Unclog Local Network Congestion Using High Capacity Mini-Roundabout: A Feasibility Study

Paper 14-4225

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Submitted for re-review
Presentation at the 2014 TRB Annual Meeting

November 15, 2013
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ABSTRACT

In local cities with only at-grade intersections, network-wide traffic congestion can often be traced to the oversaturation of one single intersection, typically, the junction of two higher-volume roads with minimal capacity constrain along their routes until they intersect each other. The sudden drop in throughput capacity at the junction creates queues extending to nearby upstream intersections, blocking those side streets and forcing some drivers to change routes. As the congested area expands, this dynamic phenomenon eventually paralyzes the surrounding street network. For recurring congestion of this type, implementing a solution that can unclog the congestion at the critical intersection alone can restore the entire network to a healthy state of traffic operation and safety. This paper presents one such solution by testing the effect of replacing an existing All-Way-Stop-Control intersection, which sits on the essential passage routes of both East-West and North-South traffic, with a high-capacity mini-roundabout. The analysis showed that this improvement can lift the level of service of 2/3 of the network intersections from the current D, E, or F during the afternoon peak period, to the projected level of service of A or B, thus solving a network-wide traffic congestion problem by improving only one critical intersection. The problem described in this paper is representative to many cities, thus the presented solution can also be considered representative and applied in that context.
INTRODUCTION

Many cities in the U.S. are experiencing area-wide traffic congestions in both primary and secondary road networks. The secondary roads are the local streets with at-grade intersections, and the predominate modes of traffic controls at these intersections are Side-Street Stop Control, also known as Two-Way Stop-Control (TWSC), All-Way Stop-Control (AWSC), and traffic signal control. A small number of intersections are also controlled by small roundabouts and neighborhood traffic circles. As the urban centers expand, coupled with the consolidations and relocations of public and private sector employers, population density gets higher, commuting distances become longer, and recreational (and other) trips happen more frequently. Eventually, the growth in travel demand will exceed the capacity limit of existing traffic control device, and start creating congested intersections and travel routes. When congestion grows to region-wide, it can inflict high social and economic harm to the local community. The situation is more painful for established communities where all available land has been fully developed, and expansion of any road element (intersection or roadway) are difficult due to the huge costs of right-of-way (ROW) acquisition, relocation of utility lines, and removal and reinstallation of storm drainage systems, etc. Sometimes even the removal of a few on-street parking spaces may be politically sensitive. This is the growing pain that has been repeated in many communities. Under such circumstance, traditional ways of increasing road capacity will not work. A drastic change in intersection traffic control is needed, and the “new” mode of traffic control must be able to serve significantly higher traffic demands than existing traffic controls without increasing the lane surface area. Given the current state of leveling or declining budgets in many cities, another mandate for the “new” traffic control is the cost of implementing the new design must be competitive comparing to the traditional improvements.

The good news is that the “new” traffic control device already exists. The above scenario reminds us of the traffic congestion situation under which the concepts of modern roundabout and mini-roundabout were born. It was the mid-1960s, Britain had enjoyed 2 decades of post WWII economic expansion, family incomes reached historic high, and car ownership skyrocketed. The number of licensed motor vehicles doubled from 4.5 million in 1950 to 9.4 million in 1960, and was projected to reach 18 million by 1970—the trend had tilted towards exponential increase. At the same time, Britain’s road network remained modest in size and scale. At junctions, due to lack of clear priority rules, drivers did not know who had the ROW, and they hesitated before venturing into the intersection. Such behavior created queues at the junctions. Since the streets were filled with cars, it did not long for the snarled up junctions to grow in number and choke up the road network. Traffic congestion in Britain at that time was a major national problem. The Road Research Laboratory estimated the costs of congestion at £250 million in 1959, about five times the annual roads budget. (Bodé and Faber, 2006; Department for Transport, 2006; 2007)

That was the background under which Professor Sir Colin Buchanan was appointed to lead a comprehensive traffic study to find possible solutions. His team visited many cities in Britain and abroad to learn how others tackled traffic congestion. They conducted numerous field studied and interviews to collect diversified information. Their diligent 2-year work led to the 1963 publication of “Traffic in Towns, A Study of the Long Term Problems of Traffic in Urban Areas”. This influential report suggested several visionary approaches in dealing with congestion:

1. The society’s dependency on motor vehicles would not fade, and therefore we must embrace them and properly manage them.
2. Building inter-city motorways and around-city bypass roads would not solve the congestion problem. Road system expansion must be integrated with environmental management and long-term urban planning to be effective in reducing congestion.

3. The road systems in Britain’s cities and towns were inherited from the medieval era that were not designed and built for mass motorized traffic. However, they were the symbols and fabrics of the British society, and that national identity must be preserved.

Approach 1 is self-explaining; Approach 2 tells us the importance of integrating road construction with urban planning. Imagine if all the jobs, shopping, and entertainment activities were in city centers (true for older cities), then inter-city motorways would only bring more traffic faster to worsen the congestion in town; Approach 3 puts limits on the physical alternation of existing infra-structure, and calls for new transport schemes that will be more efficient and can co-exist with existing environment. Balanced use of these approaches is still the core task of any infra-structure improvement projects today.

INVENTION AND EVOLUTION OF MINI-ROUNDABOUT AND FHWA’S ROLE IN PROMOTING IT

Buchanan’s report inspired many innovations in urban planning and road system improvement. The modern roundabout design invented by Frank Blackmore in 1966 was one of the innovations in high-capacity intersection design to cope with a motorized society. Roundabout improves intersections efficiency by simplifying traffic flows, reducing conflicts, and lowering the entering and crossing speeds. Mr. Blackmore went on to invent the mini-roundabout design in 1969. Mini-roundabout shares the same operational principles of regular modern roundabouts. It has one additional feature—all raised elements (central island and splitter islands, etc.) must be fully mountable by large vehicles. This is the feature that distinguishes a mini-roundabout from other types of roundabouts. Mr. Blackmore added this design feature to make the roundabout concept work at smaller intersections in established communities. The mountable central island is meant for large vehicle to drive over when necessary. This design was tested and improved in Britain, and was later adopted by Germany, France, Austria, and some other countries. (Sawers, 2007; 2009; Kennedy, 2008)

U.S. Federal Highway Administration (FHWA) defines a mini-roundabout as a single-lane roundabout with inscribed circular diameter (ICD) between 50 ft and 90 ft. Mini-roundabouts can be and have been used in different applications. Besides increasing capacity at congested intersections and providing more gaps to minor road traffic, at locations of closely spaced intersections or highly skewed intersections, a pair of mini-roundabouts may be installed to simplify the traffic flow and separate the conflicting movements. (FHWA, 2010)

Some cities in the U.S. have constructed small circular intersections with non-traversable central islands, and call them mini-roundabouts. In reality, very few fully compliant mini-roundabouts exist in the U.S. When examining the small circular intersections, one may find one or more of the following (non-desirable) features:
1. Trees or vegetations in the central island
2. Use of STOP signs at the entrance
3. Use of regular curbs (6 inch) on splitter islands and/or the central island that make those elements practically non-traversable
4. Raised central island but no modification to the approaches and/or corner curbs, causing drivers to have to make almost a full stop to enter the intersections
5. …

Small circular intersections having the above characteristics cannot serve the level of traffic demands that a true mini-roundabout can handle, and may create inescapable traps for large vehicles. Their existence misleads people’s perception about mini-roundabout, and hinders the wider implementation of mini-roundabouts. (Rodegerdts, 2007; 2010)

FHWA foresaw the potential of using mini-roundabouts in reducing urban street congestion, initiated an effort in 2009 to introduce the mini-roundabout design to the U.S., and is trying to mainstream it through the second round of the Every Day Count (EDC2) initiative. The efforts include:

1. Produce proper outreach and promotion material about mini-roundabout
2. Develop design templates (AutoCAD and Microstation) for use by practitioners
3. Recommend ranges of traffic demands/patterns under which mini-roundabout would be appropriate
4. Develop analytical and simulation models for mini-roundabouts
5. Provide technical assistance to agencies wishing to implement mini-roundabout
6. Demonstrate the effectiveness of mini-roundabout at suitable sites.

THE DETERIORATING TRAFFIC CONGESTION AND SAFETY PROBLEM FACING A COMMUNITY

This study was inspired by the traffic congestion and safety challenges facing the city of Stillwater in Washington County, Minnesota (MN). Figure 1 shows the local street map near downtown Stillwater. The junction of County State Aid Highway CSAH-5 (Owens St N) and CSAH-12 (Myrtle St W) is currently served by an AWSC. It has been operating at unacceptable level of service (LOS) during the afternoon peak hours since 2007 or earlier. Both CSAH-5 and CSAH-12 are regionally important, with Owens St providing the only practical North-South route within the city of Stillwater between CSAH-15 (Manning Ave) and Trunk Highway TH-95 (Main St N) along St. Croix River; and Myrtle St providing the only continuous East-West route through central Stillwater serving as the primary connection between Mahtomedi/Willernie (two cities west of CSAH-15) and the Stillwater Lift Bridge. According to Minnesota’s roadway functional classification system, both CSAH-5 and CSAH-12 are minor arterial routes. All intersections alone the two routes are TWSC. Their junction is the only AWSC on both routes. Based on the first come first serve rule of AWSC, this will reduce capacity by at least 75% for each approach relative to its upstream capacity and form a bottleneck for traffic in all directions through this intersection. Recurring long queues extend to nearby intersections and create operational and safety problems at many intersections that serve other collector roads.
Table 1 shows the 2002 to 2006 crash data at 11 intersections in the local network. The three highlighted intersections in Table 1, all TWSCs, have crash rates 267%, 107% and 97% (refer to Table 1) above the state average for similar intersections, they are marked by pink circles in Figure 1, and the AWSC is marked by a yellow circle. The most risky TWSC intersection is two blocks south of the AWSC, and is where CSAH-5 changes from E-W direction (Olive St) to N-S direction (Owens St.) Here, the heavy eastbound traffic from a major road has to stop and yield to conflicting N-S through traffic on a minor road. The other two risky TWSC intersections with high crash rates are on each side of the AWSC along CSAH-12 (Myrtle St.) A review of crash records indicated driver failure to yield ROW as the leading factor for the crashes, and it outranked the next closest leading factor (such as driver inattention) by ratios of 13/6, 5/1, and 4/1, respectively. Clearly, long queues originating from the AWSC intersection were a root cause of crashes.

The above descriptions were synthesized from a 2008 traffic operations study Technical Memorandum by SRF Consulting Group, commissioned by Washington County and the City of Stillwater, to identify potential solutions. The SRF study mentioned two possible solutions: Replacing the AWSC with a traffic signal, or converting the streets to 3-lane with center lane two-way left turn. The study confirmed significant demands for on-street parking during the
afternoon peak period. Some homes have no garage or driveway, and rely solely on on-street parking for their vehicles. Both recommended options would require converting the on-street parking spaces to traffic lane spaces. It was estimated that at least 25 families in the immediate area of the AWSC intersection would be affected if on-street parking spaces were taken away, and construction of new off-street parking facility would be necessary. Neither option was practical enough to pursue further then.

### TABLE 1 Study Area Intersection Crash Rates for 2002-2006 (Ranked by Crash Rate)

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Traffic Control</th>
<th>Crashes(1)</th>
<th>Crash Rate(2)</th>
<th>MnDOT Average Crash Rate(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olive St &amp; Owens St</td>
<td>Side-Street Stop</td>
<td>19 (3.8)</td>
<td>1.10</td>
<td>0.3</td>
</tr>
<tr>
<td>Myrtle St &amp; Greeley St</td>
<td>Side-Street Stop</td>
<td>14 (2.8)</td>
<td>0.62</td>
<td>0.3</td>
</tr>
<tr>
<td>Myrtle St &amp; Sherburne St</td>
<td>Side-Street Stop</td>
<td>8 (1.6)</td>
<td>0.59</td>
<td>0.3</td>
</tr>
<tr>
<td>Myrtle St &amp; Owens St</td>
<td>All-Way Stop</td>
<td>15 (3.0)</td>
<td>0.56</td>
<td>0.6</td>
</tr>
<tr>
<td>Olive St &amp; Sherburne St</td>
<td>Side-Street Stop</td>
<td>4 (0.8)</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td>Owens St &amp; Ramsey St</td>
<td>Side-Street Stop</td>
<td>3 (0.6)</td>
<td>0.22</td>
<td>0.3</td>
</tr>
<tr>
<td>Myrtle St &amp; Brick St</td>
<td>Side-Street Stop</td>
<td>3 (0.6)</td>
<td>0.17</td>
<td>0.3</td>
</tr>
<tr>
<td>Olive St &amp; Greeley St</td>
<td>Side-Street Stop</td>
<td>3 (0.6)</td>
<td>0.17</td>
<td>0.3</td>
</tr>
<tr>
<td>Olive St &amp; Brick St</td>
<td>Side-Street Stop</td>
<td>3 (0.6)</td>
<td>0.15</td>
<td>0.3</td>
</tr>
<tr>
<td>Greeley St &amp; Ramsey St</td>
<td>Side-Street Stop</td>
<td>2 (0.4)</td>
<td>0.14</td>
<td>0.3</td>
</tr>
<tr>
<td>Stillwater Blvd &amp; Pine St</td>
<td>Side-Street Stop</td>
<td>3 (0.6)</td>
<td>0.12</td>
<td>0.3</td>
</tr>
</tbody>
</table>

(1) Total number of crashes from 2002 to 2006 followed by average number of crashes per year in parentheses.
(2) Crash rate is given in crashes per million entering vehicles at the intersection.
(3) Based on Minnesota statewide average crash rates for similar intersections from 2004 to 2006.

### A PROPOSED SOLUTION – HIGH-CAPACITY MINI-ROUNDABOUT DESIGN

The problems described above resemble the situation under which the concept of mini-roundabout was born, although at a less grand scale. The traffic demands pattern requires a design offering equal access ROW to all approaches. The mandate to preserve on-street parking spaces precludes the traffic signal and 3-lane design options that need additional lanes to achieve their design objectives. Under this circumstance, mini-roundabout would seem a logical choice for consideration. Zhang, et. al (2013) estimated that by design, mini-roundabout have more than twice the capacity of AWSC. Their difference in capacity will be more pronounced at junctions having heavy left-turn demands. In a formal letter to MnDOT on trying out the mini-roundabout design, Joe Gustafson (Transportation Engineer, Washington County) wrote “This innovative treatment may offer the best combination of reduced delay, improved safety, preserved parking, improved sidewalk width, and no impacts to private property. However, neither the City nor the County will be able to advocate for this option until its impacts and expected operational performance have been appropriately considered.”

The FHWA researchers considered this intersection a prime site to showcase the effectiveness of high-capacity mini-roundabout design. However, unless the research team can deliver a solid analysis on the potential operational and safety impacts of converting the AWSC at Myrtle St and Owens St into a mini-roundabout, and produce presentation material that the county staff members can understand and use the information to convince their stakeholders, nothing might happen.
As of June 2013, the FHWA researchers had developed mini-roundabout capacity and VISSIM models, and had used the models in the operational analyses of 6 real projects, and saw their predicted performance measures (queue lengths, speed reduction, and throughput increase, etc.) came true after mini-roundabout openings (Lochrane et al., 2011; 2012.) In April 2013, Georgia DOT District 1 converted an AWSC intersection into a mini-roundabout. That AWSC intersection, located at SR 11 and SR 124 in Jefferson, GA, used to have 50-car recurring queues on the west bound approach during the afternoon peak. Upon opening to traffic, that mini-roundabout was seen to have eliminated the roughly quarter mile long recurring queue. These experiences gave the FHWA researchers the confidence to take on this network analysis task involving mini-roundabout and strict land use restrictions (Zhang et al., 2013).

THE TECHNICAL SUPPORT AND ANALYSIS APPROACH

First the research team laid out a context sensitive plan (Figure 2) for converting the existing AWSC intersection at Myrtle St and Owens St into a mini-roundabout. The plan would remove only one on-street parking space on each entrance and exit of the intersection, use corner bulb-outs to reduce pedestrian crossing distance. The elements were laid out considering the daily passage of 37-ft long school bus.

Next, network operational analyses were performed for 8 scenarios as shown below:

- **Morning Peak Period (7:00 to 8:00)**
  - 2007 Traffic: AWSC, Min-roundabout
  - 2017 Traffic: AWSC, Min-roundabout

- **Afternoon Peak Period (16:30 to 17:30)**
  - 2007 Traffic: AWSC, Min-roundabout
  - 2017 Traffic: AWSC, Min-roundabout

Field traffic data shows afternoon peak traffic is heavier, and field observations indicated that congestion during the PM peak is much worse and more widespread than AM peak. Due to space constraints, this paper will only present analysis results pertaining to the PM peak in current year (2007) and design year (2017).

The VISSIM microscopic traffic simulation models were built for both no-build and Mini-roundabout. For No-Build, STOP controls were placed on approaches as they appear in the field. For Mini-roundabout scenario, the calibrated mini-roundabout simulation model developed by Lochrane et al. (2012) was used. The only difference between the No-Build condition and proposed change is replacing the AWSC at the intersection of Myrtle St and Owens St with a mini-roundabout while the other intersections remained the same for all scenarios analyzed.

Other simulation parameters are:

- Simulation time: 2 hours with 30 min warm-up time and 30 min clearing time
- Traffic volumes: Peak-hour factor = 0.85
- Traffic composition: 98% Car, 1% Truck and 1% Bus
Zhang, W., Kronprasert, N., and Gustafson, J.

Speed (corridor): 30 mph (Myrtle St), 25 mph (Owens St and all minor roads)
Speed (crossing):
- AWSC — 15-20 mph
- Mini-roundabout — 13-17 mph

FIGURE 2 Proposed context sensitive plan of mini-roundabout design

ANALYSIS RESULTS

Figures 3 and 4 show 2007 and 2017 network intersection traffic flows. Figures 5 and 6 show the corresponding LOS at all intersections, and the average travel speeds on all links for 2007 traffic. One can see that under current traffic, converting the AWSC to mini-roundabout would improve the LOS of five intersections (including the AWSC) from D, E and F to A. The average travel speeds on different links were also raised to more desirable levels. Figures 7 and 8 show the network performances measures under 2017 traffic. This time the LOS of 8 intersections were improved from D, E and F to projected A, B, and C.
FIGURE 3 Intersection traffic flows - 2007 PM peak

FIGURE 4 Intersection traffic flows - 2017 PM peak
FIGURE 5 Network intersection LOS and link speeds – AWSC, 2007 PM Peak

Note: The letters on each approach indicate the predicted approach LOS
The circled letters on each node indicate the predicted intersection LOS
The speeds displayed for each link direction indicate the predicted average link speeds

FIGURE 6 Network intersection LOS and link speeds – Mini-roundabout, 2007 PM Peak
Figure 7 Network intersection LOS and link speeds – AWSC, 2017 PM Peak

Figure 8 Network intersection LOS and link speeds – Mini-roundabout, 2017 PM Peak

Figure 9 below shows snapshots of the queuing conditions for AWSC and mini-roundabout under 2007 and 2017 traffic demands. One can see that the congestion level is much less under mini-roundabout.
Table 2 shows detailed comparisons of performances at the intersection between AWSC and mini-roundabout options. For 2007 traffic, converting the AWSC to mini-roundabout would improve the intersection LOS from F to A; for 2017 traffic, the change would be from F to B.

Table 3 shows the travel time comparison between AWSC and mini-roundabout of one critical pair of origin-destination. It can be seen that for the CSAH 5 NB/EB direction during the PM peak period, converting the AWSC into a mini-roundabout would reduce travel time from 8.4 minutes to 2.4 minutes (71% reduction) under 2007 traffic, and from 20 minutes to 5.6 minutes (72% reduction) under 2017 traffic.

Table 4 shows the estimated annual savings in user cost during the PM peak hour if the AWSC at Myrtle St. and Owens St. is converted to a mini-roundabout. Note the actual savings in user cost would be higher if other hours during the day are also considered.
**TABLE 2 MOEs between AWSC and Mini-roundabout at Myrtle St & Owens St**

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Queue Length (ft, vehicles)</th>
<th>Throughput (veh/hr)</th>
<th>Delay (sec)</th>
<th>LOS by Approach</th>
<th>Intersection Delay (sec)</th>
<th>Intersection LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AWSC (2007 PM Peak Period)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastbound</td>
<td>230 (9)</td>
<td>335 (13)</td>
<td>280</td>
<td>77</td>
<td>F</td>
<td>54</td>
</tr>
<tr>
<td>Westbound</td>
<td>70 (3)</td>
<td>280 (11)</td>
<td>294</td>
<td>32</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Northbound</td>
<td>460 (18)</td>
<td>670 (27)</td>
<td>381</td>
<td>49</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td>315 (13)</td>
<td>820 (32)</td>
<td>304</td>
<td>58</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Mini-roundabout (2007 PM Peak Period)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastbound</td>
<td>6 (0)</td>
<td>189 (8)</td>
<td>323</td>
<td>4.7</td>
<td>A</td>
<td>6.5</td>
</tr>
<tr>
<td>Westbound</td>
<td>11 (0)</td>
<td>208 (8)</td>
<td>302</td>
<td>7.2</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Northbound</td>
<td>34 (1)</td>
<td>487 (19)</td>
<td>458</td>
<td>9.3</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td>3 (0)</td>
<td>114 (5)</td>
<td>312</td>
<td>3.5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td><strong>AWSC (2017 PM Peak Period)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastbound</td>
<td>258 (10)</td>
<td>333 (13)</td>
<td>295</td>
<td>78</td>
<td>F</td>
<td>61</td>
</tr>
<tr>
<td>Westbound</td>
<td>73 (3)</td>
<td>312 (12)</td>
<td>266</td>
<td>36</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Northbound</td>
<td>586 (23)</td>
<td>&gt; 670 (&gt; 27)</td>
<td>365</td>
<td>57</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td>583 (23)</td>
<td>&gt; 900 (&gt; 36)</td>
<td>316</td>
<td>69</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td><strong>Mini-roundabout (2017 PM Peak Period)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastbound</td>
<td>12 (0)</td>
<td>253 (10)</td>
<td>370</td>
<td>7.6</td>
<td>A</td>
<td>11.4</td>
</tr>
<tr>
<td>Westbound</td>
<td>14 (1)</td>
<td>202 (8)</td>
<td>276</td>
<td>10.4</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Northbound</td>
<td>171 (7)</td>
<td>660 (25)</td>
<td>547</td>
<td>18.6</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Southbound</td>
<td>5 (0)</td>
<td>172 (7)</td>
<td>359</td>
<td>5.1</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Note: Estimated queue lengths are given in feet, followed by queue length in equivalent number of vehicles in parentheses (the numbers are provided for ease of field verification).

**TABLE 3 Comparison of Travel Time between AWSC and Mini-roundabout**

<table>
<thead>
<tr>
<th>Movement</th>
<th>Distance (mile)</th>
<th>Current Year</th>
<th>Design Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stop Control</td>
<td>Mini-Roundabout</td>
<td>Stop Control</td>
</tr>
<tr>
<td>CSAH 5 (NB/EB)</td>
<td>0.8</td>
<td>8.4 minutes</td>
<td>2.4 minutes</td>
</tr>
<tr>
<td>CSAH 5 (SB/WB)</td>
<td>0.8</td>
<td>2.1 minutes</td>
<td>2.2 minutes</td>
</tr>
</tbody>
</table>

**TABLE 4 Annual Savings in User Cost during PM Peak between AWSC and Mini-roundabout at Myrtle St and Owens St**

<table>
<thead>
<tr>
<th>Traffic Scenarios</th>
<th>Total Vehicle-Hours of Travel (veh-hr)</th>
<th>Travel Time Savings, $D$ (veh-hr)</th>
<th>Annual Cost Saving, $D \times $13.67/hr \times 260 days/yr$ ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWSC</td>
<td>110.3</td>
<td>65.8</td>
<td>157,800</td>
</tr>
<tr>
<td>Mini-roundabout</td>
<td>205.3</td>
<td>134.1</td>
<td>253,400</td>
</tr>
</tbody>
</table>

*: The $13.67/hr user cost is the adjusted 2013 value of time ($/hr) recommended by Office of Secretary of Transportation (2011). The cost savings calculation is for week days (52 week/yr x 5 days/week = 260 days/yr), and during PM peak hour only.

**DISCUSSION**

The above analyses showed tremendous potential benefits of converting the critical AWSC intersection into a mini-roundabout. In essence, it accomplishes the mission of unclogging a congested local street network, and restores all most intersections to a healthy state of traffic operation. In potential user cost savings during the PM peak hour alone, the expected annual...
savings could be $157,820 for current traffic and $253,400 for the design year traffic. This means project expenses can be quickly re-captured through savings in user cost.

Although the safety impacts of converting the AWSC to a mini-roundabout was been rigorously assessed, it is expected that drastic improvement in traffic operation and conflict reduction/separation would reduce driver frustrations and improve network wide safety. At the affected intersection, the mini-roundabout would reduce vehicle speeds, shorten pedestrian crossing distances, eliminate multiple-threat pedestrian conflicts, and separate vehicle-pedestrian conflicts from vehicle-vehicle conflicts. All these will contribute to the better safety and revitalization of the neighborhood.

The problem that is happening in Stillwater, Minnesota is not alone. It is a representative scenario that may have been experienced by hundreds if not thousands of communities in the U.S. As such, the solution presented in this paper can be considered representative and applied in that context. This type of network congestion caused by blockage of a single intersection is not difficult to detect. The local people are most knowledgeable in identifying such problem intersections.

CONCLUSIONS

Based on the problem described and the traffic operational analysis performed, the authors conclude:

1. Congestion formed at one critical intersection can spread and cause local network wide traffic congestion.
2. If the problem location is identified correctly, capacity improvement at one single intersection has the potential to restore the entire local street network to a healthy state of operation, with expected improvements in safety.
3. Project expenses of implementing the suggested solution can be re-captured quickly through savings in user cost, fuel cost, better safety, and other derivative benefits.
4. Both the problem and the solution presented in this paper are representative, and the solution may be applied in other cities without the need of a detailed microscopic traffic study.
5. The qualitative trend of benefitting the local street network by improving one critical intersection is equally meaningful as the quantitative results presented in this paper, in terms of empowering the decision makers to make informed decision on where and how to improve their local street network.

ACKNOWLEDGEMENT

The authors wish to thank William Stein and James McCarthy, FHWA MN Division, for their contributions in promoting mini-roundabout and identifying funding sources for local governments wishing to implement this design.
REFERENCES


