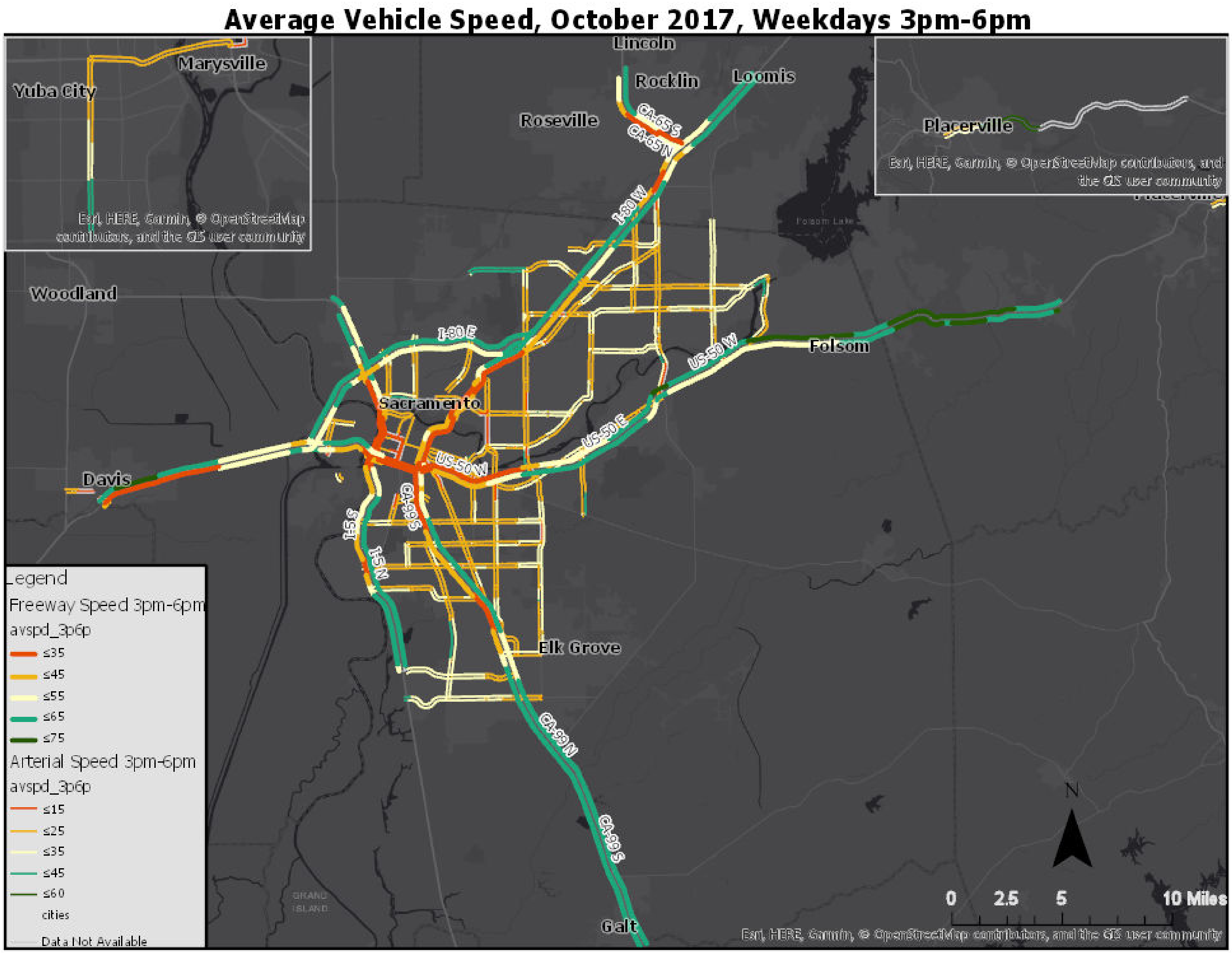


Figure 2 - PM Peak All-Vehicle Speed, October 2017



System-Level Reliability

Figure 3 below provides system level reliability data during October 2017 for the entire CMP network as well as separately for arterials and limited-access freeways. All numbers are for the month of October during AM and PM peak periods as defined in the tables.

Figure 3 – October 2017 System Reliability

Time Period	LOTTR - Systemwide[1]	Percent of CMP Directional Miles	
6am-9am	Reliable (<1.5)	83.6%	
	Unreliable (>=1.5)	16.0%	
	Unreliable with Transit[3]		7.7%
	No Data	0.4%	
3pm-6pm	Reliable (<1.5)	79.8%	
	Unreliable (>=1.5)	19.8%	
	Unreliable with Transit[3]		9.3%
	No Data	0.4%	

Time Period Fwy	LOTTR - Freeways Only[1]	Percent of CMP Freeway Directional Miles	
6am-9am	Reliable (<1.5)	90.1%	
	Unreliable (>=1.5)	9.6%	
	Unreliable with Transit[3]		4.5%
	No Data	0.3%	
3pm-6pm	Reliable (<1.5)	85.6%	
	Unreliable (>=1.5)	14.1%	
	Unreliable with Transit[3]		8.1%
	No Data	0.3%	

Time Period Artrl	LOTTR - Arterials Only[1]	Percent of CMP Arterial Directional Miles	
6am-9am	Reliable (<1.5)	79.8%	
	Unreliable (>=1.5)	19.7%	
	Unreliable with Transit[3]		9.5%
	No Data	0.5%	
3pm-6pm	Reliable (<1.5)	76.3%	
	Unreliable (>=1.5)	23.2%	
	Unreliable with Transit[3]		10.0%
	No Data	0.5%	

1 LOTTR = level of travel time reliability, which is 80th percentile epoch travel time divided by 50th percentile epoch travel time.

2 Congestion level = observed average speed / unconstrained speed. Unconstrained speed is the 85th percentile epoch speed, or speed in the epoch that was faster than 85 percent of epochs for that road segment

3 Transit miles in HOV lanes are excluded because HOV lanes theoretically protect transit vehicles from congestion delay

Approximately 60 percent of CMP network miles are served by the CMP Priority Transit network

System-Level Congestion

Figure 4 shows October 2017 system-level congestion. As provided for system-level reliability, the figure also shows congestion data separately for arterials and limited-access freeways.

Figure 4 – October 2017 System Congestion

Time Period	Congestion - Systemwide[2]	Percent of CMP Directional Miles	
6am-9am	Uncongested (>=0.6)	81.4%	
	Congested (<0.6)	18.1%	
	Congested with Transit[3]		9.0%
	No Data	0.4%	
3pm-6pm	Uncongested (>=0.6)	58.1%	
	Congested (<0.6)	41.4%	
	Congested with Transit[3]		23.0%
	No Data	0.4%	

Time Period Fwy	Congestion - Freeways Only[2]	Percent of CMP Freeway Directional Miles	
6am-9am	Uncongested (>=0.6)	91.3%	
	Congested (<0.6)	8.4%	
	Congested with Transit[3]		3.8%
	No Data	0.3%	
3pm-6pm	Uncongested (>=0.6)	79.5%	
	Congested (<0.6)	20.1%	
	Congested with Transit[3]		13.8%
	No Data	0.3%	

Time Period Artrl	Congestion - Arterials Only[2]	Percent of CMP Arterial Directional Miles	
6am-9am	Uncongested (>=0.6)	75.6%	
	Congested (<0.6)	23.9%	
	Congested with Transit[3]		12.1%
	No Data	0.5%	
3pm-6pm	Uncongested (>=0.6)	45.5%	
	Congested (<0.6)	54.0%	
	Congested with Transit[3]		28.4%
	No Data	0.5%	

1 LOTTR = level of travel time reliability, which is 80th percentile epoch travel time divided by 50th percentile epoch travel time.

2 Congestion level = observed average speed / unconstrained speed. Unconstrained speed is the 85th percentile epoch speed, or speed in the epoch that was faster than 85 percent of epochs for that road segment

3 Transit miles in HOV lanes are excluded because HOV lanes theoretically protect transit vehicles from congestion delay Approximately 60 percent of CMP network miles are served by the CMP Priority Transit network

Combined Reliability and Congestion

Figure 5 and Figure 6 visually combine congestion and reliability to give a more general picture of performance in the CMP network during the AM and PM peak periods. As Table 1 illustrates, thick red lines denote roads that are both very congested and very unreliable, while thin green lines indicate roads that are both reliable and relatively uncongested. This combined metrics allows an at-a-glance view of the most problematic parts of the CMP network.

Table 1 - Combined Congestion-Reliability Metric Parameters

	Reliable	Moderately Unreliable	Very Unreliable
Congestion Level	**LOTTR* < 1.35**	**LOTTR 1.35-1.5**	**LOTTR >=1.5**
Low (>=65% of free-flow**)	No Problem	Low Congestion, Semi-Reliable	Low Congestion, Unreliable
Med (60-65% of free-flow)	Medium Congestion, Reliable	Medium Congestion, Semi-Reliable	Medium Congestion, Unreliable
High (<60% of free-flow)	High Congestion, Reliable	High Congestion, Semi-Reliable	High Congestion, Unreliable

Figure 5 shows combined congestion and reliability for the AM peak period (6am-9am). While congestion and poor reliability crop up throughout the network, corridors that stand out as particularly problematic include Franklin Bl, Watt Avenue, and Power Inn Rd, which experienced both high levels of congestion delay and unreliable travel times.

Following, Figure 6 shows combined congestion and reliability for the PM peak period (3pm-6pm). As expected, PM peak performance is lower, generally due to higher volumes created by people making more non-commute trips. In particular, Business 80 north of the American river and I-80 through Davis are less reliable and experience more intense congestion during the PM peak than the AM peak.

Figure 7 highlights the network segments that are most consistently deficient, with segments that suffer significant congestion delay and poor reliability in both the AM and PM peaks. Longer segments that stand out are Folsom Bl surrounding Watt Avenue and 65th Street near CSUS.

Figure 5 - Combined Congestion and Reliability Map - AM Peak

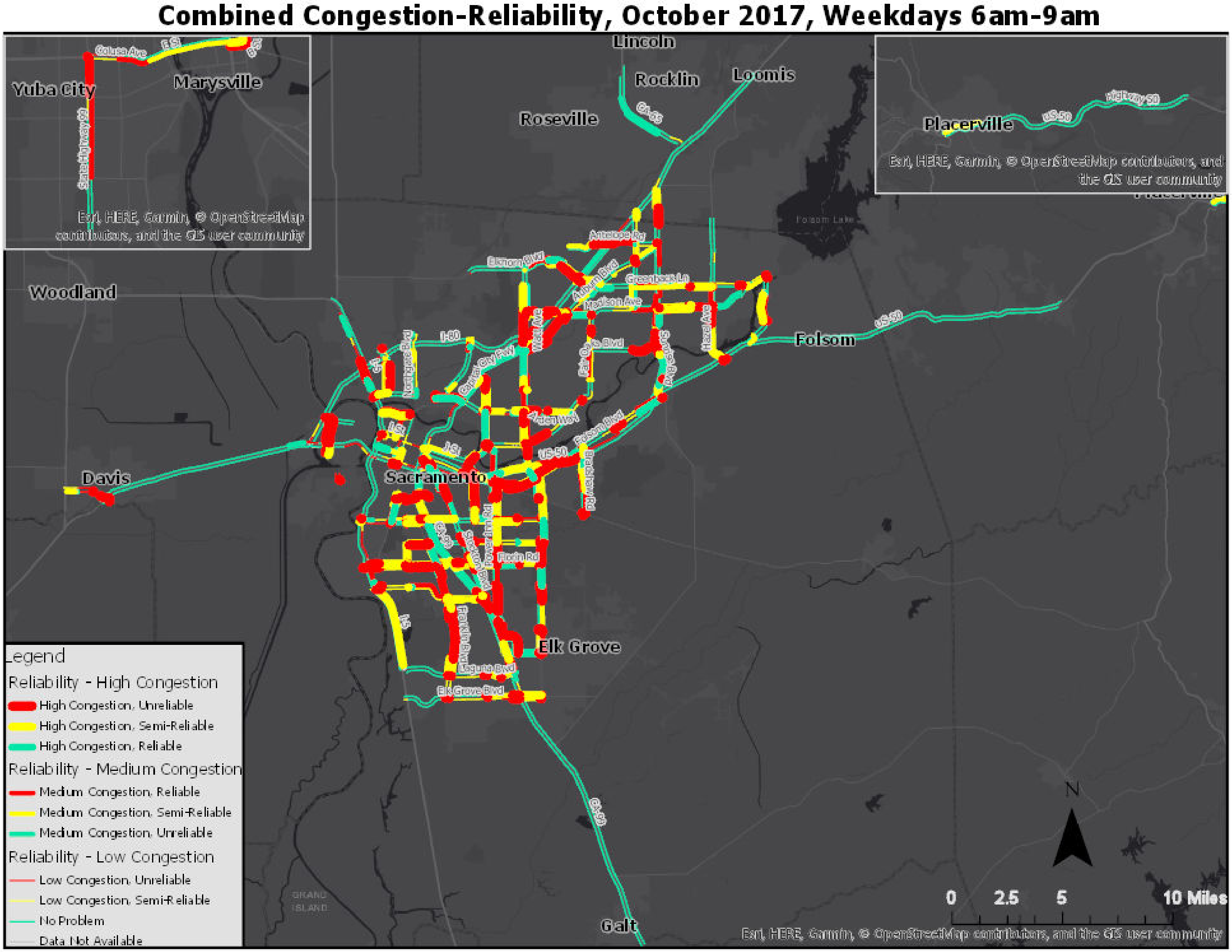


Figure 6 - Combined Congestion and Reliability Map - PM Peak

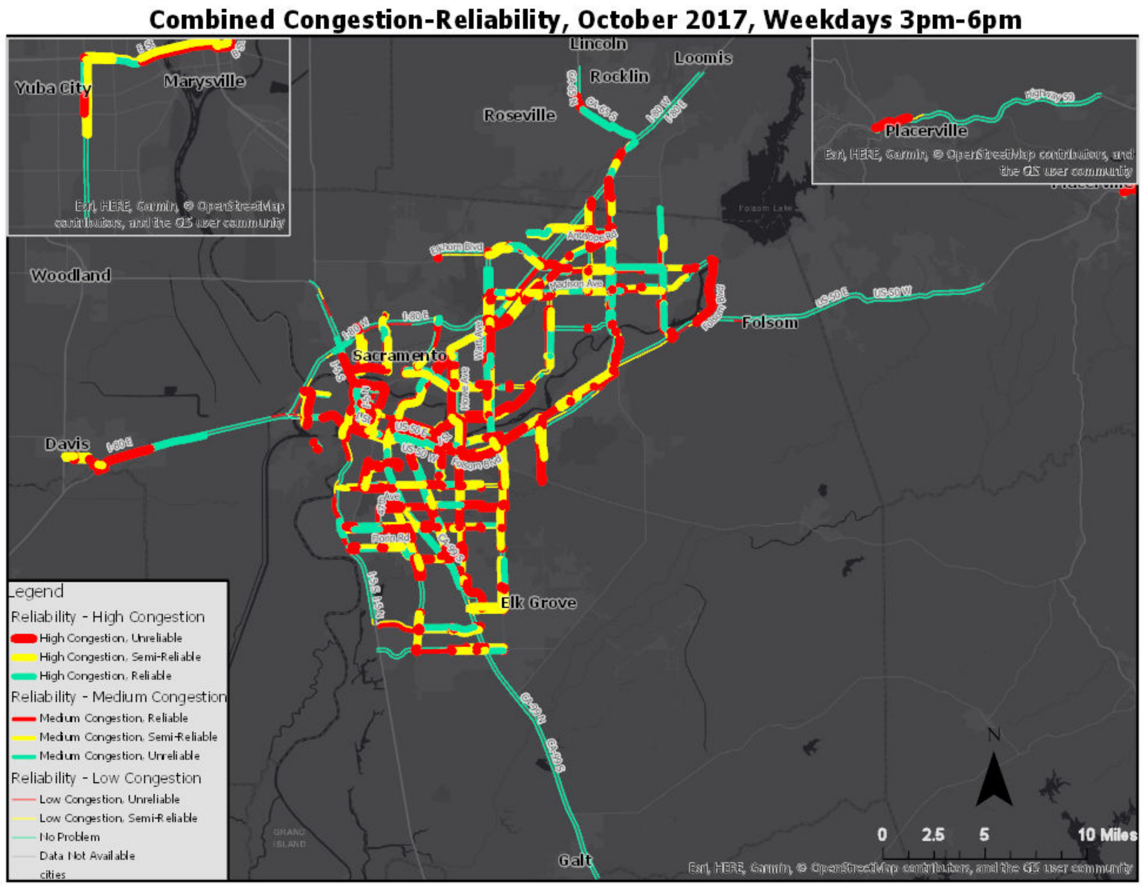
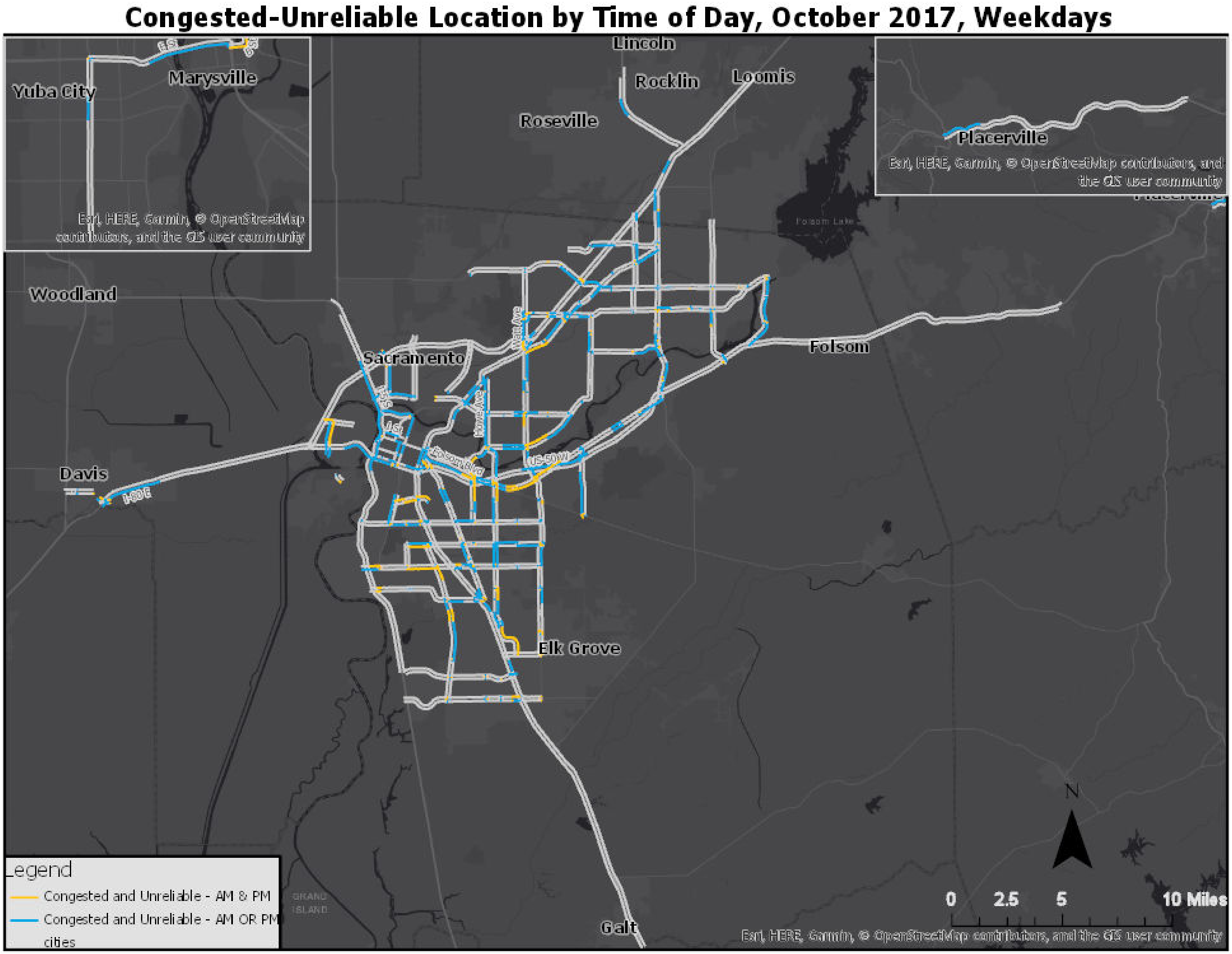


Figure 7 - Congestion and Reliability, Combining AM-PM Peaks



Truck Performance Metrics

Truck performance metrics were only considered for limited-access freeways within the CMP network to limit their evaluation to parts of the network that are designated freight corridors.

Peak Period Truck Speeds

Figure 8 shows average AM peak period (6am-9am) truck speeds during October 2017, while Figure 9 maps average PM peak period (3pm-6pm) truck speeds. Truck speeds are overall slightly lower than the all-vehicle speeds, as would be expected given their greater size and weight. Truck speed variation by time of day and location is consistent with that of the all-vehicle speeds, being slowest on roads heading into downtown Sacramento during the AM peak and leaving downtown during the PM peak, with overall speeds being slower in the PM peak than the AM peak.

Interestingly, I-80 eastbound is slow heading toward downtown Sacramento during the PM peak. A possible factor behind these slow speeds are commuters coming from major job centers like UC Davis and the Bay Area.

Figure 8 - Average Truck Speed on Freeways 6am-9am Weekdays, October 2017

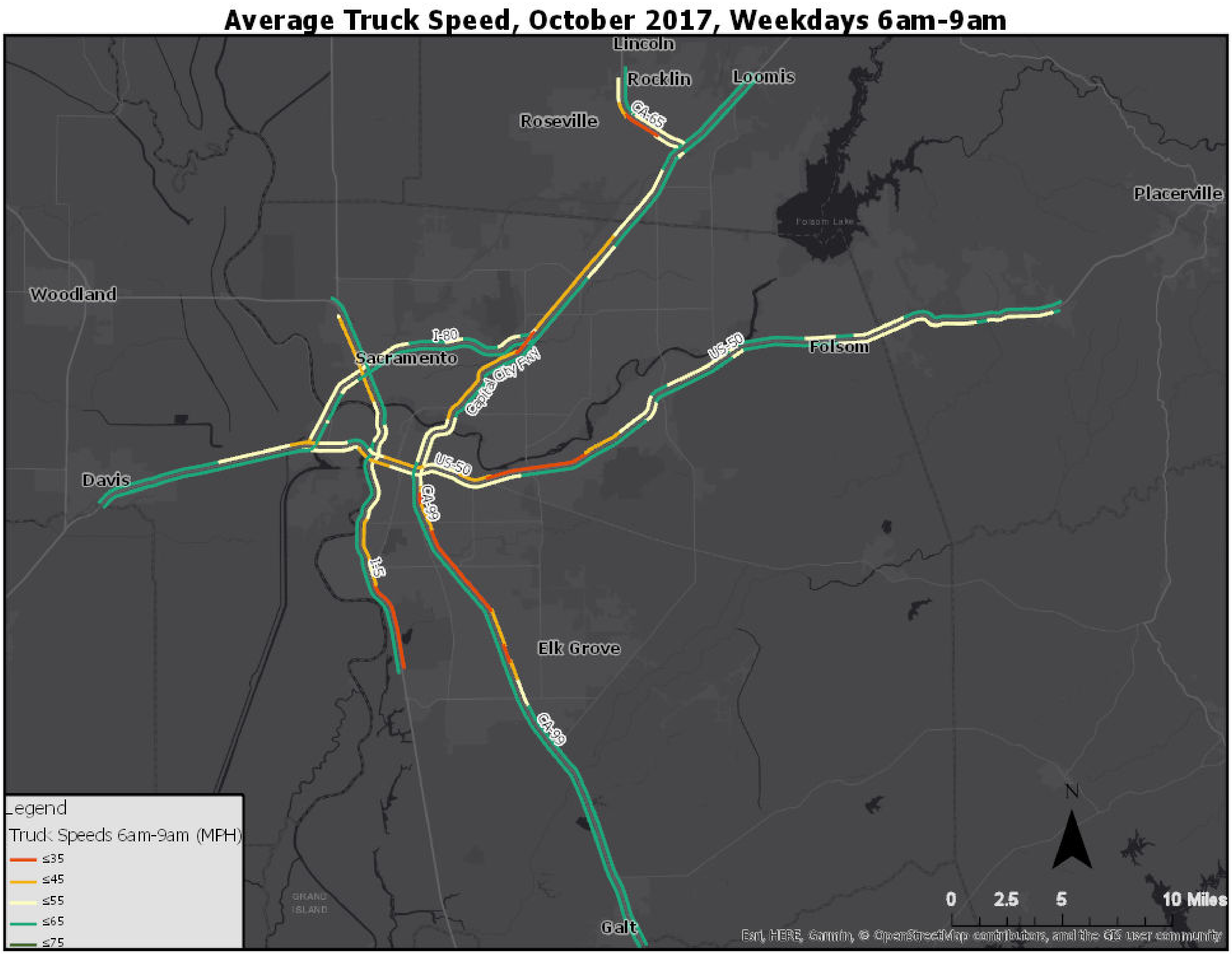
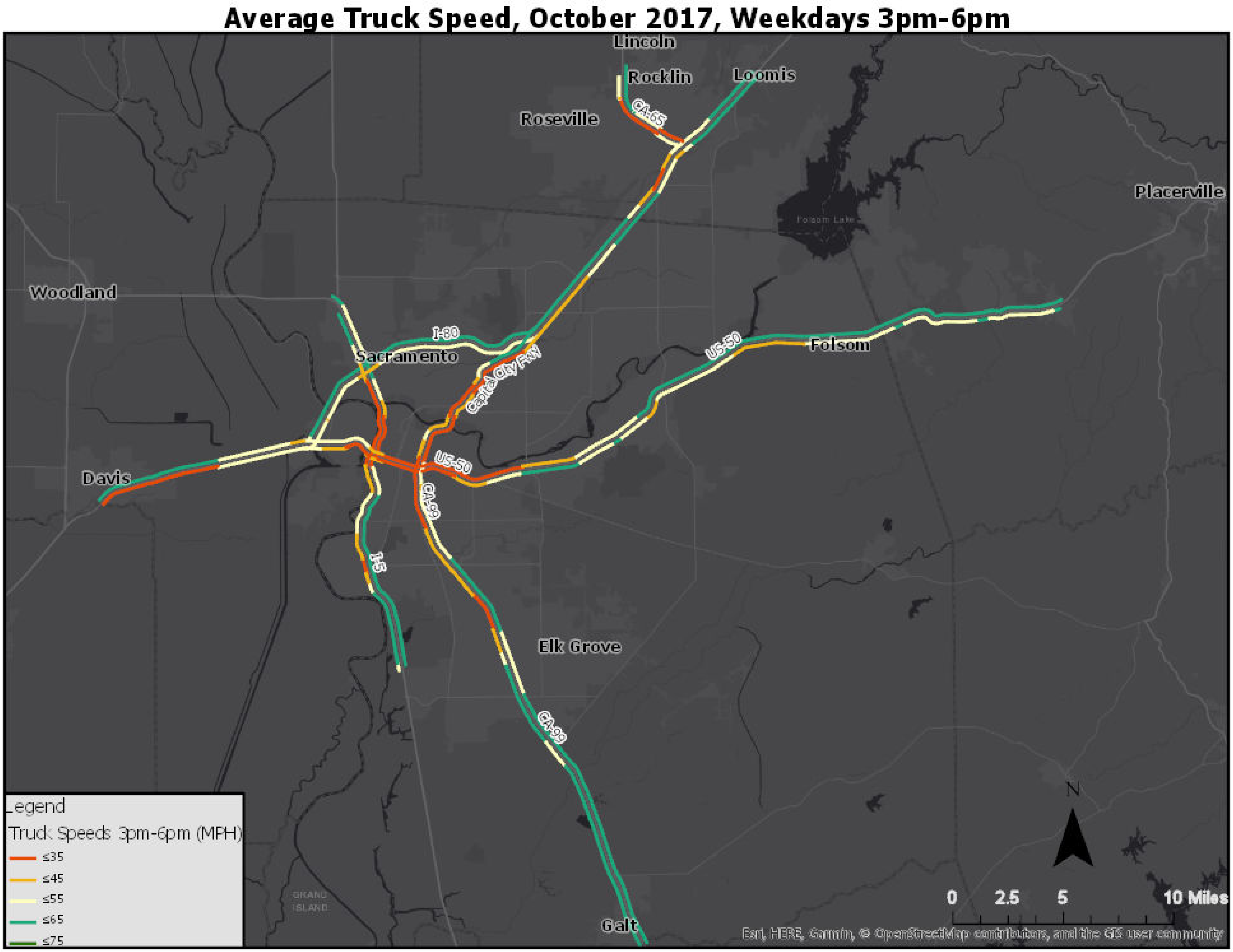


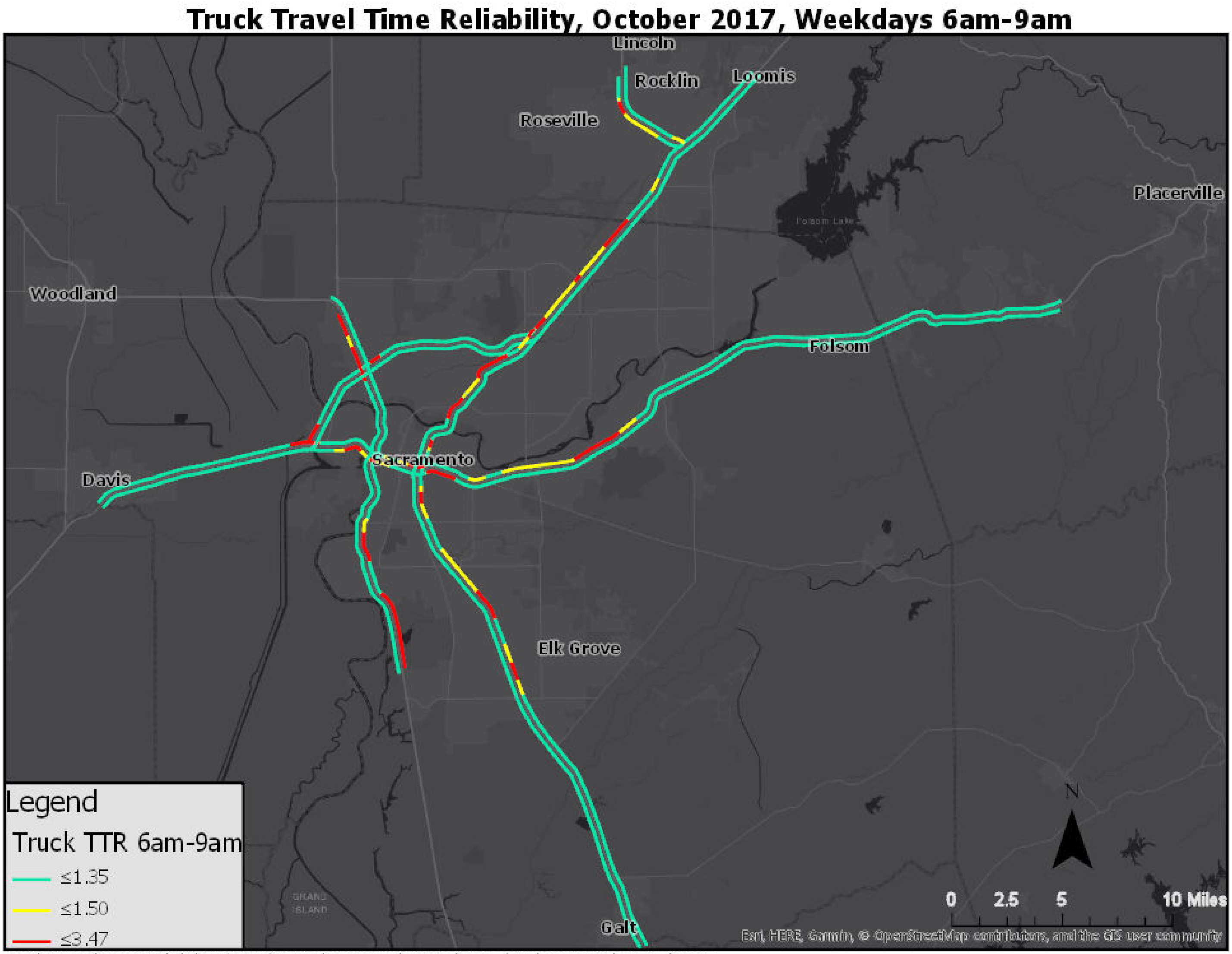
Figure 9 - Average Truck Speed on Freeways 3pm-6pm Weekdays, October 2017



Peak Period Truck Travel Time Reliability

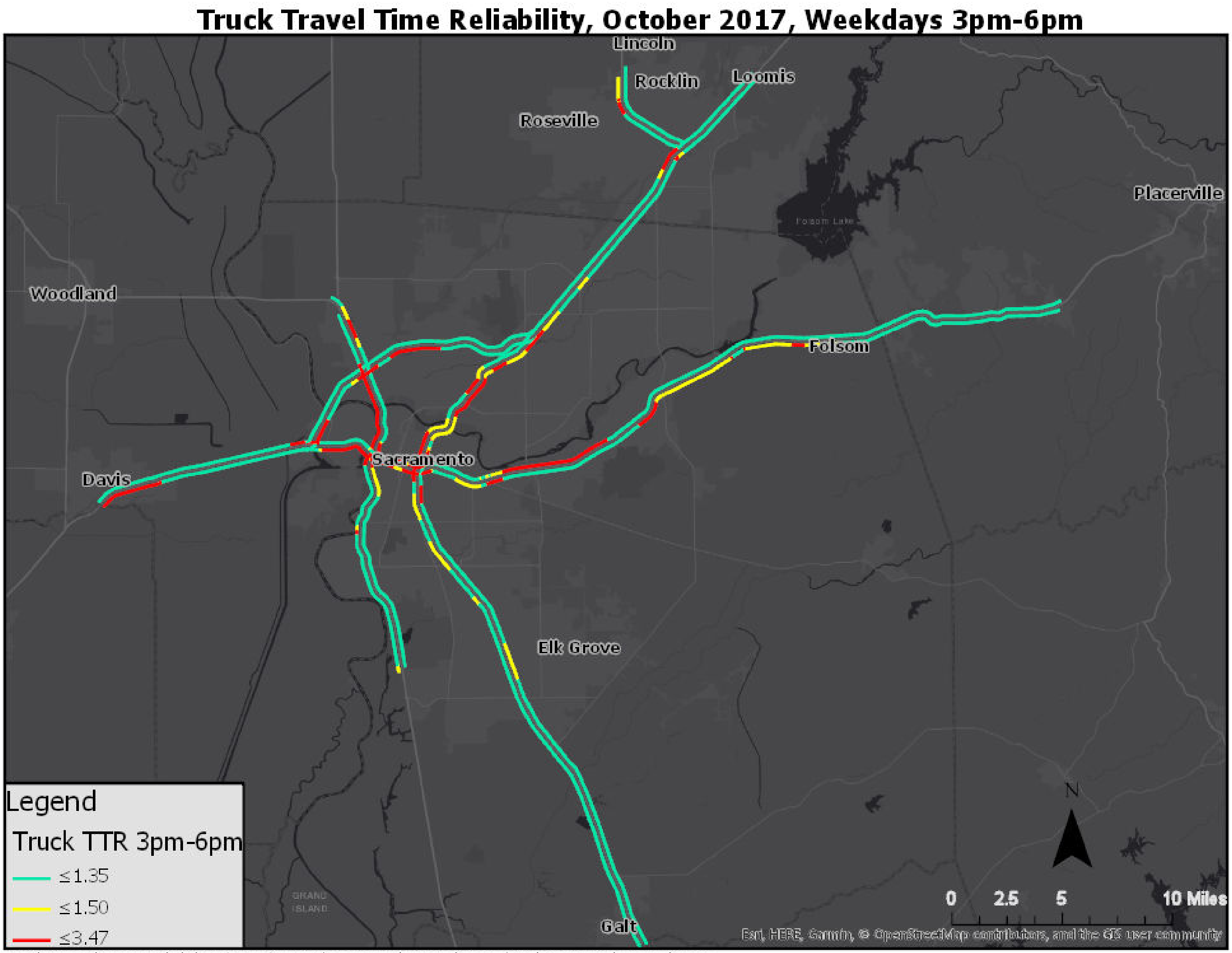
Figure 10 and Figure 11 map out peak period (6am-9am and 3pm-6pm) truck travel time reliability (TTTR) on CMP limited-access freeways during October 2017. As defined in the 2017 CMP report, TTTR is defined as the 80^{th} percentile truck travel speed divided by the 50^{th} percentile truck travel speed. Segments with a TTTR of less than 1.35 are considered reliable, a TTTR of 1.35 to 1.5 is 'moderately unreliable', and unreliable segments have a TTTR greater than 1.5 (the 80^{th} percentile travel time is more than 1.5 times the 50^{th} percentile travel time).

Figure 10 - Truck Travel Time Reliability, AM Peak, October 2017



Truck Travel Time Reliability (TTTR) = 80th percentile travel time / 50th percentile travel time

Figure 11 - Truck Travel Time Reliability, PM Peak, October 2017



Truck Travel Time Reliability (TTTR) = 80th percentile travel time / 50th percentile travel time

Changes Since 2017 CMP Report

Comparison of System-Level Metrics

Figure 12 and Figure 13 compare system-level metrics between last year's CMP Report, based on 2015 speed data from HERE Technologies, and this year's metrics, based on 2017 speed data from Inrix. Important to note is that any changes are *apparent* changes because, as discussed in the next section on dataset comparison, the vendor change from HERE to Inrix likely drove some of the apparent performance changes, making it difficult if not impossible to know how much of the difference was due to changes in real-world conditions. Unless otherwise stated, all observations are from weekdays during the AM peak in the month of October for both the 2015 and 2017 data sets.

Most notable in Figure 12 is the apparent increase in the percent of the CMP network that is reliable, with the share of reliable overall system mileage appearing to increase from 57 percent in 2015 to 84 percent during the AM peak in October 2017. However, this change is mostly driven by increases in reliability on arterials, whose share of reliable miles nearly doubled from 43 percent reliable to 80 percent reliable, and much less so by freeways, whose share of reliable mileage increased by fewer than three percentage points.

Apparent changes in congestion also stand out, but in the opposite direction. The share of congested freeway miles doubled from 4.4 percent to 8.4 percent during the AM peak in October 2017, reflecting a large proportional increase but a small absolute increase of only four percentage points. Similar to reliability, congestion appeared to change significantly more on arterials than on freeways, more than doubling from nine percent to 23 percent in the AM peak between 2015 and 2017.

The increase in both reliability and congestion imply that large portions of the CMP network, mostly on arterials, shifted from being "unreliably uncongested" to "reliably congested." There are several potential factors behind this change:

- Change in data vendor, which almost certainly drove at least part of the observed differences independent of any real-world changes that occurred between 2015-2017. A more controlled comparison of the Inrix and HERE datasets, discussed in greater detail in the next section on dataset speed comparison, suggests that when controlling for time period and location, HERE data show somewhat lower congestion and less reliability, matching the direction of the changes observed in Figure 12 and Figure 13.
- Changes to the CMP network due to changes in data availability. Several network segments whose data were included in the 2015 congestion and reliability calculations were not in the 2017 data set. These omissions were small and likely had a modest effect on the overall 2017 calculations.

We also explored the possibility that some parts of the CMP network became "reliably congested" by being on the cusp of being congested in 2015, but with an improving economy traffic volumes increased so that these portions became consistently congested, rather than intermittently congested. We discuss this in more detail below in the section on traffic volumes.

Figure 12 - 2015-2017 Reliability Comparison

Time Period	Oct LOTTR - Systemwide[1]	Percent of CMP Directional Miles			
		2015		2017	
6am-9am	Reliable (<1.5)	57.4%		83.6%	
	Unreliable (>=1.5)	35.1%		16.0%	
	Unreliable with Transit[3]		15.8%		7.7%
	No Data	7.5%		0.4%	
3pm-6pm	Reliable (<1.5)	50.1%		79.8%	
	Unreliable (>=1.5)	42.5%		19.8%	
	Unreliable with Transit[3]		18.7%		9.3%
	No Data	7.5%		0.4%	

Time Period Fwy	Oct LOTTR - Freeways Only[1]	Percent of CMP Freeway Directional Miles			
		2015		2017	
6am-9am	Reliable (<1.5)	87.3%		90.1%	
	Unreliable (>=1.5)	12.7%		9.6%	
	Unreliable with Transit[3]		4.5%		4.5%
	No Data	0.0%		0.3%	
3pm-6pm	Reliable (<1.5)	79.7%		85.6%	
	Unreliable (>=1.5)	20.3%		14.1%	
	Unreliable with Transit[3]		10.5%		8.1%
	No Data	0.0%		0.3%	

Time Period Artrl	Oct LOTTR - Arterials Only[1]	Percent of CMP Arterial Directional Miles			
		2015		2017	
6am-9am	Reliable (<1.5)	43.1%		79.8%	
	Unreliable (>=1.5)	46.5%		19.7%	
	Unreliable with Transit[3]		21.3%		9.5%
	No Data	10.4%		0.5%	
3pm-6pm	Reliable (<1.5)	36.1%		76.3%	
	Unreliable (>=1.5)	53.6%		23.2%	
	Unreliable with Transit[3]		22.6%		10.0%
	No Data	10.4%		0.5%	

1 LOTTR = level of travel time reliability, which is 80th percentile epoch travel time divided by 50th percentile epoch travel time.

2 Congestion level = observed average speed / unconstrained speed. Unconstrained speed is the 85th percentile epoch speed, or speed in the epoch that was faster than 85 percent of epochs for that road segment

3 Transit miles in HOV lanes are excluded because HOV lanes theoretically protect transit vehicles from congestion delay
Approximately 60 percent of CMP network miles are served by the CMP Priority Transit network

Figure 13 - 2015-2017 Congestion Comparison

Time Period	Oct Congestion - Systemwide[2]	Percent of CMP Directional Miles	
		2015	2017
6am-9am	Uncongested (>=0.6)	84.7%	81.4%
	Congested (<0.6)	7.9%	18.1%
	Congested with Transit[3]	3.8%	9.0%
	No Data	7.5%	0.4%
3pm-6pm	Uncongested (>=0.6)	70.0%	58.1%
	Congested (<0.6)	22.5%	41.4%
	Congested with Transit[3]	12.2%	23.0%
	No Data	7.5%	0.4%

Time Period Fwy	Oct Congestion - Freeways Only[2]	Percent of CMP Freeway Directional Miles	
		2015	2017
6am-9am	Uncongested (>=0.6)	95.6%	91.3%
	Congested (<0.6)	4.4%	8.4%
	Congested with Transit[3]	0.4%	3.8%
	No Data	0.0%	0.3%
3pm-6pm	Uncongested (>=0.6)	85.5%	79.5%
	Congested (<0.6)	14.5%	20.1%
	Congested with Transit[3]	7.8%	13.8%
	No Data	0.0%	0.3%

Time Period Artrl	Oct Congestion - Arterials Only[2]	Percent of CMP Arterial Directional Miles	
		2015	2017
6am-9am	Uncongested (>=0.6)	80.6%	75.6%
	Congested (<0.6)	9.0%	23.9%
	Congested with Transit[3]	5.1%	12.1%
	No Data	10.4%	0.5%
3pm-6pm	Uncongested (>=0.6)	63.8%	45.5%
	Congested (<0.6)	25.8%	54.0%
	Congested with Transit[3]	14.1%	28.4%
	No Data	10.4%	0.5%

1 LOTTR = level of travel time reliability, which is 80th percentile epoch travel time divided by 50th percentile epoch travel time.

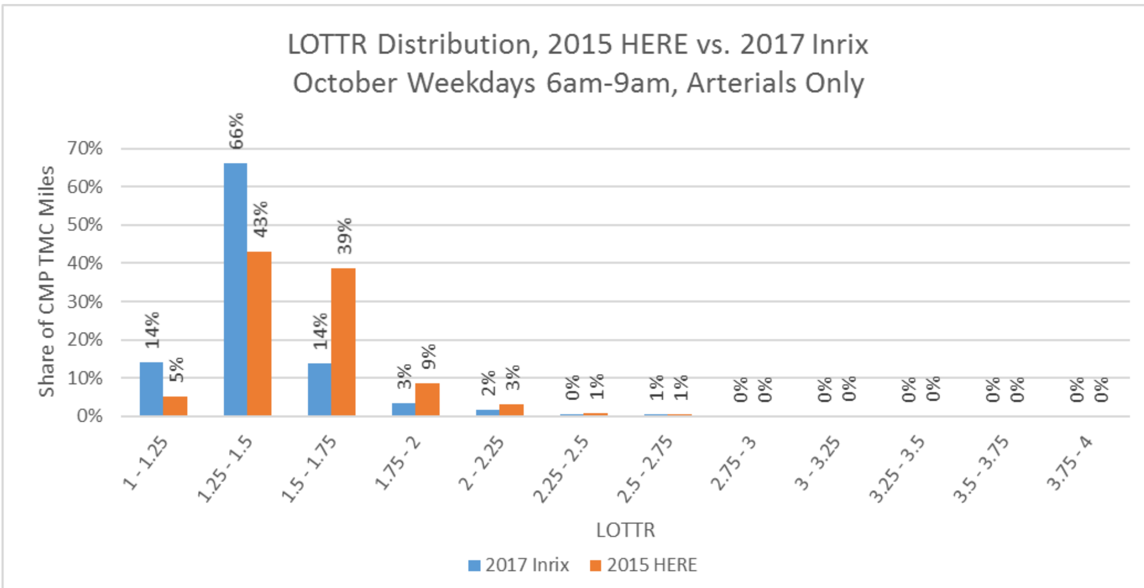
2 Congestion level = observed average speed / unconstrained speed. Unconstrained speed is the 85th percentile epoch speed, or speed in the epoch that was faster than 85 percent of epochs for that road segment

3 Transit miles in HOV lanes are excluded because HOV lanes theoretically protect transit vehicles from congestion delay
Approximately 60 percent of CMP network miles are served by the CMP Priority Transit network

Arterial Reliability Changes

Arterials appeared to become significantly more reliable from 2015 to 2017, with the share of reliable arterial miles in the AM peak nearly doubling. But as Figure 14 shows, this jump was largely driven by modest absolute changes in individual network segments. Most notably, the biggest change was due to segments having an unreliable LOTTR between 1.5 and 1.75 in 2015 moving to a reliable LOTTR between 1.25 and 1.5 in 2017. In other words, the *share* of reliable CMP network miles increased largely due to segments experiencing small absolute increases in reliability that "tipped" them from being slightly above the reliability threshold of 1.5 to being slightly below it.

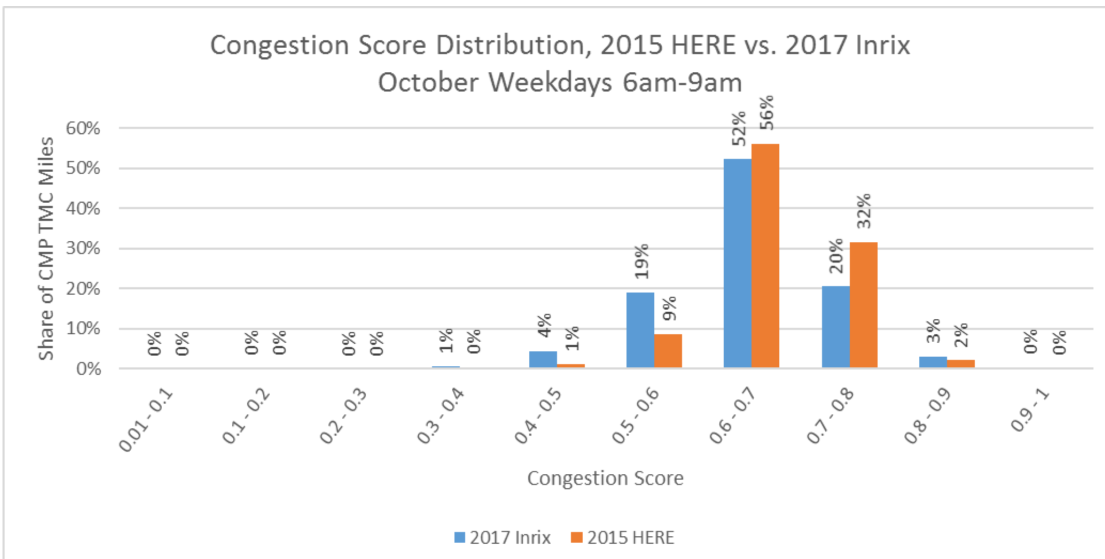
Figure 14 – Arterial LOTTR Frequency Distribution, October 2015 vs. October 2017



Arterial Congestion Changes

The increase in the share of CMP network that was congested also more significantly affected arterials, but did affect freeways to a greater extent than the changes in reliability. The histogram in Figure 15 illustrates some of the shifts between 2015 and 2017. Unlike the reliability changes, the absolute changes in congestion appear to be larger at the link level. I.e., whereas most of the LOTTR shift was from "slightly unreliable" to "slightly reliable", there was a larger shift in congested links from being substantially non-congested (with the AM peak speed being 70-80 percent of nighttime unconstrained speed[3]) to being slightly congested (AM peak speed being 50-60 percent of unconstrained speed).

Figure 15 - Arterial Congestion Frequency Distribution, 2015 vs. 2017



[3] "Unconstrained speed" refers to the speed corresponding to the 5-minute epoch range whose speed is faster than 85 percent of the other epochs in the 6pm-6am overnight time. This is an approximation of a "free-flow" speed and allows congestion to be normalized by road type (e.g., a congested speed for a freeway will not be considered a congested speed for an arterial).

Traffic Volume Changes Vs. Reliability and Congestion Changes

As mentioned earlier, many roads appear to have shifted from being "unreliable and uncongested" to "reliably congested" between 2015 and 2017. One possible explanation for this is an increase in traffic volumes on those roads, i.e., roads had 2015 traffic volumes that put them on the cusp of congestion gained enough extra traffic to make them consistently, or "reliably" congested.

We did not have readily available traffic count data for the CMP network to rigorously test this hypothesis, but looked at a small sample of count data for locations on the CMP network that became significantly more congested or more reliable to see if their traffic volumes changed. Table 2 highlights three locations that experienced significant apparent increases in congestion between 2015 and 2017 and looks at how their average daily traffic (ADT) changed during the same period. Further down, Table 3 looks at changes in traffic volumes at five locations that became significantly more reliable between 2017 and 2017.

The results show that, at least at the locations observed, traffic volumes did not change significantly between 2015 and 2017, even though these same locations appeared to have either significantly increased congestion or became significantly more reliable. Exceptions to this may be Watt Ave at the American River Bridge, which experienced a six percent increase in traffic volume which may have pushed it above its capacity, as well as Auburn Blvd at Madison Ave, which saw significantly improved reliability accompanying a nearly 10 percent drop in traffic volume.

Extrapolating to a system-wide level, seeing large changes in congestion and reliability even with small changes in traffic volumes that are both positive and negative suggests that these changes may be more due to data vendor differences rather than to significant changes in real-world conditions. However, making such an extrapolation is risky and must include the following caveats:

- The sample size, due to lack of available data for the years and locations desired, is very small and may not be representative of the whole CMP network.
- Traffic volumes are based on one to five days of count data at different times of the year, while the congestion and reliability data are based on all weekdays during the month of October.
- Traffic volumes are daily, while the congestion score is based on conditions during the peak periods. This means that although daily traffic volumes experienced minor changes between 2015 and 2017, volumes during the AM and PM peaks may have changed significantly.
- Without adequate information on each location's capacity, or the threshold volume at which it becomes congested or unreliable, it is hard to say whether the change in volume crossed that threshold.

Table 2 - Traffic Volume Changes at Locations with Increased Congestion

Traffic Volume Changes at Locations with a Significant Increase in Congestion

On Road	X Street	Congestion Change	ADT 2015	ADT 2017	ADT Change	Percent Change
WATT AVE	AMERICAN RIVER BRIDGE	-0.31	44,821	47,553	2,732	6%
FLORIN RD	CA-99	-0.17	35,993	36,485	492	1%
FOLSOM BLVD	BRADSHAW RD	-0.11	8,477	8,306	-171	-2%

Table 3 - Traffic Volume Changes at Locations with Improved Reliability

Traffic Volume Changes at Locations with a Significant Improvement in Reliability

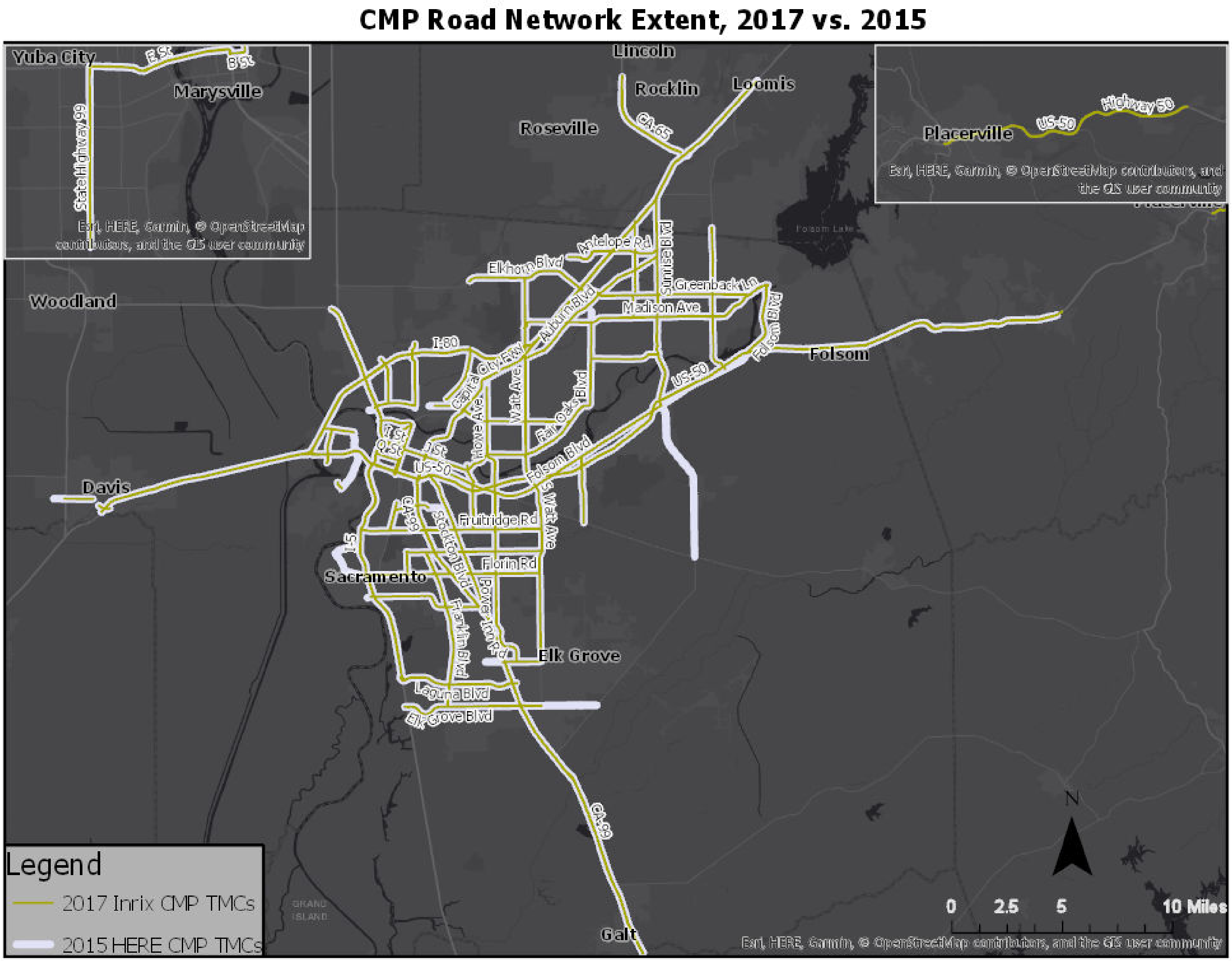
Street	X Street	LOTTR Change	ADT 2015	ADT 2017	ADT Change	Percent Change
AUBURN BLVD	MADISON AVE	-1.29	11,651	10,601	-1,050	-9%
47TH AVE	MARTIN LUTHER KING JR BLVD	-0.83	20,012	20,789	777	4%
SUNRISE BLVD	MADISON AVE	-0.67	21,615	21,933	318	1%
MANZANITA AVE	WINDING WAY	-0.51	13,890	12,960	-930	-7%
BRADSHAW RD	FOLSOM BLVD	-0.40	10,568	10,890	322	3%

Comparison of Road Network Extents

Figure 16 below overlays 2017 CMP network using Inrix TMCS on the 2015 CMP network, which uses HERE's TMCs. The light gray segments show portions of CMP arterials that had 2015 data but not 2017 data, including parts of Folsom Blvd, Sunrise Blvd, Elk Grove Blvd Jefferson Blvd in West Sacramento, and US-50 in Placerville, among others. While likely a small factor, this difference in network extent contributes to a difference in congestion and reliability levels at the system level.

Notably, Grant Line Road through the southeastern portion of Sacramento County is not currently included in the CMP network because at the time of this report it is not considered to be part of the National Highway System (NHS). However, given expected population and job growth along the Grant Line Corridor, it is likely it will be added to the CMP network in the future.

Figure 16 - 2015 vs. 2017 CMP Network Data Coverage (TMCs)



Comparison of Transit Network Extents

Transit Route Selection Criteria

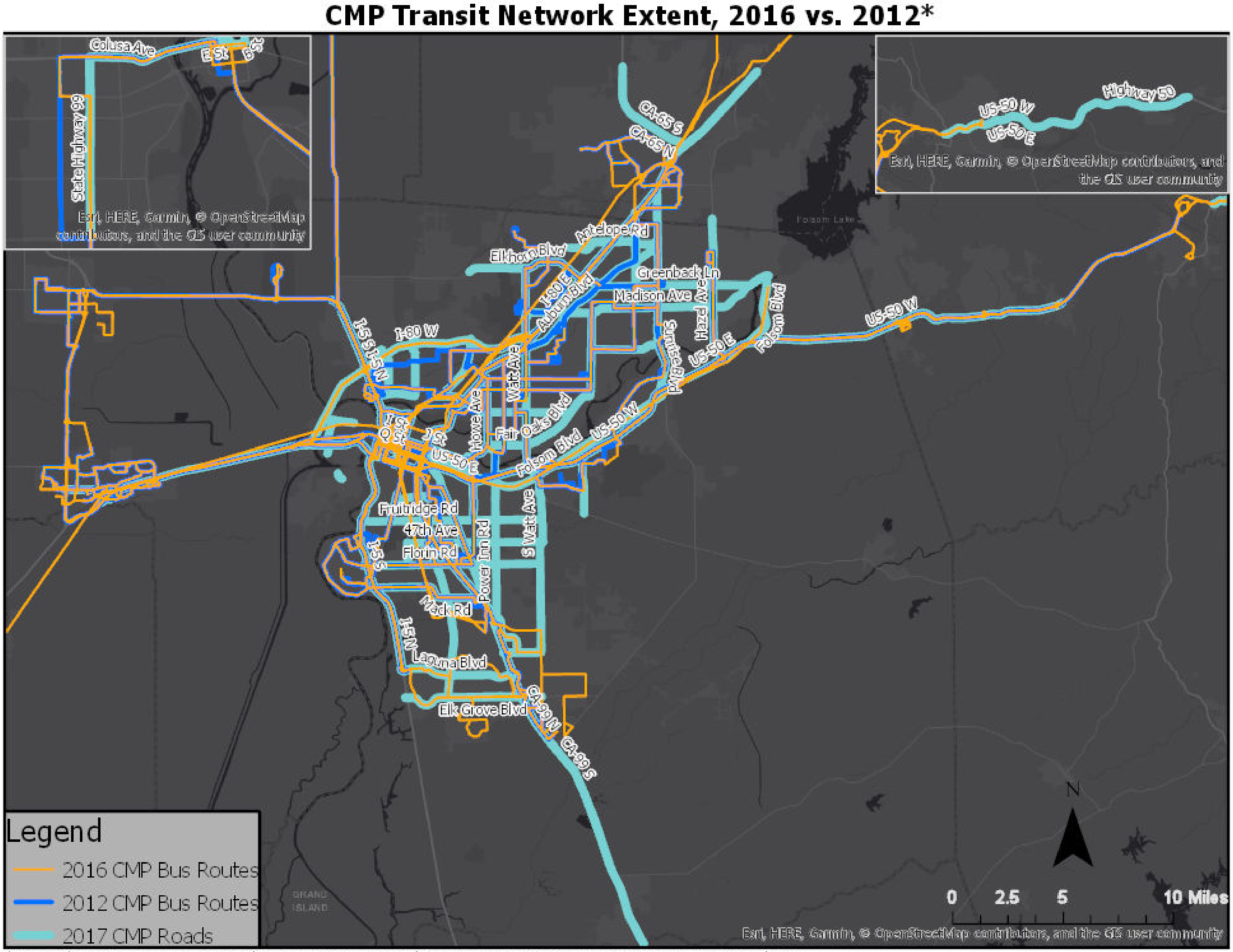
SACOG defined the transit network in its 2017 CMP Report by including only:

- Light rail and heavy rail lines,
- Local bus lines with more than 800 daily boardings in 2012
- Commuter bus lines with more than 20 boardings per trip in 2012

We used these criteria to update the transit network for this Monitoring Report, using 2016 transit ridership data. Figure 17 below overlays the 2016 transit network used for this Monitoring Report on the 2012 transit network used for the 2017 CMP Report. The most significant change between 2012 and 2016 was the addition to several commuter routes from Elk Grove and Placer County Transit's commuter route along I-80. Several local routes, however, fell off the CMP Priority Transit network, including SRTD routes 93, 86, and 1. These routes are still in service, but experienced ridership declines that placed them below the ridership threshold, 800 daily boardings, to be included in the network.

Changing the transit network extent along with the CMP road network changed the share of CMP network miles with transit and in turn at least partially explains the changes in the miles of congested CMP roads with transit service. Bearing these network changes in mind, the share of the CMP network that was congested or unreliable with transit service changed significantly between 2015 and 2017. However, as Figure 12 and Figure 13 showed earlier, the change was proportional to and in the same direction as the changes in the network as a whole.

Figure 17 - 2015 vs 2017 CMP Transit Network



*SACOG's 2017 CMP Report Used 2012 Transit Data. This 2018 Monitoring Report uses 2016 transit data.

Dataset Comparison

As mentioned in the previous section, we cannot assert that the congestion and reliability differences observed are due to changes in real-world conditions without knowing how having HERE as a data provider in 2015 versus Inrix as 2017's data provider affected the data values.

To better understand the potential influence of the data provider change on our metrics, we explored the differences for links that had overlapping data, specifically comparing speed, LOTTR, and the congestion score derived from each data set. To perform this comparison, we used one month of NPMRDS data, January 2017, with both HERE data and Inrix data, providing an opportunity to make the comparison while controlling for time period. For our comparison, we focused all calculations on weekdays in January 2017 for the 6am-9am peak period.

For each metric (speed, LOTTR, and congestion score), we looked at several high-level indicators including:

- *Largest negative/positive differences*, or the value corresponding to the TMC with the largest negative/positive difference between the Inrix in the HERE data. E.g., as Table 2 shows, the TMC on a freeway that had the largest negative difference had an Inrix-based speed that was 8.35 MPH slower than the HERE-based speed for the same location at the same time.
- *Average difference,* which is the average of the speed differences for all TMCs. E.g., per Table 2, arterial TMCs using Inrix-based data were on average 0.63 MPH slower than TMCs using HERE-based data.
- *Absolute average,* which is the same concept as the simple average difference, but averages only the absolute value of each difference. The absolute average better illustrates the magnitude of the difference than the normal average, which could appear very small if there are equal numbers of very large but opposite differences that cancel each other out (e.g. the average of +30 and -30 is zero but its absolute average is 30).

From this high-level overview, we take a more detailed look at the differences with histograms like Figure 18 which give a more nuanced idea of the magnitude and distribution of differences. From there we provide a spatial overview of where the greatest data set differences occurred with maps such as Figure 19.

Speed Comparison

Our speed comparison included Inrix TMCs[4] that had a corresponding TMC in the January 2017 HERE data, resulting in a comparison between 1,369 TMCs.

As shown in Table 2, Inrix-based speeds appear slightly slower than HERE-based speeds. Speeds on arterial TMCs generally differed by a greater magnitude than freeway TMCs, as shown by arterials having an absolute average speed difference of 2.53 MPH for arterials versus 1.31 MPH for freeways.

Table 4 - Aggregate Speed Comparison, HERE vs. Inrix Data, Jan 2017 AM Weekday Peak

Aggregate Speed Differences (Inrix Speed - HERE Speed, MPH)	Freeway	Arterial
Largest Negative Difference	-9.05	-17.71
Largest Positive Difference	10.45	32.67
Average Difference	-0.14	-0.68
Absolute Average Difference	1.31	2.53

Figure 18 dives deeper into the magnitudes of the speed differences between HERE and Inrix. As suggested by the small average values in Table 2, most of the CMP network's Inrix-based speeds were very close to the HERE-based speeds, particularly on freeways, with 59 percent of freeway miles having Inrix-based speeds within +/-1 MPH of their HERE-based speeds, and 99 percent of freeway miles having a speed difference between vendors within +/-5 MPH.

Compared to freeways, arterials showed larger speed differences between vendors, with only 37 percent of arterial miles having an Inrix-based speed within +/- 1 MPH of HERE-based speeds. However, arterials still showed generally small differences between their Inrix-based and HERE-based speeds, with 97 percent of arterial miles having a speed difference between vendors within +/-5 MPH.

[4] TMC = Traffic Message Channel. TMCs are the segments, usually one mile or less and lengths and split by direction, that make up the CMP road network and have vehicle speed data attached.

Figure 18 - Histogram Comparing Speed Differences for Inrix vs. HERE data by Facility Type

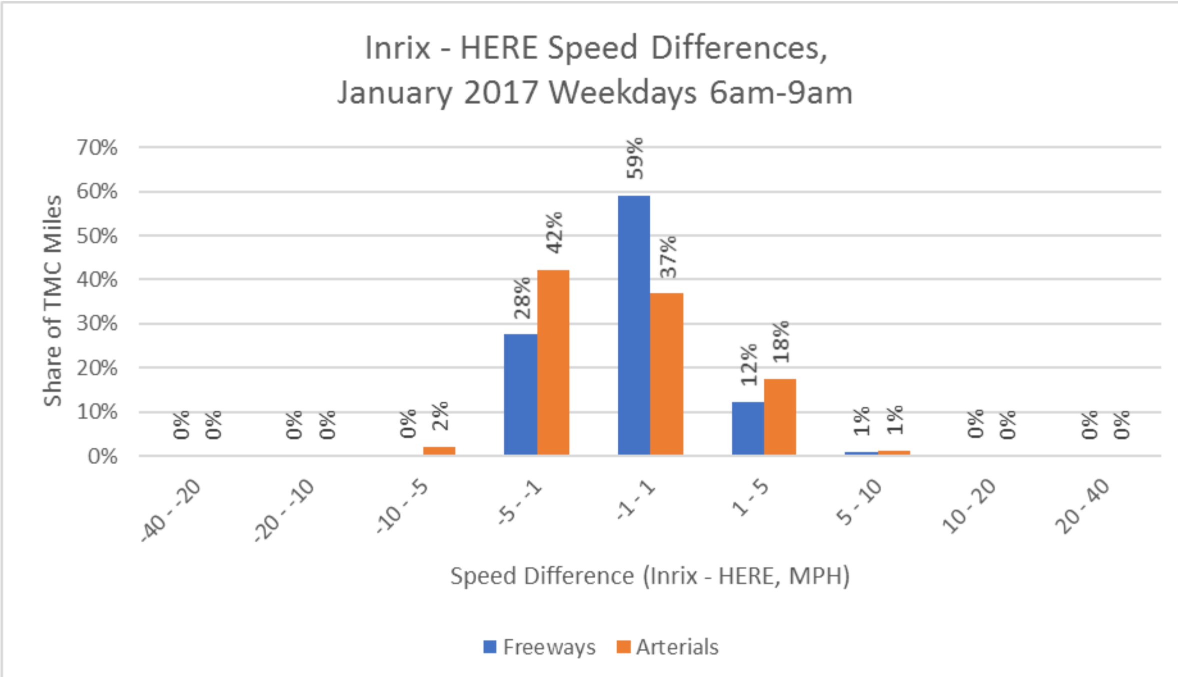
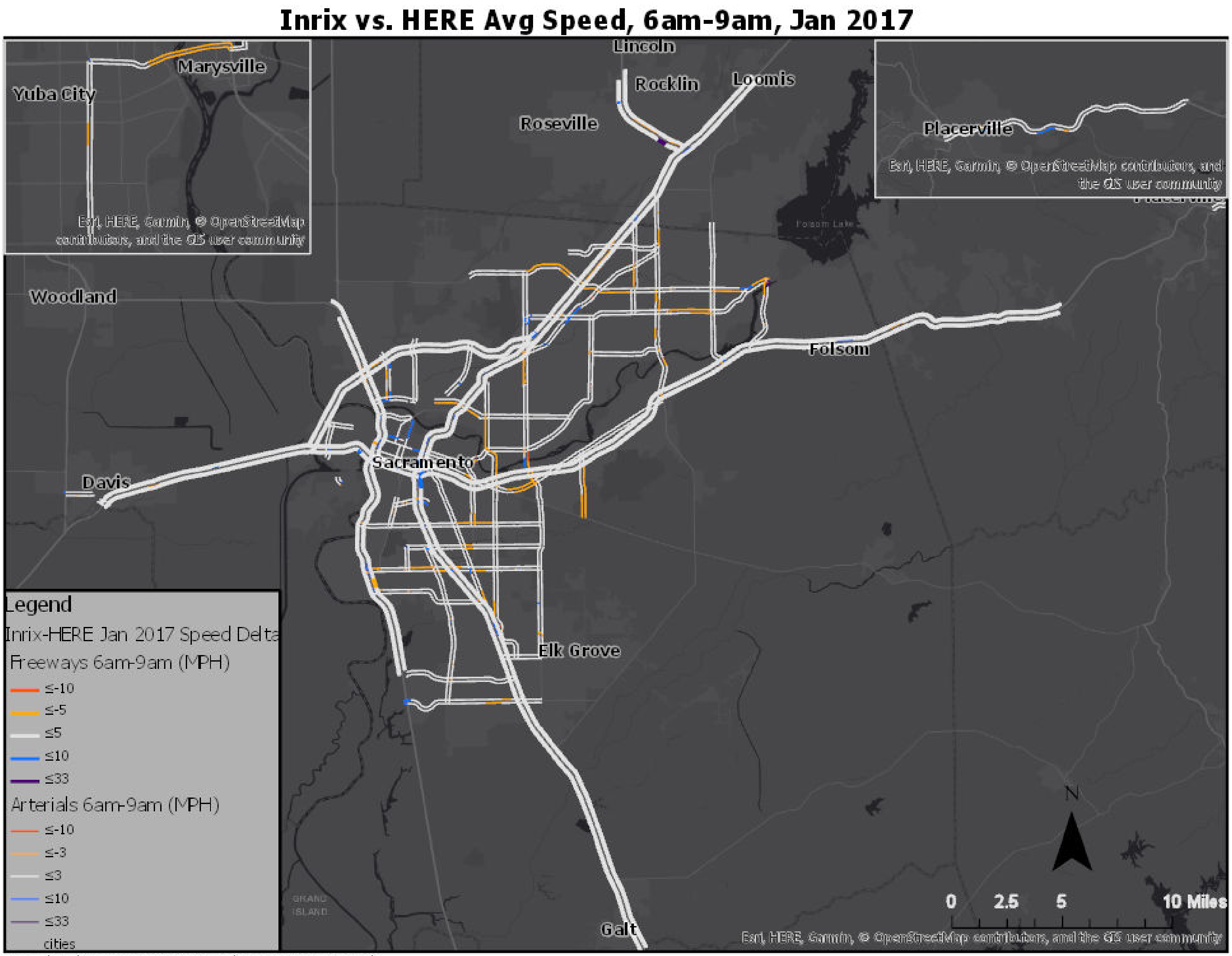


Figure 19 maps out differences in Inrix and HERE speeds at the link level and shows that most TMCs present relatively small differences (<5MPH) between the Inrix and HERE data sets. As suggested by both the map and above histogram, the largest speed differences occurred mostly on arterials. The tendency for more variation between vendors to occur on arterials may be due to one of several reasons, including:

- Small sample sizes from one or both vendors due to arterials generally having lower traffic volumes than freeways, especially when analyzing only one month of data for the peak AM hours. The section on data quality and observed differences below explores this factor in greater detail.
- More variability in speeds for any given sample due to traffic signal timing, at-grade cross traffic, etc.
- Inrix and HERE using different methods for cleaning removing outlier speeds from the data sets. These methods are proprietary so we are unable to compare them, but it is worth mentioning as a potential factor.

Figure 19 - Inrix - HERE Speed Differences, Jan 2017 Weekday AM Peak



Speed Delta = Inrix Avg Speed- HERE Avg Speed

LOTTR Comparison

The LOTTR comparison looked at 1,368 TMCs that were in both data sets and had sufficient data available from each data set to enable a comparison. As Table 3 shows, the average TMC's Inrix-based LOTTR was slightly lower than its HERE-based LOTTR, indicating that HERE data showed the average TMC to be less reliable than what the Inrix data showed.

As was the case with the speed differences, the difference between the HERE and Inrix LOTTR scores was higher for arterials than freeways, with arterials' average absolute LOTTR difference being 0.25 compared to 0.07 for freeways. Given that an LOTTR of 1.5 is the threshold between reliability and non-reliability, an absolute average difference of 0.25 that is essentially due to differences in data vendor suggests that the changes in arterial reliability seen earlier in Figure 12 are likely heavily influenced by the change from HERE to Inrix data, making it nearly impossible to say how much of the difference is due to real-world changes.

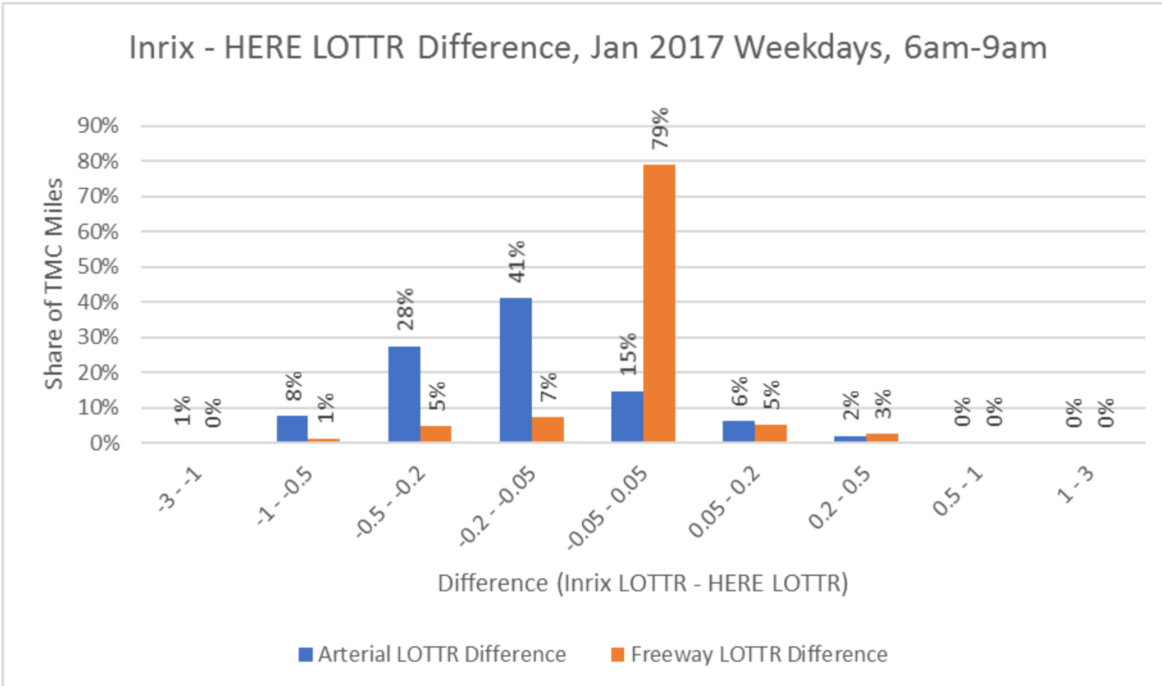
Table 5 - Aggregate Inrix - HERE LOTTR Differences, 6am-9am Peak January 2017

Aggregate LOTTR Differences (Inrix LOTTR - HERE LOTTR)	Freeway	Arterial
Largest Negative Difference	-1.56	-1.50
Largest Positive Difference	0.83	1.89
Average Difference	-0.03	-0.11
Absolute Average Difference	0.07	0.25

The histogram in Figure 20 gives a more nuanced view of the average differences above in Table 3. It corroborates the finding that the difference between the HERE- and Inrix-based LOTTR values is quite small for freeways, with nearly 80 percent of freeway CMP miles having an Inrix-based LOTTR that is within +/-0.05 of their HERE-based LOTTR.

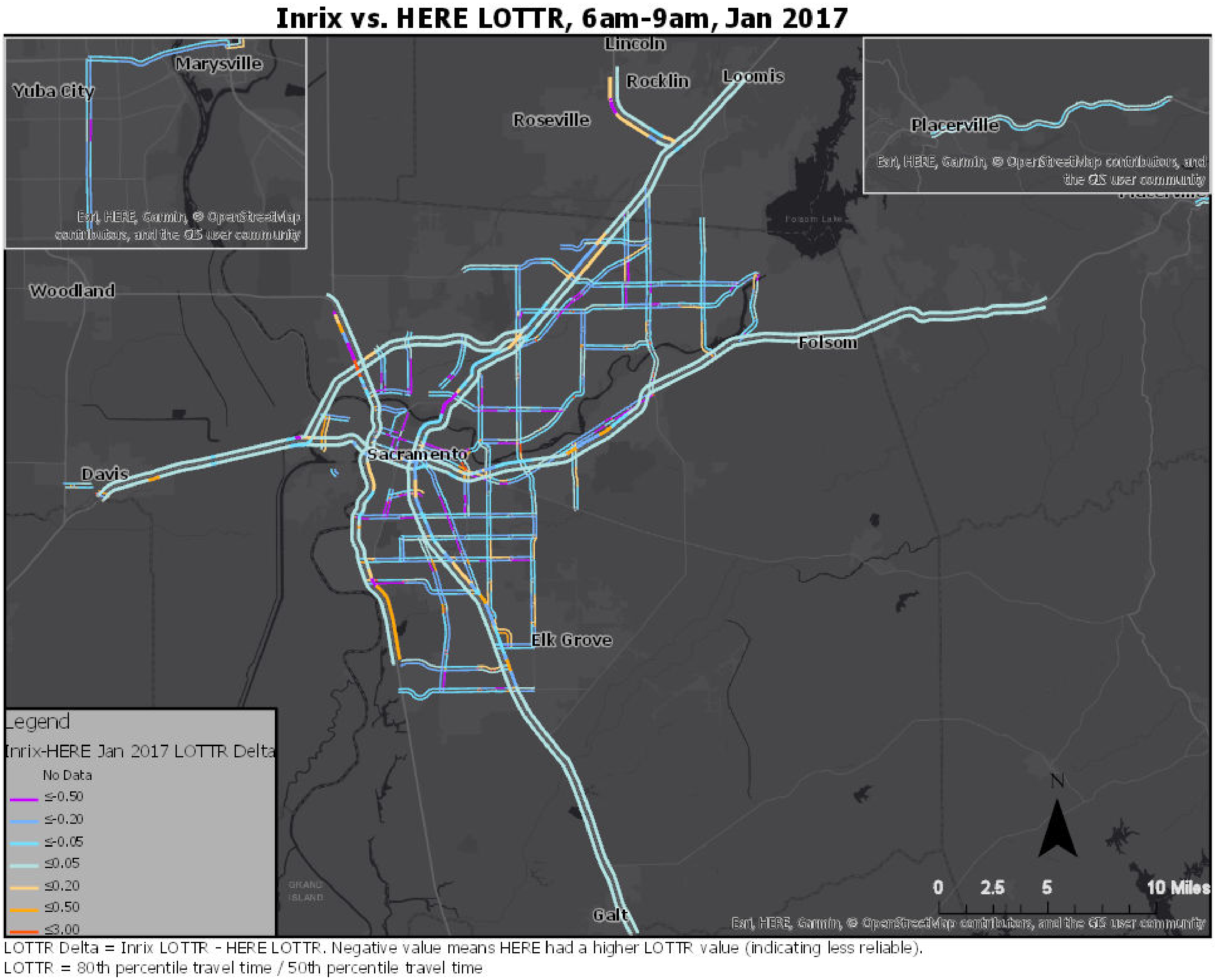
In contrast, Arterials show a clear bias in which their Inrix-based LOTTR is consistently and significantly lower than their corresponding HERE-based LOTTR. The lower Inrix LOTTR, observed even when controlling for time period, suggests that the significant increase in arterial reliability shown in Figure 12 is likely driven at least in part by the data provider change, rather than changes in real-world conditions.

Figure 20 - Inrix-HERE LOTTR Difference for Weekday AM Peak, Jan 2017



The map in Figure 21 provides an additional visualization of the differences between the HERE- and Inrix-based LOTTR values. Corroborating the findings in the histogram above in Figure 20, the significant differences are on arterials. Similar to the differences found between speeds, the larger LOTTR difference on arterials may be the result of lower data availability and smaller sample sizes on arterials due to lower traffic volumes. The section below on data quality and observed differences explores this issue in greater detail.

Figure 21 - Inrix - HERE LOTTR Differences, Jan 2017 Weekday AM Peak



Congestion Comparison

We compared congestion scores on 1,365 TMCs that were in both data sets and had sufficient speed data to calculate the congestion score and enable a comparison. Table 4 provides a high-level summary of differences, showing that on average, Inrix freeway TMCs had a mildly higher congestion score while Inrix arterial TMCs' congestion scores tended to be lower than HERE.

Table 6 - HERE vs. Inrix Congestion Score Comparison, Jan 2017 AM Peak

Aggregate Congestion Score Differences (Inrix Congestion - HERE Congestion)	Freeway	Arterial
Largest Negative Difference	-0.15	-0.45
Largest Positive Difference	0.18	0.51
Average Difference	0.02	-0.02
Absolute Average Difference	0.03	0.05

The histogram in Figure 22 shows the congestion score differences between the Inrix and HERE data sets during January 2017 in the 6am-9am weekday morning period. Further below, the map in Figure 23 maps out these differences at the TMC level. Similar to the pattern we found for speed and LOTTR differences, congestion score differences were generally smaller for freeways than arterials, with the difference between the Inrix-based congestion score and the HERE-based congestion score being less than +/-0.05 for 99 percent of CMP freeway miles. The difference between data sets was slightly larger for arterials, with 95 percent of arterials having their Inrix-based congestion score within 0.05 of their corresponding HERE-based congestion score.

For arterials with a more significant difference between the HERE-based and Inrix-based congestion levels, Inrix data tended to suggest modestly higher levels of congestion than the HERE data. For 16 percent of arterial miles, for example, the Inrix-based congestion score was between 0.05 to 0.1 less than the HERE-based congestion score.

The tendency for Inrix-based arterial congestion to be slightly worse, even when controlling for TMCs considered and time period, suggests that the apparent increase in congestion between 2015-2017, shown earlier in Figure 13 and Figure 15, is likely driven at least in part by differences in the data provider rather than real-world increases in congestion. However, as described in the next section on data quality, the size of the difference between Inrix and HERE appears to depend on data availability. In particular, the more data a TMC was missing, the greater the difference between the HERE-based and Inrix-based congestion score.

Figure 22 - Inrix-HERE Congestion Difference for Weekday AM Peak, Jan 2017

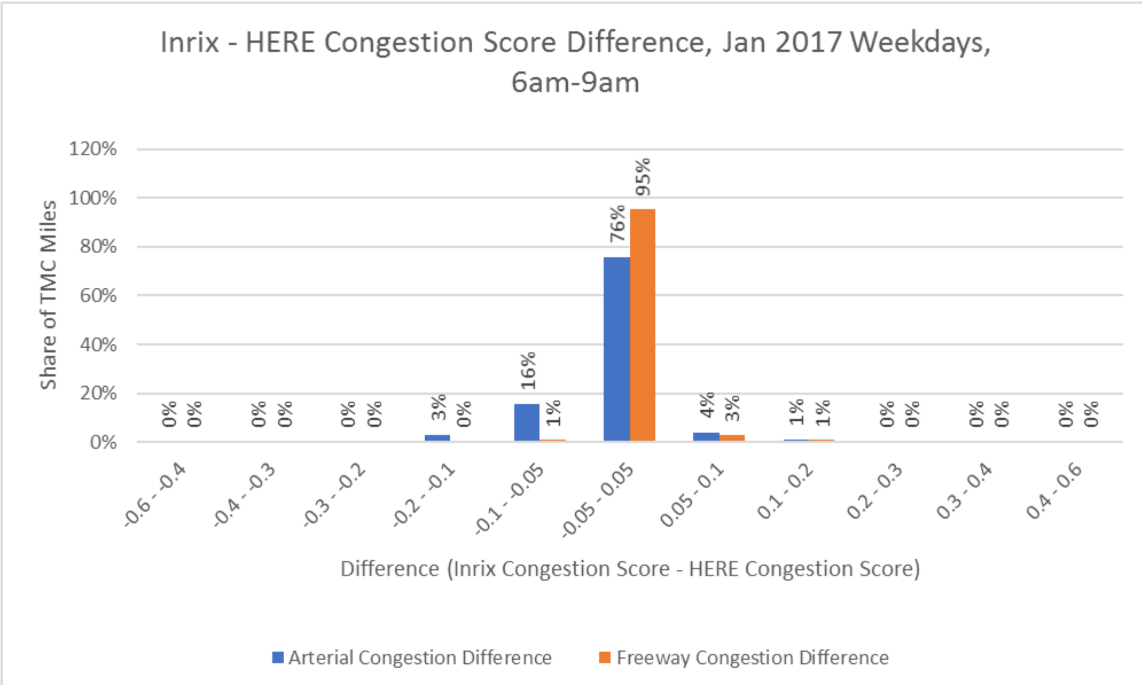
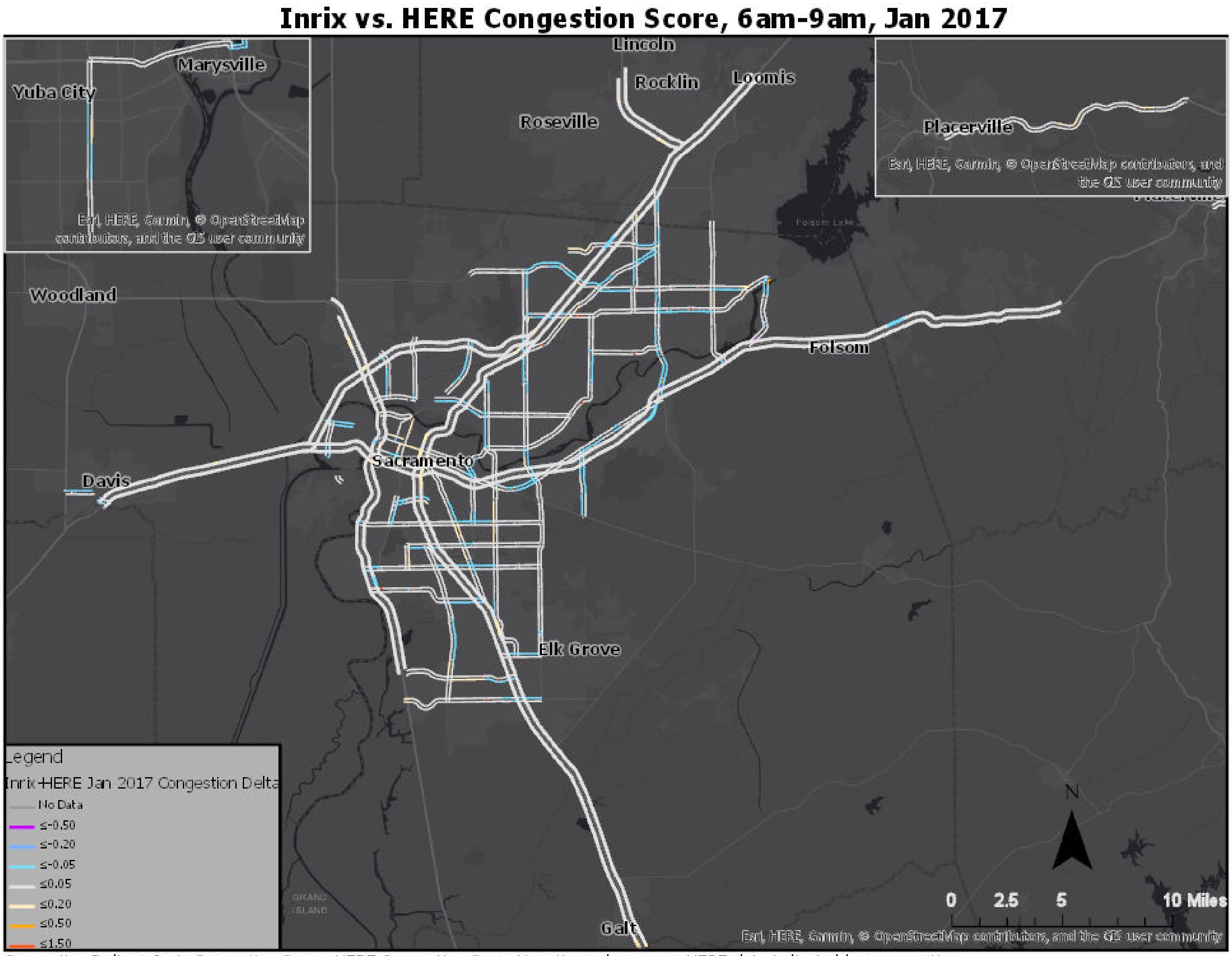


Figure 23 - Inrix vs. HERE Congestion Levels, AM Peak, Jan 2017



Congestion Delta = Inrix Congestion Score- HERE Congestion Score Negative value means HERE data indicated less congestion.
Congestion Score=Observed average travel speed / 85th percentile travel speed ("unconstrained" speed).

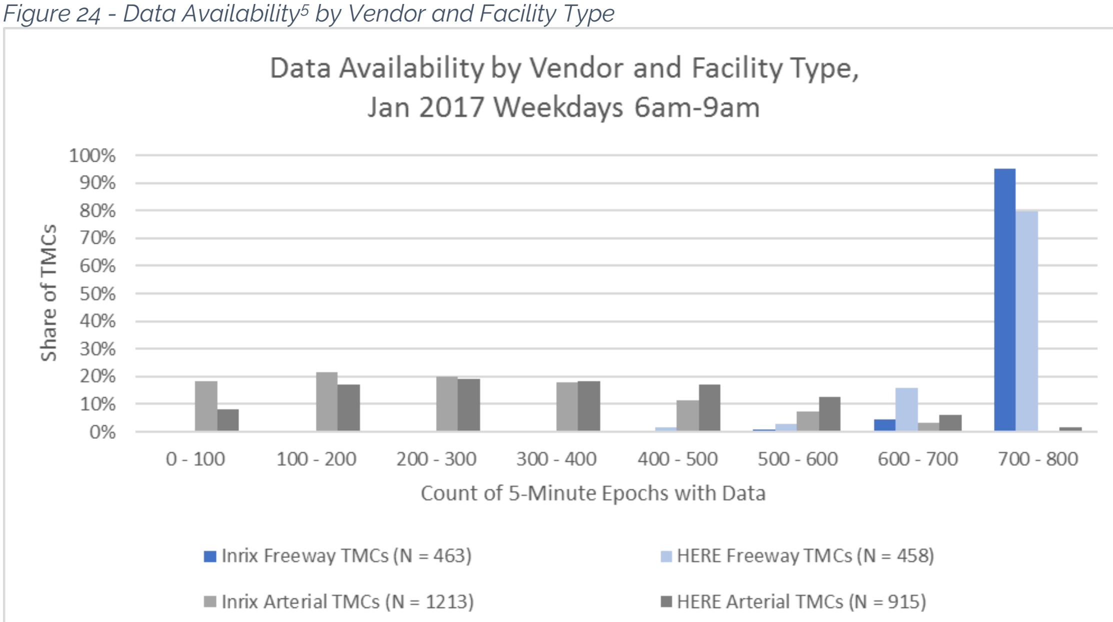
Data Quality and Observed Differences in CMP Metrics

When comparing speed, LOTTR, and the congestion score, a consistent theme was that arterials consistently showed a greater discrepancy between vendors than freeways did. One reason mentioned above and explored more is here that arterials have lower vehicle volumes than freeways. These lower vehicle volumes mean that, during a given time period, it is less likely that a vehicle with the necessary probe technology (smart phone with location services enabled, in-vehicle navigation system, etc.) will pass through the TMC and provide data.

The chart in Figure 24 illustrates data availability by comparing the number of epochs by facility type. "Epochs" are 5-minute time increments during which vehicle probes are measured traversing each TMC, and each epoch has a travel time and a speed associated with it, with the speed being the average speed of vehicles that traversed the TMC during the epoch. These epochs are the base data points on which the average period speed, LOTTR, and congestion scores are built, and if no vehicle probes are present during an epoch, then that epoch is said to be missing and is not factored in to larger averages. For example, if we want a TMC's average speed for one day during a 6am-9am period, we get the average of the speeds from the 36 five-minute epochs that are within that three-hour period. However, if no vehicles with probes passed during one or more of those 5-minute epochs, then those epochs are not factored into the three-hour average.

As Figure 24 shows, arterial speed, congestion, and LOTTR data are based on far fewer epochs of data than freeways. Because of their lower volumes, arterial TMCs are more likely to be basing their average speeds, LOTTR, and congestion on a smaller number of epochs than freeways and consequently have more volatility due to the small sample.

Figure 24 - Data Availability[5] by Vendor and Facility Type



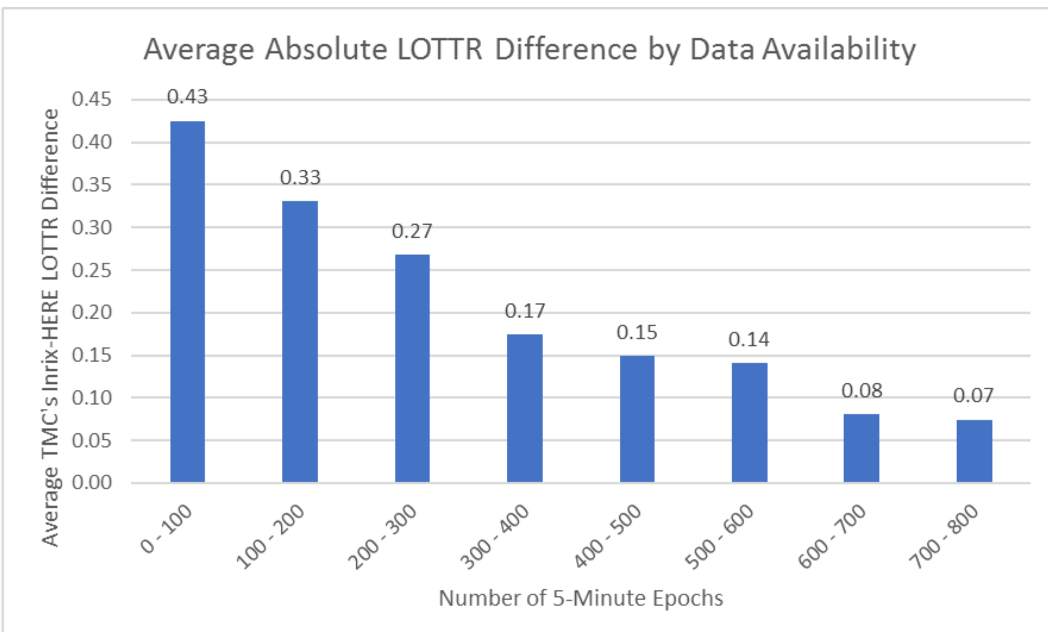
[5] For our comparison period (Jan 2017 weekdays 6am-9am), there were a total of 792 possible epochs that could have had data (12 epochs per hour * 3 hours per day * 22 weekdays in Jan 2017 = 792 epochs)

Keeping in mind the finding that arterials generally have less data available (i.e., fewer epochs with data), Figure 25 shows a distinct trend in which the absolute difference between HERE- and Inrix-based LOTTR scores generally declines as the number of epochs on a TMC increases. In other words, the more epochs with data that a TMC had during the January 2017 control period, the smaller the difference between its Inrix- and HERE-based speed, LOTTR, and congestion.

An important implication of this finding is that the modest differences between 2015-2017 seen in Figure 12 and Figure 13 are probably reflective of real-world changes for freeways, which have higher vehicle volumes and therefore more epochs with data. In contrast, the large changes shown for arterials are less likely due to real-world changes and more the result of differences due to data vendor.

This finding is also important to consider going forward for evaluating changes in performance, even if using the same vendor, by requiring us to consider sample size when trying to identify which areas experienced a real-world change in performance versus which areas' apparent changes may be due more to random variation due to a small sample size (i.e., a small number of epochs).

Figure 25 - Data Availability vs. Inrix-HERE LOTTR Difference, January 2017 AM Peak



Considerations for Future CMP Updates

The next CMP update will be a "major" update and will review what metrics should be updated, added, or removed as CMP metrics, in addition to providing up-to-date performance numbers. Ideally the data provider for the NPMRDS traffic speed data will not change between this update and the next one, so as to enable a more apples-to-apples comparison of different years of data without having to be concerned about differences existing due to who the data provider is.

However, even if the next CMP update uses the same data provider, it will be important to factor in data availability and sample size when attempting to explain changes in performance. In particular, if there are parts of the network that experience very large changes in performance, it will be important to investigate how complete the data are for those parts.