Traffic Flow and Public Opinion: Newly Installed Roundabouts in New Hampshire, New York, and Washington

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ABSTRACT

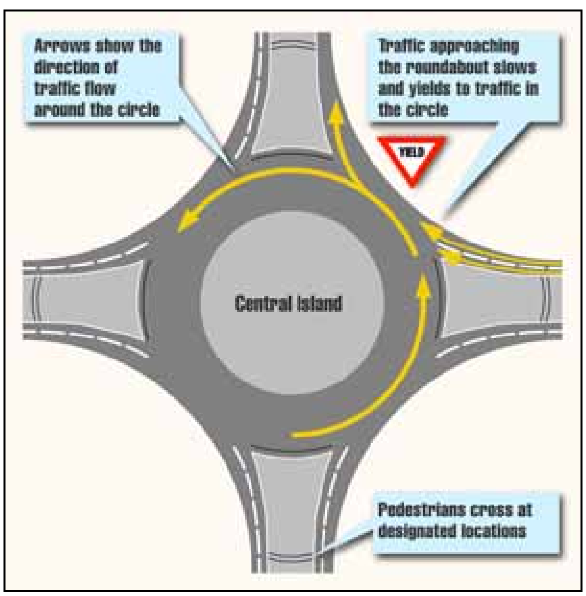
Roundabouts can provide substantial safety and traffic flow benefits compared with conventional intersections, but they often are opposed in the planning stage by local residents and elected officials who question their effectiveness. The purpose of the present study was to measure public opinion before and after construction of roundabouts in several communities and to evaluate the impact of roundabout construction on traffic flow. Three communities where stop-sign- or traffic-signal-controlled intersections were replaced with roundabouts in 2004 were the subjects of this research. Overall, 36 percent of drivers supported the roundabouts before construction compared with 50 percent shortly after construction. Roundabouts had very positive effects on traffic flow. Average intersection delays during peak hours at the three sites were reduced by 83-93 percent. Traffic congestion, as measured by the vehicle-to-capacity ratio, was reduced by 58-84 percent. These results provide further evidence that roundabouts can improve traffic flow and that public support for roundabouts increases after they are in place.

INTRODUCTION

The modern roundabout is a type of circular intersection that requires drivers to yield to traffic in the circle when entering and allows for continuous traffic flow through the intersection at low speeds (Figure 1). They are used throughout Europe and Australia to manage traffic at busy intersections, and they increasingly are being used in the United States in place of traffic signals and stop signs.

When properly designed (Kansas Department of Transportation, 2005), roundabouts can provide substantial safety benefits compared with conventional intersections. Persaud et al. (2001) evaluated changes in motor vehicle crashes following conversion of 23 intersections from either stop signs or traffic

Figure 1
Typical Roundabout



signals to roundabouts. Overall, crashes of all severities were reduced by 40 percent; injury crashes were reduced by 80 percent. These results are consistent with findings reported by Schoon and van Minnen (1994), who studied the conversion of 181 intersections in the Netherlands from traffic signals or stop signs to roundabouts. The authors reported that crashes and injuries were reduced by 47 and 71 percent, respectively; more severe injury crashes were reduced by 81 percent. Crash reductions resulting from installation of modern roundabouts can be attributed primarily to two factors: reduced traffic speeds and elimination of the possibility of right-angle collisions, which frequently occur at perpendicular intersections.

Each year about 2 million police-reported motor vehicle crashes occur at traffic signals and stop signs in the United States (National Highway Traffic Safety Administration, 2005). About one-third of these crashes result in injuries to vehicle occupants or pedestrians. Thus widespread use of roundabouts could prevent substantial numbers of motor vehicle crashes and injuries.

In addition to reducing crashes, roundabouts can improve traffic flow and increase vehicle capacity. At three intersections converted from stop signs to roundabouts, average vehicle delay was reduced by 13-23 percent (Retting et al., 2002). For specific approaches at intersections with the longest vehicle delays, reductions in average delay ranged from 48 to 57 percent. Reductions in the percentage of drivers that stopped at the intersection approaches ranged from 14 to 37 percent.

Despite demonstrated improvements in safety and traffic flow, construction of roundabouts in some communities has been impeded by opposition from some local residents and elected officials. Some communities have constructed roundabouts in spite of such opposition, and some evidence suggests that public acceptance generally increases once local residents adapt to this new form of traffic control (Retting et al., 2002). But more information would be useful regarding public opinion of roundabouts, including reasons for driver opposition and effects of roundabout construction on traffic operations.

The purpose of the present study was to sample public opinion before and after the construction of roundabouts in several communities and to evaluate the impact of roundabouts on traffic flow.

METHOD

Three small communities that replaced stop-sign- or traffic-signal-controlled intersections with roundabouts in 2004 were the subjects of this research: Nashua, New Hampshire; Greenwich, New York; and Bellingham, Washington. A primary factor in selecting locations was the desire to observe the effect of roundabouts in communities with limited prior experience with them. Greenwich did not have roundabouts, and Bellingham and Nashua each had one roundabout, built approximately 1 year prior to the study. A second factor was the desire to include intersections with a variety of traffic control devices prior to the construction of roundabouts. The study sites included a traffic signal, two-way stop signs, yield signs, and all-way stop signs. Geographic diversity also was a consideration.

The Nashua roundabout (Figure 2) was located adjacent to a community college. The previous “T” intersection was controlled by a combination of stop signs and yield signs and had an estimated annual average daily traffic (AADT) volume of 8,700 vehicles. The Bellingham roundabout (Figure 3) also was located adjacent to a community college. The previous four-leg intersection was controlled by all-way stop signs and had an estimated AADT of 11,250 vehicles. The Greenwich roundabout (Figure 4) was abutted by retail land use and located close to the county fair grounds. The previous “T” intersection was controlled by a traffic signal and had an estimated AADT of 7,600 vehicles.

Figure 2
Nashua Roundabout – South Main and Main Street

Before

After

Figure 3
Bellingham Roundabout – Cordata Parkway at West Kellogg Road

Before

After

Figure 4
Greenwich Roundabout – Route 29 and Route 40

Before

After

Telephone Surveys

In each community, random digit dialing methods were used to select a representative sample of licensed drivers 18 or older. Telephone interviews were completed with respondents who said they drove through the study intersections frequently or occasionally. In the surveys conducted prior to roundabout construction, respondents were provided with a brief description of the roundabout and asked if they had previously driven through one. In the surveys conducted approximately 6 weeks after roundabouts were constructed, interviews were completed only for drivers who said they had driven through the intersections since the new roundabouts were built.

A total of 7,781 telephone numbers were called at least once (not counting cases where there was no answer or a busy signal). Of these calls, 2,419 (31 percent) could not be completed due to language/ hearing problems, answering machines, invalid numbers, or because the numbers were not associated with households. Of the 5,362 potential survey participants contacted, 1,837 (34 percent) refused to participate. Of the 3,525 people willing to participate, about half (1,811) met the criteria for participation. Thus a total of 908 interviews were completed before roundabout construction and 903 after. Roughly equal numbers of interviews were conducted in each of the three communities.

Traffic Analyses

Video cameras were used to record traffic flow before and after roundabout construction. Observations conducted during the after period were made approximately 1 month after completion of the Bellingham and Greenwich roundabouts and 5 months after completion of the Nashua roundabout.

Cameras mounted on utility poles or luminaires provided views of the intersections and all approaches. Traffic flow was recorded at each site from approximately 7 a.m. to 7 p.m. for five weekdays before and after construction. From these tapes, traffic data were extracted manually. Traffic flow data included the number of vehicles observed for each direction of travel and turning movements. For each day, two peak periods were identified for analysis: 7 to 9 a.m. and 4 to 6 p.m. These peak periods provided a total of 20 hours of data per intersection (4 hours per day for 5 days) for both the before and after periods. For the three sites combined, a total of 120 hours of peak traffic flow were analyzed.

To ensure the before/after comparisons were based on periods of comparable traffic volumes, the peak traffic counts at each site taken before and after construction were subjected to a series of statistical tests (Russell et al., 2004). In this procedure, if traffic counts from the before and after periods are not statistically similar, an elimination process is undertaken in which 1 hour or more of high or low counts are dropped until the before and after datasets are statistically similar. The before and after datasets in this study tested statistically similar, so no data were dropped from the analyses.

Operational measures of intersection performance were estimated before and after roundabout construction using aaSIDRA traffic analysis software, version 2.0 (Akcelik & Associates, 2003). This widely used software was designed to analyze traffic flow at intersections with and without traffic signals, including roundabouts. For each community, data were analyzed for the morning and evening peak periods separately and for the periods combined. Because the results were consistent, only the findings for the combined morning and evening peak periods are reported here. Wilcoxon nonparametric and t-tests were applied to determine statistical significance. The following operational measures of intersection performance were computed:

- *Average intersection delay* – average delay for all entering vehicles, expressed in seconds per vehicle.
- *Maximum approach delay* – average vehicle delay for approach with highest average vehicle delay, expressed in seconds per vehicle.
- *Total effective stops* – estimated number of vehicles per hour that stopped, expressed in vehicles per hour.
- *Effective stop rate* – average number of stops per vehicle (some vehicles stopped more than once while queued in traffic waiting to enter the intersection).
- *Degree of saturation* – ratio of demand to available capacity; also referred to as vehicle-to-capacity, or v/c, ratio; capacity is defined in terms of maximum flow rate that a given traffic facility can accommodate under normal conditions (e.g., no severe weather; during this study, normal conditions prevailed); the maximum v/c ratio, under fully saturated conditions, equals 1.0, with lower values associated with less traffic congestion.

RESULTS

Telephone Surveys

In the surveys conducted prior to roundabout construction, 90 percent of drivers said they had previously driven through roundabouts. As indicated in Table 1, drivers in Nashua were slightly more likely than those in Bellingham and Greenwich to say they had previously driven through roundabouts prior to construction ($\chi^2 = 8.3$, $p = 0.02$).

Table 1
Percentage of Respondents in Before Survey Who Said They Previously Had Driven Through at Least One Roundabout

	Nashua (n = 301)	Bellingham (n = 300)	Greenwich (n = 307)	Total (n = 908)
Yes	94	88	88	90
No	5	6	9	7
Don’t know	1	4	2	2

$\chi^2 = 8.33$, $p = 0.0155$

Table 2 shows that before construction, a majority (54 percent) of drivers in all three communities combined opposed the planned installation of roundabouts. Many (35 percent) were strongly opposed. Nashua had the largest proportion of drivers opposed to new roundabouts (58 percent opposed, 43 percent strongly opposed). After construction, public opinion changed considerably. In all three communities combined, the proportion of drivers opposed to new roundabouts declined from 54 to 36 percent, and the proportion of drivers in favor increased from 36 to 50 percent. Still, 26 percent were strongly opposed after construction. The proportion of drivers who neither favored nor opposed roundabouts increased from 9 to 14 percent. This pattern of change in public opinion was fairly consistent across the three communities and statistically significant for all communities combined ($\chi^2 = 60.7$, $p < 0.01$).

Table 2
Percentage of Respondents in Favor of/Opposed to New Roundabouts

	Nashua		Bellingham		Greenwich		Total	
	Before (n = 301)	After (n = 300)	Before (n = 300)	After (n = 302)	Before (n = 307)	After (n = 301)	Before (n = 908)	After (n = 903)
Strongly favor	16	27	17	24	18	27	17	26
Somewhat favor	18	23	20	24	19	26	19	24
Total in favor	34	50	37	48	37	53	36	50
Somewhat oppose	15	9	22	10	20	9	19	9
Strongly oppose	43	29	31	28	31	23	35	26
Total opposed	58	37	53	38	51	32	54	36
Don't know	8	13	10	14	11	15	9	14

Before/after comparisons: Nashua ($\chi^2 = 25.4$, $p < 0.0001$), Bellingham ($\chi^2 = 13.0$, $p = 0.0015$), Greenwich ($\chi^2 = 24.1$, $p < 0.0001$), and Total ($\chi^2 = 60.7$, $p < 0.0001$).

Drivers opposed to the construction of new roundabouts were asked why (Table 3). Some respondents provided multiple reasons, the most common being that roundabouts were unsafe (24 percent before, 23 percent after). Some differences in reasons given for opposition before and after construction were observed. The proportion of drivers opposed to the roundabouts because they preferred traffic signals declined from 18 percent before to 10 percent after ($\chi^2 = 11.3$, $p = 0.0008$). The proportion of drivers opposed to the roundabouts due to congestion increased from 13 percent before to 21 percent after ($\chi^2 = 8.8$, $p = 0.0030$). The proportion of drivers opposed to the roundabouts because they thought they were too costly increased from 5 percent before to 14 percent after ($\chi^2 = 17.2$, $p < 0.0001$).

Traffic Flow Analyses

Table 4 summarizes changes in five operational measures of effectiveness for the three study sites. The unit of analysis for each location was the entire intersection, combining values for both the major and minor intersection approaches. For all study sites, conversion to roundabouts resulted in substantial reductions in vehicle delays, vehicle stops, and traffic congestion. Average intersection delays during peak hours at the three sites were reduced by 83-93 percent; delays on the intersection approaches

Table 3
Reasons Given for Opposing New Roundabouts (Percent)

	Nashua		Bellingham		Greenwich		Total	
	Before (n = 174)	After (n = 112)	Before (n = 158)	After (n = 115)	Before (n = 157)	After (n = 95)	Before (n = 489)	After (n = 322)
Unsafe	29	32	22	23	20	13	24	23
Confusing	18	20	23	24	20	20	20	21
Prefer traffic signal	20	14	20	5	14	10	18	10
Congestion	18	23	16	30	6	8	13	21
Just don't like it	13	12	16	16	12	16	13	15
Leave as is/was	8	0	6	2	10	3	8	2
Too costly	5	15	8	13	4	13	5	14
Other	27	16	20	16	36	24	28	18

Note: Because some respondents provided multiple responses, the totals for each city add to more than 100 percent.

Table 4
Operational Measures of Effectiveness for Morning and Evening Peak Hours Combined

	Nashua			Bellingham			Greenwich		
	Before	After	Percent Change	Before	After	Percent Change	Before	After	Percent Change
Average intersection delay (seconds per vehicle)	20.1	1.8	-91	73.7	5.5	-93	40.0	7.0	-83
Maximum approach delay (seconds per vehicle)	128.7	5.3	-96	183.1	12.2	-93	46.3	9.8	-79
Total stops (vehicles per hour)	553	265	-52	4,859	644	-87	856	587	-31
Stop rate (per vehicle)	0.4	0.2	-51	3.0	0.4	-85	0.8	0.5	-35
Degree of saturation (v/c ratio)	0.9	0.3	-62	1.3	0.2	-84	0.7	0.3	-58

with the greatest delay were reduced by 79-96 percent. Vehicle stops also were reduced, and roundabouts were particularly effective in Bellingham, where the study site was converted from four-way stop sign control. And traffic congestion, as measured by the vehicle-to-capacity ratio, at the three sites was reduced by 58-84 percent. All changes at each site were statistically significant at the $p < 0.05$ level.

DISCUSSION

This study demonstrates the nature and magnitude of traffic flow improvements that can be achieved when conventional intersections are converted to roundabouts. All measures of intersection operational performance were improved substantially after roundabouts were constructed. These findings are consistent with prior research showing that roundabouts can provide substantial traffic flow benefits (Retting et al., 2002; Robinson et al., 2000). These findings also document benefits for conversions from a variety of traffic control devices (traffic signal, two-way stop sign, four-way stop sign, and yield sign). Although potential impacts on crashes were not evaluated in this study, there is clear evidence that motor vehicle crashes, especially those involving injuries, are reduced significantly when stop signs and traffic signals are replaced with roundabouts (Eisenman et al., 2005; Persaud et al., 2001).

Some drivers who reported they were familiar with roundabouts prior to construction of the study sites may have confused modern roundabouts with older forms of circular intersections known as traffic circles or rotaries. Roundabouts differ from these in two principal ways: Vehicles entering a roundabout must yield to those already within the circulating roadway, and roundabout geometry produces much slower vehicle speeds (about 15-20 mph). Because of these design features, modern roundabouts generally are more efficient and safer than older forms of circular intersections. The significant change in public opinion following construction of roundabouts suggests that many drivers may not have been familiar with this relatively new type of intersection.

Although opposition declined as drivers adapted to the new roundabouts, about one-third of respondents still opposed the roundabouts when interviewed shortly after construction. Drivers opposed to roundabouts were more likely after construction to cite traffic congestion as their reason for opposition, even though analyses of traffic data showed there were substantial reductions in vehicle stops, delays, and congestion. These seemingly inconsistent findings may have two possible explanations. First, surveys conducted during the after period were made soon after construction (within the first 2 months) when drivers still may have been mindful of temporary traffic delays and other inconveniences associated with the construction process. The increased proportion of drivers who did not have an opinion about the roundabouts following construction suggests that more time may be needed for some drivers to form an opinion. At the Bellingham roundabout, signs that were supposed to be installed well in advance of the entrance to the roundabout initially were installed much closer. This may have contributed to some driver confusion during the first few months of operation. Such problems have since been addressed but may have affected driver attitudes when post-construction surveys were conducted. Second, it is possible that despite the fact that roundabouts promote smooth, orderly traffic flow and reduce vehicle stops, delays, and congestion, many drivers associate the slower traffic speeds at roundabouts with congestion.

Because roundabouts are controversial and often elicit opposition when proposed, officials in communities where roundabouts are planned should conduct public information campaigns to familiarize drivers with the operational characteristics and safety benefits of modern roundabouts. Given the observed increase following construction in the proportion of drivers who opposed roundabouts because they thought they were too costly, education campaigns should include information regarding the costs and potential savings from building roundabouts. Roundabouts eliminate the expense of installing and maintaining traffic signals; installation of a traffic signal costs an estimated $150,000 (City of Hampton, 2005). Roundabouts also eliminate the electricity consumption and routine maintenance required to operate traffic signals, estimated at $3,000 annually (Washington State Department of Transportation, 2005). There also are costs associated with roundabout construction; however, because the costs for building roundabouts vary widely based on site-specific factors, it is not possible to make generalized cost comparisons between roundabouts and traffic signals. Reasonable measures should be taken to address driver concerns about safety and confusion at roundabouts, such as ensuring that adequate traffic signs and pavement markings are installed.

It also is important to ensure that roundabouts are properly designed and located where they can improve traffic flow and safety (Kansas Department of Transportation, 2005). Despite their operational and safety benefits, roundabouts are not the best solution at all locations. Intersection characteristics that do not favor roundabouts include very unbalanced traffic flows (i.e., very high traffic volumes on the main street and very light volumes on the side street), locations where topographic or site constraints limit the ability to provide appropriate geometry, and locations in close proximity to persistent bottlenecks.

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REFERENCES

Akcelik & Associates Pty Ltd. 2003. aaSIDRA User Guide 2.0. Melbourne, Australia.

City of Hampton. 2005. Traffic signal systems. Hampton, VA: City of Hampton, Department of Public Works. Available: http://www.hampton.gov/publicworks/traffic_signal_systems.html.

Eisenman, S.; Josselyn, J.; List, G.; Persaud, B.; Lyon, C.; Robinson, B.; et al. 2005. Operational and safety performance of modern roundabouts and other intersection types. Albany, NY: New York State Department of Transportation.

Kansas Department of Transportation. 2005. Kansas roundabout guide. Topeka, KS. Available: http://www.ksdot.org/burtrafficeng/Roundabouts/Roundabout_Guide/RoundaboutGuide.asp.

National Highway Traffic Safety Administration. 2005. Traffic safety facts, 2003. Washington, DC: U.S. Department of Transportation.

Persaud, B.N.; Retting, R.A.; Garder, P.E.; and Lord, D. 2001. Safety effect of roundabout conversions in the United States: empirical Bayes observational before-after study. *Transportation Research Record* 1751:1-8. Washington, DC: Transportation Research Board.

Retting, R.A.; Luttrell, G.; and Russell, E.R. 2002. Public opinion and traffic flow impacts of newly installed modern roundabouts in the United States. *ITE Journal* 72:30-32,37.

Robinson, B.; Rodegerdts, L.; Scarborough, W.; Kittelson, W.; Troutbeck, R.; Brilon, W.; et al. 2000. Roundabouts: an informational guide. Report no. FHWA RD-00-067. Washington, DC: U.S. Department of Transportation.

Russell, E.; Mandavilli, S.; and Rys, M. 2004. Operational performance of Kansas roundabouts: Phase II. Topeka, KS: Kansas Department of Transportation.

Schoon, C. and van Minnen, J. 1994. The safety of roundabouts in the Netherlands. *Traffic Engineering and Control* 33:142-48.

Washington State Department of Transportation. 2005. Traffic signals: frequently asked questions. Olympia WA: Available: http://www.wsdot.wa.gov/biz/trafficoperations/traffic/signals.htm.