Evaluation of TomTom Historical Average Speed Data

Texas Transportation Institute (TTI)
June 15, 2012

Introduction

The Texas Transportation Institute (TTI) routinely develops highway performance statistics that use historical average travel time data, and TomTom is one of several possible data providers. To gain a better understanding of their prevailing data quality, TTI evaluated the accuracy of a sample of TomTom historical travel time data for the city of Houston, Texas. The historical data were provided by TomTom at no cost through a standard evaluation agreement.

Evaluation Methods

The accuracy evaluation methods used by TTI are consistent with national best practices (specifically, the Guidelines for Evaluating the Accuracy of Travel Time and Speed Data\(^1\) and I-95 Corridor Coalition testing\(^2\)). These two best practices are based on real-time data; however, this evaluation applied similar procedures to historical average data.

The benchmark or “ground truth” data used to evaluate accuracy came from two Houston TranStar (\(\text{http://traffic.houstontranstar.org}\)) sources:

1. Toll tag-based traffic monitoring system
2. Bluetooth-based arterial street monitoring system

Houston TranStar’s toll tag-based traffic monitoring system is a mature, extensively-tested, fully-operational system that has been installed on Houston freeways since the late 1990s. As of early 2012, there are at least 3 million electronic toll tags in the Houston region.

Houston TranStar’s Bluetooth-based arterial street monitoring system has been operational on several streets since 2010, and is quickly expanding in the arterial street network in West Houston. The Bluetooth-based travel times are included in publicly available traveler information in the Houston region.

Evaluation Parameters

A total of 11 directional segments on US 290 and 18 directional segments on Westheimer Road (Figure 1) were used to assess TomTom data accuracy. US 290 is a very congested freeway that is access-controlled. Westheimer Road is a major arterial street with coordinated traffic signal control, and extends from the developing areas of West Houston to the central business district.

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\(^1\) Version 1.0, June 2011, available at \(\text{http://www.pooledfund.org/Document/Download/2543}\).

\(^2\) I-95 Corridors Coalition’s evaluation methods and results available at \(\text{http://www.i95coalition.org/I95/Projects/ProjectDatabase/tabid/120/agentType/View/PropertyID/107/Default.aspx}\).
The segmentation and respective lengths are as follows.

**US 290 Eastbound:**
1. Barker-Cypress to FM 1960, 4.05 miles
2. FM 1960 to Sam Houston Tollway, 5.10 miles
3. Sam Houston Tollway to Fairbanks-N. Houston, 1.55 miles
4. Fairbanks-N. Houston to Pinemont, 2.90 miles
5. Pinemont to West 34th Street, 2.45 miles
6. West 34th Street to Dacoma, 1.10 miles

**US 290 Westbound:**
7. Dacoma to West 34th Street, 1.10 miles
8. West 34th Street to Pinemont, 2.45 miles
9. Pinemont to Fairbanks-N. Houston, 2.90 miles
10. Fairbanks-N. Houston to Sam Houston Tollway, 1.55 miles
11. Sam Houston Tollway to FM 1960, 4.25 miles

**Westheimer Rd Eastbound:**
1. SH 6 to Eldridge, 1.2 miles
2. Eldridge to Dairy Ashford, 1.1 miles
3. Dairy Ashford to Kirkwood, 1.0 mile
4. Kirkwood to Wilcrest, 1.0 mile
5. Wilcrest to Gessner, 2.0 miles
6. Gessner to Fondren, 1.1 miles
7. Fondren to Hillcroft, 1.2 miles
8. Hillcroft to Chimney Rock, 1.5 miles
9. Chimney Rock to Post Oak, 1.0 mile

**Westheimer Rd Westbound:**
10. Post Oak to Chimney Rock, 1.0 mile
11. Chimney Rock to Hillcroft, 1.5 miles
12. Hillcroft to Fondren, 1.2 miles
13. Fondren to Gessner, 1.1 miles
14. Gessner to Wilcrest, 2.0 miles
15. Wilcrest to Kirkwood, 1.0 mile
16. Kirkwood to Dairy Ashford, 1.0 mile
17. Dairy Ashford to Eldridge, 1.1 miles
18. Eldridge to SH 6, 1.2 miles
Average annual hourly day-of-week speeds and travel times were evaluated for calendar year 2010. That is, all Mondays in 2010 from 5 am to 6 am were grouped together for an average statistic, and so forth for all days of the week for all 11 directional freeway segments and 18 direction street segments. Comparisons of TomTom data were made to the accuracy benchmark only between 5 am and 8 pm, when the toll tag and Bluetooth monitoring systems have large samples sizes (i.e., an average of 4 tag-equipped vehicles every minute) with high degrees of confidence. Therefore, for each directional segment, 105 comparisons were made (i.e., 15 hours \( \times 7 \) days of the week).

The primary measure of accuracy used in the evaluation was the average absolute error of travel speed (Equation 1). The average absolute error is a simple accuracy measure that is easy to calculate and easy to understand. Average absolute error conveys the average magnitude of the error (in mph), regardless of whether the error is positive or negative. However, the average absolute error does not indicate if there is a consistent negative or positive bias.

**Equation 1**  
\[
\text{Average absolute error (mph)} = \frac{1}{n} \sum_{i=1}^{n} \text{abs}(x_i - \mu_i)
\]

where  
\( \mu_i \) = benchmark (toll-tag based) value for the \( i \)th comparison (mph)  
\( x_i \) = the \( i \)th TomTom travel speed estimate (mph)  
\( n \) = number of estimate-to-benchmark comparisons
The benchmark data was based on the most detailed segmentation possible given the existing installed roadside tag and Bluetooth readers. TTI provided TomTom with exact location of segment endpoints, and TomTom combined their network segmentation to match the toll tag and Bluetooth-based segmentation. The historical average travel time and speeds provided by TomTom were ready for comparison to toll tag and Bluetooth-based average speeds.

Additionally, the harmonic mean speed was calculated for benchmark data, as the TomTom travel times are also based upon harmonic mean speed calculations.

To assess the quality of travel speed data in different traffic conditions, the average absolute error on US 290 (i.e., freeway) was calculated for these 4 speed ranges:

1. 0-30 mph
2. 31-45 mph
3. 46-60 mph
4. Greater than 60 mph

Since Westheimer Road is an arterial street and operates in a slower speed range, the average absolute error was calculated for these 3 speed ranges:

1. 0-15 mph
2. 16-30 mph
3. 31-45 mph

**Evaluation Results**

Tabular results of the comparison are shown in Table 1 (US 290) and Table 2 (Westheimer Road). The results are shown visually in Figures 2 through 29, and demonstrate how closely the TomTom historical data tracks the toll tag and Bluetooth-based benchmark.

For US 290 (i.e., heavily congested freeway), the results indicate that average absolute error was less than 5 mph on 10 of the 11 directional freeway segments. This was the case for all speed ranges; in fact, the error at the slowest speed category (less than 30 mph) was comparable to the error at free-flow speeds (i.e., 2.7 mph versus 2.2 mph).

For Westheimer Road (i.e., major arterial street), the results indicate that average absolute error was greater than on US 290, but was less than 8 mph on 17 of the 18 directional segments. The highest error (5.4 mph) was in the highest speed category, 31 to 45 mph.
Table 1. Summary of Average Absolute Error for TomTom Historical Speed Data: US 290 (Freeway with Access Control)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Origin</th>
<th>Destination</th>
<th>Error (in mph) for Benchmark Speed Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-30 mph</td>
</tr>
<tr>
<td>EB</td>
<td>Barker Cypress</td>
<td>FM 1960</td>
<td>1.7</td>
</tr>
<tr>
<td>EB</td>
<td>FM 1960</td>
<td>S. Houston Tollway</td>
<td>2.2</td>
</tr>
<tr>
<td>EB</td>
<td>S. Houston Tollway</td>
<td>Fairbanks-N Houston</td>
<td>1.8</td>
</tr>
<tr>
<td>EB</td>
<td>Fairbanks-N Houston</td>
<td>Pinemont</td>
<td></td>
</tr>
<tr>
<td>EB</td>
<td>Pinemont</td>
<td>W 34th</td>
<td>1.7</td>
</tr>
<tr>
<td>EB</td>
<td>W 34th</td>
<td>Daoma Rd</td>
<td>5.0</td>
</tr>
<tr>
<td>WB</td>
<td>Daoma Rd</td>
<td>W 34th</td>
<td>4.6</td>
</tr>
<tr>
<td>WB</td>
<td>W 34th</td>
<td>Pinemont</td>
<td>3.4</td>
</tr>
<tr>
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<td>Pinemont</td>
<td>Fairbanks-N Houston</td>
<td>2.2</td>
</tr>
<tr>
<td>WB</td>
<td>Fairbanks-N Houston</td>
<td>S. Houston Tollway</td>
<td>3.4</td>
</tr>
<tr>
<td>WB</td>
<td>S. Houston Tollway</td>
<td>FM 1960</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Average for all links** | 2.7 | 3.4 | 1.6 | 2.2 |

Note: A blank cell indicates that no comparisons were possible in that speed category.

Table 2. Summary of Average Absolute Error for TomTom Historical Speed Data: Westheimer Road (Major Arterial Street with Coordinated Traffic Signal Control)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Origin</th>
<th>Destination</th>
<th>Error (in mph) for Benchmark Speed Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-15 mph</td>
</tr>
<tr>
<td>EB</td>
<td>SH 6</td>
<td>Eldridge</td>
<td>4.2</td>
</tr>
<tr>
<td>EB</td>
<td>Eldridge</td>
<td>Dairy Ashford</td>
<td>4.2</td>
</tr>
<tr>
<td>EB</td>
<td>Dairy Ashford</td>
<td>Kirkwood</td>
<td>3.2</td>
</tr>
<tr>
<td>EB</td>
<td>Kirkwood</td>
<td>Wilcrest</td>
<td>4.2</td>
</tr>
<tr>
<td>EB</td>
<td>Wilcrest</td>
<td>Gessner</td>
<td>5.7</td>
</tr>
<tr>
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<td>Gessner</td>
<td>Fondren</td>
<td>2.0</td>
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<td>EB</td>
<td>Fondren</td>
<td>Hillcroft</td>
<td>1.4</td>
</tr>
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<td>Chimney Rock</td>
<td>2.6</td>
</tr>
<tr>
<td>EB</td>
<td>Chimney Rock</td>
<td>Post Oak</td>
<td>1.3</td>
</tr>
<tr>
<td>WB</td>
<td>Post Oak</td>
<td>Chimney Rock</td>
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<td>3.6</td>
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<td>Wilcrest</td>
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<td>4.1</td>
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<td>Dairy Ashford</td>
<td>1.0</td>
</tr>
<tr>
<td>WB</td>
<td>Dairy Ashford</td>
<td>Eldridge</td>
<td>3.2</td>
</tr>
<tr>
<td>WB</td>
<td>Eldridge</td>
<td>SH 6</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Average for all links** | 1.3 | 3.5 | 5.4 |

Note: A blank cell indicates that no comparisons were possible in that speed category.
Figure 4
US 290 EB: Sam Houston to Fairbanks-N Houston -- 2010 Weekdays

Figure 5
US 290 EB: Pinemont to W 34th -- 2010 Weekdays
Figure 8
US 290 WB: W 34th to Pinemont -- 2010 Weekdays

Figure 9
US 290 WB: Pinemont to Fairbanks-N Houston -- 2010 Weekdays
Figure 18
Westheimer EB: Gessner to Fondren -- 2010 Weekdays

Figure 19
Westheimer EB: Fondren to Hillcroft -- 2010 Weekdays
Figure 20
Westheimer EB: Hillcroft to Chimney Rock -- 2010 Weekdays

Figure 21
Westheimer EB: Chimney Rock to Post Oak -- 2010 Weekdays
Figure 24
Westheimer WB: Hillcroft to Fondren -- 2010 Weekdays

Figure 25
Westheimer WB: Fondren to Gessner -- 2010 Weekdays
Figure 26
Westheimer WB: Gessner to Wilcrest -- 2010 Weekdays

Figure 27
Westheimer WB: Wilcrest to Kirkwood -- 2010 Weekdays
Figure 28
Westheimer WB: Kirkwood to Dairy Ashford -- 2010 Weekdays

Figure 29
Westheimer WB: Dairy Ashford to Eldridge -- 2010 Weekdays