Validation of Streetlight Insight® 2021 Vehicle Volume Metrics in Maine

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The Transportation Infrastructure Durability Center (TIDC) is the 2018 US DOT Region 1 (New England) University Transportation Center (UTC) located at the University of Maine Advanced Structures and Composites Center. TIDC's research focuses on efforts to improve the durability and extend the life of transportation infrastructure in New England and beyond through an integrated collaboration of universities, state DOTs, and industry. The TIDC is comprised of six New England universities, the University of Maine (lead), the University of Connecticut, the University of Massachusetts Lowell, the University of Rhode Island, the University of Vermont, and Western New England University.

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16 Abstract

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List of Key Terms

- AADT: Annual Average Daily Traffic
- MADT: Monthly Average Daily Traffic
- DOW: monthly average daily traffic for Days Of the Week
- HOD: monthly average hourly traffic for Hour Of the Day
- TMC: Turning Movement Counts
- MAPE: Mean Absolute Percent Error
- NRMSE: Normalized Root Mean Square Error
- IQR: InterQuartile Range

Abstract

The University of Maine's Margaret Chase Smith Policy center undertook a validation effort on behalf of MaineDOT to better understand the accuracy of StreetLight Insight's vehicle volume metrics for monthly, daily, and hourly time periods. We examine the impact of two characteristics of the traffic counter location on the accuracy and precision: the annual average daily traffic (AADT) and MaineDOT's factor group classification. The factor groups were created to classify roads with high and low seasonal variability of traffic volume due to tourism. We also present a preliminary analysis of StL's turning movement counts (TMC). We employ similar statistical methodologies to those published by StL and the FHWA (Federal Highway Administration) to validated StL's AADT metrics. We find that the accuracy of the MADT and DOW estimates are very similar to the AADT estimates and should therefore be considered sufficiently accurate in most cases. The use of StL's MADT estimates for low-volume roads (under 5,000 AADT) will require judgment on the part of MaineDOT's staff and consultants before use in transportation planning. The Levene's test of equality of variance finds that the variance of StL metrics is different between Factor Group I & II, meaning that Factor Group two is significantly affecting the precision of the MADT, whereas the AADT Range does not significantly change the variance. In the analysis of the Day of the Week (DOW estimates), there is a significant difference in accuracy between weekdays (Mon-Fri) and weekends (Sat-Sun). The analysis of the Hour of the Day (HOD) estimates found that StL underestimates traffic volume in the morning, and increasingly overestimates traffic in the afternoon and evening. Using the average difference of short-term counts of 1.8% (as a percent of intersection traffic), 62.5% of turning movements could be considered within an acceptable error margin.

Executive Summary

Introduction

Streetlight Insight® provides calibrated estimates of traffic volume for all roads across the United States and Canada, using large and anonymous location-based services collected from cellphone apps.1 The Maine Department of Transportation (MaineDOT) has a license to use these metrics for traffic planning and engineering studies, as well as for the operation and maintenance of road infrastructure. The University of Maine's Margaret Chase Smith Policy center undertook a validation effort on behalf of MaineDOT to better understand the accuracy of StreetLight Insight's vehicle volume metrics for monthly, daily, and hourly time periods:

- MADT: Monthly Average Daily Traffic
- DOW: Monthly Average Daily Traffic for Days Of the Week
- (Mon-Sun & weekdays vs weekend)
- HOD: Monthly Average Hourly Traffic for Hour Of the Day
- (24hr, 12hr peak, 5 StL-determined default time periods)

Streetlight (hereafter StL) has internally validated the accuracy of its annual average traffic volume estimates. This report describes our efforts to validate the accuracy of StL metrics for the time periods outlined above. We used one year of hourly data collected in 2019 from 48 fixed physical counters Automated Traffic Recording (ATR) Stations. The StL metrics for the same locations and dates were generated in May 2021, using the newly released 2021 AADT metrics with improved accuracy in low-volume roads.

We examine the impact of two characteristics of the traffic counter location on the accuracy and precision: the annual average daily traffic (AADT) and MaineDOT's factor group classification. The factor groups were created to classify roads with high and low seasonal variability of traffic volume due to tourism. We also present a preliminary analysis of StL's turning movement counts (TMC).

Methodology

The first part of this validation verifies the completeness of the StL and MaineDOT's data sets to ensure that the distribution of missing data does not introduce bias into the analysis. Datasets for MADT and DOW time periods are mostly complete, with only 9% and 6% of data missing respectively. The missing ATR data appear to be due to equipment outages. StL's missing data occurs on low-volume roads, where a low device count triggers a data suppression mechanism meant to ensure privacy. In contrast, the HOD dataset for the full 24-hour period is missing 46% of the StL hourly estimates, and between 60 to 90% of StL estimates between 6pm to 6am.

We employ similar statistical methodologies to those published by StL and the FHWA (Federal Highway Administration) to validated StL's AADT metrics. This allows us to generate

[1] See https://www.streetlightdata.com/ for further introductory material to their data and platform.

comparable results for the MADT, DOW, and HOD time periods. The exploratory data analysis uses linear regression and the coefficient of determination (R2) to determine the overall fit of StL metrics, and in addition, uses:

- Boxplots visualize the average error and spread of error
- Probability distribution functions visualize bias either over or under estimation
- Scatter plots and bar charts visualize distribution of error across possible explanatory variables.
- Summary tables provide statistics on the error across variables and show whether the variables significantly affect the accuracy of the volume metrics.

We use the same precision targets used by StL for the median percent error (MPE), mean absolute percent error (MAPE), and the normalized root mean square error (NRMSE), by AADT range - see Table 1.

Table 1. StL AADT validation and precision threshold by AADT range

	MPE (%)	MAPE (%)	NRMSE (%)
AADT Range	Target	Target	Target
500 - 1,999	0.0%	10.0%	12.9%
2,000 - 4,999	2.2%	10.4%	17.2%
5,000 - 9,999	3.1%	9.2%	13.9%
10,000 - 19,999	1.1%	8.9%	12.9%
20,000 - 34,999	0.8%	8.1%	13.2%
35,000 - 54,999	0.4%	7.2%	9.7%

Results of Monthly ADT and Day of Week ADT

We find that the accuracy of the MADT and DOW estimates are very similar to the AADT estimates and should therefore be considered sufficiently accurate in most cases (see seasonality and traffic volume discussion below). A linear regression of StL MADT data for all locations and road volumes results in an R^2 of 0.979, a result very close to the R2 of 0.9782 reported in StL's 2019 AADT validation paper. Table 2 shows the MPE, MAPE, and NRMSE for AADT, MADT and DOW time periods, grouped into AADT ranges.

Table 2. MADT and DOW summary statistics

	MPE (%)				MAPE (%)				NRMSE (%)			
AADT Range	Target	AADT	MADT	DOW	Target	AADT	MADT	DOW	Target	AADT	MADT	DOW
500 - 1,999	0.0	-6.9	-	-	10.0	15.2	-	-	12.9	19.4	-	-
2,000 - 4,999	2.2	-5.7	14.7	14.9	10.4	12.5	19.8	22.0	17.2	16.4	24.0	26.6
5,000 - 9,999	3.1	-3.3	6.4	5.4	9.2	10.5	8.8	11.7	13.9	13.4	9.7	14.8
10,000 - 19,999	1.1	-2.0	-1.0	-2.2	8.9	9.5	7.6	10.4	12.9	12.1	9.9	13.2
20,000 - 34,999	0.8	-2.2	-5.6	-8.6	8.1	8.9	12.3	14.4	13.2	11.7	13.1	16.8
35,000 - 54,999	0.4	-1.9	3.8	1.2	7.2	8.3	5.1	8.9	9.7	11.1	6.9	11.5
All Roads		-	4.1	2.4		-	10.6	12.9		-	14.7	21.3

Impact of AADT Road Volume

StL's validation report states that, as the number of devices increases along road segments, the volume metrics become more accurate. We concur, finding that roads with over 5,000 AADT have a MAPE of about 8.5%, compared to 19.8% for roads under 5,000. The median bias and NRMSE also improves (decreases) with increases in traffic volume.

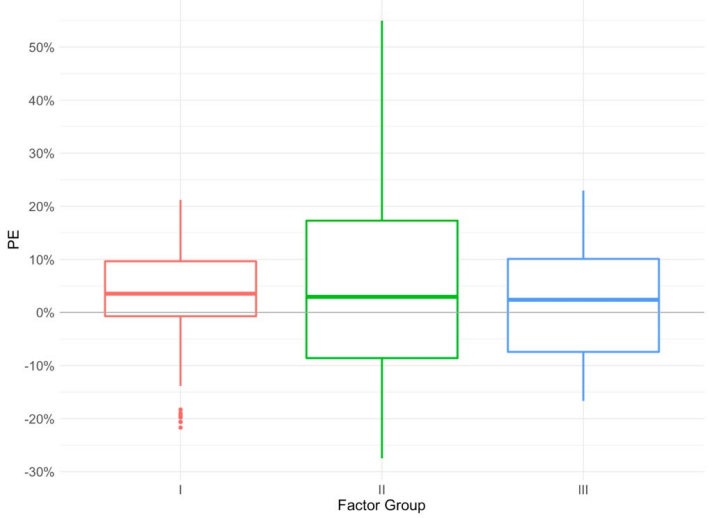
This finding suggests that the use of StL's MADT estimates for low-volume roads (under 5,000 AADT) will require judgment on the part of MaineDOT's staff and consultants before use in transportation planning. StL continues to improve the accuracy of vehicle volume metrics, and this should be reviewed in the future. In the meantime, we recommend using the AADT metric for roads under 5,000 AADT.

Impact of Seasonality and Factor Group

We also examine the change in accuracy and precision by month and across roads that experience more variability of traffic volumes from the summer to winter season. The MADT median and interquartile range (IQR) - middle 50% of data - is lowest and most accurate during the summer and fall, corresponding with the peak tourism period from July to September.

While we know that increases in volume improve accuracy, we want to understand if the seasonal traffic variability is also impacting the precision of StL estimates independent of the annual average traffic volume. Figure 1 shows a box plot of MADT percent error by Factor Groups, which shows that Factor Group 2, representing 16 ATR counters, has the largest percentage error as measured by the MAPE and IQR. Factor Group 1 (23 counters) and Factor Group 3 (5 counters) have smaller MAPE and IQRs.

Figure 1. Box plot of MADT percent error by Factor Groups



The relative factor analysis test measures the contribution to the total R2 of a regression by a group of variables. For MADTs, 10.3% of the R2 is explained by both the AADT and factor group classification. Of that 10.3%, 92% is attributed to the AADT while the remaining 8% is attributed to the factor group. The Levene's test of equality of variance finds that the variance of StL metrics is different between Factor Group I & II, meaning that Factor Group two is significantly affecting the precision of the MADT, whereas the AADT Range does not significantly change the variance.

Days of the Week

In the analysis of the Day of the Week (DOW estimates), there is a significant difference in accuracy between weekdays (Mon-Fri) and weekends (Sat-Sun). The median PE (percent error) of weekdays is -1.1%, whereas the median PE of weekends is 14.9%. During the winter months, the MAPE of DOW estimates increases for both weekdays and weekends. As the summer weekend traffic increases, the MAPE decreases. Throughout the year, Weekday (M-F) MAPE ranges from 9.3% -13.5% and weekend MAPE ranges from 15.2% -24.2%.

Hour of the Day

The analysis of the Hour of the Day (HOD) estimates found that StL underestimates traffic volume in the morning, and increasingly overestimates traffic in the afternoon and evening. This over/under estimation trend is observable during all seasons and across all traffic volumes. It is possible that the calibration of the StL algorithm does not account for local conditions in Maine, such as the earlier workday start times, or the driving requirements of the rural-based economy. The reasons for a skewed error profile requires further investigation by StL's data analyst team.

Turning Movement Counts

We present a preliminary evaluation of StL's new turning movement count metrics, which were released in the spring of 2022. Validation of this data is challenging due to the smaller volumes for individual turning movements, and the smaller number of counts undertaken per year across the state. MaineDOT provided daily TMC observations for 30 intersections that have two short-term counts (STC) conducted within the last 5 years. MaineDOT proposed evaluating turning movement counts as the percentage of the total intersection traffic because this ratio is more useful for traffic signal design. StL's TMC precision is compared to the difference between the two STCs at that intersection. The median percent error of Streetlight's estimate as a proportion of the error of the STC is -24.8%, meaning that StL is underestimating TMCs. The MAPE is 69.5%, which is quite high compared to the MADT's MAPE of 10.9% and the MAPE 20% for low-volume roads.

The precision threshold using the short-term counts is too variable and yields inconsistent results, and only 20% of TMC pass the test. We suggest using the average difference of short-term counts of 1.8% as the precision threshold for turning movement count accuracy. Using this target, 62.5% of turning movements are considered acceptable. Since the StL TMC metrics have only been available for a year, we anticipate that their algorithms will improve as more calibration data becomes available. We recommend future validation of the turning movement counts in order to assess their reliability and use as a substitute for field counts.

Conclusions

This report has validated StL's monthly average traffic volume estimates across a range of roads in Maine, as well as through a preliminary analysis of turning movement counts. We found that most MADT metrics, and monthly daily and hourly metrics are within industry standards for accuracy and variance. Larger errors are found where there are few devices recorded - including low volume roads below 5,000 AADT, seasonal roads within Factor Group 2, as well as off peak hours (7 pm - 6 am).

StL's AADT vehicle volume metrics have continued to improve with each iteration of its algorithm. We recommend ongoing monitoring of Streetlight's published validation white papers for vehicle volumes, turning movement counts, as well as the new pedestrian and bike count metrics.

Chapter 1: Introduction and Background

1.1 Project Motivation

This validation effort seeks to better understand the accuracy and reliability of StreetLight Insight's (StL) vehicle volume metrics. These metrics are used in planning and traffic engineering studies, as well as for planning in operations and maintenance improvements of road infrastructure.

StL metrics are a new and powerful tool for transportation planners and engineers providing numerous data and time ranges that would be otherwise cost prohibitive. The traditional method for DOTs to estimate average daily traffic for roads is to collect traffic counts from either short-term counts or more advanced permanent traffic counters. The cost of operating these counters can be expensive, only providing snapshots of traffic at a few locations.

StL offers traffic volume estimates for all US and Canada locations for time periods as small as 15 minutes and produces results in response to requests made by users of StL's online analysis platform. Traffic volumes can be estimated for all road segments in the transportation network. StL's proprietary algorithms use machine learning to calibrate anonymous location-based service data to real traffic count trips. StL continues to improve their metrics and publishes the accuracy of their AADT metrics in a series of white papers.

In this report, we compare the accuracy of StL monthly average traffic volume metrics with their annual metrics. We also analyze the impact of seasonal variations in traffic and low-volume roads on StL's accuracy. StL's published AADT validation concludes that low volume roads are less accurate because its algorithm has fewer data points with which to generate an estimate. We test StL's assertion that accuracy improves as AADT increases. In addition, we examine the impacts of seasonal traffic variations due to tourism in a variety of locations across the state. We hypothesize that roads with higher variability during on- and off-peak tourism seasons will have a larger variance (typical and maximum error ranges) and possibly a larger mean absolute percent error. Factor Groups I, II, III are used by the DOT to classify roads with variable seasonal traffic. We test whether these Factor Groups impact StL's accuracy.

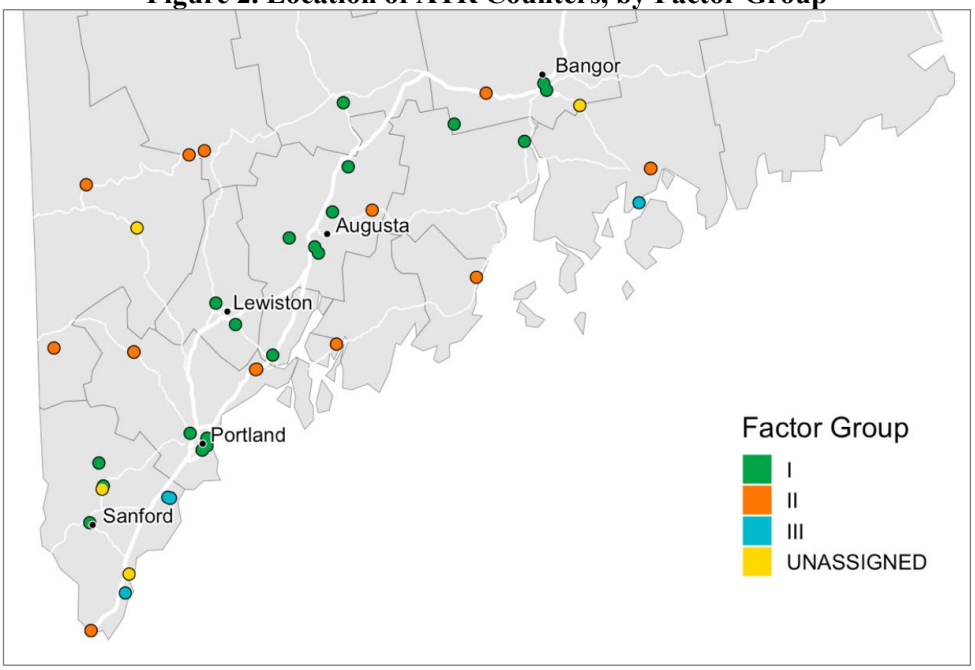
1.2 Research, Objectives, and Tasks

The accuracy and variance of StL's vehicle volume metrics are compared to benchmark observations at 48 permanent traffic counter locations provided by MaineDOT for the time period of January 1 to December 31, 2019 (Figure 2). MaineDOT's Automatic Traffic Recorders (ATR) monitor real-time traffic across the state. We compare StL metrics to real traffic volume observations from 48 locations across the state and for three time periods, including:

- MADT: Monthly Average Daily Traffic
- DOW: monthly average of daily traffic for each Day Of the Week
- HOD: monthly average of hourly traffic for each Hour Of the Day

MaineDOT staff provided a StL zone set to generate metrics at the same locations as the ATR station locations. The zone set is a linear "gate" zone drawn perpendicularly to roads at each ATR counter location and is then used by StL as a user-defined geography input for Zone Activity runs. Most counts are bi-directional, meaning both directions of travel are included in one count. In the case of two locations with separate directional counts, volumes are combined into a bi-directional count.

Figure 2. Location of ATR Counters, by Factor Group



The Factor Group classifications and AADT range variables are used to identify the changes in accuracy and precision due to low volume counts and seasonal traffic patterns that fluctuate with increased recreation and tourism during the summer. Factor Groups are defined as:

URBAN (I) **Roadways which carry commuter traffic and exhibit little seasonal change in traffic volume.**

ARTERIAL (II) **Roadways which carry commuter traffic but exhibit moderate seasonal changes in summer traffic volume.**

RECREATIONAL (III) **Roadways which are heavily influenced by summer seasonal traffic.**

The characteristics of the 48 ATR station locations include each road's AADT range, its Factor Group, federal functional class, federal urban/rural classification, and corridor priority – see Table 3.

Table 3. Count of ATR Location Characteristics

ATR Location Characteristics		Count
AADT Range	1,000- 2,499	1
	2,500- 4,999	9
	5,000- 9,999	13
	10,000- 24,999	17
	25,000- 49,999	8
Factor Group	I	23
	II	16
	III	5
	UNASSIGNED	4
Fed Functional Class	Interstate	12
	Major Collector	7
	Minor Arterial	9
	Minor Collector	1
	Other Freeway or Expressway	3
	Other Principal Arterial	16
Corridor Priority	1	29
	2	11
	3	6
	4	2
Fed Urban/Rural	Rural	28
	Urban	20

Chapter 2 Methodology

The methodology section of the report will first describe the data cleaning processes utilized as we assessed the completeness of the StL and ATR data sets. We will then describe how statistics and graphs are used to evaluate precision, as well as how the characteristics of traffic count locations may impact the accuracy of the metrics. An overview of the proposed approach for validating turning movement counts is also included. Appendix B includes the formulas and tabular results for all 30 intersections included in the analysis.

2.1 Data Cleaning

If missing data in the ATR and StL datasets are unevenly distributed between traffic counter locations, this could potentially introduce bias into the analysis. This is because roads have significantly different characteristics.

2.1.1 Monthly Average Daily Traffic

The StL MADT data set is complete for 2019, but MaineDOT's ATR traffic counts are missing a number of hourly data, such that we could not accurately calculate the MADT for all months and all ATR locations (12 x 48). Of these 576 possible MADT data, ATRs MADT are missing for 52

monthly metrics. The missing ATR observations do not appear to be correlated to road characteristics such as the road segment's AADT or the factor group classification. Each location has at least 8 out of 12 complete MADTs, and two thirds of locations have all 12 MADTs. We conclude that the missing ATR hourly data appears to be the result of external conditions such as hourly readings not being recorded due to a loss of power or a communication failure in the sensor. Since there appears to be no systematic locational pattern to the non-recorded data, we do not think that the missing data imposes a bias on the dataset. Consequently, we drop incomplete ATR traffic count locations from further analysis. The road characteristics and percent of missing data per location are included in Appendix A.

2.1.2 Average Daily Traffic by Day of the Week

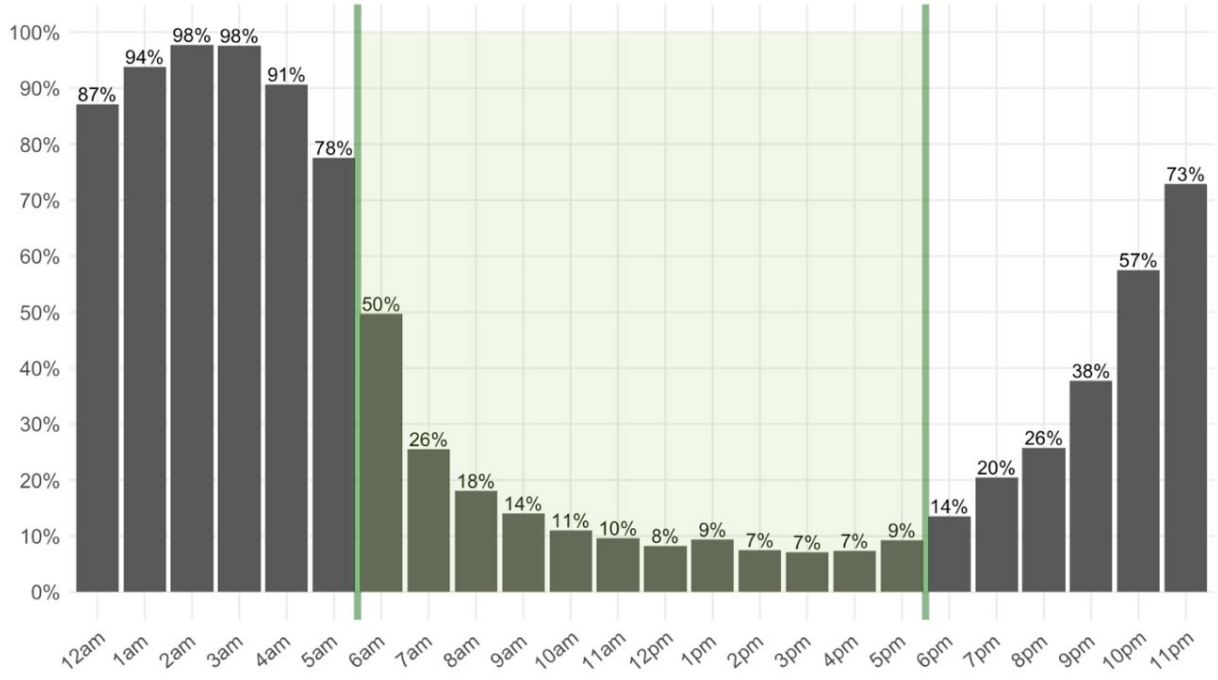
For the 48 locations in this study a total of 6% of the DOW data were missing from StL and MaineDOT combined (243 out of 4032). 2.2% of DOW observations were missing from MaineDOT's ATR counts. The cause of missing ATR data is most likely due to equipment failure or maintenance. 3.8% of DOW metrics were missing in the StL dataset. Only 5 of the 48 locations account for the missing StL data. These five locations are all low-volume roads with AADT below 5000.

Both lower volume roads and smaller time periods of analysis increase the chances that StL's results were being omitted because there were fewer than 100 personal devices acting as data source, a situation that, if left un-omitted, would violate their privacy policy.

2.1.3 Average Hourly Traffic by Hour of the Day

Figure 3 shows the distribution of the missing HOD data, which are significantly high during the off-peak period. The full 24-hour period is missing 46% of HOD estimates (39.5% comes from StL), but that is halved to 23% (14.7% comes from StL) during the 12-hour peak period of 6am - 6pm. Counters with large proportions of missing StL data are largely rural and low volume locations. The five locations missing the most HOD data are the same locations with the missing StL DOW data.

Figure 3. Missing HOD data, per Hour



2.1.4 Statistical Analysis of Monthly Average Volume Metric Accuracy

We employ similar statistical methodologies to those used by StL and the FHWA (Federal Highway Administration) for AADT in order to generate comparable results for the MADT, DOW, and HOD time scales. The target level of precision suggested by the FHWA for traffic volume counts is between 16%- 20% - see Table 4.

Table 4. 2019 StL AADT validation and precision threshold by AADT range

	Mean Abs. Error (%)	Mean Abs. Error (%)	Median (%)	Normalized Root Mean Square Error	Normalized Root Mean Square Error
AADT Range	Target	AADT	AADT	Target	AADT
1,000 - 2,499	NA	24.92%	13.34%	47%	29.29%
2,500 - 4,999	NA	16.33%	5.19%	36%	21.18%
5,000 - 9,999	20%	13.32%	3.07%	29%	17.78%
10,000 - 24,999	20%	10.21%	0.97%	25%	13.76%
25,000 - 49,999	16%	9.46%	0.84%	22%	13.71%

To test StL's accuracy, we first determine the bias of the dataset - whether StL counts are over or underestimating traffic count, and by how much. Another measure of accuracy is the mean absolute percent error (MAPE). By removing the sign of the percent error values - they can be

positive or negative - the MAPE will measure how big the error of StL estimates is when compared to MaineDOT's benchmark ATR counts.

To better understand how the percent error is distributed across a variable range, such as months of the year, we use a boxplot graph to visualize the median and quartiles. Each box represents the middle range of points from the 25th to 75th percentile, which is also called the InterQuartile Range (IQR). The black line intersecting the box is the median value, and the tails extending from the box represent the minimum and maximum values of the first and fourth quartiles. Outliers are shown as dots extending beyond the line. Boxplots are particularly helpful to visualize the different error ranges across categories, such as the average percent error on weekdays vs weekends.

The range of StL's MADT precision can also be measured using the 68% and 95% confidence intervals. The 68% confidence interval is typically known as the standard deviation for normally distributed data. Because we don't assume to have normally distributed data, it is measured as the difference between the 16th and 84th percentiles. StL's validation white paper for the AADT volume metrics notes that this value should be interpreted as the expected 'typical' error. The 95% confidence interval (95% percentile of absolute PE) is interpreted as the upper limit of expected error, or rather the maximum of the error range.

The Normalized root mean square error (NRMSE) is another measure of error that penalizes large errors making it more sensitive to the accuracy of AADT estimation on high-volume roads. The equation for normalized root mean square error (NRMSE) is:

$$NRMSE = 100 * \frac{\sqrt{\left(\frac{1}{n}\right) * \sum_{i=1}^{n}\left(AADT_{Permanent\ counter(i)} - AADT_{Estimate(i)}\right)^2}}{\left(\frac{1}{n} * \sum_{i=1}^{n}(AADT_{Permanent\ counter(i)})\right)}$$

We use a summary table of these statistics to compare the accuracy of estimates across time periods (the median error of AADT vs MADT), but also for variables such as the average daily travel and factor group classification.

2.2 Turning Movement Counts (TMC)

The project includes a preliminary evaluation of StL new turning movement count metrics, which were released in the spring of 2022. Validation of this data is challenging due to the smaller volumes for individual turning movements, and the smaller number of counts undertaken per year across the state. As mentioned above, small volumes can often trigger the privacy protection standards of StL and will result in more omitted observations. Further complicating the effort are temporary one-day counts for turning movements that are not averaged over time. The variability in collection method and time of year, as well as measurement error, all contribute to a less ideal validation data set. It is, however, the best source of data available. MaineDOT provided daily TMC observations for 30 intersections that have two turning movement counts conducted within the last 5 years.

We follow MaineDOT's proposed methodology that turning movement be expressed as the percentage of the total intersection traffic because this ratio impacts traffic signal design. MaineDOT further proposes evaluating StL's TMC precision using the difference between two short term counts (STC) as the target precision between STCs and StL estimates. The StL estimate is considered as outside of the observed variability if the difference of StL and STC is larger than the target precision.

Chapter 3 Results and Discussion

We first want to know if the monthly, day of the week, and hour of day monthly averages are within the precision thresholds typically used for traffic volume estimates, which in this analysis is simplified to ±20% or less error percent error. The following graphs are used to explore and visualize how the accuracy of StL's metrics vary as the time periods used become more fine-grained:

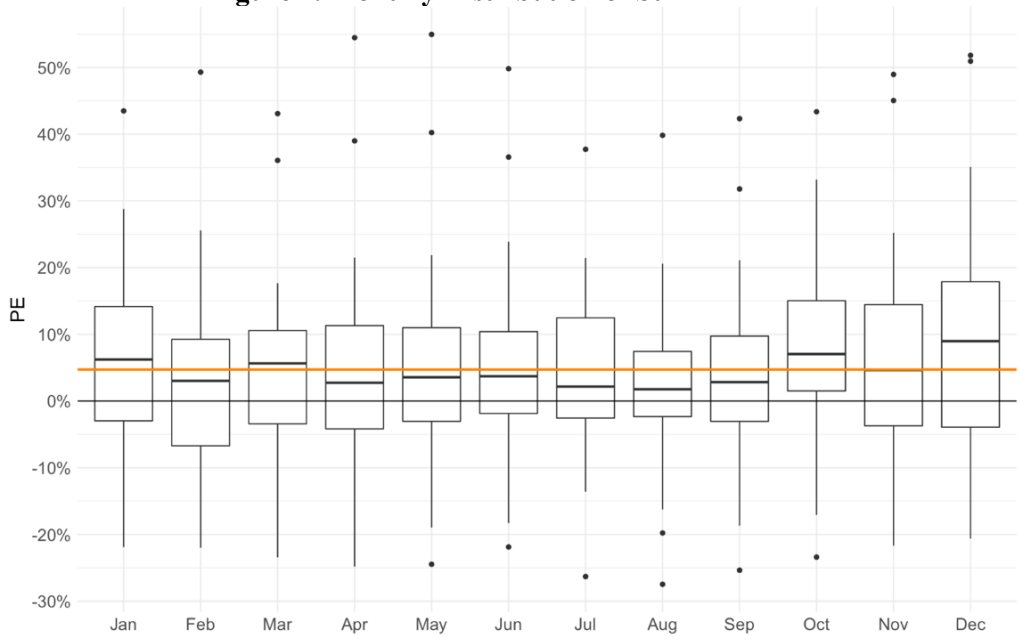
- Boxplots visualize the average error and spread of error
- Probability distribution functions visualize bias
- Scatter plots and bar charts visualize distribution of error across possible explanatory variables.
- Summary tables provide statistics on the error across variables and show whether there are significant variables that affect the accuracy of the volume metrics.

3.1 Monthly Average Daily Traffic (MADT) Estimates

The boxplot in Figure 4 shows the monthly distribution of MADT percent error for each of the 48 count locations. The box represents the interquartile range (25th to 75th percentile) while the black line inside the box represents the monthly median. The mean percent error of all MADT estimates is 4.7% and is represented by the orange line.

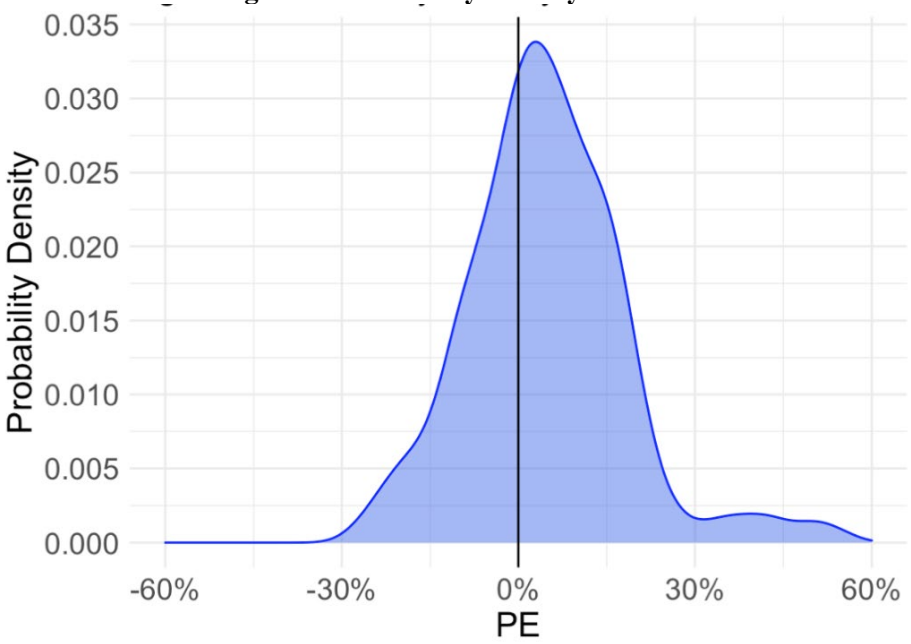
The monthly median percentage errors and the size of the IQRs fluctuate depending on the season. They are most precise from July to September during peak tourism months; the median error and IQR are less precise in winter months. Since traffic levels increase during the peak tourism months, it is likely that the lower percent errors during the tourist season are the result of improved StL estimates due to higher traffic volumes.

Figure 4. Monthly Distribution of StL MADT PE



The probability density function in Figure 5 visually shows the bias of StL metrics, which are consistently overestimating MADTs. While the 68% CI is 13%, the longer right tail in the graph indicates that the error is not normally distributed and that there are a number of MADT estimates that are overestimated by 30-50%. The reason for this error will be examined in the next section.

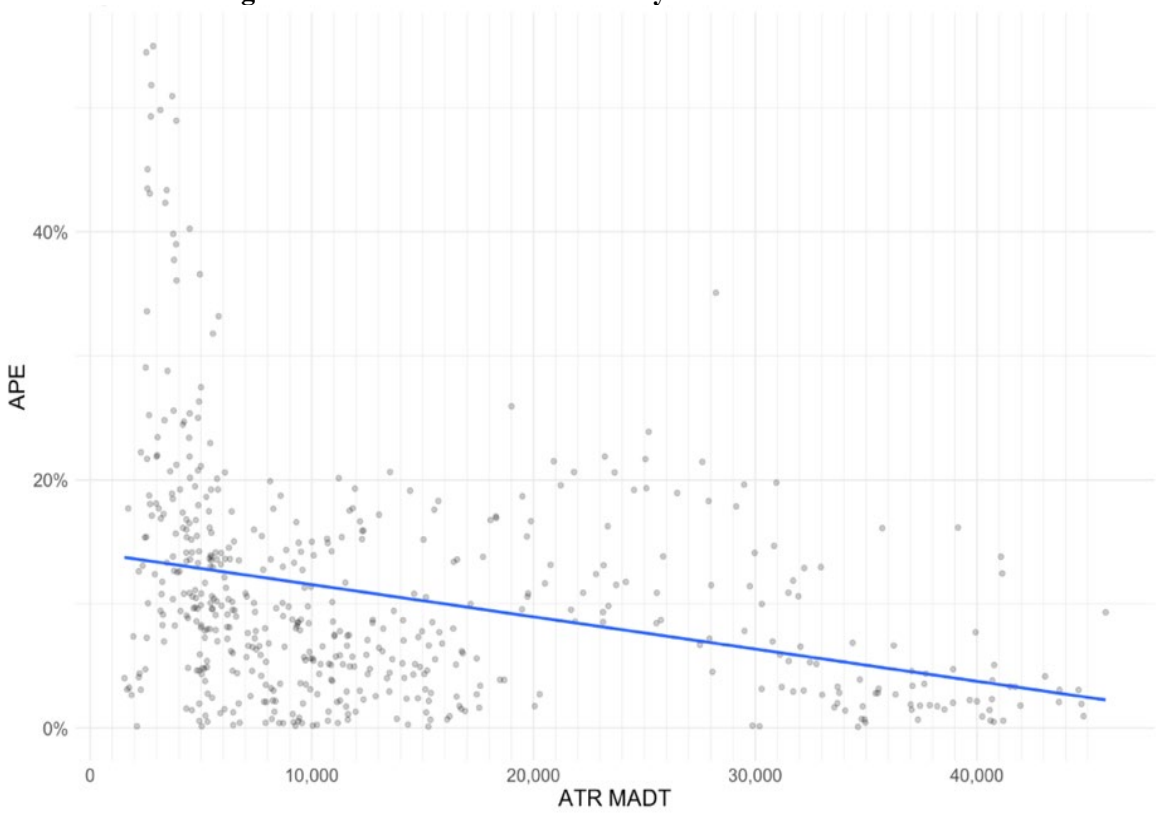
Figure 5. Probability Density Function of MADT Percent Error



3.1.1 Effect of AADT

As hypothesized earlier, higher road volumes should improve the accuracy of the MADT. The trendline line of absolute percent error vs AADT in Figure 9 shows that the percent error of StL's MADT estimates does decrease as the volume increases. The scatter plot in Figure 6 shows that the majority of MADT data on roads over 5,000 AADT meets the threshold of ±20% error range. Likewise, there are a number of MADTs on roads under 5,000 AADT that exceed 30% error. In effect, the 'bump' in Figure 7 shows higher error in low-volume roads.

Figure 6. Absolute Percent Error by ATR MADT Volume



The boxplot in Figure 7 divides the MADTs into the 5 AADT ranges previously used by StL for validation. This boxplot shows how both the median and IQR increase in accuracy as the AADT range increases. The 1,000 - 2,499 range contains MADTs for one location, which is too small a sample size to infer meaningful statistics about this AADT range.

Figure 7. Boxplot of MADT PE, by AADT Range

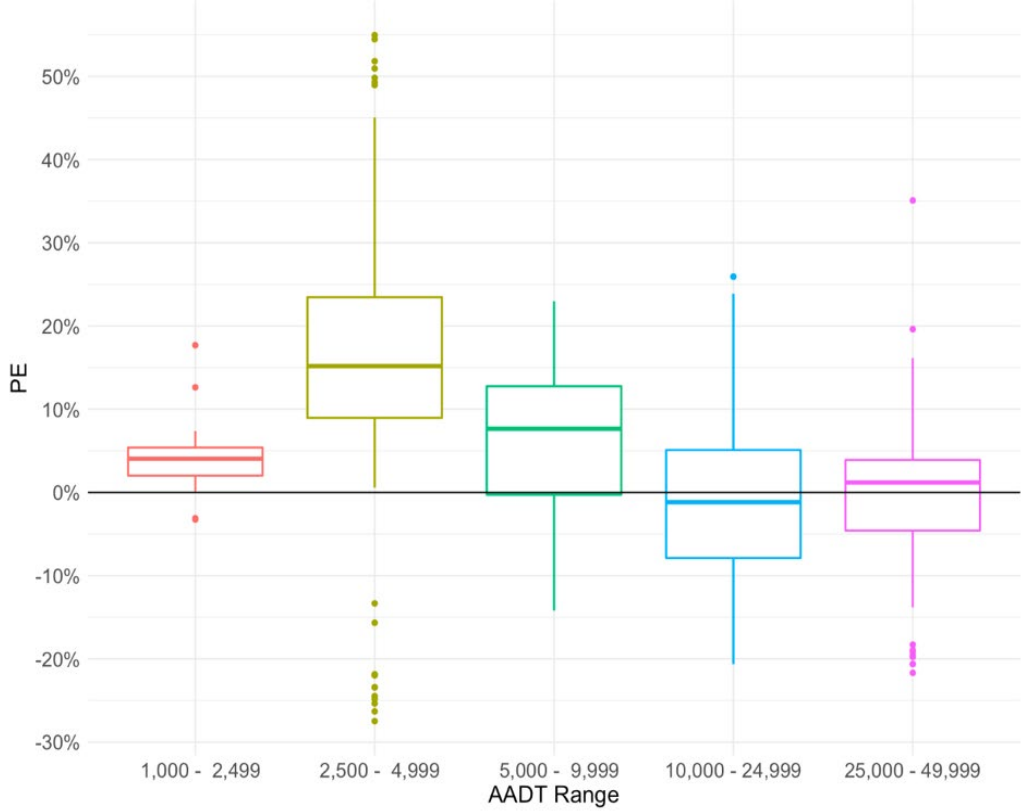


Table 5 provides more detailed descriptive statistics to evaluate StL's metrics, and to compare these metrics to StL's own AADT validation findings. For the roads over 5,000 AADT, the accuracy measured by the absolute percent error is better than StL's AADT as reported for each AADT range2, and is also well under the AADT's precision target of 20%.

However, roads in the 2,500-4,999 AADT range have a worse median, mean, and absolute percent error, between 15-20%. This exceeds the accuracy found in StL's 2019 AADT validation, as well as AADT precision targets suggested by StL in their 2020 AADT validation paper.

Altogether, the accuracy and precision of MADT estimates for roads under 5,000 AADT are significantly poorer than roads over 5,000 AADT and will require judgment on the part of DOT staff and its consultants before using these data. AADT–rather than MADT– volume estimates should be used for roads with less than 5,000 AADT.

[2] Streetlight Insight (2020). StreetLight AADT 2019 Methodology and validation White Paper. page 5, Table 1a

Table 5. 2019 StL MADT Percent Error Summary Statistics

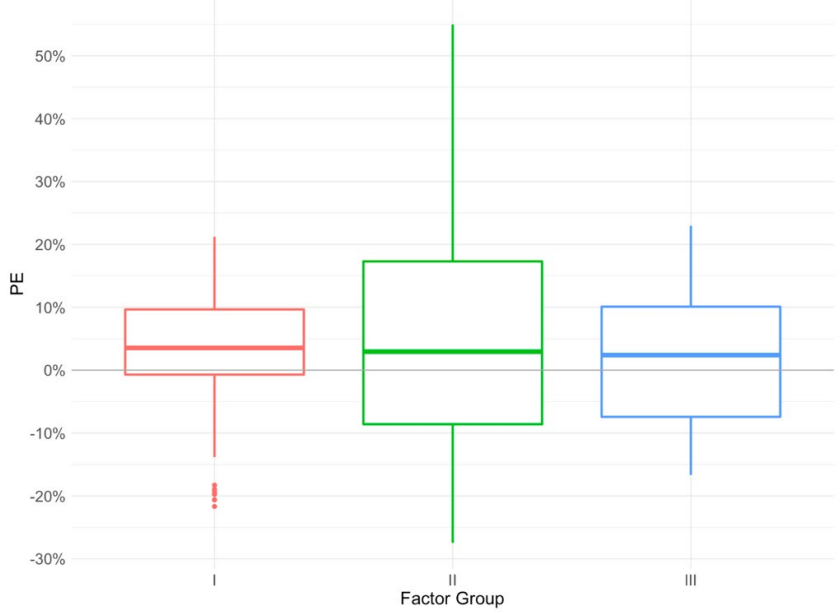
Road Class	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE
2,000 - 4,999	108	14.7	13.9	19.8	18.0	33.1	76.2	24.0
5,000 - 9,999	164	6.4	8.0	8.8	13.1	16.4	29.6	9.7
10,000 - 19,999	135	-1.0	-0.3	7.6	12.6	17.2	35.3	9.9
20,000 - 34,999	50	-5.6	-9.5	12.3	8.9	16.7	44.1	13.1
35,000 - 54,999	67	3.8	2.7	5.1	5.3	10.1	22	6.9
All Roads	524	4.7	4.1	10.6	16.1	23.7	60.3	12.1

3.1.2 Effect of Factor Group Classification

The factor group classification distinguishes roads with variable seasonal traffic, and so we would like to know if the increased variability of factor group II (roads with seasonal tourism) increases the percent error in comparison to the steadier commuter roads in factor group I. Factor group III would provide an interesting triangulation in data contrast, but it only includes 6 ATR locations, too small a sample size to interpret the accuracy and precision of its data. We have, however, included it in the charts for reference.

The boxplot in Figure 8 shows the median MADT percent error and IQR for Factor Groups I, II & III. It is clear that the IQR for Factor Group I is smaller than the Factor Groups II & III, and is therefore more precise, and is within the precision threshold. However, the IQR of Factor Group I is almost completely above 0%, meaning that close to 75% of MADTs in Factor Group I are overestimated. Factor Group II and III are relatively more evenly centered around the observed MADT.

Figure 8. Boxplot of MADT Percent Error by Factor Group



The Factor Group I MAPE is 7.5%, whereas the MAPE for Factor Group II is 15.7% - a table of descriptive statistics is shown in Table 6. The IQR for Factor Group II is approximately double that of Factor Group I, however there isn't a significant difference in the median percent error.

Table 6. MADT Descriptive Statistics, by Factor Group

Factor.Group	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE
I	246	3.8	3.5	7.5	10.4	17	38.1	8.6
II	172	6.0	2.9	15.7	25.9	35	73.9	17.6
III	58	1.6	2.4	8.8	17.5	21.8	34.4	12.4
UNASSIGNED	48	8.9	9.5	10.3	11.0	15.7	29	9.2

3.1.3 Relative Effects of Factor Group and Traffic Volume

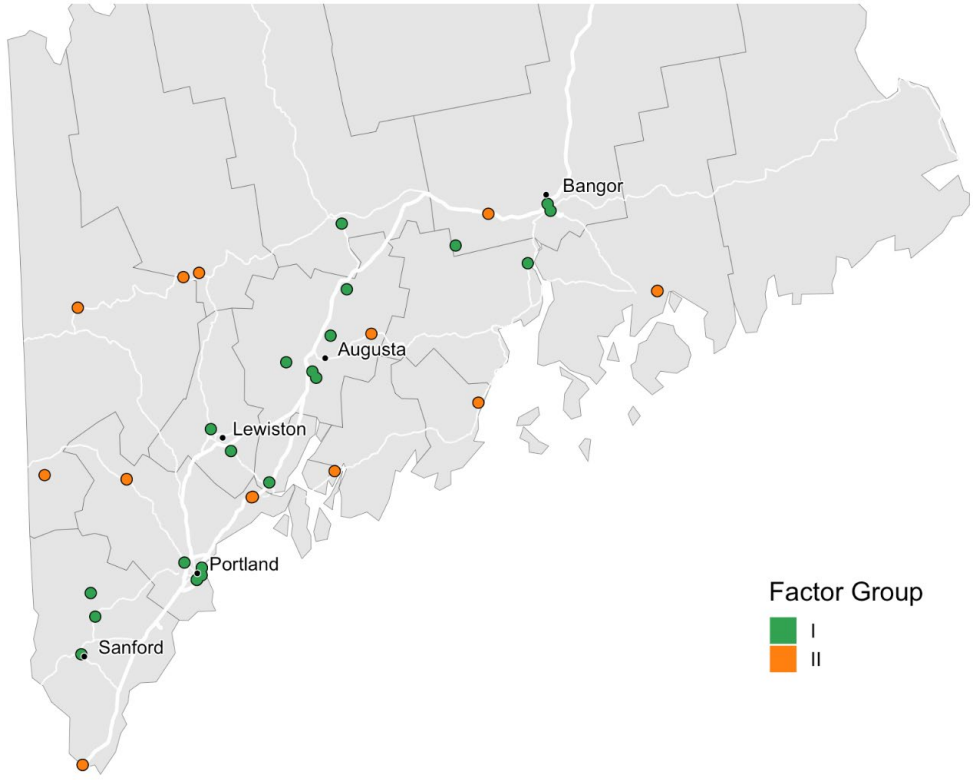
This section analyzes whether the factor group classification has an effect on the accuracy of StL metrics independent of the road's AADT range. The relative importance analysis is used to quantify the impact of factor groups on the accuracy of the StL volume metrics. This method allows us to determine the contribution to total R2 of a regression by individual variables or linear combination of individual variables. In our case, we wanted to compare the relative importance of Factor Group classification and annual average daily traffic (AADT) on the accuracy (percent error). The regression formula is:

$$\text{Percent Error}_i = \int (\text{FactorGroup}_i + \text{AADT}_i)$$

The result of this regression is that 10.3% of the R2, or total variance in accuracy, is explained by both the AADT and factor group classification. Of that 10.3%, 92% is attributed to the AADT while the remaining 8% is attributable to the factor group. Therefore, we determine that the AADT impacts on the accuracy of StL and that the Factor Groups have a minimal effect.

A second statistical test is used to determine whether Factor Groups or AADT are more important in explaining the larger standard deviation observed in Factor Group 2. Posed another way, we are seeking to determine whether the Interquartile Range (IQR) for Factor Group II volume is larger than Factor Group I because the Factor Group II roads are lower volume or more seasonal.

Figure 9. Distribution of Factor Group I and II ATR locations



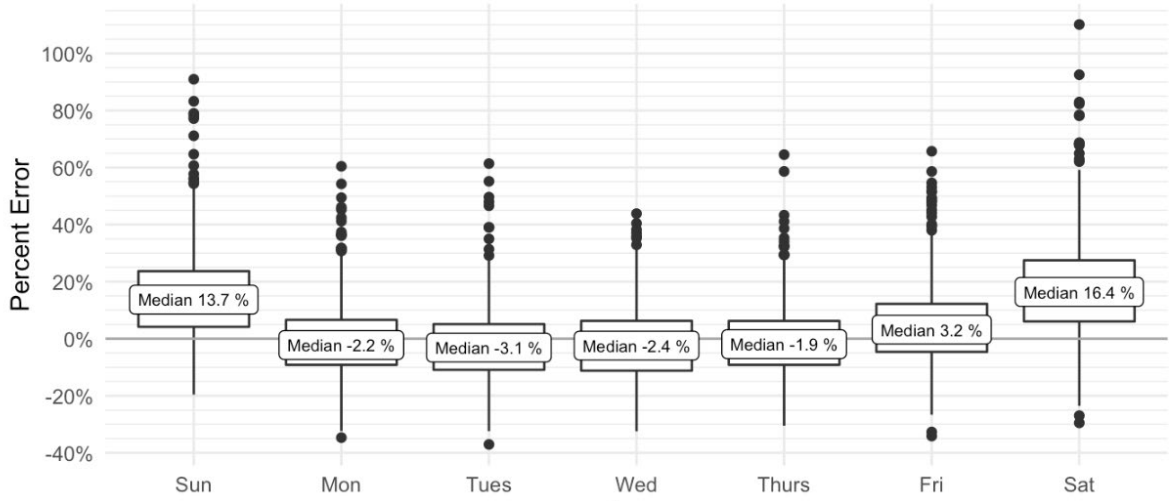
The Levene's test of equality of variance tests whether variance is the same between two or more groups, in this case, Factor Groups I & II. The test results tell us that the variance between factor groups is significantly different. The Levene's test was repeated for the AADT range, and found that the variance in the high, medium, and low AADT are not statistically different from one another. Therefore, the higher IQR in Factor Group II is a result of the seasonality of roads and not because of the AADT. We conclude that the variance of SL MADT metrics is different between Factor Groups, but the AADT levels do not significantly change the variance.

3.2 Day of the Week (DOW) Estimates

The monthly average daily traffic for a particular day of the week uses records from 4-5 days (i.e., 4 Tuesdays in a given month) instead of the average 30 days for the MADT. We examine how this more granular temporal estimate compares to the monthly and annual estimates.

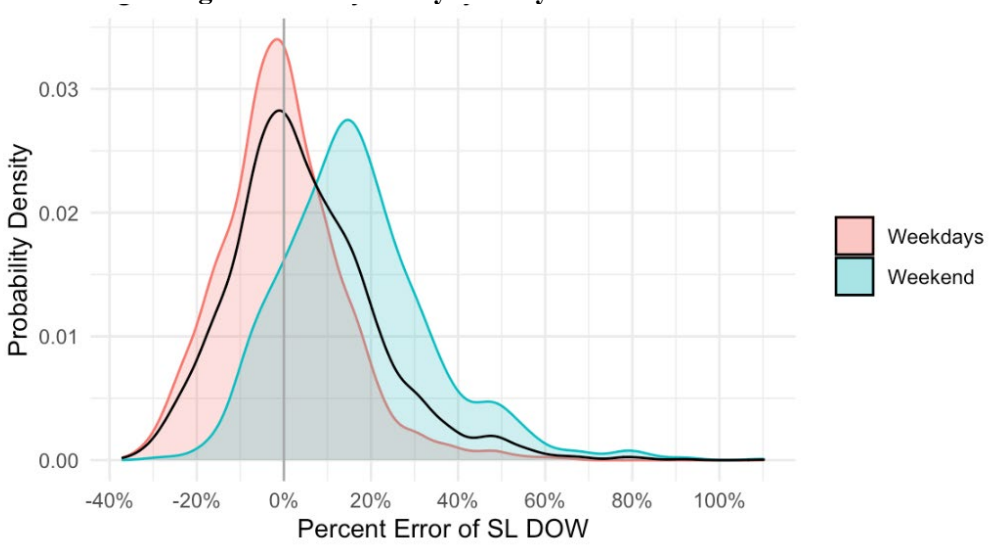
The boxplot in Figure 10 plots the distribution of the percent error for each day of the week. It is clear to see that weekdays are more accurate than weekends. The median percent error for weekdays (Mon - Thu) is slightly underestimated, whereas the median percentage error on the weekend days is much more overestimated.

Figure 10. Boxplot of StL Percent Error by Day of the Week



The median weekday percent error is -1.1% with more than half of the estimates under ±10% error. Weekdays have a similar accuracy as the monthly and annual daily traffic. The median weekend percent error is 14.9%, and the Interquartile Range (IQR) - middle 50% of observations represented by the box - is entirely above 0%, which means that over three-quarters of weekend estimates are overestimating their MADT.

Figure 11. Probability Density Function of StL DOW Percent Error



The probability density function in Figure 11 further illustrates the variance of the StL DOW metrics, which on weekdays are narrower and, on the weekend, more normally distributed. Table 7 provides more detailed statistics for weekdays and weekends.

Table 7. Day of the Week Summary Statistics

Count	Day of the Week	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE
3789	All Days	4.6	2.4	12.9	20.2	30.2	70.2	16.8
2701	Weekdays	-0.4	-1.1	10.6	16.4	25.8	56.6	13.7
1088	Weekend	16.8	14.9	18.9	20.2	31.2	66.4	24.6

3.2.1 Effects of AADT

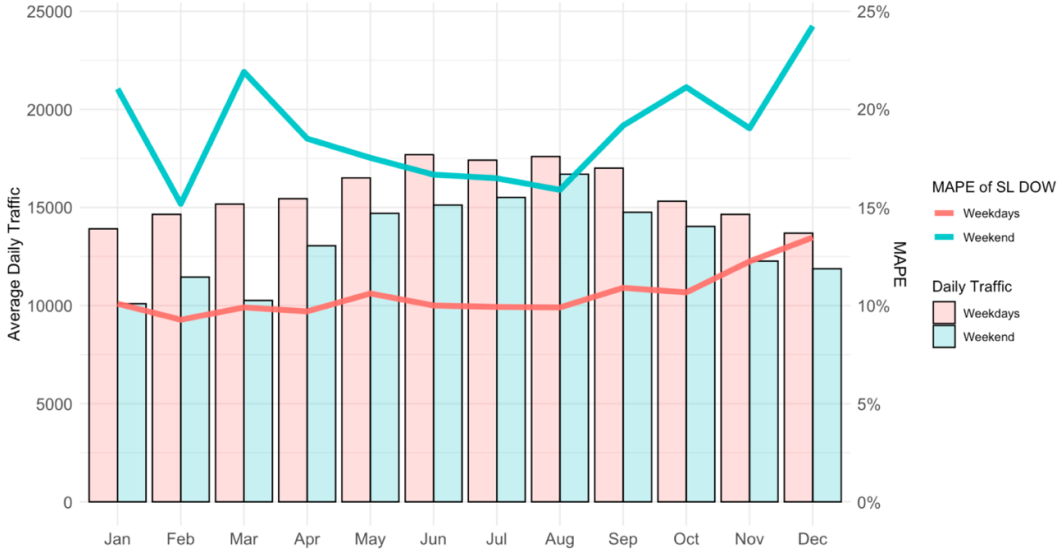
Our analysis of StL's MADT metrics found that the accuracy and variance of StL metrics was significantly correlated with the count location's AADT range and factor group classification, respectively. Here again, the estimation error decreases when the road volume increases. The scatter plot in Figure 12 shows the absolute percent error distribution by AADT and includes trendlines for weekday and weekend.

Figure 12. Mean Absolute Percent Error of StL DOW, for Weekdays and Weekends

StL's DOW accuracy also varies month to month, with the variation in part due to seasonal changes in travel volumes. Figure 13 shows the month by month change of the mean absolute percent error for weekdays and weekends as a line graph and is superimposed over the average daily traffic for weekdays and weekends. As the summer weekend traffic increases, the MAPE improves for the weekends.

Weekdays, however, vary much less, remaining close to 10%, and climbing up to 13% during Nov-Dec. This is most likely due to the reduction of commuter trips during holiday vacations. These are similar to other decreases in accuracy as the volume drops. Throughout the year, the weekend MAPE ranges between 15.2% and 24.2%. During months that experience a drop in the weekend traffic volume, there are corresponding spikes in error.

Figure 13. DOW Average Daily Traffic and Mean Abs. Percent Error, by weekday type



The changes in accuracy and variance across 5 AADT road classes are provided in Table 8. These can be used to compare DOW statistics with those of the MADT and AADT in more detail.

Table 8. DOW Summary Statistics, by AADT Range

AADT Range	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE
All Roads	3789	4.6	2.4	12.9	20.2	30.2	70.2	16.8
2,000 - 4,999	603	16.3	14.9	22.0	26.1	39.6	96.6	26.6
5,000 - 9,999	1167	6.7	5.4	11.7	18.1	26.3	52.9	14.8
10,000 - 19,999	987	-0.4	-2.2	10.4	15.8	26.0	52.7	13.2
20,000 - 34,999	473	-5.0	-8.6	14.4	22.3	30.1	71.5	16.8
35,000 - 54,999	559	4.3	1.2	8.9	16.4	22.0	41.5	11.5

3.2.2 Effects of Factor Group

The MADT analysis found that the Factor Group II classification significantly decreases the precision of StL's estimates but does not affect the average error. The boxplot in Figure 14 and Table 9 divides the distribution of DOW percent error by Factor Groups, which has a similar distribution as those of the MADT. The bias of Factor Group II is similar to Factor Group I but its variance and MAPE are larger than that of groups I and III.

Figure 14. Boxplot of DOW PE, by Factor Group

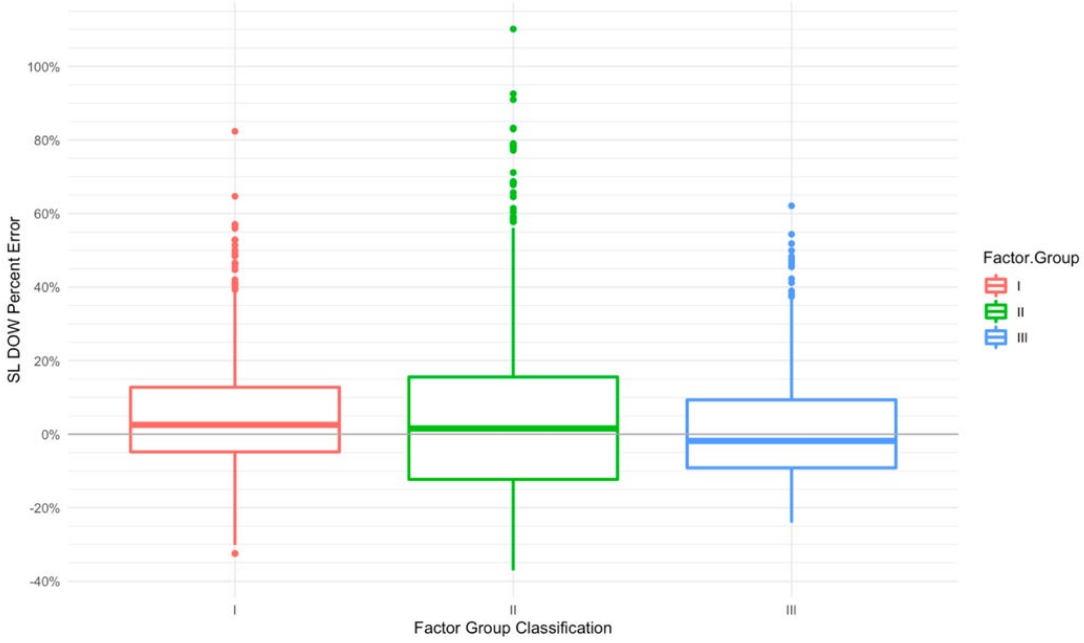


Table 9. DOW Summary Statistics, by Factor Group

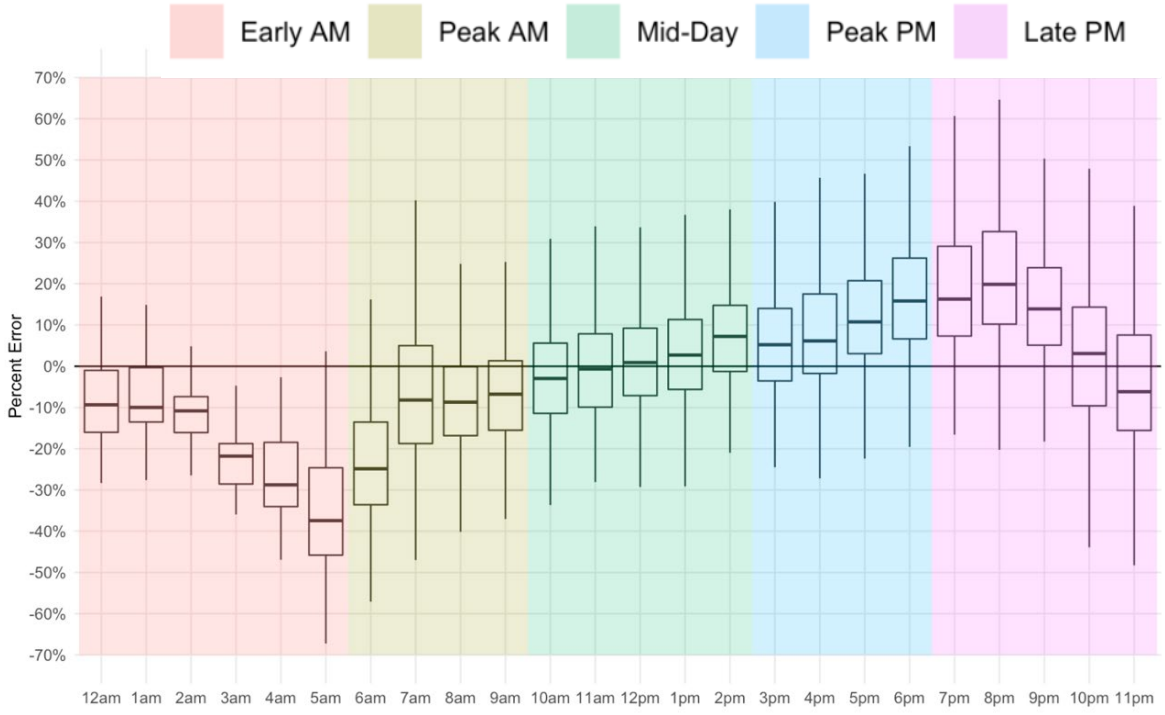
Factor.Group	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% (%)	95% (%)	NRMSE (%)
All Roads	3789	4.6	2.4	12.9	20.2	30.2	70.2	16.8
I	1822	4.1	2.4	10.6	17.5	24.1	56.3	13.1
II	1213	5.2	3.1	16.7	27.5	40.3	81.6	21.9
III	418	1.8	-1.8	11.8	18.5	29.6	58.7	16.5
UNASSIGNED	336	8.5	6.1	13.8	21.5	29.9	66.8	17.4

3.3 Hour of the Day (HOD) Estimates

This section analyzes the accuracy and variance of hourly traffic averages by each month (e.g., 12-1pm in April) for: the full 24-hour day, a 12-hour peak period (6am to 6pm), and StL's default time periods: Early AM (12am-6am), Peak AM (6am-10am), Mid-Day (10am-3pm), Peak PM (3pm-7pm), Late PM (7pm-12am). We find that the StL volume metrics are overestimating volume in the afternoon and evening and underestimating it in the morning.

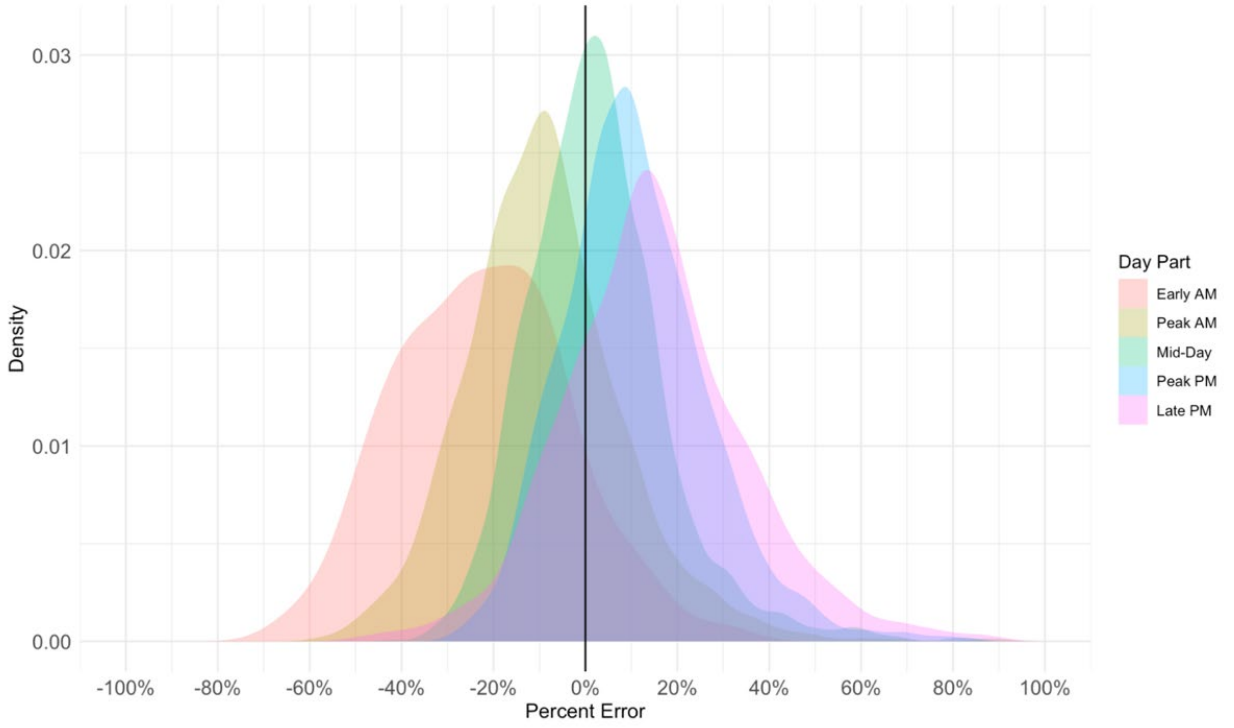
The boxplot of the percent error of HOD in Figure 15 shows how the accuracy and variance changes throughout the day. StL is underestimating HOD volume in the early hours of the day, with a median percent error of -38% at 5am. The accuracy starts to improve by 7am and is best during the midday period. From 2pm onward, StL HOD is increasingly overestimated, until 8pm when the median peaks at around +20% before dropping at the end of the late PM period.

Figure 15. Boxplot of StL HOD Percent Error, by Hour and Day Part



The flattening curves in the probability density functions (PDF) in Figure 16 show how the variance of the estimates differ across the StL default zones.

Figure 16. Probability Density Functions of StL HOD Percent Error, by Day Part



The MAPE in Table 10 shows that the estimates are most precise during the mid-day and are worst in the early AM and late PM periods. The variance of the estimates (68% error range) is lower for the peak (~31%) and mid-day (26.5%) time periods and is higher during the early AM period (37.8%) and late PM period (37.1%). This inaccuracy also increased the error range and NMRSE, most notably in the Early AM time period.

Excluding the off-peak hours of 6pm to 6am improved accuracy, lowering the mean percent error from 4.0% to 1.2%, and the MAPE from 15.2% to 13.2%. The peak 12 hr. period as well as the mid-day have a fairly low bias and variance and are comparable in accuracy with the MADT and DOW metrics. In order to use the peak AM and peak PM periods, a correction factor could perhaps be applied to negate the consistent bias observed.

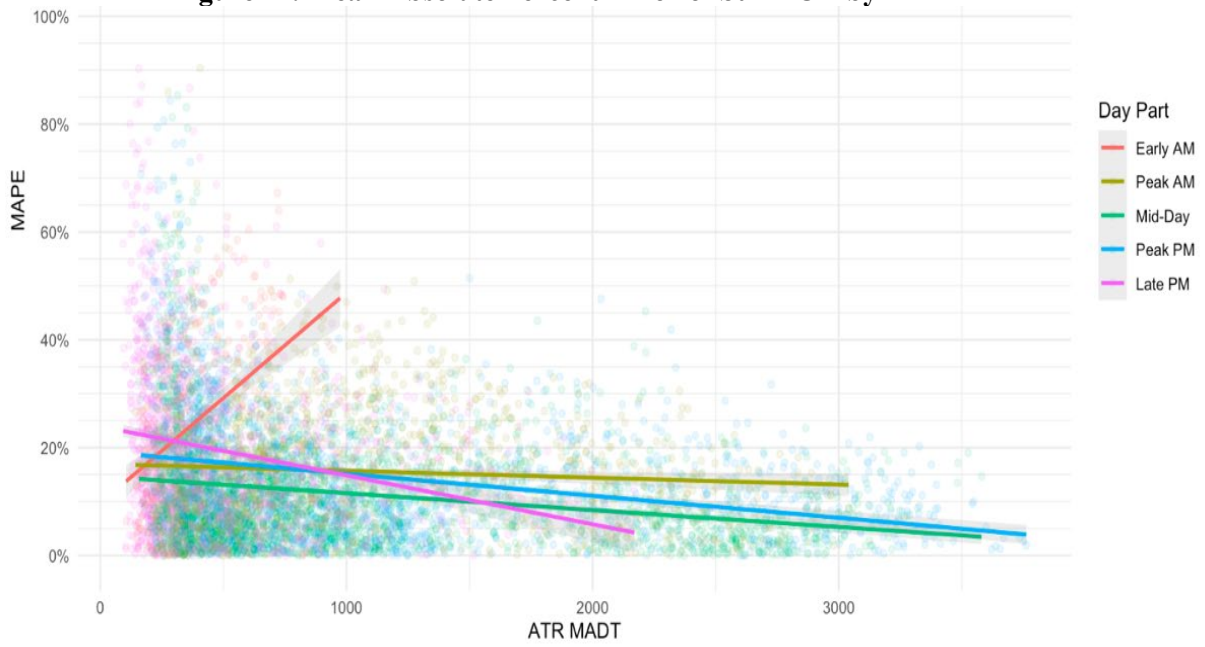
Table 10. Hour of the Day Summary Statistics

Day Part	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE (%)
All Hours	7460	4.0	3.2	15.2	23.4	35.4	80.0	17.9
Peak 12 hrs	5321	1.2	0.7	13.2	21.2	31.2	69.7	16.3
Early AM	250	-22.3	-23.0	24.7	26.7	37.8	70.2	39.3
Peak AM	1495	-8.7	-9.7	15.8	20.5	31.4	69.5	20.8
Mid-Day	2378	2.5	1.6	11.4	18.0	26.5	61.8	13.8
Peak PM	1898	10.9	9.6	14.8	19.5	30.0	62.5	16.9
Late PM	1439	14.9	13.9	19.5	24.5	37.1	81.1	23.8

3.3.1 Effects of AADT

Similar to the DOW estimates, the absolute percent error of StL's HOD estimates improves as traffic volume increases for four out of five time periods. Accuracy statistics in Table 11 follows the trends seen in MADT and DOW metrics. The early AM period (especially between 3 - 6am) is anomalous because the error significantly increases as the volume increases – see red trend line in Figure 17.

Figure 17. Mean Absolute Percent Error of StL HOD by ATR MADT



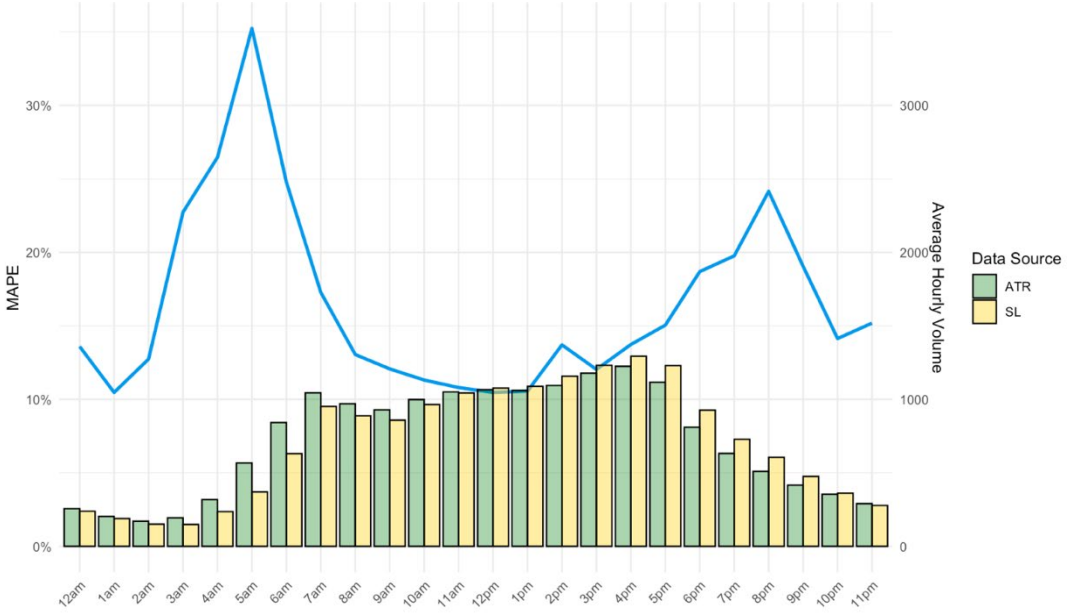
This pattern contradicts the general finding that increasing traffic volume reduces error. The most probable reason for this anomaly is that there are between 60-98% of data missing during the off-peak hours of 6pm-6am. We postulate that the missing data are partially skewing the analysis, but this requires further investigation by StL's analyst team.

Table 11. HOD Summary Statistics, by AADT Range

AADT Range	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE (%)
All Roads	7460	4.0	3.2	15.2	23.4	35.4	80.0	17.9
2,000 - 4,999	610	18.3	15.0	25.0	34.8	51.6	102.9	33.1
5,000 - 9,999	2270	8.6	7.4	14.9	22.0	32.7	69.6	16.7
10,000 - 19,999	2202	1.2	1.0	13.6	23.4	32.9	66.3	15.7
20,000 - 34,999	925	-6.0	-8.2	16.8	19.8	38.5	79.9	18.3
35,000 - 54,999	1453	1.3	3.2	12.8	18.4	29.5	68.1	13.8

The hourly absolute percent hour superimposed over hourly traffic in Figure 18 further illustrates this anomaly. The error is lowest during the middle of the day from 10am to 1pm and highest at 5am and 9pm, where traffic volume is lower. However, the error then starts to decrease, even as the volume continues to decrease. The MAPE is similar at 1am to what it was at 1pm.

Figure 18. Mean Absolute Percent Error by Hour of the Day and Hourly Volume



3.3.2 Effect of Factor Group

As with MADT and DOW estimates, the variance of HOD in Factor Group II (roads with higher seasonal variation due to tourism) was significantly higher than groups I and III. Figure 19 shows that this is still the case for the HOD subset. All three groups show the same AM undercounting and PM overcounting pattern and are shown in Table 12.

Figure 19. Boxplot of StL HOD Mean Percent Error, by Factor Group

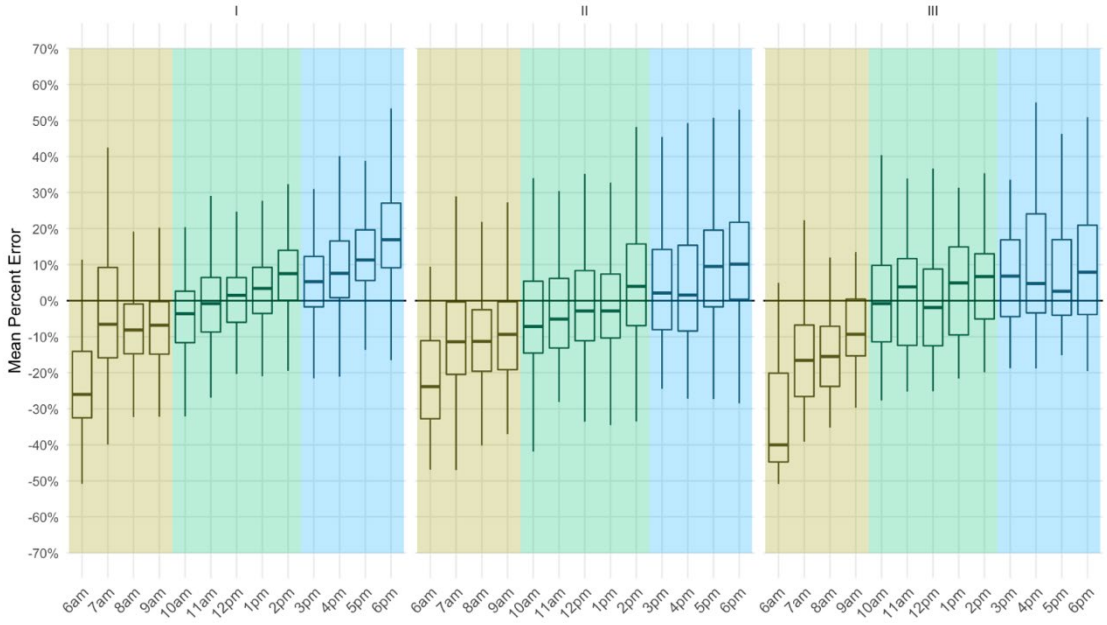


Table 12. HOD Summary Statistics, by Factor Group

Factor Group	Count	Mean PE (%)	Median PE (%)	MAPE (%)	IQR	68% CI (%)	95% CI (%)	NRMSE (%)
All Roads	7460	4.0	3.2	15.2	23.4	35.4	80.0	17.9
I	3818	3.6	3.6	14.4	21.8	33.7	75.2	15.7
II	2089	3.0	0.2	16.3	26.5	39.0	85.1	21.2
III	859	2.6	2.4	14.7	23.8	35.6	74.6	18.0
UNASSIGNED	694	10.5	8.5	16.5	20.0	33.7	84.4	17.6

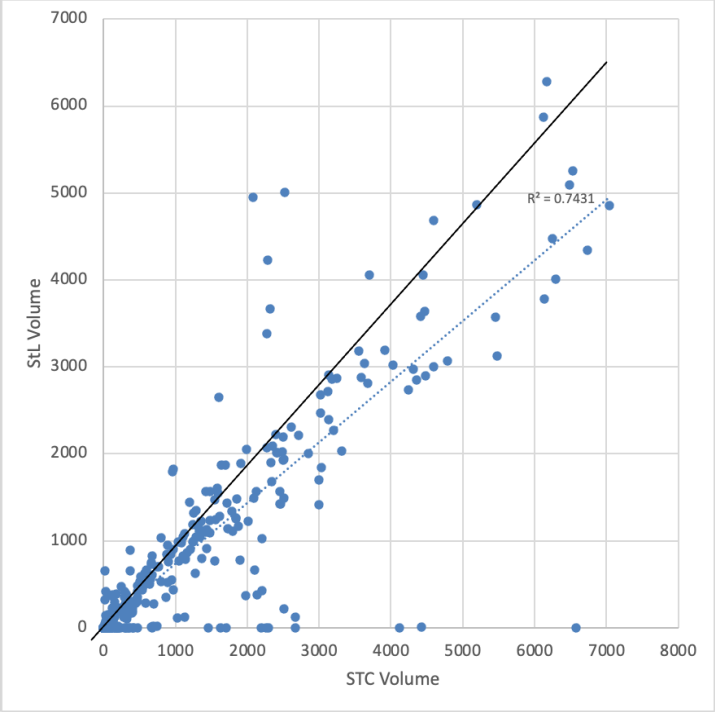
3.4 Turning Movement Counts (TMC)

The turning movement analysis attempts to assess the reliability of the StL TMC counts compared to existing short-term counts of intersections. These counts are either taken manually over the course of one day or captured using special cameras that can detect turning movements. MaineDOT provided data for 30 intersections with two counts taken at each intersection within 5 years. The StL analysis was run during the month of the most recent short-term count–typically September or October.

Turning movements that are less than 0.05% of the intersection traffic are removed from the analysis and should be examined separately. Low volume turning movements are more likely to have larger errors because of the larger impact of smaller changes in volume. After removing these TMC, there are 307 counts out of a possible 360.

There are also 56 StL turning movements with a TMC of 0 and can be seen along the x-axis in Figure 20. Half of these data (29) are at turning movements below 100 vehicles per day, and account for less than 0.01% of the total intersection traffic. These TMC are most likely suppressed due the 100 device privacy criteria. The remaining 27 intersections with StL values of 0 have large volumes of traffic and percent of intersection traffic, and so should have returned an estimate. There may be an issue with the drawing of the analysis zone, such as misaligned geometry of the intersection, or perhaps the error is due to an unknown variable that affects the StL algorithm. More investigation into these missing data is recommended in conjunction with StL technical support staff. Figure 22 plots StL TMC volume to STC TMC volume, and the R2 coefficient of a linear regression is 0.7431.

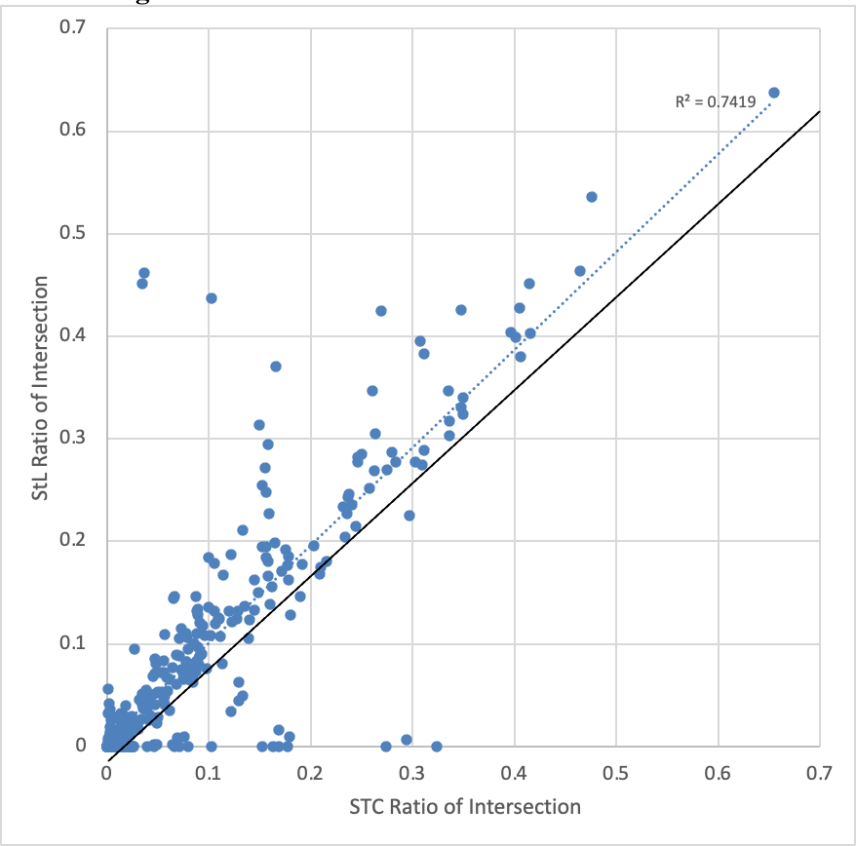
Figure 20. TMC volume, Streetlight vs Short Term Count



The trendline in Figure 20 shows that StL is undercounting volume, and that, for some intersections, the error can be quite large. The difference in count of vehicles for StL volumes compared to STCs is -313 vehicles on average, with outliers in the 1000's. The median percent error of Streetlight's estimate as a proportion of the STC is -24.8% and the absolute mean percent error is 69.5%. This error is quite high compared to the MADT's median percent error of 4% and absolute mean of 10.9% and is more comparable to the error of MADT of low-volume roads.

Figure 21 plots StL TMC' ratio of intersection volume to STC TMC ratio of intersection volume, and the R2 coefficient of a linear regression is 0.7419. The trendline shows that the median error of the StL intersection volume ratio is close to 0 (-0.02%) and the absolute mean is 2.77%.

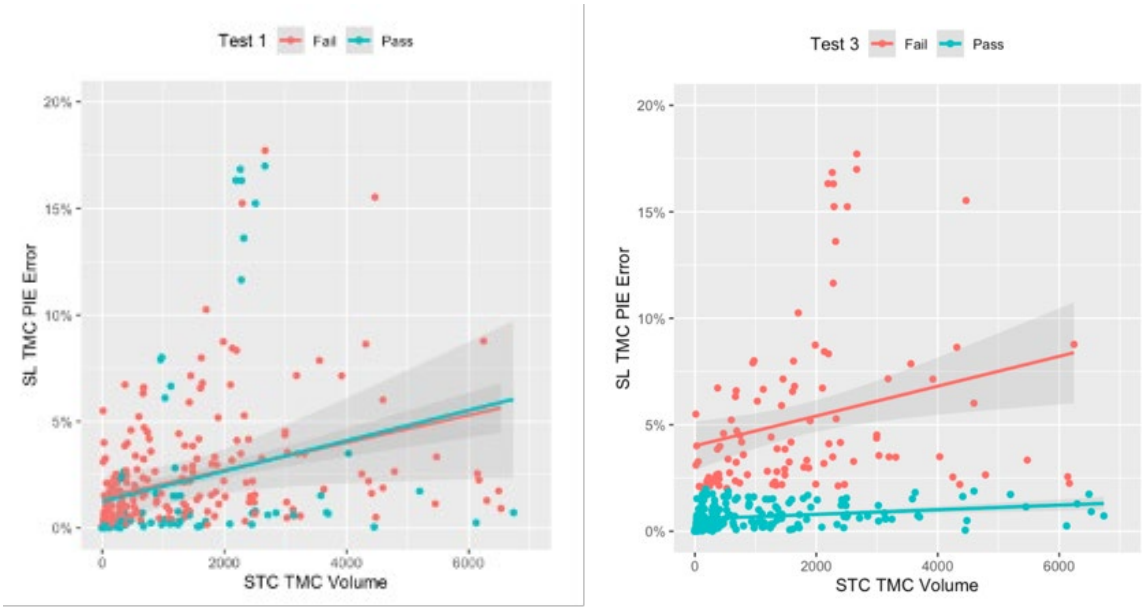
Figure 21. StL vs STC Ratio of intersection volume



The first precision threshold is defined as the difference between the intersection ratios of the two short term counts. The median of this measure is 0.35%, but the standard deviation is 2.82% and the absolute mean error is 0.95%, which is close to the 75th percentile of 0.97%. This is because a number of outliers have skewed the mean upwards. We suggest a second alternative test of the TMC accuracy to use a general precision threshold of 1%, representing the absolute mean error of the STC precision, or 2.8%, representing the standard deviation of the STC precision.

Figure 22 below visualizes the results of two precision test approaches. The first test proposed by MaineDOT requires StL's turning movements counts to have a variance equal to or less than that of the short-term count precision for that specific intersection, and this yields a 20.2% pass rate. The second test, which uses the precision threshold of 1%, results in a 46.3% pass rate. If the precision threshold is increased to 2.8%, which is the standard deviation of the STC precision, then the pass rate climbs to 75.2%. A full summary table of the results for each intersection is included in Appendix B.

Figure 22. Test results by TMC Percent Error and TMC volume



We see many data in test 1 that fail the precision test but are more accurate (close to a 45-degree line). This indicates that the precision threshold using the short-term counts is too variable. We conclude that either a 1% or 2.8% precision threshold provides a better estimate of StL TMC accuracy. We recommend further validation of the turning movement counts in order to assess their reliability and use as a substitute for field count.

Chapter 4 Conclusions and Recommendations

This report has validated StL's monthly average traffic volume estimates across a range of roads in Maine, as well as through a preliminary analysis of turning movement counts. We found that most MADT metrics, and monthly daily and hourly metrics are within industry standards for accuracy and variance. Larger errors are found where there are few devices recorded - including low volume roads below 5,000 AADT, seasonal roads within Factor Group 2, as well as off peak hours (7 pm - 6 am). We assessed the relative impact of AADT and Factor Group in its relation to the accuracy and variance of StL estimates. We found that AADT will have an impact on the median and absolute mean error. For Factor Group II roads (those with a large seasonal variation in traffic volume), StL is less accurate, meaning that it has a higher variation in predicted v. actual road volumes, though without significant directional bias.

The estimated TMC volumes, as well as the percent of turning movement as a portion of total intersection traffic, are less precise than the two short term traffic counts from MaineDOT at the same intersection for 80% of turning movements. We used scatterplots to identify whether there was an increase in precision either as TMC volumes increased or during turning movements with high percentages of total traffic; none were found. We recommend using a 1% or 2.8% precision threshold for TMC, which yields a 46.3% and 75.6% success, respectively. StL's AADT metric has continued to improve with each iteration of its algorithm. Since the TMCs have only been

available for a year, we anticipate that their algorithms will improve as more calibration data becomes available.

References

Streetlight AADT 2021 Methodology and Validation White Paper, v1.2, Streetlight Insight, October 2022

Streetlight AADT 2020 Methodology and Validation White Paper, v1.0, Streetlight Insight, May 2021

Streetlight AADT 2019 Methodology and Validation White Paper, v2.0, Streetlight Insight, May 2020

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Independent Evaluation of a Probe-Based Method to Estimate Annual Average Daily Traffic Volume, FHWA, Texas A&M Transportation Institute, Cambridge Systematics, September 2021

Guidelines for Obtaining AADT Estimates from Non-Traditional Sources, FHWA and Streetlight Insight, September 2021

Krile, R., Todt, F., Schroeder, J. (2015). Assessing Roadway Traffic Count Duration and Frequency Impacts on Annual Average Daily Traffic Estimation (FHWA-PL-16-008). United States Federal Highway Administration

Appendix A Counter location characteristics and missing data

Table A1: Characteristics of the 48 ATR counter locations.
Missing data shows the total percent of observations missing from both StL and ATR

Counter ID	Town	Urban/Rural	AADT Range	Factor Group	Missing MADT	Missing DOW	Missing HOD (peak)
31907	DIXMONT	Rural	1,000 - 2,499	I	-	69%	94%
102	TOPSHAM	Urban	2,500 - 4,999	I	-	-	41%
34500	BROWNFIELD	Rural	2,500 - 4,999	II	-	-	34%
36907	WILTON	Rural	2,500 - 4,999	II	-	27%	85%
37007	WATERBORO	Rural	2,500 - 4,999	none	-	-	22%
56304	WILTON	Rural	2,500 - 4,999	II	-	29%	90%
57501	HANCOCK	Rural	2,500 - 4,999	II	-	18%	55%
74400	HANOVER	Rural	2,500 - 4,999	II	-	39%	80%
92003	SACO	Urban	2,500 - 4,999	III	8%	-	22%
97805	VASSALBORO	Rural	2,500 - 4,999	I	-	-	25%
401	YORK	Rural	5,000 - 9,999	III	-	-	8%
2605	HALLOWELL	Urban	5,000 - 9,999	I	-	-	7%
7507	SACO	Urban	5,000 - 9,999	III	-	-	11%
13204	BANGOR	Urban	5,000 - 9,999	I	17%	-	6%
36304	WATERBORO	Rural	5,000 - 9,999	I	-	-	9%
38701	NAPLES	Rural	5,000 - 9,999	II	-	-	10%
38704	NAPLES	Rural	5,000 - 9,999	II	-	-	3%
56204	SKOWHEGAN	Rural	5,000 - 9,999	I	-	-	19%
56401	FRANKFORT	Rural	5,000 - 9,999	I	-	-	16%
59705	WOODSTOCK	Rural	5,000 - 9,999	none	-	-	12%
66007	CHINA	Rural	5,000 - 9,999	II	-	-	21%
92008	SACO	Urban	5,000 - 9,999	III	8%	-	4%
92304	CHELSEA	Rural	5,000 - 9,999	I	-	-	5%
704	SANFORD	Urban	10,000 - 24,999	I	8%	-	-
2600	OGUNQUIT	Rural	10,000 - 24,999	none	-	-	5%
3606	ROCKPORT	Rural	10,000 - 24,999	II	-	-	7%

5206	WATERVILLE	Urban	10,000 - 24,999	I	-	-	8%
7208	WESTBROOK	Urban	10,000 - 24,999	I	-	-	-
10600	LEWISTON	Urban	10,000 - 24,999	I	17%	-	-
30200	BREWER	Urban	10,000 - 24,999	I	8%	-	-
30405	WATERBORO	Rural	10,000 - 24,999	I	-	-	-
41704	HOLDEN	Rural	10,000 - 24,999	none	-	-	1%
41907	WINTHROP	Rural	10,000 - 24,999	I	33%	-	-
51906	WISCASSET	Rural	10,000 - 24,999	II	17%	-	1%
52100	CARMEL	Rural	10,000 - 24,999	II	33%	-	1%
53901	BRUNSWICK	Rural	10,000 - 24,999	II	25%	-	-
53902	BRUNSWICK	Rural	10,000 - 24,999	II	25%	-	-
57507	HANCOCK	Rural	10,000 - 24,999	II	-	-	3%
78700	TRENTON	Rural	10,000 - 24,999	III	-	-	2%
54701	KITTERY	Urban	25,000 - 49,999	II	33%	-	-
54702	KITTERY	Urban	25,000 - 49,999	II	33%	-	-
90109	PORTLAND	Urban	25,000 - 49,999	I	33%	-	-
90110	PORTLAND	Urban	25,000 - 49,999	I	33%	-	-
90307	PORTLAND	Urban	25,000 - 49,999	I	17%	-	-
90308	PORTLAND	Urban	25,000 - 49,999	I	17%	-	-
90511	PORTLAND	Urban	25,000 - 49,999	I	17%	-	-
90516	PORTLAND	Urban	25,000 - 49,999	I	17%	-	-

Appendix B Turning Movement Count Evaluation

Formulas

We applied the following formulas to test each whether the STL percent of total intersection (PTI) for each TMC direction is within a precision household, $\underline{e}$:

a_{pct} = PTI, 1st short term count (STC)

$$a_{pct} = \frac{a}{a_t} * 100$$

where:
a = individual turning movement count
a_t = sum of all turning movements at the intersection
b_{pct} = PTI, 2nd STC

$$b_{pct} = \frac{b}{b_t} * 100$$

c_{pct} = PTI, StL TMC estimate

$$c_{pct} = \frac{c}{c_t} * 100$$

d_{pct} = Average PTI for STC a & b

$$d_{pct} = \frac{a_{pct} + b_{pct}}{2}$$

$\underline{e}$ = Precision of PTI, STC a & b

$$\underline{e} = | b_{pct} - a_{pct} |$$

$\underline{s}$ = Precision of STL PTI compared to average of STC PTI

$$\underline{s} = | c_{pct} - d_{pct} |$$

Test if STL difference is greater than the DOT difference

$$If\ \underline{s} - \underline{e} \leq 0,$$

$$then:\ Streetlight\ is\ within\ STC's\ precision\ (\underline{e})$$

else: Streetlight exceeds STC's precision

Turning Movement Counts Precision Test Results

Legend: red = fail, green = pass, yellow = changed from fail to pass in Test #2.

Table B-1 Abbreviated results table showing the results of precision test 1 and 2

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Unit			Count	%	Count	%	%	%	%	Test 1	Test 2
Formula			ab	ab%	c	c%	d% = abs(a%-b%)	e% = abs(c%-ab%)	e% - d%	Is e% larger than d%?	Is e% larger than 1.8% (mean)
Average for 307 TMC:									1.8%	20.2%	62.5%
Augusta 048	N	T	6243	30.7%	4478	39.5%	0.4%	8.8%	8.4%	over	over
Augusta 048	N	R	6243	11.5%	1897	16.7%	0.6%	5.3%	4.7%	over	over
Augusta 048	N	L	2327	8.0%	0	0.0%	0.9%	8.0%	7.1%	over	over
Augusta 048	N	T	1624	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Augusta 048	N	R	7	7.1%	0	0.0%	0.7%	7.1%	6.4%	over	over
Augusta 048	S	L	1453	10.2%	4950	43.7%	0.7%	33.4%	32.7%	over	over
Augusta 048	S	T	2080	32.4%	0	0.0%	1.4%	32.4%	31.0%	over	over
Augusta 028	N	L	6582	28.0%	4061	28.7%	1.9%	0.7%	-1.3%	under	under
Augusta 028	N	R	3699	0.6%	150	1.1%	0.1%	0.5%	0.4%	under	under
Augusta 028	N	T	77	12.2%	2655	18.7%	0.4%	6.6%	6.2%	over	over
Augusta 028	N	R	1609	29.7%	3193	22.5%	1.0%	7.1%	6.1%	over	over
Augusta 028	S	L	3921	2.2%	348	2.5%	0.4%	0.3%	-0.1%	under	under
Augusta 028	S	T	290	14.5%	1889	13.3%	1.1%	1.1%	0.0%	under	over
Augusta 028	S	R	1909	12.9%	1867	13.2%	1.2%	0.3%	-0.9%	under	under
Augusta 028	W	T	1697	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Augusta 116	N	L	1	1.6%	256	2.3%	0.2%	0.6%	0.4%	under	under
Augusta 116	N	T	385	10.0%	2092	18.5%	0.8%	8.4%	7.6%	over	over
Augusta 116	N	R	2358	8.9%	1496	13.2%	0.8%	4.3%	3.5%	over	over
Augusta 116	N	L	2090	1.2%	165	1.5%	0.1%	0.3%	0.2%	under	under
Augusta 116	N	T	275	15.6%	2812	24.8%	1.6%	9.2%	7.6%	over	over
Augusta 116	N	R	3673	1.7%	211	1.9%	0.1%	0.2%	0.1%	under	under
Augusta 116	S	L	391	13.3%	2395	21.1%	0.3%	7.8%	7.5%	over	over
Augusta 116	S	T	3139	10.6%	2027	17.9%	0.9%	7.3%	6.5%	over	over
Augusta 116	S	R	2487	1.3%	209	1.8%	0.2%	0.5%	0.4%	under	under
Augusta 116	W	L	311	7.8%	1251	11.0%	0.0%	3.2%	3.2%	over	over
Augusta 116	W	T	1840	15.2%	2882	25.4%	1.6%	10.2%	8.6%	over	over

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Augusta 116	W	R	3582	12.7%	1413	12.5%	0.9%	0.3%	-0.6%	under	under
Augusta 118	N	L	2996	2.5%	303	2.0%	0.1%	0.5%	0.4%	under	under
Augusta 118	N	T	467	2.4%	321	2.1%	0.2%	0.3%	0.1%	under	under
Augusta 118	N	R	446	1.7%	225	1.5%	0.3%	0.2%	-0.1%	under	under
Augusta 118	N	L	313	8.5%	1548	10.0%	0.1%	1.5%	1.4%	under	over
Augusta 118	N	T	1594	35.0%	5258	34.1%	0.9%	0.9%	0.0%	under	under
Augusta 118	N	R	6528	2.4%	289	1.9%	0.1%	0.5%	0.4%	under	under
Augusta 118	S	L	445	1.6%	418	2.7%	0.2%	1.1%	0.9%	under	over
Augusta 118	S	T	296	1.9%	311	2.0%	0.2%	0.1%	-0.1%	under	under
Augusta 118	S	R	351	5.9%	1041	6.7%	0.3%	0.8%	0.5%	under	under
Augusta 118	W	L	1104	1.7%	240	1.6%	0.7%	0.1%	-0.5%	under	under
Augusta 118	W	T	317	34.8%	5098	33.0%	0.3%	1.7%	1.4%	under	over
Augusta 118	W	R	6491	1.7%	385	2.5%	0.1%	0.8%	0.7%	under	under
Belfast 113	N	L	319	11.4%	768	8.1%	0.2%	3.3%	3.1%	over	over
Belfast 113	N	T	1553	0.5%	64	0.7%	0.2%	0.2%	0.0%	under	under
Belfast 113	N	R	71	2.9%	182	1.9%	0.0%	1.0%	1.0%	under	over
Belfast 113	N	L	403	3.5%	486	5.1%	0.1%	1.6%	1.5%	under	over
Belfast 113	N	T	478	33.6%	3006	31.7%	0.6%	1.9%	1.3%	over	over
Belfast 113	N	R	4596	2.7%	897	9.5%	0.5%	6.7%	6.2%	over	over
Belfast 113	S	L	375	1.8%	190	2.0%	0.0%	0.2%	0.2%	under	under
Belfast 113	S	T	247	0.9%	56	0.6%	0.2%	0.3%	0.1%	under	under
Belfast 113	S	R	127	4.0%	441	4.7%	0.0%	0.7%	0.7%	under	under
Belfast 113	W	L	542	2.1%	124	1.3%	0.1%	0.8%	0.8%	under	under
Belfast 113	W	T	293	35.0%	3065	32.4%	1.7%	2.6%	1.0%	over	over
Belfast 113	W	R	4786	1.5%	193	2.0%	0.1%	0.6%	0.5%	under	under
Belfast 116	N	L	201	0.1%	0	0.0%	0.0%	0.1%	0.1%	under	under
Belfast 116	N	T	14	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Belfast 116	N	R	3	0.4%	0	0.0%	0.0%	0.4%	0.4%	under	under
Belfast 116	N	L	39	5.7%	665	10.9%	0.3%	5.2%	4.9%	over	over
Belfast 116	N	T	601	23.8%	1496	24.6%	0.3%	0.8%	0.5%	under	under
Belfast 116	N	R	2511	0.2%	0	0.0%	0.0%	0.2%	0.1%	under	under
Belfast 116	S	L	17	20.9%	1025	16.8%	1.4%	4.1%	2.7%	over	over
Belfast 116	S	T	2207	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Belfast 116	S	R	3	7.3%	700	11.5%	0.2%	4.2%	4.0%	over	over
Belfast 116	W	L	771	0.3%	0	0.0%	0.1%	0.3%	0.3%	under	under
Belfast 116	W	T	35	23.2%	1425	23.4%	1.2%	0.2%	-1.0%	under	under
Belfast 116	W	R	2451	18.0%	780	12.8%	0.1%	5.2%	5.1%	over	over
Bethel 036	N	L	1898	24.6%	1570	27.8%	2.7%	3.2%	0.5%	over	over
Bethel 036	N	T	2125	15.6%	1040	18.4%	0.2%	2.8%	2.6%	over	over

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Bethel 036	N	R	1350	2.3%	0	0.0%	0.9%	2.3%	1.4%	over	over
Bethel 036	N	L	199	1.8%	141	2.5%	0.6%	0.7%	0.1%	under	under
Bethel 036	N	T	157	2.4%	0	0.0%	0.2%	2.4%	2.2%	over	over
Bethel 036	N	R	205	28.4%	1566	27.7%	2.2%	0.7%	-1.5%	under	under
Bethel 036	S	L	2458	0.9%	0	0.0%	0.2%	0.9%	0.7%	under	under
Bethel 036	S	T	79	15.6%	1103	19.5%	1.0%	3.9%	2.8%	over	over
Bethel 036	S	R	1354	3.5%	233	4.1%	1.0%	0.7%	-0.4%	under	under
Bethel 036	W	L	300	1.5%	0	0.0%	0.5%	1.5%	1.0%	under	over
Bethel 036	W	T	127	2.4%	0	0.0%	0.3%	2.4%	2.1%	over	over
Bethel 036	W	R	207	1.1%	0	0.0%	0.1%	1.1%	0.9%	under	over
Cumberland 004	N	L	94	3.6%	202	3.7%	1.2%	0.1%	-1.1%	under	under
Cumberland 004	N	T	276	24.5%	1172	21.5%	2.9%	3.0%	0.0%	over	over
Cumberland 004	N	R	1875	4.7%	222	4.1%	1.3%	0.7%	-0.6%	under	under
Cumberland 004	N	L	363	3.9%	205	3.8%	0.0%	0.2%	0.2%	under	under
Cumberland 004	N	T	302	6.9%	484	8.9%	0.6%	2.0%	1.4%	over	over
Cumberland 004	N	R	526	3.8%	206	3.8%	1.6%	0.0%	-1.6%	under	under
Cumberland 004	S	L	290	6.1%	355	6.5%	1.1%	0.4%	-0.7%	under	under
Cumberland 004	S	T	470	23.4%	1113	20.4%	1.7%	3.0%	1.3%	over	over
Cumberland 004	S	R	1795	4.2%	163	3.0%	0.2%	1.3%	1.1%	under	over
Cumberland 004	W	L	325	4.5%	272	5.0%	1.6%	0.5%	-1.0%	under	under
Cumberland 004	W	T	342	7.1%	573	10.5%	0.9%	3.4%	2.5%	over	over
Cumberland 004	W	R	546	7.2%	481	8.8%	1.8%	1.7%	-0.2%	under	over
Ellsworth 451	N	L	548	8.9%	1227	8.3%	0.1%	0.5%	0.4%	under	under
Ellsworth 451	N	R	1351	0.8%	67	0.5%	0.4%	0.4%	0.0%	under	under
Ellsworth 451	N	T	128	40.5%	6285	42.7%	0.9%	2.3%	1.3%	over	over
Ellsworth 451	N	R	6168	8.7%	1113	7.6%	0.3%	1.2%	0.9%	under	over
Ellsworth 451	W	L	1331	0.9%	143	1.0%	0.1%	0.1%	-0.1%	under	under
Ellsworth 451	W	T	140	40.2%	5869	39.9%	0.3%	0.3%	0.0%	under	under
Falmouth 022	N	L	6122	21.0%	2035	17.5%	0.7%	3.5%	2.8%	over	over
Falmouth 022	N	T	3310	5.6%	843	7.3%	2.4%	1.6%	-0.8%	under	over
Falmouth 022	N	R	883	4.0%	501	4.3%	0.7%	0.3%	-0.4%	under	under

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Falmouth 022	N	L	638	3.2%	529	4.6%	0.2%	1.3%	1.1%	under	over
Falmouth 022	N	T	511	15.9%	1936	16.7%	1.2%	0.8%	-0.5%	under	under
Falmouth 022	N	R	2507	19.0%	1696	14.6%	0.1%	4.4%	4.3%	over	over
Falmouth 022	S	L	2993	0.1%	651	5.6%	0.1%	5.5%	5.4%	over	over
Falmouth 022	S	T	16	5.6%	518	4.5%	0.9%	1.2%	0.3%	under	over
Falmouth 022	S	R	887	4.7%	21	0.2%	1.0%	4.5%	3.5%	over	over
Falmouth 022	W	L	743	4.1%	563	4.8%	0.9%	0.7%	-0.1%	under	under
Falmouth 022	W	T	655	16.5%	2305	19.8%	0.5%	3.3%	2.8%	over	over
Falmouth 022	W	R	2614	0.2%	27	0.2%	0.0%	0.0%	0.0%	under	under
Falmouth 026	N	L	30	13.0%	668	6.2%	3.1%	6.7%	3.6%	over	over
Falmouth 026	N	T	2101	0.4%	101	0.9%	0.4%	0.6%	0.2%	under	under
Falmouth 026	N	R	60	12.2%	370	3.5%	1.0%	8.7%	7.7%	over	over
Falmouth 026	N	L	1983	0.2%	93	0.9%	0.0%	0.6%	0.6%	under	under
Falmouth 026	N	T	40	27.5%	2897	27.0%	0.3%	0.5%	0.2%	under	under
Falmouth 026	N	R	4480	8.8%	1572	14.7%	0.5%	5.9%	5.4%	over	over
Falmouth 026	S	L	1427	0.7%	94	0.9%	0.0%	0.2%	0.2%	under	under
Falmouth 026	S	T	115	0.4%	152	1.4%	0.2%	1.1%	0.9%	under	over
Falmouth 026	S	R	60	0.3%	119	1.1%	0.1%	0.8%	0.7%	under	under
Falmouth 026	W	L	51	11.0%	1343	12.5%	1.2%	1.5%	0.3%	under	over
Falmouth 026	W	T	1785	24.7%	3022	28.2%	4.8%	3.5%	-1.3%	over	over
Falmouth 026	W	R	4032	0.9%	293	2.7%	0.4%	1.8%	1.4%	over	over
Falmouth 050	N	L	151	8.9%	1096	12.8%	1.1%	3.9%	2.8%	over	over
Falmouth 050	N	T	1484	0.1%	10	0.1%	0.0%	0.1%	0.0%	under	under
Falmouth 050	N	R	11	10.3%	3	0.0%	0.3%	10.3%	9.9%	over	over
Falmouth 050	N	L	1703	0.4%	0	0.0%	0.1%	0.4%	0.2%	under	under
Falmouth 050	N	T	59	26.0%	2971	34.7%	0.8%	8.6%	7.9%	over	over
Falmouth 050	N	R	4314	12.9%	384	4.5%	1.8%	8.4%	6.6%	over	over
Falmouth 050	S	L	2133	0.3%	0	0.0%	0.1%	0.3%	0.2%	under	under
Falmouth 050	S	T	43	0.1%	43	0.5%	0.1%	0.4%	0.3%	under	under
Falmouth 050	S	R	20	0.5%	0	0.0%	0.2%	0.5%	0.2%	under	under
Falmouth 050	W	L	75	13.3%	426	5.0%	0.8%	8.3%	7.6%	over	over
Falmouth 050	W	T	2201	26.9%	3638	42.4%	1.8%	15.5%	13.7%	over	over
Falmouth 050	W	R	4466	0.4%	0	0.0%	0.2%	0.4%	0.2%	under	under
Farmington 001	N	L	58	8.5%	623	6.3%	0.0%	2.2%	2.2%	over	over
Farmington 001	N	R	1282	0.1%	321	3.2%	0.1%	3.1%	3.0%	over	over
Farmington 001	N	L	19	41.6%	4012	40.3%	0.0%	1.3%	1.3%	under	over

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Farmington 001	N	R	6296	9.0%	793	8.0%	0.4%	1.0%	0.6%	under	over
Farmington 001	S	L	1365	0.2%	419	4.2%	0.1%	4.0%	3.9%	over	over
Farmington 001	S	R	31	40.6%	3783	38.0%	0.7%	2.6%	1.9%	over	over
Farmington 002	N	L	6140	9.0%	1322	13.4%	0.9%	4.4%	3.5%	over	over
Farmington 002	N	T	1256	30.3%	2737	27.7%	1.4%	2.5%	1.1%	over	over
Farmington 002	N	R	4248	6.2%	348	3.5%	0.6%	2.7%	2.1%	over	over
Farmington 002	N	L	865	0.4%	37	0.4%	0.1%	0.1%	-0.1%	under	under
Farmington 002	N	T	60	1.1%	127	1.3%	0.3%	0.2%	-0.1%	under	under
Farmington 002	N	R	158	9.4%	1158	11.7%	0.9%	2.3%	1.5%	over	over
Farmington 002	S	L	1317	2.3%	108	1.1%	0.0%	1.2%	1.2%	under	over
Farmington 002	S	T	326	31.1%	2851	28.9%	1.6%	2.2%	0.6%	over	over
Farmington 002	S	R	4362	0.6%	18	0.2%	0.2%	0.4%	0.3%	under	under
Farmington 002	W	L	87	6.4%	758	7.7%	0.5%	1.3%	0.8%	under	over
Farmington 002	W	T	898	0.9%	135	1.4%	0.2%	0.4%	0.2%	under	under
Farmington 002	W	R	131	2.2%	265	2.7%	0.1%	0.5%	0.4%	under	under
Farmington 069	N	L	304	1.8%	0	0.0%	0.3%	1.8%	1.5%	under	over
Farmington 069	N	T	286	33.5%	3572	34.7%	1.1%	1.1%	0.1%	under	over
Farmington 069	N	R	5452	9.1%	1239	12.0%	0.6%	2.9%	2.4%	over	over
Farmington 069	N	L	1481	0.2%	0	0.0%	0.1%	0.2%	0.2%	under	under
Farmington 069	N	T	38	0.4%	0	0.0%	0.0%	0.4%	0.4%	under	under
Farmington 069	N	R	72	2.5%	0	0.0%	0.0%	2.5%	2.5%	over	over
Farmington 069	S	L	401	4.5%	702	6.8%	0.4%	2.3%	1.9%	over	over
Farmington 069	S	T	739	33.7%	3124	30.3%	1.0%	3.3%	2.4%	over	over
Farmington 069	S	R	5475	0.1%	0	0.0%	0.1%	0.1%	0.0%	under	under

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Farmington 069	W	L	18	8.8%	1133	11.0%	0.2%	2.2%	2.0%	over	over
Farmington 069	W	T	1432	0.4%	0	0.0%	0.0%	0.4%	0.4%	under	under
Farmington 069	W	R	71	4.9%	534	5.2%	0.8%	0.3%	-0.6%	under	under
Farmington 070	N	T	801	41.5%	4852	45.2%	1.4%	3.7%	2.2%	over	over
Farmington 070	N	R	7045	5.7%	438	4.1%	0.7%	1.6%	0.9%	under	over
Farmington 070	S	L	968	4.1%	273	2.5%	0.0%	1.6%	1.5%	under	over
Farmington 070	S	T	699	39.7%	4340	40.4%	1.0%	0.7%	-0.3%	under	under
Farmington 070	W	L	6735	5.6%	551	5.1%	1.1%	0.4%	-0.7%	under	under
Farmington 070	W	R	948	3.4%	285	2.7%	0.6%	0.8%	0.1%	under	under
Gardiner 001	N	L	581	8.0%	1223	6.6%	0.0%	1.5%	1.5%	under	over
Gardiner 001	N	T	2015	5.0%	997	5.3%	0.3%	0.3%	0.1%	under	under
Gardiner 001	N	R	1258	12.0%	2471	13.2%	0.1%	1.2%	1.1%	under	over
Gardiner 001	N	L	3021	6.9%	1136	6.1%	0.1%	0.8%	0.7%	under	under
Gardiner 001	N	T	1724	17.6%	3586	19.2%	0.6%	1.6%	1.0%	under	over
Gardiner 001	N	R	4413	9.3%	1679	9.0%	0.2%	0.3%	0.2%	under	under
Gardiner 001	S	L	2341	1.3%	142	0.8%	0.1%	0.5%	0.5%	under	under
Gardiner 001	S	T	329	5.7%	916	4.9%	0.4%	0.8%	0.4%	under	under
Gardiner 001	S	R	1436	9.8%	1424	7.6%	0.6%	2.2%	1.6%	over	over
Gardiner 001	W	L	2464	9.6%	2013	10.8%	1.0%	1.2%	0.3%	under	over
Gardiner 001	W	T	2409	14.5%	3038	16.3%	0.5%	1.8%	1.3%	over	over
Gardiner 001	W	R	3627	0.3%	28	0.2%	0.2%	0.1%	-0.1%	under	under
Gardiner 002	N	L	62	5.4%	605	5.3%	0.8%	0.1%	-0.7%	under	under
Gardiner 002	N	T	679	25.8%	2868	25.2%	0.1%	0.6%	0.5%	under	under
Gardiner 002	N	R	3244	15.8%	2051	18.0%	0.9%	2.2%	1.3%	over	over
Gardiner 002	S	L	1991	1.7%	227	2.0%	0.1%	0.3%	0.2%	under	under
Gardiner 002	S	T	215	24.0%	2680	23.5%	0.3%	0.5%	0.2%	under	under
Gardiner 002	S	R	3025	3.0%	234	2.1%	0.7%	0.9%	0.3%	under	under
Gardiner 002	W	L	374	19.2%	2018	17.7%	1.2%	1.5%	0.2%	under	over
Gardiner 002	W	T	2420	4.2%	587	5.2%	0.3%	1.0%	0.7%	under	over
Gardiner 002	W	R	523	1.0%	115	1.0%	0.0%	0.0%	0.0%	under	under
Portland 314	N	L	124	0.4%	0	0.0%	0.4%	0.4%	0.0%	under	under
Portland 314	N	T	54	46.4%	4054	46.4%	4.6%	0.1%	-4.5%	under	under
Portland 314	N	L	4452	2.4%	0	0.0%	3.1%	2.4%	-0.7%	over	over

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Portland 314	N	R	310	0.5%	0	0.0%	0.5%	0.5%	0.0%	under	under
Portland 314	S	T	57	47.6%	4688	53.6%	3.4%	6.0%	2.6%	over	over
Portland 314	S	R	4597	2.7%	0	0.0%	4.0%	2.7%	-1.4%	over	over
Sanford 029	N	R	357	0.6%	70	0.5%	0.2%	0.1%	-0.1%	under	under
Sanford 029	W	R	97	0.6%	371	2.7%	0.1%	2.1%	2.0%	over	over
Sanford 050	N	L	98	1.8%	221	1.8%	0.2%	0.1%	-0.1%	under	under
Sanford 050	N	T	237	23.6%	2718	22.7%	0.7%	0.9%	0.2%	under	under
Sanford 050	N	R	3122	13.9%	1267	10.6%	0.4%	3.3%	2.9%	over	over
Sanford 050	N	L	1844	1.1%	178	1.5%	0.3%	0.4%	0.1%	under	under
Sanford 050	N	T	149	7.8%	989	8.3%	1.5%	0.4%	-1.0%	under	under
Sanford 050	N	R	1042	2.5%	357	3.0%	0.1%	0.5%	0.4%	under	under
Sanford 050	S	L	327	1.4%	386	3.2%	0.3%	1.8%	1.6%	over	over
Sanford 050	S	T	184	23.7%	2907	24.3%	1.0%	0.6%	-0.4%	under	under
Sanford 050	S	R	3135	1.0%	97	0.8%	0.2%	0.2%	0.0%	under	under
Sanford 050	W	L	135	14.0%	1479	12.4%	0.7%	1.7%	1.0%	under	over
Sanford 050	W	T	1860	7.3%	898	7.5%	1.0%	0.2%	-0.9%	under	under
Sanford 050	W	R	976	1.8%	474	4.0%	0.1%	2.1%	2.0%	over	over
Sanford 060	N	L	243	1.1%	0	0.0%	0.1%	1.1%	1.0%	under	over
Sanford 060	N	T	99	2.5%	0	0.0%	0.4%	2.5%	2.1%	over	over
Sanford 060	N	R	229	1.7%	0	0.0%	0.3%	1.7%	1.4%	under	over
Sanford 060	N	L	154	1.6%	225	3.1%	0.1%	1.5%	1.4%	under	over
Sanford 060	N	T	147	25.0%	2073	28.5%	0.4%	3.5%	3.1%	over	over
Sanford 060	N	R	2270	1.3%	0	0.0%	0.1%	1.3%	1.1%	under	over
Sanford 060	S	L	116	17.2%	1247	17.1%	0.1%	0.1%	-0.1%	under	under
Sanford 060	S	T	1562	2.1%	0	0.0%	0.2%	2.1%	1.9%	over	over
Sanford 060	S	R	191	1.4%	227	3.1%	0.1%	1.7%	1.7%	under	over
Sanford 060	W	L	127	2.0%	0	0.0%	0.7%	2.0%	1.2%	over	over
Sanford 060	W	T	178	26.4%	2224	30.5%	0.6%	4.2%	3.5%	over	over
Sanford 060	W	R	2397	17.8%	1286	17.7%	0.3%	0.1%	-0.2%	under	under
Sanford 068	N	L	1614	8.9%	988	9.7%	1.5%	0.8%	-0.7%	under	under
Sanford 068	N	T	1246	21.6%	1843	18.1%	1.7%	3.6%	1.9%	over	over
Sanford 068	N	R	3031	2.0%	239	2.3%	0.2%	0.3%	0.2%	under	under
Sanford 068	N	L	279	7.9%	827	8.1%	0.6%	0.2%	-0.4%	under	under
Sanford 068	N	T	1110	4.8%	727	7.1%	0.4%	2.4%	1.9%	over	over
Sanford 068	N	R	667	10.2%	1103	10.8%	1.9%	0.6%	-1.3%	under	under
Sanford 068	S	L	1429	3.9%	562	5.5%	0.7%	1.6%	1.0%	under	over
Sanford 068	S	T	542	20.3%	2000	19.6%	0.7%	0.7%	0.0%	under	under
Sanford 068	S	R	2847	8.1%	788	7.7%	0.4%	0.4%	0.0%	under	under
Sanford 068	W	L	1140	2.6%	284	2.8%	0.0%	0.2%	0.2%	under	under

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Sanford 068	W	T	358	4.9%	826	8.1%	0.6%	3.2%	2.7%	over	over
Sanford 068	W	R	680	4.9%	20	0.2%	0.5%	4.7%	4.2%	over	over
Sanford 106	N	L	689	8.4%	863	6.9%	7.0%	1.5%	-5.5%	under	over
Sanford 106	N	R	1164	6.5%	1798	14.4%	13.0%	7.9%	-5.1%	over	over
Sanford 106	N	L	957	2.3%	0	0.0%	4.6%	2.3%	-2.2%	over	over
Sanford 106	N	T	313	15.6%	3387	27.2%	31.1%	11.6%	-19.5%	over	over
Sanford 106	N	R	2278	8.8%	906	7.3%	5.9%	1.5%	-4.4%	under	over
Sanford 106	S	L	1214	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Sanford 106	S	R	6	2.6%	0	0.0%	5.1%	2.6%	-2.5%	over	over
Sanford 106	W	L	351	6.7%	1826	14.7%	13.2%	8.0%	-5.1%	over	over
Sanford 106	W	T	975	15.8%	3665	29.4%	31.7%	13.6%	-18.1%	over	over
Sanford 106	W	R	2318	0.0%	0	0.0%	0.0%	0.0%	0.0%	under	under
Waterville 045	N	L	3	6.0%	413	5.4%	0.3%	0.6%	0.3%	under	under
Waterville 045	N	T	475	65.5%	4866	63.7%	1.8%	1.7%	-0.1%	under	over
Waterville 045	N	R	5197	10.0%	1039	13.6%	2.4%	3.6%	1.2%	over	over
Waterville 045	N	L	798	4.9%	172	2.3%	0.1%	2.7%	2.6%	over	over
Waterville 045	N	T	393	3.9%	272	3.6%	0.5%	0.3%	-0.2%	under	under
Waterville 045	W	T	308	4.7%	652	8.5%	0.2%	3.9%	3.6%	over	over
Waterville 045	W	R	372	5.0%	220	2.9%	0.2%	2.1%	2.0%	over	over
Wells 041	N	L	399	5.6%	622	8.3%	0.4%	2.7%	2.4%	over	over
Wells 041	N	T	573	6.5%	13	0.2%	1.0%	6.3%	5.3%	over	over
Wells 041	N	R	669	0.7%	114	1.5%	0.2%	0.8%	0.6%	under	under
Wells 041	N	L	77	0.2%	0	0.0%	0.1%	0.2%	0.1%	under	under
Wells 041	N	T	23	31.1%	2859	38.3%	3.2%	7.2%	3.9%	over	over
Wells 041	N	R	3181	5.3%	539	7.2%	0.1%	1.9%	1.8%	over	over
Wells 041	S	L	548	4.0%	0	0.0%	1.1%	4.0%	2.9%	over	over
Wells 041	S	T	412	6.6%	0	0.0%	1.3%	6.6%	5.3%	over	over
Wells 041	S	R	680	0.2%	0	0.0%	0.1%	0.2%	0.2%	under	under
Wells 041	W	L	25	0.3%	139	1.9%	0.1%	1.5%	1.4%	under	over
Wells 041	W	T	34	34.7%	3182	42.6%	1.4%	7.9%	6.5%	over	over
Wells 041	W	R	3557	4.6%	0	0.0%	0.3%	4.6%	4.3%	over	over
Winslow 003	N	L	472	27.5%	0	0.0%	1.5%	27.5%	26.0%	over	over
Winslow 003	N	T	4122	17.7%	0	0.0%	0.9%	17.7%	16.8%	over	over
Winslow 003	N	R	2666	1.1%	0	0.0%	0.1%	1.1%	0.9%	under	over
Winslow 003	N	L	159	3.7%	484	46.2%	0.5%	42.5%	42.0%	over	over
Winslow 003	N	T	551	0.5%	27	2.6%	0.1%	2.1%	2.0%	over	over
Winslow 003	N	R	71	29.4%	7	0.7%	0.1%	28.7%	28.6%	over	over
Winslow 003	S	L	4421	0.2%	8	0.8%	0.0%	0.6%	0.6%	under	under
Winslow 003	S	T	26	15.2%	0	0.0%	0.4%	15.2%	14.8%	over	over

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Winslow 003	S	R	2292	3.5%	473	45.2%	0.1%	41.7%	41.6%	over	over
Winslow 003	W	L	529	0.7%	0	0.0%	0.5%	0.7%	0.2%	under	under
Winslow 003	W	T	109	0.4%	38	3.6%	0.1%	3.3%	3.1%	over	over
Winslow 003	W	R	55	0.2%	10	1.0%	0.1%	0.7%	0.6%	under	under
Winslow 007	N	L	32	0.9%	99	0.8%	0.1%	0.0%	-0.1%	under	under
Winslow 007	N	T	120	10.6%	1565	13.2%	0.5%	2.6%	2.1%	over	over
Winslow 007	N	R	1482	12.3%	1432	12.1%	0.0%	0.2%	0.1%	under	under
Winslow 007	N	L	1718	2.0%	122	1.0%	0.0%	1.0%	1.0%	under	under
Winslow 007	N	T	281	17.8%	1924	16.3%	0.9%	1.6%	0.7%	under	over
Winslow 007	N	R	2497	0.9%	80	0.7%	0.0%	0.2%	0.2%	under	under
Winslow 007	S	L	127	7.8%	975	8.2%	0.3%	0.5%	0.2%	under	under
Winslow 007	S	T	1088	11.1%	1468	12.4%	0.6%	1.3%	0.7%	under	over
Winslow 007	S	R	1550	2.1%	152	1.3%	0.2%	0.8%	0.6%	under	under
Winslow 007	W	L	297	9.2%	1044	8.8%	0.5%	0.3%	-0.1%	under	under
Winslow 007	W	T	1283	17.9%	2190	18.5%	0.1%	0.7%	0.5%	under	under
Winslow 007	W	R	2499	7.5%	771	6.5%	0.6%	1.0%	0.4%	under	over
Winslow 011	N	L	1053	0.9%	0	0.0%	0.1%	0.9%	0.9%	under	under
Winslow 011	N	T	94	0.7%	0	0.0%	0.2%	0.7%	0.5%	under	under
Winslow 011	N	R	77	1.7%	0	0.0%	0.2%	1.7%	1.5%	under	over
Winslow 011	N	L	175	1.4%	130	1.6%	0.0%	0.2%	0.2%	under	under
Winslow 011	N	T	143	31.0%	2266	27.5%	0.7%	3.5%	2.7%	over	over
Winslow 011	N	R	3198	0.9%	0	0.0%	0.2%	0.9%	0.7%	under	under
Winslow 011	S	L	91	15.9%	1874	22.7%	0.6%	6.8%	6.2%	over	over
Winslow 011	S	T	1643	0.9%	0	0.0%	0.3%	0.9%	0.6%	under	under
Winslow 011	S	R	94	3.1%	138	1.7%	0.1%	1.5%	1.4%	under	over
Winslow 011	W	L	324	2.0%	21	0.3%	0.5%	1.7%	1.2%	under	over
Winslow 011	W	T	203	26.2%	2216	26.9%	0.8%	0.6%	-0.2%	under	under
Winslow 011	W	R	2713	15.3%	1607	19.5%	1.5%	4.2%	2.7%	over	over
Winslow 056	N	L	1583	0.4%	44	0.6%	0.0%	0.2%	0.1%	under	under
Winslow 056	N	T	33	13.5%	1085	13.7%	0.3%	0.2%	-0.1%	under	under
Winslow 056	N	R	1130	7.5%	565	7.1%	0.4%	0.4%	0.0%	under	under
Winslow 056	N	L	630	0.6%	37	0.5%	0.1%	0.1%	0.0%	under	under
Winslow 056	N	T	49	16.0%	1095	13.9%	1.3%	2.2%	0.9%	over	over
Winslow 056	N	R	1339	0.4%	76	1.0%	0.1%	0.5%	0.5%	under	under
Winslow 056	S	L	35	11.2%	848	10.7%	0.4%	0.5%	0.0%	under	under
Winslow 056	S	T	936	14.9%	1190	15.1%	1.6%	0.2%	-1.5%	under	under
Winslow 056	S	R	1243	0.6%	44	0.6%	0.2%	0.0%	-0.2%	under	under
Winslow 056	W	L	47	8.0%	747	9.4%	0.1%	1.5%	1.4%	under	over
Winslow 056	W	T	666	16.2%	1229	15.5%	0.3%	0.7%	0.4%	under	under

Intersection	Dir.	Turn	Mean of STC #1 & STC #2		StL Estimated TMC		STC Precision	Abs. Diff. of StL and mean STC	Diff. between Precision of STC and StL	Is the difference of StL larger than of the STC?	Is the precision of STL greater than 1.8%?
Winslow 056	W	R	1358	10.7%	946	12.0%	0.1%	1.3%	1.2%	under	over

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