4-2003

A Safety analysis of roundabouts in the Las Vegas Valley Clark County, Nevada

Michael J. Janssen
Univeristy of Nevada Las Vegas

A SAFETY ANALYSIS

OF ROUNDABOUTS IN THE

LAS VEGAS VALLEY

CLARK COUNTY, NEVADA

By

Michael J. Janssen

Associate of Applied Science
State University of New York, Canton
1991

Bachelor of Science
Rochester Institute of Technology
1994

A professional paper submitted in partial fulfillment
of the requirements for the

Master of Public Administration
Greenspun College of Urban Affairs
Department of Public Administration
University of Nevada, Las Vegas
April 2003

ABSTRACT

A SAFETY ANALYSIS

OF ROUNDABOUTS IN THE

LAS VEGAS VALLEY

CLARK COUNTY, NEVADA

By

Michael J. Janssen

Dr. Anna Lukemeyer, Committee Chair
Department of Public Administration Professor
University of Nevada, Las Vegas

This professional paper reviews current research on the safety of modern roundabouts and studies the recent, widespread use of them in the Las Vegas valley of Southern Nevada. A roundabout is a form of intersection control (as opposed to a traffic signal or stop sign) that is common in Europe and Australia. Only recently have they been used significantly in the United States.

A safety analysis of roundabouts in the Las Vegas Valley was conducted. The study reviewed accident data and hard copy accident reports, obtained average daily traffic counts, and compared these operational aspects of the roundabouts with intersections serving similar traffic volumes controlled by the more traditional traffic signal or stop sign.

It is the goal of this paper to fill a void that exists within the available research that has been done on roundabouts throughout the world. Specifically, the roundabouts studied in this paper are all roundabouts that were built during *initial* construction of new

roadways whereas prior research has focused on roundabouts that have replaced other forms of intersection control at existing intersections. In addition, this paper adds to the limited research that has been done on roundabouts operating in the United States.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Unlike many older "big cities" such as New York, Boston, and Chicago, the Las Vegas area does not yet have a mass transit system adequate enough to allow residents to leave their automobiles home when commuting to work or for simply getting around. In fact, it is almost a necessity to have a car to get to work. This was shown in the most recent U.S. Census Bureau statistics for the year 2000 in which only 4.4% of Clark County residents were shown to use public transportation as a means of transportation to work. Comparatively, the Chicago area (Cook County) showed 17.3%, the Boston area (Suffolk County) showed 32.3%, and the New York City area (New York County), a staggering 59.6% (U.S. Census Bureau, "Census Transportation Planning Package", 2002).

As can be expected in an area with an estimated 1.5 million residents (U.S. Census Bureau, "Census Transportation Planning Package", 2002) and an average of 35 million tourists per year (Las Vegas Convention and Visitors Authority, "Visitor Statistics", 2002), there are a lot of cars on Las Vegas Valley roads. Add to this the areas explosive growth rate and you can see why government officials, developers, engineers, and contractors cannot build roads soon enough to move all the traffic.

While many factors affect a roadway's ability to move traffic (such as road width, horizontal and vertical alignment, and control of access), it is the intersections along the roadway that can become the most critical factor in a road's ability to move traffic safely and efficiently. The most common intersection design in use throughout the Las Vegas valley and most of the country involves the use of a traffic signal or stop sign to assign right of way to motor vehicles, pedestrians, and bicyclists. Recently however, traffic engineers have turned to an improved version of the old traffic circle intersection design in hopes of moving traffic more safely and efficiently.

Traffic circles were often used throughout the United States in the early 1900's up until the early 1960's, when there was a loss of confidence in them due to an increasing number of accidents (Jacquemart, 1998). Many of the old traffic circles were replaced by traffic signals. Now, the new version of the traffic circle, commonly called a modern roundabout, is vastly improved and different in many design and operational aspects. Most interesting perhaps, is the fact that the first modern roundabout in the United States was built in 1991 in the Summerlin community right here in Las Vegas, Nevada.

Fatal accidents on Nevada roadways have been going down slightly in the last few years. In 2001, there were 313 fatal accidents while the prior three years had 323, 350, and 361 respectively. This reduction in fatal accidents is not a national trend as national fatal accident statistics continue to rise. Between 1998 and 2001 those numbers were 41501, 41717, 41821, and 42116 respectively (Bureau of Transportation Statistics, "FARS: Accident Sum: Number of Fatalities by State", 2002). As a result, many local leaders and traffic engineers across the country are seeking safer ways to design streets without giving up any efficiency to process traffic. Modern roundabouts are one of the proposed solutions.

In the Las Vegas valley, many new roadways have been built, are under construction, or are in the design phase with a modern roundabout. In addition, some older roadway intersections controlled by stop signs have recently been converted to a roundabout design. However, limited data are available to assess their effectiveness in solving or at least helping reduce the accident and fatality problems on roads.

RESEARCH QUESTIONS

This paper seeks to answer two research questions. First, are the roundabouts in the Las Vegas valley safer than stop sign or traffic signal controlled intersections serving similar traffic volumes? Second, do the results of this study concur with the results of safety studies performed on modern roundabouts in other countries, and the limited studies performed in the United States?

To better understand the safety of the roundabouts, an extensive review of current research and available literature on roundabouts was conducted. Information was then gathered for the study by conducting site visits, obtaining average daily traffic counts (ADT's), reviewing accident reports and accident data, and by reviewing civil engineering as-built drawings or proposed construction drawings for numerous roundabouts in the Las Vegas Valley.

DEFINITION OF ROUNDABOUTS USED IN THE STUDY

While many types of circular intersections exist throughout the world, this paper is studying **modern roundabouts** only. Therefore, old traffic circles and rotaries, which may look like roundabouts, must not be confused with the modern roundabout. Old traffic circles and rotaries use stop control or no control at entry. The FHWA (2000) identified some of the things to further distinguish them from a modern roundabout and included the following:

1) They may require circulating traffic to yield to entering traffic
2) They may allow parking within the circulatory roadway

3) They may allow left-turning vehicles to pass to the left of the central island
4) They may allow pedestrians access to the central island
5) Rotaries in particular, are designed to have a very high design speed and as a result, are very large in circular diameter when compared to a modern roundabout.

Each of the modern roundabouts included in this study adheres to the basic definition of a modern roundabout in that:

- Entering traffic must yield to traffic in the circulatory roadway prior to entering the roundabout
- Geometric elements assist in controlling the entry and circulatory speed of vehicles versus signs or pavement markings
- Vehicles are channelized on the approach prior to entering the roundabout.

(FHWA, 2000)

Figure 1.0 below provides for a better understanding of the basic geometric elements of a modern roundabout:

Figure 1.0: Key Roundabout Elements (FHWA, 2000, p. 131)

CHAPTER 2: THE NATIONAL INTERSECTION SAFETY PROBLEM

All across the United States, a primary concern for city, county, state, and federal roadway/transportation agencies is intersection safety. Consider these staggering statistics (as shown in Table 2 below): in the year 2000, more than 2.8 million intersection-related crashes occurred, representing almost 44 percent of all reported crashes. Approximately 8500 fatalities (23 percent of total fatalities) and almost 1 million injury crashes occurred at or within intersections. It is estimated that these intersection-related crashes cost society nearly $40 billion a year.

Table 2: Year 2000 intersection statistics (FHWA, "Intersection Safety Brief", 2003)

	Number	Percent Total
Total Fatality Crashes	37,409	
Total intersection-related fatal crashes	8,474	22.6
Total Injury Crashes	2,070,000	
Total intersection-related injury crashes	995,000	48.1
Total property-damage-only (PDO) crashes	4,286,000	
Total PDO intersection related crashes	1,804,000	42.1
All Crashes	6,394,000	
Total intersection-related crashes	2,807,000	43.9
Total Fatalities	41,821	
Total intersection-related injured persons	1,596,128	

Why are there so many intersection-related crashes? Because intersections are areas of roadways that produce conflicts among vehicles and pedestrians due to entering and crossing movements. According to the Federal Highway Administration (FHWA), despite improved intersection design and more sophisticated applications of traffic engineering measures, the annual toll of human loss due to motor vehicle crashes has not substantially changed in more than 25 years. A combination of efforts has been tried to reduce fatalities and injuries. These efforts include the use of better road design, comprehensive traffic safety laws and regulations, increased enforcement, improved safety systems in vehicles, and increased education of drivers and pedestrians (FHWA, "Intersection Safety Briefs", 2003).

CHAPTER 3: ROUNDABOUTS AS INTERSECTIONS

"Roundabouts may improve the safety of intersections by eliminating or altering conflict types, by reducing speed differentials at intersections, and by forcing drivers to decrease speeds as they proceed into and through the intersection"(FHWA, 2000, p.103). In the FHWA publication *Roundabouts: An informational Guide* (2000), the reasons for the increased safety levels at roundabouts are as follows:

- They have fewer conflict points in comparison to conventional intersections. The potential for hazardous conflicts, such as right angle and left turn head on crashes is eliminated with their use. Single-lane approach roundabouts produce greater safety benefits than multilane approaches because of fewer potential conflicts between road users, and because pedestrian crossing distances are short.
- The low absolute speeds associated with roundabouts allow drivers more time and distance to react to potential conflicts.

- Because most road users travel at similar speeds through roundabouts, i.e. have low relative speeds, crash severity can be reduced when compared to traditionally controlled intersections.
- Pedestrians need only cross one direction of traffic at a time at each approach as they traverse roundabouts, as compared with unsignalized intersections. The conflict locations between vehicles and pedestrians are generally not affected by the presence of a roundabout, although conflicting vehicles come from a more defined path at roundabouts (and thus pedestrians have fewer places to check for conflicting vehicles). In addition, the speeds of motorists entering and exiting a roundabout are reduced with good design.

Diagrams of vehicle – vehicle conflict points for traditional three and four-leg intersections versus three and four-leg roundabouts are shown in Exhibit 3.1A and 3.1B. In a three-leg intersection, conflict points are reduced from nine to six and in a four-leg intersection they are reduced from thirty-two to eight.

Exhibit 3.1A Three-leg Intersection Conflict Points (FHWA, 2000, p. 105)

Exhibit 3.1B Four-leg intersection conflict points (FHWA, 2000, p. 106)

CHAPTER 4: HISTORY OF ROUNDABOUTS

While not a modern roundabout, the first traffic circle was constructed in New York when Columbus Circle was constructed in 1905. A few years later, the Place De l'Etoile in Paris was constructed in 1907. During 1925-1926 they were introduced in London at multiple locations including Parliament Square, Hyde Park Corner, Marble Arch, Trafalgar Square, and at Aldwych. While many additional traffic circles were built throughout the United States up until the 1950s, most were soon replaced in the 1960s by traffic signals. Not until 1966, in the United Kingdom, did the modern roundabout first appear. It was at that time, that the off-side priority rule was adopted (when an entering vehicle gives way to circulating vehicles) and the yield-at-entry operation became standard. (Taekratok, 1998)

The success of the new modern roundabout in the United Kingdom "provoked a renewal of interest in the use of roundabouts worldwide. Modern roundabouts were reintroduced in France in 1972 and yield at entry imposed in 1983" (Taekratok, 1998, p. 6). By mid-1997, there were "about 15,000 modern roundabouts in France. Other

European countries have also adopted this form of intersection as a standard design solution. In addition to their popularity in Great Britain and France, roundabouts are very common in Germany, Switzerland, the Benelux countries, the Nordic countries, Spain, and Portugal. Outside of Europe the modern roundabout is a standard feature in Australia, and it is becoming more common in New Zealand, South Africa, and Israel" (Jacquemart, 1998, p.11).

In March 1990, construction began on the first modern roundabout in the United States. It was open to traffic in 1991 in the Summerlin community of Las Vegas, Nevada. In 1992, the Gainesville, Florida, roundabout was the first in the U.S. to replace a traffic signal. The I-70/Vail Road interchange, completed in 1995, was the first roundabout retrofit of a highway interchange (Jacquemart, 1998).

Jacquemart (1998) reported on a National Cooperative Highway Research Program (NCHRP) which performed an exhaustive survey of transportation departments across the U.S. and identified thirty-eight operating roundabouts in the U.S. and nine more that were either in design or under construction. Of these, only six were in Nevada. As of this writing, Southern Nevada has thirty-three roundabouts (which are listed in Table 4.0 below), twenty of which are operating and thirteen others that are either in design or under construction.

Table 4.0: Southern Nevada Roundabouts

City of Las Vegas:

Town Center Drive / Village Center Circle	**Constructed 1991**	**4 leg/2 lane**
Village Center Circle / Hills Center Drive	**Constructed 1992**	**4 leg/1 lane**
Hills Drive / Longspur Drive	**Constructed 1992**	**3 leg/1 lane**
Town Center Drive / Hualapai Way	**Constructed 1995**	**4 leg/3 lane**

Town Center Drive / Banbury Cross/ Canyon Run	**Constructed 1995**	**4 leg/3 lane**
Lake South / Crystal Water	**Constructed 1995**	**4 leg/1 lane**
Grand Canyon / Gowan	**Constructed 1997**	**4 leg/1 lane**
Carriage Hill / Park Vista / Vista Run	**Constructed 2001**	**3 leg/1 lane**
Vista Center/Vista Run/Park Vista	**Constructed 2003**	**3 leg/1 lane**
Summerlin Village 23A #1	**Under Construction**	**4 leg/1 lane**
Summerlin Village 23A #2	**Under Construction**	**4 leg/1 lane**
Summerlin Village 23B #1	**Under Design**	**3 leg/1 lane**
Summerlin Village 23B #2	**Under Design**	**4 leg/1 lane**
Summerlin Village 22 #1	**Under Design**	**4 leg/1 lane**
Summerlin Village 22 #2	**Under Design**	**3 leg/1 lane**
Summerlin Village 22 #3	**Under Design**	**4 leg/1 lane**
Summerlin Village 21 #1	**Under Design**	**4 leg/1 lane**
Summerlin Village 21 #2	**Under Design**	**3 leg/1 lane**
Summerlin Village 21 #3	**Under Design**	**4 leg/1 lane**
Summerlin Village 21 #4	**Under Design**	**3 leg/1 lane**
Red Hills / Apple (replace T-Intersection)	**Under Design**	**3 leg/1 lane**
Unincorporated Clark County:		
Blue Willow / Desert Marigold / Desert Primrose	**Constructed 1999**	**4 leg/1 lane**
Navajo Willow / Desert Marigold / Havenwood	**Constructed 1999**	**3 leg/1 lane**
Spotted Leaf / Golden Willow / Havenwood	**Constructed 2000**	**4 leg/1 lane**
Pavilion Center / Desert Primrose/ Spotted Leaf	**Constructed 2000**	**3 leg/1 lane**
Flamingo Road / Granite Ridge	**Constructed 2002**	**3 leg/ 1 lane**
City of Henderson:		
Grand Hills/Rio Secco	**Constructed 1999**	**3 leg/2 lane**
Kelso Dunes / Julia	**Constructed 2002**	**3 leg/1 lane**
Kelso Dunes / Marks	**Constructed 2002**	**4 leg/1 lane**

Cloudcrest / Burkholder	**Under Design**	**4 leg/1 lane**
<u>City of North Las Vegas</u>:		
Carey Avenue / Hamilton (replace 4way stop)	**Constructed 2001**	**4 leg/2 lane**
Carey Avenue / Revere (replace 4way stop)	**Constructed 2001**	**4 leg/2 lane**
Carey Avenue/ Belmont (replace 4way stop)	**Constructed 2001**	**4 leg/2 lane**

It is not known how many roundabouts exist today across the United States. The NCHRP has implemented project 3-65, which has an estimated completion date of June 2005 in which, among other things about roundabouts in the U.S., they will "update and expand the inventory of U.S. roundabouts and make it available to transportation professionals" (Transportation Research Board, "NCHRP Project 3-65: Applying Roundabouts in the United States", 2003).

CHAPTER 5: ROUNDABOUT SAFETY STUDIES

OUTSIDE THE UNITED STATES

As indicated earlier in this paper, the modern roundabout has been much more commonly used outside the U.S. As a result, numerous studies have been performed on them. However, the NCHRP argues that "perceived differences in driver behavior raise questions about how appropriate some international research and practices are for the U.S." (Transportation Research Board, "NCHRP Project 3-65: Applying Roundabouts in the United States", 2003) Exactly what these differences in driver behavior are was not identified. It has been suggested that something as simple as a "no overtaking" sign used commonly in European multi-lane roundabouts to reduce lane change accidents would never work in the U.S. because drivers are not as courteous. It is hoped that the new

NCHRP project 3-65 will further identify reasons for accepting or not accepting the international research that has been done so far.

Regardless of the NCHRP's concerns, the data that have come from these studies is still compelling. The following are the countries and their related research data from the NCHRP report prepared by Jacquemart (1998).

The Netherlands

In 1992, the Netherlands performed a before and after study of 181 roundabouts that were previously stop or yield sign controlled. They found that the average annual number of accidents dropped 51% (before roundabout conversion the 181 intersections each had an average of 4.9 accidents/yr and after conversion 2.4 accidents/yr). Injury accidents went down 72% (before roundabout conversion 1.3 injuries/yr and after conversion 0.37/yr). Moped/bicycle injuries fell 44% (before roundabout conversion 0.55/yr and after conversion 0.31/yr). They found the most impressive reduction in the more severe injuries (those requiring hospital admissions) category in which an 81% drop was found.

Australia

In 1981, Australia performed a before and after study of 73 roundabouts that replaced signal or stop sign controlled intersections. They found a 74% reduction in the casualty accident rate and a 32% reduction in property damage accidents.

Germany

In 1996, Germany studied 34 roundabout intersections and found accident reductions of 40%. The number of accidents with heavy property damage decreased from 24 to 3.

Great Britain

In 1984, a Great Britain study of 84 four-leg roundabouts found an average crash frequency of 3.31 injury accidents per year, 16 percent of which were classified as fatal or serious. The average accident rate per million vehicles entering (MVE) the intersection was 3.64. Pedestrian crashes represented 4-6% of all crashes. Surprisingly, this study also showed that bicyclists were involved in 13-16% of all accidents and motorcyclists in 30-40%. These findings of bicycle and motorcycle involved accidents are much higher than any other studies reviewed. It was not noted why they were so high. Perhaps motorcycles and bicycles make up a larger portion of the vehicle mix at the Great Britain intersections that were studied.

France

In 1986, France studied 83 roundabouts and concluded that the transformation of a traditional intersection into a roundabout resulted in significant safety benefits. Injury accidents were reduced by 78% (before roundabout conversion 1.42/yr and after 0.31/yr). Fatalities were reduced by 88% (before roundabout conversion 0.16/yr and after 0.02). A 1988 study of 522 roundabouts having an average ADT of 12,500 found that 90% of them had no injury accidents at all, with an average injury accident rate / MVE of 0.10.

Switzerland

In Switzerland, two roundabouts built in 1977 and 1980 to replace previously signalized intersections were studied 4-8 years following conversion. They were found to reduce total accidents by 75 percent and total injuries by 90%.

Other Studies Outside the United Sates

Besides the NCHRP report, Ourston and Bared (1995) reported that in Germany, 28 intersections were studied wherein it was found that the number of accidents per million vehicles entering in old traffic circles was 6.58, in signalized intersections 3.35, and in roundabouts 1.24.

At the 2003 Transportation Research Board Annual Meeting, Elvik (2003) presented "Effects on road safety of converting intersections to roundabouts: A review of evidence from non-US studies" in which he provided both positive and negative statistics related to roundabout use throughout the world. The presentation provided information from numerous studies that were performed between 1975-1997. Some of the more interesting statistics include a 1981 Denmark study in which property-damage-only accidents went up 426% after installation of a roundabout; a 1983 Sweden study in which serious injuries went up 171%; and three other 1992 Sweden studies in which property-damage-only accidents went up 135%, 103%, and 143% (Elvik, 2003)

In summary, most studies outside the U.S. show that roundabouts improve safety. A few, however, have clearly shown problems with roundabout use and increases in accidents.

INSIDE THE UNITED STATES

The first roundabout to be constructed in the City of Kennewick, Washington was studied by Beaudry (2003). This roundabout was constructed as part of a City of Kennewick Hazard Elimination Program. Prior to the roundabout construction, an offset T-intersection with one-way stop signs controlled the intersection. Based on traffic volumes and intersection crashes it also met some signal warrants. Residents in the area complained of speeding, numerous accidents, and significant delays at the existing intersection. A capacity analysis showed that the roundabout would perform much better than a four-way stop (which would require realigning the 2 offset T-intersections) or traffic signal. Because of the capacity advantage and expected safety benefits of a roundabout, the roundabout was constructed in August 2000.

"In the four years prior to the start of construction of the roundabout, there were 40-reported collisions at the offset T – intersections on 27th Avenue at Union Street and Union Loop Road. Seventeen of the collisions were rear-end collisions, 14 involved left-turning vehicles and the remaining nine were angle (t-bone) type crashes. Fourteen of the 40 crashes involved injuries" (Beaudry, 2003, p. 4). Subsequently, "In the two years following the completion of the roundabout there were six reported collisions in the vicinity of the roundabout: four were rear-end crashes and two were run-off the road collisions" (Beaudry, 2003, p. 4). It should be noted that the two run-off the road collisions were reported to be caused by icy road conditions. Overall, total collisions were reduced by almost 73%. Before the roundabout, the crash rate was 2.88 acc/MVE and after 0.79 acc/MVE. Additionally, the injury accident rate was reduced by over 90%. Before the roundabout it was 0.99 inj/MVE and after it was 0.10 inj/MVE.

In 2002, the New York State Department of Transportation began a roundabout research project. While no information is currently available on the findings of this project, List et al (2002) is currently preparing the final report entitled "Operational and Safety Performance of Modern Roundabouts and Other Intersection Types". In this report they will have performed "an in-depth examination of the relative safety and operation of modern roundabouts. It will also examine the trade-offs between capacity and safety and various design features. It will provide more information about the benefits of roundabouts and how these benefits compare to the cost of building new ones and the incremental cost of transforming existing ones. Planners and designers will benefit from the study because they will be better prepared to determine where it would be most cost-effective to use roundabouts to reduce intersection accidents and congestion" (List et al, 2002, "Operational and Safety Performance of Modern Roundabouts and Other Intersection Types", 2003).

In October 2001, the Maryland State Highway Administration (2001) provided an informational report on their experience with roundabouts. As of September 2001, Maryland had more than 25 active modern roundabouts, with their first roundabout being put into operation in April 1993. Of these, eight replaced conventional intersections for which "before" and "after" accident data were reviewed.

The eight roundabouts had single lane entry and one circular lane. The average daily traffic (ADT) entering these roundabouts ranged between 9,000 and 14,000. The annual accidents at these locations dropped from an average of 5 accidents / year in the non-roundabout condition to 1.8 accidents / year in the roundabout condition (a 64% reduction). In addition, accident severity was reduced wherein injury accidents went down from an average of 3 injury accidents / year to 0.5 injury accidents/ year (an 83% reduction). The eight roundabouts had a before accident rate of 1.53 acc/MVE and an after rate of 0.48 acc/MVE. The mean injury rate before was 0.97 inj/MVE and after a 0.11 inj/MVE.

One other roundabout in Maryland received additional discussion in the report. It was a 2-lane roundabout that replaced a previously signalized intersection. The ADT was

50,000. Since its opening, it has experienced a nearly fourfold increase in annual property damage accidents. A rate of 2.6/yr jumped to 10/yr. On the positive side, injury accidents were reduced by almost two-thirds. A rate of 4.2/yr dropped to 1.5/yr.

Also in 2001, Flannery (2002) studied U.S. roundabouts in Florida. These single lane roundabouts replaced previous stop-controlled intersections. The accident data showed an overall reduction in crashes after installation of the roundabouts. The roundabouts and their related ADT's, accident rates / MVE, and injury rates/ MVE were as follows:

1) Palm Beach – 7600 ADT; 0.54 before / 0.54 after; 0.5 before/ 0.0 after (previously 2 way stop controlled)
2) Tallahassee - 17,825 ADT; 0.69 before/ 0.23 after; 0 before/ 0 after (previously T-intersection)
3) Ft. Walton Beach – 12,000 ADT; 1.83 before / 0.45 after; 2.0 before / 0 after (previously T-intersection).

Russell et al (2000) performed a safety evaluation of the first modern roundabout constructed in Kansas. This roundabout replaced a two-way stop controlled intersection in 1997. Crash data was examined for three years prior to the installation of the roundabout and for 29 months following the installation of the roundabout. There were nine reported crashes at the intersection in the 3 years prior to the roundabout. "All nine of these crashes involved a driver failing to yield the right of way or failing to stop for a stop sign. All of the nine crashes were right angle" (Russell et al, 2000, p. 45). Four of the nine crashes involved injuries. The roundabout had no reported crashes in the 29 months of operation that was studied.

The Insurance Institute for Highway Safety (IIHS) published a report by Persaud et al (2000), that evaluated changes in motor vehicle crashes following conversion of 24 U.S. intersections from stop sign or signal control to roundabouts. Combining the results of the 24 intersections studied, injury crashes were reduced 76% and overall crashes were reduced by 39%. In addition, collisions involving fatal or incapacitating injuries fell as much as 90%.

Scalici et al (1999) studied the redesign process of New York City's Frederick Douglas Circle. The original traffic circle was determined to be a nuisance for motor vehicles and the very high amount of pedestrian traffic. It was desired by residents and officials to make it into a safe and unique gateway into Harlem. Converting the circle into a modern roundabout was one of four alternatives that was considered but was not chosen. The roundabout ranked highest in terms of traffic capacity and level of service but because it was believed to place the most emphasis on vehicle throughput and less consideration on the crossing pedestrian, it was not chosen. The central island was something the community wanted as a focal point for pedestrians to use almost like a park. Roundabouts do not permit the use of the central island by pedestrians. "The roundabout was also dismissed for a number of other reasons. First, the special-need pedestrians, such as children either walking or biking to the park, the elderly and parents with strollers, would not be adequately served. Second, since traffic signals control all streets directly down and upstream of the roundabout, the issue of signal coordination – or noncoordination – would become a major concern. Third, the turning radius for trucks was one specific geometric design constraint that precluded a small center island" (Scalici et al, 1999, p. 50). In the end, a signalized traffic circle was chosen.

The 1998 NCHRP report prepared by Jacquemart discussed a 1997 survey that produced before-and-after accident statistics for 11 U.S. roundabouts that were previously controlled by stop signs or traffic signals. On an individual basis, each roundabout experienced a reduction in injury crashes that ranged from 20 – 100 %. Two of the roundabouts experienced increases in property-damage-only crashes.

No published research was found on a U.S. roundabout that did not *replace* an existing traffic signal or stop sign controlled intersection. Of the 20 roundabouts in operation in the Las Vegas valley, only 3 were replacements for previous stop sign controlled intersections, making the research findings in this report somewhat unique.

REASONS FOR DIFFERENT SAFETY STUDY FINDINGS

As can be seen in the aforementioned safety studies performed both inside and outside the U.S., results can vary significantly. There is no easy answer as to why the results can be so different. It is the opinion of this author any many others within the traffic engineering community that the differing results can be attributed primarily to differences in design. These design differences may not be visible to the "untrained eye". Only when measuring specific geometric dimensions at each roundabout will the differences become evident. "The link between roundabout geometric design and the resulting operational and safety performance is more pronounced than other types of intersections" (Flannery, 2002, p.1). Also, "the geometry of many studied sites may not necessarily conform to good roundabout design. Improved design principles, such as an emphasis on achieving consistent speeds, may result in better safety performance. It should also be noted that these reported crash reductions are generally for sites where roundabouts were selected to replace problem intersections. Therefore, they do not necessarily represent a universal safety comparison with all other intersection types" (FHWA, 2000, p.113).

As indicated in the FHWA guide, multi-lane roundabouts are not as safe as single-lane roundabouts because they introduce more potential conflict points, which may lead to higher accident rates. Many of the studies performed outside the U.S. involved hundreds of roundabouts. Perhaps some of the variance in safety studies is due to the number of multi-lane roundabouts that were included in the various studies (i.e. the more multi-lane roundabouts included in the studies the higher the overall accident rates, injury rates, etc.).

CHAPTER 6: METHODOLOGY

Based upon methodologies used in previous studies of roundabouts, the following are the steps used in this report:

Step 1: Identify Modern Roundabouts for Use in the Study

The focus of this step is to identify and field verify the design characteristics of the roundabouts to be used in the study. Field verification is needed to ensure that each roundabout used in the study met the FHWA definition of a modern roundabout (previously stated in the introduction). Some roundabouts initially identified in discussions with local entities were eliminated for use in this study because field verification showed that they were lacking one or more of the critical modern roundabout design elements.

Step 2: Identify Average Daily Traffic (ADT) Counts for Selected Locations

The average daily traffic counts were obtained by using tube-counting machines. These machines are widely accepted in the traffic engineering community. Tube counters were placed at each roundabout entry leg for a minimum of 24 hours. The information was then processed using software provided by tube counting machine manufacturers.

Step 3: Identify Comparison Intersections Controlled by Stop Signs or Signals

The key element in choosing a good comparison intersection is the ADT of the intersection. The form of intersection control used at any intersection is, for the most part, predisposed upon how much traffic needs to be processed within a tolerable length of delay. Without the use of a roundabout, every intersection in this study would have been, or could be converted to another form of intersection control such as a 1-way stop (at a T-intersection), a 2-way stop, a 4-way stop, or traffic signal controlled. Traffic engineers typically use engineering judgement and the *Manual of Uniform Traffic Control Devices* to select the applicable form of control. This step required a review of existing intersections and their related ADT's. This information was obtained from the City of Las Vegas traffic count database. Once comparable ADT's were found, intersections were field checked to ensure that each comparison study was between similar legged intersections (i.e. 3-leg roundabout and 3 leg stop controlled intersection or 4-leg roundabout and 4-leg traffic signal). In some cases, new tube counts were obtained to verify ADT data that was more than two years old. Some intersections that were originally selected for use in the comparison study were rejected after a field check uncovered an unfavorable horizontal or vertical alignment that may have provided skewed accident results. For example, it was found that one of the signalized intersections originally identified for use in the study had both horizontal and vertical alignments that may have provided less than the ideal stopping site distance necessary for the posted speed limit. This may have led to high rear end and opposing left-turn accidents. In addition, only intersections that have retained the same form of intersection control during the 3-year crash data period were selected. Some intersections had a control change during the 3-year period and were rejected from further study. For example, one intersection changed from a 2-way stop to a 4-way stop 2-years into the crash data. Another intersection changed from a 4-way stop to a signalized intersection 1 year into the crash data.

Step 4: Obtain Accident Data for each Intersection Used in the Study

Accident data were obtained from the State of Nevada Department of Transportation (NDOT) Safety Division. This division maintains a database of accident report statistics related to a crash on public streets within Nevada. The NDOT data was retrieved through the use of a GIS based software program entitled *Intersection Magic,* which the City of Las Vegas utilizes to access accident data. Also, actual hard-copy accident reports were obtained from the City of Las Vegas Traffic Engineering Division Intersection Accident Report Files so that driver testimonials and investigating police officer comments could be reviewed to obtain additional background information related to each accident (such as property damage severity and injury severity).

Step 5: Calculate Accident Statistics

Three years of accident data (from 9/1/99 to 8/31/02) were used to calculate the following at each studied intersection: the average accident frequency per year, accident rate (per million vehicles entering or MVE), average injury accident frequency per year, and injury accident rate (per million vehicles entering or MVE).

Average Accident Frequency / year = total number of accidents/3

Accident Rate / MVE = Average Accident Frequency / (ADT * 365 / 1,000,000)

Average Injury Accident Frequency / year = total number of injury accidents/3

Injury Accident Rate / MVE = Avg. Injury Accident Freq. / (ADT * 365 / 1,000,000)

Step 6: Compare Results

In this step, the accident statistics are compared between the different forms of intersection control and between the results found in prior research.

CHAPTER 7: FINDINGS

The results of the statistical findings as shown in Table 7.0 on page 33 are very different for each "level" of ADT processed in the intersections. It is necessary to classify the intersections studied in this paper as being minor-level (less than 10000 ADT), mid-level (between 10000 and 15000 ADT), or major-level (greater than 15000 ADT).

Table 7.0 lists the roundabouts and non-roundabout intersections used in the comparison study and their corresponding ADT's. Three roundabouts were classified in the minor-level intersection group with ADT's between 2668 and 6229. Five non-roundabout intersections were classified in the minor-level group and were 1 or 2 way stop-controlled, having ADT's between 2357 and 6336. One roundabout had an ADT of 12,021 and was classified in the mid-level intersection group. Three non-roundabout intersections were classified in the mid-level intersection group and were 4-way stop-controlled, having ADT's between 11,019 and 14,701. Three roundabouts were classified in the major-level intersection group and had ADT's between 21,480 and 26,660. Six non-roundabout intersections were classified in the major-level intersection group and were signalized, having ADT's between 18,338 and 30,663.

MINOR-LEVEL INTERSECTIONS

The minor intersections controlled by roundabouts had accident rates between 0 and 0.80 accidents / MVE (an average of 0.41) and injury accident rates between 0 and 0.16 injury accidents / MVE (an average of 0.10). In comparison, the minor intersections controlled by stop signs had accident rates between 0.32 and 1.11 accidents / MVE (an average of 0.71) and injury accident rates between 0 and 0.43 injury accidents / MVE (an average of 0.26).

These statistics would appear to give roundabouts a significant advantage in safety over stop-sign control (73.2% less accidents/MVE and 160% less injury accidents/MVE) at minor intersections. In addition, the injury accident rate of 0.10 is consistent with findings in the France study discussed earlier in this report wherein it was found that a study of 522 roundabouts had an injury accident rate of 0.15. However, because so few accidents occur at these minor intersections, it is my opinion that a much larger number of roundabout and stop sign controlled minor intersections would need to be studied in order to obtain statistically significant results and validate the roundabout advantage.

MID-LEVEL INTERSECTIONS

The only mid-level roundabout that was available for study had an accident rate of 0.08 accidents / MVE and had no injury accidents reported in the 3-year study period. This roundabout has performed exceptionally well with only 1 accident occurring in the 3-year study period. In comparison, three mid-level intersections controlled by 4-way stop signs had accident rates between 0.25 and 0.67 accidents / MVE (an average of 0.50) and injury accident rates between 0.12 and 0.25 accidents / MVE (an average of 0.18).

These statistics show the roundabout control at the mid-level intersection to be much safer. It should be noted that at one of the mid-level 4-way stop intersections, every accident resulted in an injury accident. However, because of the limited number of mid-level intersection roundabouts available for comparison, further study should be done when more roundabouts are available to obtain statistically significant results to validate this study.

MAJOR-LEVEL INTERSECTIONS

The statistical results and hard copy accident reports for the major-level intersections provide the most interesting results of this study. The roundabouts had an alarming number of accidents in the 3-year study period. They had an average yearly accident frequency of 22.23 compared to the comparison intersections, which were signalized and had 5.22. The roundabouts had accident rates between 0.89 and 3.98 accidents / MVE (an average of 2.40) and injury accident rates between 0 and 0.65 injury accidents / MVE (an average of 0.32). In comparison, the signalized intersections had accident rates between 0.31 and 0.75 accidents / MVE (an average of 0.60) and injury accident rates between 0.04 and 0.35 injury accidents / MVE (an average of 0.22).

These statistics would appear to show that traffic signals are a much better alternative to roundabouts at major intersections. In fact, the results show the signalized intersections to have almost 300% less accidents / MVE and about 45% less injury accidents / MVE. However, a review of the hard copy accident reports and a closer look at the roundabout designs point to a different conclusion.

When looking at the multi-lane roundabout designs and the accident statistics it is clear that a relatively simple modification to two of the three roundabouts might change the results significantly. One roundabout at Town Center Drive and Village Center Circle had a similar ADT as the other two roundabouts along Town Center Drive, but had no injury accidents in the 3-year study period and had a much lower accident rate. This roundabout had three lanes of traffic on the approach legs just like the other higher accident roundabouts, but forced the outer lane to turn right allowing only two lanes to circulate in and around the roundabout. This modification would significantly reduce the conflict points that presently occur in the 3 lane roundabout designs. It is now being implemented by a NDOT safety project as shown in Figure 7.0 below.

Figure 7.0: NDOT safety project modifications to triple-lane roundabout

While reviewing the hard copy accident reports, it was also clearly evident that the three lane designs were the reason for most of the accidents. Police officers who were involved in the investigations (on numerous occasions), stated in their reports that the accidents were due to one of the two inside lanes trying to make a right turn to get out of the roundabout only to crash into a car in the right lane. As noted above, the right lane is completely separated in the roundabout design that performed well. In numerous reports officers stated “poor road design of roundabout” and “roundabout not marked or signed properly”. The most common cause of accident in the three-lane roundabouts were failure to maintain lane / unsafe lane change, resulting in a sideswipe accident. Of the 200 accidents that occurred in the multi-lane roundabouts, almost 59.5% were classified as sideswipe accidents (a complete breakdown of all the accident types occurring in the major-level intersections is shown in Table 7.1 on sheet 33).

Another interesting piece of information coming from the hard copy accident reports concerned property damage severity and injury severity. Unfortunately, some of the hard copy accident reports were not completely filled out by the investigating officers and some were not available for review. However, based on the reports that were reviewed, some things were clearly evident. The majority of accidents occurring at the roundabouts had property damage severity in the minor category while at the signalized intersections the property damage severity was moderate or major. Out of 184 vehicles that were involved in the 97 roundabout accident reports reviewed, 61.4% were classified as having minor property damage whereas out of the 120 cars involved in the 57 signalized intersection accident reports reviewed, 64.5% were classified as having moderate or major property damage. Also, almost every injury occurring at a roundabout did not require ambulance transport to a hospital (2 out of 15 did) while a much larger percentage of injury accidents occurring at signals required ambulance transport to the hospital (9 out of 19 did), indicating a higher severity of injuries. The more severe injury and property damage accidents at the signalized intersections can be attributed to the fact that almost 3 times as many angle and left-turn accidents occurred in them. This is shown in Table 7.1.

One additional interesting piece of information coming from a review of the hard copy accident reports was that numerous officers stated how a person involved in an accident indicated that they were not familiar or were simply not used to driving in roundabouts. This can be understood when considering the limited number of roundabouts in use throughout the United States. In addition, the State of Nevada Department of Motor Vehicles does not address how you are supposed to drive at or in a roundabout in the driver's license handbook. Also, the reported lack of guide signs and lane striping at the multi-lane roundabouts did not help. It should be noted that lane striping and guide signs will soon be added to the roundabouts in conjunction with an NDOT safety project.

In an effort to see if the higher number of accidents in the roundabouts were caused by other circumstances such as daylight / dark conditions or wet / dry conditions on the roadways, all of the accident data was analyzed as shown in Table 7.2. The roundabouts had 25.5% of the accidents during dark conditions versus 33% at the signalized intersections. The roundabouts had 6% of the accidents during wet roadway conditions versus 9.6% at the signalized intersections. Based upon this information, no statistically relevant conclusions can be made regarding the effects of daylight/ dark and wet / dry roadway conditions at a roundabout.

The findings in the hard copy accident reports would appear to agree with some of the findings discussed earlier in this report:

1) The IIHS report in which roundabouts were found to reduce fatal / incapacitating injuries.
2) The German study in which heavy property damage is reduced with roundabouts.
3) The Netherlands study in which roundabouts provided a major reduction in severe injuries requiring hospital admission.

Table 7.0: Intersection Accident Statistics From 9/1/99 to 8/31/02

INTERSECTION NAME	CONTROL	ADT	ACC /MVE	ACC / YR	INJ ACC / MVE	INJ ACC /YR
MINOR –LEVEL INTERSECTIONS						
Hills Drive / Longspur	**Roundabout**	**2668**	**0**	**0**	**0**	**0**
Crystal Water Way / Lake South	**Roundabout**	**5718**	**0.80**	**1.67**	**0.16**	**0.33**
Gowan / Grand Canyon	**Roundabout**	**6229**	**0.44**	**1.0**	**0.15**	**0.33**
Harmony / Michael	**One-way Stop**	**2357**	**0.57**	**0.67**	**0**	**0**
Soaring Gulls / Coral Shores	**One-way Stop**	**5080**	**0.32**	**1.0**	**0.18**	**0.33**
Alpine / Brush	**Two-way Stop**	**5202**	**0.70**	**1.33**	**0.35**	**0.67**
Edmond / O'Bannon	**Two-way Stop**	**5750**	**1.11**	**0.67**	**0.32**	**0.67**
Starboard / Lake East	**One-way Stop**	**6336**	**0.87**	**2.0**	**0.43**	**1.0**
MID-LEVEL INTERSECTIONS						
Hills Center Drive / Village Center Circle	**Roundabout**	**12021**	**0.08**	**0.33**	**0**	**0**
Marion / Washington	**Four-way Stop**	**11019**	**0.58**	**2.33**	**0.17**	**0.67**
Del Webb / Sungold	**Four-way Stop**	**11144**	**0.87**	**2.0**	**0.43**	**1.0**
Oakey / Tenaya	**Four-way Stop**	**14701**	**0.37**	**2.0**	**0.12**	**0.67**
MAJOR-LEVEL INTERSECTIONS						
Town Center Dr / Village Center / Library Hill	**Roundabout**	**21480**	**0.89**	**7.0**	**0**	**0**
Town Center Dr / Banbury Cross / Canyon Run	**Roundabout**	**24563**	**2.34**	**21.0**	**0.30**	**2.67**
Town Center Dr / Hualapai / Far Hills	**Roundabout**	**26660**	**3.98**	**38.7**	**0.65**	**6.33**
Michael / Vegas	**Signalized**	**18338**	**0.75**	**5.0**	**0.35**	**2.33**
Lindell / Oakey	**Signalized**	**20588**	**0.31**	**2.33**	**0.04**	**0.33**
Tenaya / Vegas	**Signalized**	**21901**	**0.63**	**5.0**	**0.21**	**1.67**
Arville / Pennwood	**Signalized**	**22151**	**0.66**	**5.33**	**0.17**	**1.33**
Arville / Oakey	**Signalized**	**28913**	**0.73**	**7.67**	**0.28**	**3.0**
Alta / Upland	**Signalized**	**30663**	**0.54**	**6.0**	**0.24**	**2.67**

Table 7.1: Major-Level Intersection Accident Types

CRASH TYPE	AT ROUNDABOUT	AT SIGNAL
Ran-Off Road	**12%**	**7.4%**
Sideswipe	**59.5%**	**8.5%**
Left-Turn	**2.5%**	**13.8%**
Rear-End	**13.5%**	**39.4%**
Angle	**8.0%**	**18.1%**

Other	**4.5%**	**12.8%**
TOTAL	**100%**	**100%**

Table 7.2: Major-Level Intersection Lighting and Road Environment Data

LIGHTING CONDITION	AT ROUNDABOUT	AT SIGNAL
Daylight	71%	62.8%
Dark	25.5%	33%
Dusk	3.5%	4.2%
TOTAL	100%	100%
ROADWAY ENVIRONMENT		
Wet	6%	9.6%
Dry	92%	86.2%
Unknown	2%	4.2%
TOTAL	100%	100%

CHAPTER 8: CONCLUSIONS

Because the use of roundabouts across the United States is still very limited and because many of the roundabouts in the Las Vegas valley are in operation less than three years (or are still under construction / under design), this report can only provide the foundation for further study.

Until more roundabout data becomes available to test a roundabouts safety record against other forms of intersection control, the initial findings in this report should be used as a guidance for traffic engineers and others involved in the roadway design process when considering forms of intersection control. It is hoped that as more data becomes available, a higher level of analysis can be performed using statistical analysis so that linear regression techniques can be used to make accurate inferences from a sample of roundabouts to a population.

This report strongly suggests that roundabout control of minor and mid-level intersections can have a safety performance that is as good or even better then stop signs. At major-level intersections where traffic signals are normally used, this study cannot yet strongly suggest using roundabouts as an alternative. The data in the hard copy accident reports is promising, with property damage and injury severity appearing to be much less in a roundabout accident when compared to what occurs at a traffic signal accident. However, the sheer volume of accidents occurring in the multi-lane roundabouts is not acceptable. With some design modifications to the triple-lane roundabouts, the switch from traffic signals to roundabouts may become much more desirable. Once modifications to the triple-lane roundabouts are completed and new data is available, they should be re-evaluated.

A limitation of this study concerns the selection of the comparison intersections. Because the study was exploratory, a formal procedure to randomly select the comparison intersections was not followed. A list of comparison intersections was initially assembled based solely on ADT. Some of the initially selected intersections had to be discarded once certain criteria, as defined in the methodology, were looked at.

Lastly, there have been some recent concerns with roundabouts and pedestrian safety. "Many pedestrians do not perceive roundabouts to be safe. This issue is further complicated by the fact that the general public and politicians believe that signalized intersections provide the greatest safety for pedestrians" (Jacquemart, 1998, p. 39). In addition, the Institute of Transportation Engineers has cautioned traffic engineers across the U.S. that pedestrian organizations (specifically those representing the blind and handicapped) are actively pursuing legislation which may require the installation of costly pedestrian actuated traffic signals at all roundabouts. The results of this study show that pedestrians have not been involved in a single accident at any of the roundabouts studied.

CHAPTER 9: RECCOMENDATIONS FOR FURTHER STUDY

Once more roundabout intersections and a longer history of accident data (such as 8 – 10 years) are available for the roundabouts, they should be re-evaluated. Additionally, environmental impacts of roundabouts, such as how they may help reduce air pollution should be studied. An overall cost / benefit analysis of roundabouts should be performed. Also, how a driver's age affects the safety results of a roundabout should be reviewed.

REFERENCES

Beaudry, P. "*Kennewick's first Roundabout"*. Institute of Transportation Engineers TSC Newsletter, March 2003, p.3-4

Bureau of Transportation Statistics (2002). *FARS Accident Sum: Number of Fatalities by State.* Retrieved January 13, 2003, from http://www.transtats.bts.gov

Census Bureau (2001). *United States Census 2000 Population Tables and Reports.* Retrieved January 13, 2003, from http://www.census.gov/main/www/cen2000.html

Elvik, R. "*Effects on Road Safety of Converting Intersections to Roundabouts: A review of Evidence from non-US Studies" (Paper No. TRB 03-0106).* Annual Transportation Research Board Meeting, Pre-Print CD ROM, 2003

FHWA, United States Department of Transportation. (2000). *Roundabouts: An informational guide* (Report FHWA-RD-00-67). McLean, Virginia

FHWA, United States Department of Transportation (2002). *Intersection Safety Brief.* Retrieved January 7, 2003, from http://www.fhwa.dot.gov/safety/fourthlevel/interbriefing

Flannery, A., "*Key Design Elements that Influence Roundabout Safety"*. 2002 ITE Compendium of Technical Papers, (2002)

Jacquemart, G. "*Modern Roundabout Practice in the United States, Synthesis of Highway Practice 264*", Washington D.C., National Cooperative Highway Research Program, Transportation Research Board, National Research Council, 1998

Las Vegas Convention and Visitors Authority (2002) *Visitor Statistics.* Retrieved December 14, 2002, from http://lvcva.com/press/visitor_stats.html

List, G., Robinson, B., Troutbeck, R., Persaud, B. "*Operational and Safety Performance of Modern Roundabouts and Other Intersection Types"*. Retrieved April 28, 2003, from http://RPI.edu/dept/cits/roundabouts.html

Maryland State Highway Administration. (2001). *Maryland Roundabout Safety Experience.* Office of Traffic and Safety, Maryland State Highway Administration

NDOT, Nevada Department of Transportation. 1999-2002 Traffic Crash Data. Prepared by the Nevada Department of Transportation Safety Engineering Division in Cooperation with Nevada Department of Motor Vehicles and Public Safety, and State and Local Law Enforcement Agencies.

Ourston, B., and Bared, J. (1995). Roundabouts: A Direct Way to Safer Highways. *Public Roads, Autumn,* 41-49.

Persaud, B.H., Retting, R., Garder, P., and Lord, D. "*Crash Reductions Following Installation of Roundabouts in the United States"*. Insurance Institute for Highway Safety, Arlington, VA, 2000.

Russell, E., Rys, M., Luttrell, G. *Modeling Traffic Flows and Conflicts at Roundabouts* (Report MBTC 1099). Kansas State University (2000). Kansas City, Kansas.

Scalici, S., & Quinn, P. "*Building Livable Communities through Transportation: Redesigning New York City's Frederick Douglas Circle"*. ITE Journal, August 1999, p.42-50.

Taekratok, T. *Modern Roundabouts for Oregon* (Report OR-RD-98-17). Oregon Department of Transportation (1998). Salem, Oregon.

Transportation Research Board (2002). *NCHRP Project 3-65: Applying Roundabouts in the United States.* Retrieved January 7, 2003, from http://www4.trb.org /trb/crp.nsf

VITA

Department of Public Administration
University of Nevada, Las Vegas

Michael J. Janssen

Home Address:
70 Magical Mystery Lane
Henderson, NV 89074

Degrees:
Associate of Applied Science, Construction Engineering Technology, 1991
State University of New York, Canton

Bachelor of Science, Civil Engineering Technology, 1994
Rochester Institute of Technology

Title: A Safety Analysis of Roundabouts in the Las Vegas Valley

Examination Committee

Chairperson, Dr. Anna Lukemeyer, Ph.D
Committee Member, Dr. E. Lee Bernick, Ph.D
Committee Member, Dr. Karen Layne, Ph.D
Committee Member, Dr. Shashi S. Nambisan, Ph.D, P.E.

About the Author:

Mr. Janssen is currently a Traffic Engineering Project Manager for the City of Las Vegas Department of Public Works. He manages the Operations and Research Section of the Traffic Engineering Division. He is registered as a Professional Civil Engineer in Nevada and Pennsylvania. He is also a member of ITE and ASCE.

Comparison Intersection

Aerial Photos

And

Crash Data

Roundabout

Aerial Photos

And

Crash Data