TECHSUMMARY *January 2021*

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Determining Louisiana's Roundabout Capacity

INTRODUCTION

While indispensable to our roadway system, intersections are highly crash-prone zones. They present complex traffic situations for planners, designers, and drivers alike. Intersections create opportunities for interface between vehicles, pedestrians, and cyclists, thus resulting in a myriad of scenarios with a high crash potential. In the United States, over the last several years, intersections have represented on average, one-quarter of all traffic fatalities and roughly one-half of all traffic injuries. At signalized intersections, angle crashes account for over 40% of fatal crashes, left-turn crashes account for over 20% of fatal crashes, and pedestrians/bicyclists crashes account for 25% of fatal crashes.

Roundabouts are arguably the fastest growing intersection improvement type within the U.S. The usage of modern roundabouts, as an alternative to traffic control devices, is becoming more popular in the U.S. as a result of beneficial design modifications and safety improvements. Roundabouts at intersections have resulted in a 35% reduction in all crashes and a 76% reduction in injury crashes. Severe crashes and fatal injuries are rare, as one study reported 89% reduction in these types of crashes while another study reported 100% reduction in fatal crashes.

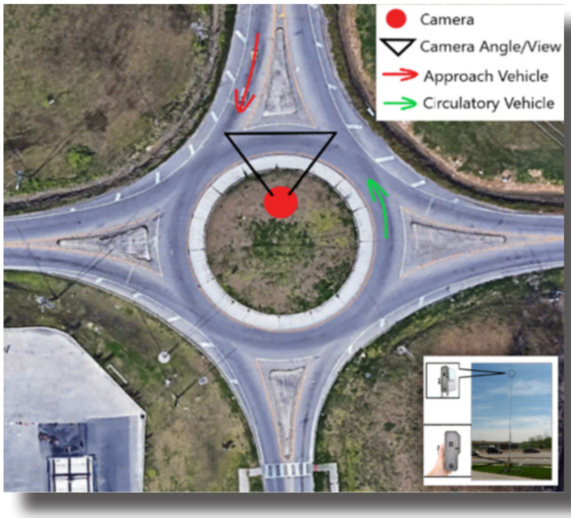

Figure 1
Data collection setup

The Highway Capacity Manual 2010 ("HCM 2010") and the Highway Capacity Manual 6th Edition ("HCM 6") provide models to estimate the approach lane capacity of roundabouts, depending on the observed number of circulatory vehicles. The models are based on nationally conducted studies to evaluate driver behavior at roundabouts within the U.S. While both models fairly provide roundabout capacity estimates, the models are generic and not customized for specific geographic regions or locations, since driver behavior patterns are often uniform in specific regions and not across a country. To reduce the magnitude of the unknowns, or those variables that cannot be directly catered for by the capacity models, the HCM recommends that agencies calibrate roundabout capacity models to their regions to capture and make provision for the nature of driving behaviors common amongst locals.

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OBJECTIVE

Primarily, this project sought to use local data to determine Louisiana's single-lane roundabout capacity and compare it to software (SIDRA INTERSECTION or SIDRA) outcomes that are currently used in the planning and design of modern roundabouts in Louisiana. Specifically, tasks performed to meet the objectives were:

- Conduct a literature review on the roundabout capacity models as presented in the HCM 2010 and HCM 6, highlighting differences and similarities and comparing to SIDRA capacity estimation methods.
- Select candidate sites for local data collection to be used for parameter estimation.
- Compare parameters obtained from site observations to HCM 2010, HCM 6, and SIDRA outputs.
- Validate Environmental factor (EF) value used in SIDRA for Louisiana purposes.
- Make a recommendation on best practices to be followed in determining parameters that best reflect local driver behavior.

DATA COLLECTION

To meet the outlined objectives of this research, a preliminary assessment was conducted for several state-maintained roundabouts that had been constructed at the time of consideration and met the criteria for site selection. Consideration was given to both urban and rural locations to identify a possible difference in driver behavior for either location. Sites were also clustered into functional classes as well as DOTD districts to test for a possible difference in driving patterns across clusters. Only single-lane roundabouts were explored. Data collection involved mounting up cameras at roundabout sites to record approach and circulating lane vehicles. Figure 1 illustrates the data collection setup at one site. Altogether, field data from 41 approaches from 17 roundabouts were collected for analysis.

METHODOLOGY

Data reduction was achieved using a roundabout event recorder to extract timestamps of qualifying events. These were used to determine gap acceptance parameters—follow-up headway and critical headway—considered as a reflection of driver behavior/patterns within Louisiana. Using these parameters, the study calibrated the capacity model to suit local conditions. The peak flows that represented the worst-case scenarios were considered to measure average delays, level of service (LOS), and 95% back of queue lengths at each roundabout approach and compared to SIDRA outputs generated for each approach. The purpose of the SIDRA task was to determine the EF value that would generate corresponding approach-lane capacities that will most closely match the field-observed capacities. The EF, resulting in the least RMSE when generated approach-lane capacities were compared to field-observed capacities, was further used to generate corresponding approach-lane average delays, level of service, and 95% back of queue lengths.

CONCLUSIONS

The analysis warranted the following conclusions:

- The average follow-up headway for Louisiana was computed as 3.36 seconds, and the average critical headway as 4.76 seconds. These are larger than the national averages (from HCM 6) of 2.60 seconds and 4.70 seconds, respectively
- No notable difference in gap acceptance parameters existed across DOTD districts/parishes, nor different functional classes of roads, although arterials had the least follow-up times and critical headways.
- The impact of certain roundabout geometric features—inscribed circle diameter (ICD), splitter (island) width, central island diameter, and approach lane width—on follow-up headways were found to be very weak.
- As shown in Figure 2, it was observed that the HCM 6 capacity model overestimated the capacities at Louisiana sites, but the HCM 2010 capacity model generated much closer capacities for a given circulatory volume.
- The local model was developed by recalibrating the HCM 6 model to a fixed intercept based on the average observed follow-up headway and a slope parameter based on regression of the data. Considering the fitness of the model, the recommended capacity model for Louisiana roundabouts is $C_{pce} = 1072.3e^{-0.0009*V_{c,pce}}$ [where, C_{pce} = approach-lane capacity, adjusted for heavy vehicles (pc/h), and $V_{c,pce}$ = circulating flow rate (pc/h)].
- From the SIDRA analysis, the study determined that an EF of 1.06 resulted in the lowest RMSE between field-observed capacities and SIDRA-derived capacities. However, the average age of roundabouts assessed was approximately 8 years. Using a Design Build (20 years) EF of 1.0 and extrapolating the EF to a Build Year (zero years) yielded an EF of 1.1.
- The comparison of field-observed capacities and SIDRA-derived capacities at EF of 1.2 shows SIDRA output underestimating the capacity of each approach.
- The result shows mixed output with capacities and queue lengths being closer to field derived estimates at EF of 1.06, while the remaining parameters, delay, and LOS, show estimates closer to field-derived estimates at EF of 1.2. Queue lengths, delay, and LOS were obtained from theoretical calculations and not directly observed from field.

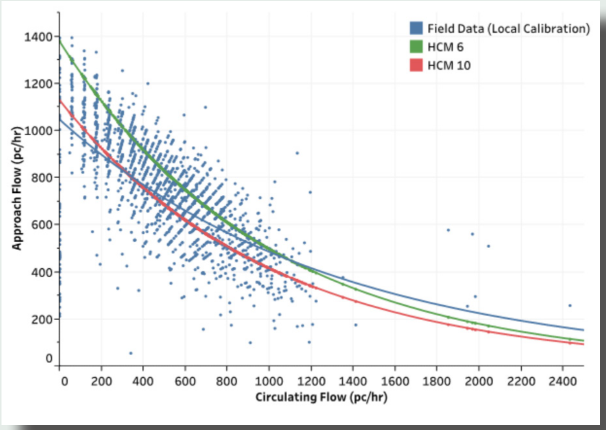

Figure 2
Capacity models

RECOMMENDATIONS

The findings from this study warranted the following recommendations.

- Considering the fitness of the model, the study recommended a local capacity model for single-lane Louisiana roundabouts as, $C_{pce} = 1072.3e^{-0.0009*V_{c,pce}}$. This takes into account the established gap acceptance parameters for Louisiana: a follow-up headway of 3.36 seconds and a critical headway of 4.76 seconds.
- An extrapolated EF of 1.1 is recommended for Build Year when using SIDRA with the HCM 6 capacity model.
- Field delays, LOS, and queue lengths were theoretically determined rather than directly observed from the field, so future studies should find innovative ways to determine these parameters directly from the field to compare with SIDRA outputs.