Calibration Potential of Common Analytical and Micro-simulation Roundabout Models:  
A New England Case Study

Conrad Gagnon  
Undergraduate Research Assistant  
School of Engineering  
University of Vermont, Burlington, VT 05405  
Phone: (603) 714-0320  
E-mail: crgagnon@uvm.edu

Adel W. Sadek, Ph.D.***  
Associate Professor  
School of Engineering  
University of Vermont, Burlington, VT 05405  
Phone: (802) 656-4126  FAX: (802) 656-8446  
E-mail: asadek@cem.s.uvm.edu

Andrew Touchette  
Undergraduate Research Assistant  
School of Engineering  
University of Vermont, Burlington, VT 05405  
Phone: (518) 275-7110  
E-mail: atouchet@uvm.edu

&

Mark Smith, P.E.  
Resource Systems Group, Inc.  
60 Lake Street, Unit 1E  
Burlington, VT 05401  
Phone: (802) 383-0118  FAX: (802) 383-0122  
E-mail: msmith@rsginc.com

Transportation Research Board  
87th Annual Meeting  
Washington, D.C.

*** Corresponding Author

Word Count: 5163 text words + 7 Figures + 2 Tables = 7413 equivalent words
ABSTRACT

Recent interest in using modern roundabouts as an effective and safe method for intersection control in the United States stresses the need for accurate modeling tools. The objective of this paper is to assess the calibration potential of common analytical and micro-simulation roundabout models to operations at modern roundabouts. The models considered were aaSIDRA and RODEL (on the analytical side); and PARAMICS, SimTraffic, and VISSIM (on the micro-simulation side). For this study, two modern roundabouts from New Hampshire were selected and video-taped over peak hour conditions. The models’ approach delay outputs were compared to the measured field delay from the video tapes. Model calibration parameters were systematically changed to assess their impact on the results with respect to field observations. Among the conclusions of the study are that current roundabout analysis models vary in terms of the calibration options, that calibration can have a significant impact on improving the model’s results, and that calibration might be site-specific.

Key Words: Roundabouts, model calibration, aaSIDRA, RODEL, Microscopic Simulation
Calibration Potential of Common Analytical and Micro-simulation Roundabout Models: A New England Case Study

INTRODUCTION
Recent years have witnessed a genuine interest in the U.S. in using modern roundabouts as an effective and safe method of intersection control. This is supported by the increased number of roundabouts in various stages of planning, design, and construction. The majority of models currently used in the U.S. are based on research conducted overseas, primarily European and Australian. Increased domestic interest stresses the need for accurate analysis models able to replicate domestic field operating conditions.

Models available for roundabouts analysis and design can be broadly classified into two groups: (1) analytical models; and (2) microscopic simulation models. Analytical models are based on empirical observations that relate the roundabout capacity to traffic characteristics and roundabout geometry. In the U.S., a survey conducted by Jacquemart (1) in 1998, showed that aaSIDRA (2) and RODEL (3) were the two most commonly used analytical roundabout analysis procedures. While analytical-type models are quite useful in the design and analysis of roundabouts, their major limitation lies in treating the roundabout as an isolated intersection. Attempts to account for platooning come mainly through the use of adjustment factors.

Microscopic simulation models allow the roundabout to be treated as a part of a system. They offer additional advantages, including realistic modeling of vehicle arrival and departures, the ability to study the spatial extent of queues, and more refined estimation of fuel consumption and emissions. Microscopic simulation models, however, must be calibrated first against field data or against other validated analytical models to ensure accuracy. This crucial step of calibration is unfortunately often neglected.

PURPOSE AND SCOPE
This paper evaluates the calibration potential of common analytical and micro-simulation roundabout models used in New England to replicate observed local operating conditions. The paper also investigates how to best calibrate models in order to yield results closer to field observations. Analytical models (aaSIDRA and RODEL) and micro-simulation models (PARAMICS (4), SimTraffic (5) and VISSIM (6)) are considered. Model evaluation is based on comparing approach delay values, obtained from uncalibrated and calibrated models, to actual field delays. Two modern roundabouts case studies from the State of New Hampshire (Nashua and Keene) are considered. Both are single-lane roundabouts built within the past five years, representative of typical, modern roundabouts in New England. Based on this evaluation, observations regarding calibration potential are summarized.

The paper is organized as follows. First, a brief discussion of previous studies related to calibration of analytical and microscopic simulation models for roundabouts analysis is provided, followed by an overview of the five models considered in this study. The study’s methodology is then described. Next, the results are presented and discussed. Finally, the paper concludes by summarizing the main conclusions derived from the study.
LITERATURE REVIEW
Given space limitations, this section only focuses on previous studies that calibrated roundabout models against field measurements. Akcelik (7) presented a single-lane roundabout case study from the United States comparing capacity estimates from four different analytical models: aaSidra, the UK linear regression model, the HCM 2000 model, and the old Australian NAASRA 1986 model. Flannery et. al. (8) measured field delay at six roundabouts in Florida and Maryland using video cameras to validate a model of mean service time. Garder (9) measured field delay at the Gorham, Maine roundabout, and compared these values to those predicted by nomographs developed in Australia; average delay in the two peak hours studied was quite low, however.

Recently, the National Cooperative Highway Research Program (NCHRP) funded a major study (NCHRP 3-65) to refine safety estimations of U.S. roundabouts. The research team compared capacity and delay estimates produced by RODEL and aaSIDRA to field estimates. The NCHRP study pointed out that when queues persisted for a full minute both RODEL and aaSIDRA’s delay estimates were typically low. With partial queuing under a minute, RODEL’s delay exceeded the field and aaSIDRA’s estimates were lower (10).

For microscopic simulation models, studies specifically addressing the validation or calibration of roundabouts are lacking. Most discussions of the subject of roundabout or network modeling, however, emphatically call attention to the need for precisely that (11, 12). A comparison and sensitivity analysis between microscopic simulation and analytical-type deterministic models for operational parameters related to roundabouts (such as follow-up headway, speed and critical gap) was made by Kinzel and Trueblood (11). The variability of these parameters is also discussed, but the results are not compared to field data. Stanek and Milam (13) compare the capacity of roundabouts with flared entry and double lanes obtained from RODEL, aaSIDRA, VISSIM, and PARAMICS, but did not mention any calibration techniques or comparisons to field data. Finally, Bared and Edara (14) investigate high-capacity roundabouts and their integration into smart signalized streams using VISSIM. Calibration is based mostly on smooth simulation flow and capacity results were compared to 434 one-minute data collections from 15 different sites. However, they do not compare modeled delay values against field observations.

As can be seen from the above, only very few previous studies compared the performance of roundabouts analysis models against field measurements. This is especially true for microscopic simulation models. In addition, none of the studies focused on the calibration potential to operating conditions in the New England region.

ROUNDABOUT ANALYSIS MODELS

RODEL Model
RODEL (ROundabout DELay) is an empirical, regression-based model, intended to help designers choose appropriate roundabout geometry, as well as predict roundabout performance and capacity. The model equations were created using geometric and flow data collected at many congested roundabouts in the UK. Inputs to the model include entry lane geometry (width, flair, radii and angle), circle diameter and turning flows. Outputs included capacity estimates, average
and maximum delay, queues for each leg, and an estimate for overall delay. No calibration variables are built into the model (3).

**aaSIDRA Model**
The aaSIDRA (akcelik & associates Signalized and unsignalized Intersection Design and Research Aid) model uses gap-acceptance parameters determined from field surveys conducted at numerous modern Australian roundabouts. The model predicts delay, queue length, and capacity based on expected flows and driver gap acceptance. Estimated capacity is sensitive to variations in approach and circulating lane use, the Origin-Destination demand flow pattern, and the amount of queuing on the approaches. A calibration module had been added to recent versions of the aaSIDRA software (2).

**PARAMICS Model**
PARAMICS, a suite of microscopic traffic simulation software, has its roots in several European research and development projects (4). Since its release for commercial application, the model has been validated, especially in the United Kingdom (UK), against other approved Department of Transport software. For modeling drivers’ behavior, PARAMICS used a variant of Fritzsche’s psycho-physical car-following model (15).

**Synchro/SimTraffic Model**
Synchro is a software package designed for optimizing signal timings, and modeling signalized and unsignalized intersections. The latest version, Synchro7, is the first version capable of evaluating roundabout delay. To determine delay at roundabouts, the model utilizes Synchro’s micro-simulation model, SimTraffic. SimTraffic has the ability to report the delay for each approach and the total stop time. According to Synchro’s website, improvements to the roundabout program are underway. The version used in this study could only model single-lane roundabouts with less than 1200 vehicles per hour per approach (5).

**VISSIM 4.10**
VISSIM, developed by the German traffic engineering software company PTV, is a powerful microscopic simulation model for analyzing and optimizing intersections and road networks. VISSIM models many details of the transportation system and provides the user with great flexibility in modeling. For roundabouts, the user can control the junction geometry, the location of the stop line, as well as gap acceptance and driver behavior-type parameters. Among several other measures, the model can report the roundabouts approach delay (6).

**METHODOLOGY**

**Case Studies**
Several factors were considered for selecting the representative case studies. The most important factors were: (1) 4-way single-lane roundabout with few geometric quirks, nearby intersections, bypass lanes, heavy pedestrian traffic, or steep grades; (2) relatively balanced flows and operating conditions close to capacity during peak hour; and (3) a modern design, providing for good deflection on entry and low entry and circulating speeds. Two such roundabouts were identified.
The Nashua roundabout, built in 2003, lies at the intersection of State Route 130 (Broad Street), a road accessing a large regional high school to the east (Chuck Drudging Drive) and a suburban residential area to the west (Coburn Avenue). Traffic volumes fluctuated greatly during the day, making Nashua an optimal case study. The Keene roundabout, also built in 2003, is located at the intersection of Court Street, Allen Court, and the Cheshire Medical Center (CMC). The roundabout was built to help with high volumes of traffic introduced by CMC. Table 1 summarizes the main geometric and traffic flow characteristics of the roundabouts.

<table>
<thead>
<tr>
<th>Table 1: Roundabout Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NASHUA</strong></td>
</tr>
<tr>
<td>Outer Diameter (ft)</td>
</tr>
<tr>
<td>Outer Diameter (ft)</td>
</tr>
<tr>
<td>Inner Diameter (ft)</td>
</tr>
<tr>
<td>Radius of Curvature (ft)</td>
</tr>
<tr>
<td>Lane Width (ft)</td>
</tr>
<tr>
<td>Entry Width (ft)</td>
</tr>
<tr>
<td>Entry Length L’ (ft)</td>
</tr>
<tr>
<td>Average Volume (vph)</td>
</tr>
<tr>
<td>Average Degree of Saturation *</td>
</tr>
</tbody>
</table>

| **KEENE**                       |
| Outer Diameter (ft)             | 84         | 84        | 84         | 84        |
| Inner Diameter (ft)             | 44         | 44        | 44         | 44        |
| Radius of Curvature (ft)        | 180        | 11        | 37         | 33        |
| Lane Width (ft)                 | 12         | 11        | 12         | 11        |
| Entry Width (ft)                | 16         | 14.5      | 16         | 14.5      |
| Entry Length L’ (ft)            | 63.5       | 18.5      | 74         | 26.5      |
| Centerline Angle Phi (deg)      | 12         | 18        | 20         | 17.5      |
| Capacity (vph)                  | 1196       | 856       | 1154       | 700       |
| Average Volume (vph)            | 516        | 188       | 378        | 24        |
| Average Degree of Saturation *  | 43%        | 22%       | 33%        | 3%        |

* For calculating the degree of saturation, approach capacities were estimated from the aaSIDRA software

**Data Collection**

Both roundabouts were video-taped by four cameras. The Nashua roundabout was recorded from 7AM-12 PM and from 12-6 PM. Historically, Keene’s peak volumes occurred in the afternoon, therefore the roundabout was recorded from 3:10 PM-6:10 PM.

**Data Reduction**

The following data were extracted from the tapes: (1) the volume of traffic entering, exiting and circulating at each approach; (2) the number of right turns made from each approach; (3) the approach delay for the three busiest approaches of a given roundabout; and (4) drivers’ acceptable gaps and headway. Information regarding the circulating diameter, entry width, angle and radius, lane widths, and center island diameter was collected from the field and aerial photography.

It should be noted that the data reduction process for this project was quite labor-intensive. Each roundabout approach was observed several times for extracting the volumes and...
again separately for measuring the approach delay. Difficulties such as high volumes, blocked views from circulating traffic, poor camera angles, and monotony further complicated the process. Based on the experience of the researchers, a rough estimate of the time needed for data reduction would be 15 times the length of the recording period. Securing more sophisticated equipment such as an overhead fisheye camera would have made this process easier, albeit cost-prohibitive for this project’s budget.

Volume and delay information were collected per 5-minute time increments, based on vehicle entry of the roundabout. 15-minute volume and delay intervals were created by combining sets of three concurrent 5-minute values. 15-minute periods served as the building blocks for one-hour periods used in analysis. Specifically, one hour periods were created by adding rolling 15-minute periods. For example, the first hour period for the Nashua roundabout represented the volume and delay values for the hour between 7:15 AM and 8:15 AM, and the second hour period were those between 7:30 AM and 8:30 AM., etc. This method helped maximize the data available for analysis. The following sections describe data reduction in more detail.

**Estimating Turning Movements**

Turning movement estimates were derived from collected volume data as recommended in the Federal Highway Administration (FHWA) Roundabouts Informational Guide (16). The FHWA procedure required the entering, exiting, circulating, and right turns for each leg of the traffic circle (Figure 1). Traffic passing ‘through’ the roundabout and ‘left turning’ vehicles were determined from Equations 1 and 2, respectively.

**Figure 1: Necessary Turning Movements per Approach**

\[
VEB, through = VEB, entry + VWB, exit - VEB, right - VNB, right - VNB, circ \quad \text{[Equation 1]}
\]

\[
VEB, left = VEB, entry - VEB, through - VEB, right \quad \text{[Equation 2]}
\]
Measuring Approach Delay
Measuring field delay values for roundabouts is more challenging than at signalized
intersections. Most cars did not stop, but slowed down to varying degrees when approaching the
roundabout. Many vehicles joined moving queues or shock waves, creating a wide range of
spacing and speeds. Traditional field delay measurement techniques needed to be adapted to
measure the total approach delay of a roundabout.

After experimenting with several delay measurement methods, this study chose to use a
data collector developed by JAMAR Technologies (17), capable of measuring stopped delay.
This was adapted to measure the total approach time. A ‘travel zone’ was defined by a known
point upstream of any queuing to the yield bar. Approach travel time was measured for each
vehicle completing the travel zone trip. By definition, geometric delay caused by the roundabout
was omitted from the approach delay. The average approach delay was then calculated by
subtracting the free flow time from the average total travel time determined from the JAMAR
data collector, as shown in Equation 3.

\[ \text{Approach Delay} = \text{Measured Travel Time} - \text{Free Flow Travel Time} \]  

Free flow travel time was measured by timing vehicles that encountered no obstacles to
entering the roundabout using the JAMAR counter. This value was compared to the theoretical
free flow time, obtained by dividing the approach distance by the speed limit. For analysis
purposes, though, the measured free flow values were used.

Like the volumetric data, average delay values were measured in five-minute increments,
based on vehicle entry to the roundabout. For vehicles entering the travel zone that did not
discharge from the yield bar before the five-minute period, their travels times were included in
the successive five-minute period. This process was also followed for the turning movement
counts. The 15-minute period delays were then derived from the weighted average of three 5-
minute periods. Fifteen minute delays were likewise averaged to create one hour delays
corresponding to the hourly volume periods.

Quality Control on the Data Collected
As previously discussed, obtaining the required data for the analysis was a labor-intensive
process and prone to error. The JAMAR method of measuring average travel time provided an
independent method to evaluate the quality of the data, because the counter also kept a tally of
the number of vehicles that entered and left the queue. This number therefore was compared to
the sum of the right, through and left turning movements for each approach, independently
determined from watching the video-tapes. For Nashua, the average difference between the
video and the JAMAR counts was 1.10 veh/15min period, and the two sets had a correlation
coefficient, $R^2$ of 0.985. For Keene, the average difference was 0.014 veh/15min with an $R^2$ of
0.997. Therefore, the data was statistically viable for further calculations.

Assessing the Calibration Potential of Roundabout Analysis Models
With the required data sets compiled, the study proceeded to evaluate the calibration potential of
two analytical-type models, RODEL and aaSIDRA, and three micro-simulation models,
PARAMICS, SimTraffic and VISSIM. Because microscopic simulation models are stochastic models whose results vary depending on the random seed number used, it was necessary to run each model multiple times and average the results. For these models, each scenario was run between 12 and 15 times in order to provide a 95% confidence in reported delay with a confidence interval of ±0.25 seconds.

The calibration potential assessment procedure followed the five steps below.

1. The study identified the calibration parameters of each model. Models were first run using the default settings for the identified calibrating parameters, as set by the developer, for both case studies.
2. The study then compared the approach delays estimated by the model (using the model’s defaults) to the field delay measurements.
3. Focusing on the Nashua roundabout, the calibration parameters were systematically varied to: (a) identify the impact of changing the parameters on the model results; and (b) identify an “optimal” set of values for these parameters that brought the Nashua model results closest to field observations.
4. Step three was repeated for the Keene roundabout, determining the “optimal” calibration parameters for the models.
5. The study tried to use the Nashua parameters for the Keene model, to evaluate whether the “optimal” values identified for Nashua could still yield good results for Keene. This would indicate that the Nashua results could be generalized, and would in turn make the calibration easier for new roundabouts.

Before the analysis could be performed, it was necessary to ensure that the model delay output values reported are consistent and comparable to the approach delay, as defined in Equation 3. This permits fair model comparison. In some cases, simple modifications to delay reports made this possible, as described below.

According to the software designer, RODEL reports queuing delay. This was the value that was compared to the approach delay, although it appears that queuing delay ignores some the deceleration delay included in the approach delay as measured in the field. aaSidra had a detailed delay report consisting of various delay components. Approach delay was assessed by adding the total stop-line delay to the deceleration delay resulted in the approach delay. Deceleration delay was assumed to be half the acceleration/deceleration delay. Finally, PARAMICS, SimTraffic, and VISSIM all reported link delay, which is directly comparable to the approach delay measured in the field.

RESULTS AND ANALYSIS OF CALIBRATION ABILITY

RODEL
No specific calibrating parameters could be identified for RODEL. Essentially, the only input information was the volume and geometric data. Consistently, RODEL’s average delay estimates were larger than the field measurements. For the Nashua roundabout, the average error (i.e. difference between the RODEL delay estimate and the field measurements) was about 5.2 seconds/vehicle. Although the actual value of the error is relatively small, this value corresponds
to a 119.5% percent error (defined as the percent of the difference relative to the field measured values). For Keene, the average error was 6.36 seconds/vehicle, resulting in 143% error.

**aaSidra**
To calibrate aaSIDRA, the study examined two global calibration factors: (1) the Entry/Circulating Flow Adjustment (ECFA) factor and (2) the Environment Factor (EF). The ECFA factor is intended to reflect the observation that at higher entry traffic volumes, higher roundabout capacity values are possible because drivers tend to accept shorter gaps in such cases. Four levels of ECFA are provided in aaSIDRA: high, medium, low and none, with the higher level indicating shorter acceptable gaps. With ECFA, roundabouts could be calibrated for the ratio of the entry to circulating flow (2). The EF, on the other hand, adjusts the model for roundabout speed limits, grade, vehicle size, driver alertness and aggressiveness. The factor ranges between 0.7 and 1.3. Low-volume roundabouts and roundabouts with greater constriction call for a higher EF value (2). The default values for ECFA and EF are “medium” and 1.0, respectively.

**Nashua Results**
Figure 2 compares the aaSIDRA results for the Nashua roundabout for each approach and hour period. For example, N1 corresponds to the Northbound first hour period, where W13 corresponds to the Westbound 13th hour period. The model was first run at the default settings for ECFA and EF. These values were then changed in an effort to bring the model’s results closer to the field. Generally, aaSIDRA results appear to be close to field measurements, especially for the North Bound approach. Using the default settings, the average error was -2.10 sec/veh, corresponding to a -44% error.

To calibrate the model, ECFA was changed to “none” because the roundabout exhibited a low volume/capacity ratio and hesitant driver behavior. As seen in Figure 4, this increased the acceptable gap and hence the values of the delay. However, the increase in the delay was very modest. Next, the study increased the values for the EF from 1.0 to 1.05. In addition to slightly raising the delay estimates, increasing EF to 1.05 greatly increased the variability in the results and made the model more sensitive to volume variations. Changing EF appeared to have a more pronounced impact compared to changing ECFA. The combination of an EF of 1.05 and an ECFA of “medium” gave the best average error of about -1.75 sec/veh and a -35% percent error.

To ascertain whether calibration had a statistically significant impact on improving performance, a Tukey t-test on the delay errors obtained from the different calibration runs was conducted using $\alpha = 0.01$. The null hypothesis was that no significant difference was seen through calibration (i.e. p-values less than $\alpha$ show a significant difference due to calibration). For the aaSIDRA model, a p-value of 0.078 was obtained, falling short of the $\alpha = 0.01$ significance level and rendering the difference not statistically significant.
Keene Results

Figure 3 shows the aaSIDRA results obtained for Keene. Using the default settings for ECFA and EF gave an average error of -2.79 sec/veh and a percent error of -52%. Using the Nashua “optimized” ECFA and EF values for Keene did not significantly improve the results. Calibrating the Keene roundabout required much larger values for EF. Best calibration results were obtained with an EF of 1.3, and an ECFA value of “none”. With these settings, the average error was only -1.12 sec/veh, which corresponded to a percent error of -13%. Calibration, therefore, dramatically reduced the percent error from -52% to -13%. The calibration, however, appears to be site-specific, which presents a challenge to calibrating roundabouts that are still in the planning or design stages.

A Tukey t-test was performed on the three errors; default, Nashua, and optimal. The p-value for the comparison between default and Nashua was 0.46, rendering the difference insignificant. The difference between default values and optimal values, however, gave a p-value of 0.004, suggesting a statistically significant difference.
PARAMICS

For PARAMICS, the study focused on calibrating the model’s headway factor. In PARAMICS, this factor can be used to adjust the mean target headway, which controls the model’s car following and gap acceptance behavior. The default value is 1.0.

**Nashua Results**

Figure 4 shows the PARAMICS results obtained for Nashua when PARAMICS was run with the headway factors of 1.0, 1.25, and 0.8. PARAMICS appears to overestimate the delay. The average error for the default setting was 2.08 sec/veh, corresponding to a percent error of 46%. As can be seen, changing the headway factor did not seem to change the results. The Tukey t-test revealed a p-value of 0.23 when comparing all three errors, showing no significant change.

**Keene Results**

Figure 5 shows the results for Keene. As opposed to Nashua, PARAMICS underestimated Keene’s approach delay, yielding an average error of -1.74 sec/veh or a percent error of -30%. PARAMICS was also re-run using headway factors of 1.25 and 0.8. Once again, changing the headway factor did not seem to impact the results. The Tukey t-test confirmed this, providing a p-value of 0.93 when comparing all three errors, rendering the difference moot.
Figure 4: Nashua Delay- Paramics Parameter Comparison

Figure 5: Keene Delay- Paramics Parameter Comparison
Synchro/SimTraffic
Synchro/SimTraffic did not offer many options in terms of calibrating a roundabout model. The model, however, did a decent job predicting performance. The average error for Nashua was -1.53 sec/veh (percent error of -11%), and -2.02 sec/veh for Keene (percent error of -26%).

VISSIM
VISSIM appeared to be the model with the most available options for roundabout model calibration. VISSIM enabled the user to change numerous variables including driver behavior, desired speed, reduced speed zone definition, yield bar placement adjustment, minimum allowable headway, and minimum gaps. Minimum gaps can vary by approach. The VISSIM default for minimum headway was 16.4 feet and 3 seconds for the minimum gap.

Nashua Results
Figure 6 shows the VISSIM defaulted results for Nashua, which resulted in an average error of -2.98 sec/veh or an average percent error of -63%. For calibration, this study focused on adjusting reduced speed zone definitions, minimum allowable headways, and minimum gaps. To mimic actual driver behavior, the speed in the vicinity of the Nashua roundabout was changed from 35 mph to a range of 18-25 mph. After several trials, the values that gave the best results were a minimum headway value of 25 feet, and minimum gaps of 3.8 seconds for the Southbound approach, 5 seconds for the Eastbound, and 4 seconds for both the Northbound and Westbound. Figure 6 shows the results obtained using this “optimal” set of values. In this case, the average error dropped to only -0.71 sec/veh representing a percent error of -14%. The change was rather significant. A p-value of 5.21 x 10^-9 was calculated using the Tukey t-test, indicating a statistically significant difference.

Figure 6: Nashua Delay- VISSIM Parameter Comparison
**Keene Results**

Figure 7 shows the Keene results using the default values. First, the model was run using the default settings which resulted in an average error of -3.87 sec/veh or a -68% error. Next, the model was run using Nashua’s “optimal” set of parameters to check whether this previously determined calibration could be used for Keene. As seen in Figure 7, the Nashua parameters did not significantly improve the Keene results (Tukey t-test p-value = 0.51), indicating the need for site-specific calibration. Calibrating the Keene roundabout required larger minimum acceptable gaps compared to those used for Nashua. Specifically, a minimum gap of 5 seconds was used for the Northbound, Southbound and Westbound approaches, and a gap of 7 seconds was used for the Eastbound approach. This “optimal” set of parameters achieved a significant improvement in the results (Figure 7). The average error dropped to only -0.21 sec/veh or a percent error of -0.3%. Calibration dramatically reduced the percent error from -68% to less than 1%. Tukey t-test confirms the results: p-value = 1.15 x 10^{-10}.

**Figure 7: Keene Delay- VISSIM Parameter Comparison**

**Results Summary**

Table 2 summarizes the results obtained from the different models to provide for a single source to cross-compare the results. Specifically, the table lists the average error, along with its standard deviation, for each approach for both the default and the optimal values for the calibrating parameters. Also listed is the percent error for each approach.
**Table 2: Model Delay Results and Calibration Effects**

<table>
<thead>
<tr>
<th></th>
<th>Northbound</th>
<th>Southbound</th>
<th>Westbound</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RODEL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>7.12 : 1.00</td>
<td>195</td>
<td>6.59 : 0.54</td>
</tr>
<tr>
<td>aaSidra</td>
<td>-1.03 : 0.69</td>
<td>-25.4</td>
<td>-3.05 : 0.95</td>
</tr>
<tr>
<td>Optimal</td>
<td>-0.64 : 1.69</td>
<td>-10.8</td>
<td>-2.90 : 0.99</td>
</tr>
<tr>
<td><strong>Paramics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>2.70 : 2.24</td>
<td>74.2</td>
<td>0.97 : 2.00</td>
</tr>
<tr>
<td>HF = 1.25</td>
<td>3.54 : 3.23</td>
<td>96.0</td>
<td>1.44 : 2.40</td>
</tr>
<tr>
<td>HF = 0.8</td>
<td>2.44 : 2.21</td>
<td>67.6</td>
<td>0.34 : 1.43</td>
</tr>
<tr>
<td><strong>SimTraffic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>1.32 : 1.32</td>
<td>38.7</td>
<td>-0.81 : 1.00</td>
</tr>
<tr>
<td>VF = 0.8</td>
<td>-0.64 : 1.87</td>
<td>-12.9</td>
<td>-0.53 : 1.67</td>
</tr>
<tr>
<td><strong>KEENE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RODEL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>8.23 : 0.54</td>
<td>251</td>
<td>4.44 : 0.86</td>
</tr>
<tr>
<td>aaSidra</td>
<td>-1.43 : 0.34</td>
<td>-42.6</td>
<td>-5.27 : 0.67</td>
</tr>
<tr>
<td>Nashua</td>
<td>-1.21 : 0.35</td>
<td>-36.0</td>
<td>-5.16 : 0.65</td>
</tr>
<tr>
<td>Optimal</td>
<td>0.35 : 0.38</td>
<td>11.4</td>
<td>-4.14 : 0.36</td>
</tr>
<tr>
<td><strong>Paramics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>-0.52 : 0.58</td>
<td>-14.5</td>
<td>-1.86 : 1.11</td>
</tr>
<tr>
<td>HF = 1.25</td>
<td>-0.32 : 0.50</td>
<td>-8.6</td>
<td>-2.27 : 0.95</td>
</tr>
<tr>
<td>HF = 0.8</td>
<td>-0.63 : 0.49</td>
<td>-17.7</td>
<td>-1.61 : 0.74</td>
</tr>
<tr>
<td><strong>SimTraffic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default</td>
<td>1.02 : 0.30</td>
<td>31.8</td>
<td>-3.37 : 0.85</td>
</tr>
<tr>
<td>VF = 0.8</td>
<td>-1.37 : 0.31</td>
<td>-40.8</td>
<td>-6.64 : 1.00</td>
</tr>
<tr>
<td>Nashua</td>
<td>-0.64 : 0.75</td>
<td>-18.9</td>
<td>-6.26 : 0.91</td>
</tr>
<tr>
<td>Optimal</td>
<td>0.44 : 0.40</td>
<td>14.1</td>
<td>-0.595 : 1.10</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

This paper examined the calibration ability of five popular roundabout models to match roundabout operations using two case studies from New England. While the delay experienced at the two roundabouts was rather on the low side, it should be noted that the roundabouts selected are among the busiest in New England. The two roundabouts were video-taped for sufficient time to allow for an adequate evaluation. Hourly volumes and approach delays were measured from the videotapes. The field delays were then compared against the delays...
estimated by each model. The calibrating parameters for each model were systematically changed in order to improve the model’s results compared to field observations. The study sheds some light on the capacity of the models evaluated to mimic roundabouts operations at low delay levels, which are often the case in the field. Among the main conclusions of the study are:

1. Available roundabouts analysis models vary in terms of the options they provide for calibration. Among the models considered in this study, VISSIM appears to be the most versatile, and RODEL seems to be the least.

2. For aaSIDRA, the EF appears to have the most significant impact on the results. For VISSIM, adjusting the minimum acceptable gap is a very powerful tool in calibrating the model. However, for best results with VISSIM, minimum acceptable gaps may vary from one roundabout approach to another.

3. While PARAMICS offers a number of calibrating factors, changing some of these parameters in this study did not impact the results.

4. For aaSIDRA and VISSIM, calibration appears to have a significant impact on improving results. For example, calibration helped reduce the average percent error for the aaSIDRA Keene roundabout model from -52% down to -13%. For VISSIM’s Keene roundabout model, calibration reduced the average percent error from -68% to -0.3%.

5. The calibration process may be site-specific. In other words, the “optimal” set of calibrating parameters determined for one roundabout may not prove adequate for modeling another. In the future, it is recommended to conduct further research to perhaps develop taxonomy of locations such that a specific set of parameters could be used for locations of similar type.

It should be noted that the conclusions derived above are specific to the case studies considered in this research. In the future, it is recommended to consider additional case studies from other geographic regions with hopefully higher delay values in order to validate these results. Additionally, multilane roundabouts should also be considered.

ACKNOWLEDGEMENTS
Funding for this research has been provided partially by the National Science Foundation (NSF) under grant number CMS-0133386, and partially by the New England Transportation Consortium (NETC). The authors would like to thank NSF and NETC for their support.
REFERENCES


