Impacts of Roundabouts on Passenger Vehicle Use and Greenhouse Gas Emissions

Policy Brief

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California Environmental Protection Agency
Air Resources Board

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Policy Description

Roundabouts are a traffic control strategy used at intersections in place of two- or four-way stop-signs or signals. In roundabouts in the U.S., traffic moves counter-clockwise around a circle in one or more lanes (Figures 1 and 2). Two key characteristics of the modern roundabout are the requirement that entering traffic yields to traffic in the circle, and geometric design features that slow vehicles entering the circle (Rodegerdts et al., 2007). Roundabouts are distinct from rotaries, an older technique in which the circle is larger and speeds are higher, and from the small traffic circles used to slow traffic in residential areas (Federal Highway Administration, 2010).

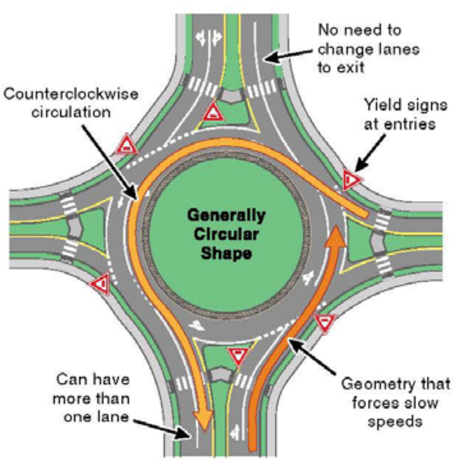

Figure 1: Key Roundabout Characteristics.

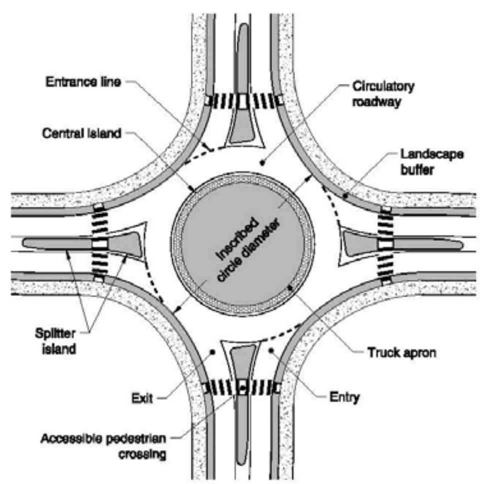

Figure 2: Roundabout Design Features

Source: Federal Highway Administration, 2010

Impacts of Roundabouts

The impacts of roundabouts on greenhouse gas (GHG) emissions depend on their effect on traffic flow, particularly traffic speeds, accelerations, and decelerations for the vehicles traveling through the roundabout. The available studies report the impacts of replacing an intersection controlled by stop signs (stop-controlled) or by signals with a roundabout on GHG emissions, fuel consumption, or both.

Effect Size

The selected studies provide a wide range of estimates of the impacts of roundabouts on fuel consumption and GHG emissions (Table 1). One study reports decreases in GHG emissions from converting a stop-controlled intersection to a roundabout (Mandavilli et al., 2008), while a second study reports increases in both GHG emissions and fuel consumption for conversions of both stop-controlled and signalized intersections (Ahn et al., 2009). The two remaining studies report mixed effects, both increases and decreases in fuel consumption and/or GHG emissions (Várhelyi, 2002; Hallmark et al., 2011). Given the wide range of estimated impacts, it is not possible to conclude that roundabouts will reduce fuel consumption and GHG emissions in all cases.

Table 1. Impact of Roundabouts on fuel consumption and GHG emissions

Study	**Study location**	**Study year**	**Results**		
			Type of traffic control replaced	*Outcome measured*	*Change in outcome*
Várhelyi, 2002	Växjö, Sweden	1991	Signalized	Fuel consumption	-28%
			Yield-controlled		+3%
Mandavilli et al., 2008	Kansas, Nevada	c.2000	Stop-controlled	CO_2	-16% in AM -59% in PM
Ahn et al., 2009	Loudon County, VA	c.2008	Stop-controlled	CO_2	+9 to 10%
				Fuel consumption	+13 to 18%
			Signalized	CO_2	+1%
				Fuel consumption	+5%
Hallmark et al., 2011	Woodbury, MN	c. 2010	Stop-controlled	CO_2	-3 to -12%
			Signalized		-21% to +25%

Evidence Quality

The four studies cited in Table 1 use widely different methodologies to estimate the impacts on GHG emissions and fuel consumption. None of the studies directly measured emissions or fuel consumption before and after the installation of the roundabouts. Two studies measured traffic flow before and after the installation of the roundabouts and then used models to estimate changes in emissions based on the observed changes in traffic flow, but the two studies used different methods for both parts of the analysis (Várhelyi, 2002; Mandavilli et al., 2008). One study used a cross-sectional design in which emissions were directly measured for test drivers along two road corridors with intersections of different types, including a roundabout (Hallmark et al., 2011). The fourth study performed a simulation of the effects of changing a stop-controlled intersection to a signalized intersection or a roundabout (Ahn et al., 2009). The significant differences in methodologies likely contribute to the wide variation in results.

Caveats

The studies were conducted in very different contexts, and none was conducted in California. Emissions estimates are highly dependent on driver behavior (Hallmark et al., 2011), which may vary systematically by region. Other factors that influence the impacts of roundabouts include the design of the intersection prior to the installation of the roundabout, the design of the roundabout, and the relative volumes of traffic on the roads entering into the roundabouts (Várhelyi, 2002; Mandavilli et al., 2008; Hallmark et al., 2011).

GHG Emissions

Three of the four cited studies provide estimates of the impact of roundabouts on CO_2 emissions. Note that these studies evaluate only the emissions generated by vehicles using the roundabout and do not take a life-cycle analysis approach to evaluating GHG emissions for roundabouts that would take into account emissions from construction, maintenance, and other phases of the life of a roundabout. One study reports estimated impacts on fuel consumption that are somewhat higher than estimated impacts on CO_2 emissions but does not offer an explanation for this difference (Ahn et al., 2009).

Co-benefits

Roundabouts are most often implemented to improve efficiency and safety. Roundabouts have been shown to reduce traffic delay in comparison to signalized and stop-controlled intersections, at least when operating within their capacity and especially at off-peak times (Federal Highway Administration, 2010). Reductions in delay can reduce the need for traffic lanes between intersections (Federal Highway Administration, 2010). However, these benefits may be less in the U.S. than in other countries as U.S. drivers are less efficient in their use of roundabouts (Rodegerdts et al., 2007). Roundabouts have also reduced crash rates, particularly injury crash rates, relative to other forms of traffic control (with the exception of all-way stops) in urban, suburban, and rural settings (Rodegerdts et al., 2007). Other benefits may include improved access to commercial and residential driveways (given the ease of making u-turns), reductions in vehicle speed that improve safety, improved crossing opportunities for pedestrians (though not for pedestrians with visual impairments), aesthetic benefits in the form of landscaping and community gateways, and reduced operations and maintenance costs in comparison to signalized intersections (Federal Highway Administration, 2010).

Examples

Roundabouts are used far more widely used outside the U.S.; as of 2006, approximately 2,000 have been built in the United States, while there are approximately 20,000 in France, 15,000 in Australia, and 10,000 in the United Kingdom (Ahn et al., 2009). But their popularity as a traffic control device is growing in California. As of 2012, Caltrans listed 20 existing roundabouts on the state highway system, with 22 programmed in the State Transportation Implementation Plan, and 38 more in the planning phase (Caltrans, 2012). Roundabouts are found throughout the state, from urban contexts such as Long Beach to small town contexts such as Arcata to rural contexts such as Truckee.

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