ASSESSING THE CLEARWATER BEACH ENTRYWAY ROUNDABOUT

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Abstract - The transportation profession has seen a great surge of interest in modern roundabouts in the past two years on the part of planners, developers, city managers and even citizens, as well as transportation professionals themselves. The Federal Highway Administration is publishing the first U.S. national guide to roundabout design.[1] The United States is witnessing a significant upsurge in roundabout building, which constitutes the first really major departure from traffic engineering convention in years. Now is a good time to examine one of the latest and best examples of large modern roundabout design.

The Clearwater Beach Entryway Roundabout is on the island of Clearwater Beach, a $12 million project sited at the junction of the island's street network and the causeway carrying traffic from the mainland. Seasonal traffic volume varies from 30,000-58,500 vehicles per day. The roundabout project replaced nine existing intersections, three of which were signalized. The beach district is a tourist destination, congested with drivers and pedestrians of all ages, bicyclists, roller-bladers and skate-boarders, all of whom are welcome and even more of whom are needed to support the economic revitalization of the district, which currently receives 1.4 million visitors annually.

The Clearwater Beach Entryway Roundabout. View looking southeast. Photo by Betsey Clement

The project represents an outstanding effort to balance the safety, traffic flow and ambience needs of all users, both motorized and non-motorized. These goals were pursued through use of computer modeling, traffic calming techniques, landscaped buffers, separate trail facilities, paver bricks, specialized lighting, a pedestrian-activated signal, a spectacular oval central

The Clearwater Beach Entryway Roundabout Project. Graphics by Phil Graham Associates

island fountain, and close attention to detail at pedestrian scale.

This paper describes the project and examines how far it has gotten toward achieving its ambitious goals six months after opening.

I. CONTEXT OF THE PROJECT

Clearwater is located about midway along Florida's west coast. Downtown Clearwater is situated on a low bluff overlooking the Intracoastal Waterway. On the far side of the Waterway lies the island of Clearwater Beach, two miles to the west of downtown. The Memorial Causeway across the Waterway links downtown Clearwater with Clearwater Beach and is considered "An example of a road designed within the appropriate context – as a gateway to a beach resort. This is a design aspect the [AASHTO] Green Book is not intended to address."[2]

Clearwater Beach is typical of many barrier islands that sit just off both coasts of Florida. Oriented north-south, the island is 3 ¾ miles long and 3/8 of a mile wide.

As with any tourist destination, a primary purpose of the Beach District is to contribute to the local economy. More than any other sector of its economy, tourism is vital to Clearwater and its future.

Despite being ten years into the longest economic boom in U.S. history, there are vacant storefronts in the Beach District and other inconspicuous early warning signs of economic stagnation and the possibility of a slow decline, if nothing is done. Meanwhile, competing destinations are upgrading their ability to attract tourists.

In 1997 the City of Clearwater announced a new, unified, vision for its future under the slogan "*One City, One Future*." As part of the *1C1F* initiative, the Beach District was targeted for economic revitalization.

At the center of Clearwater Beach island was an unattractive, dysfunctional collection of nine intersections, which handled both the traffic flowing between the north and south sections of the island and the major traffic flows between the island and the mainland via Memorial Causeway. In essence, the streets here comprised an eight-lane one-way pair, four lanes in each direction (east and west). Unpleasant and frustrating to drive for Beach residents and tourists alike, the complex of intersections included the most dangerous intersections on the island.

Worse, this island center did not provide the kind of quality walking, biking and skating experience that helps bring tourists back year after year. The City recognized that "A first class pedestrian environment is essential for the Beach to prosper as a resort and residential community."[3] People spend money while on foot, not behind the wheel, and the more comfortable they are, the longer they stay at the beach, out of their cars. Furthermore, a high degree of pedestrian congestion is part of the critical mass necessary to attract beach tourists from afar, as people-watching is a time-honored beach district pastime.

In early 1999 the Clearwater City Commission decided to commence the Beach District revitalization with construction of a signature project, the Clearwater Beach Entryway Roundabout. This project would also be the first *1C1F* project.

The Clearwater Beach Entryway Roundabout Project.
View looking north northwest. Photo by Ken Sides

II. THE PROJECT CHALLENGE: A BALANCED DESIGN

The Clearwater Beach Entryway Roundabout project replaced the nine intersections at the island's midpoint, three of which were signalized.

This transportation project was unusual in that, to be truly successful, it must not merely satisfy but actually *please* a long list of users, all present in large numbers: residents carrying on their daily lives; tourists arriving by car; families on foot with small children; beach-goers toting chairs, towels, blankets and coolers; bicyclists; skaters. Further, the project would have to accommodate and delight an even greater volume of users in the future, as revitalization bore fruit.

Despite all the recent attention in the transportation press to non-motorized users, the vast majority of new intersections still overwhelmingly favor motorized users at the expense of non-motorized users, partly because designers fear that shifting the balance too much away from motorized users will result in unacceptable congestion and delay for motorized users.

The engineering challenge at Clearwater Beach was to design an efficient intersection to provide good service and a pleasant experience to the whole spectrum of users, a spectrum as broad as humanity, including children, novice users, impaired persons, elderly persons, and tourists, as well as fit adults familiar with the area. And these users would travel not only in cars and trucks, but on foot, bicycles, rollerblades, quad-rollers, skateboards, baby strollers and wheelchairs.

The challenge was made more difficult by the differing profiles of operating characteristics among the various user categories. Many tourists are retirees and others are families with small children.

The user profiles had strong implications for intersection design, especially given the volume of users in each category. Compared to adults, children have a narrower visual field, less ability to isolate sounds and determine the direction of approaching traffic by auditory cues, and less ability to judge closure speed. Children cannot understand complex situations or focus on multiple thoughts at once. They have a desire for constant motion and once in motion, have a compulsion to complete the motion. They are more prone to fearlessness and less able to perceive risk. Children assume adults will assure their safety; they live in a self-centered world where fantasy is mixed with reality.[4]

A big, complicated intersection with many cars taking many paths at speed, all governed by abstract rules and regulated by overhead changing colored lights (signals), presents a deadly puzzle to young users. Children on foot, bicycles or skates require slow-moving motorized traffic and uncomplicated situations, both potentially attainable with modern roundabout design.

Older persons differ from their younger selves in many ways that bear on intersection design for both driver and pedestrian usability. Older persons have diminished static acuity and dynamic acuity (the abilities to see unmoving and moving objects) and diminished depth perception. Scanning ability is diminished, as is neck and trunk flexibility.

Older persons need reduced demands to judge closing speeds of fast traffic accurately and reduced demands to accurately judge gaps in fast oncoming traffic. They need less complicated situations to interpret and simpler decision-making than when they were younger. They need more time to perceive and evaluate situations, more time to make decisions, and more time to take action,[5] all of which are provided by lower traffic speeds.

Demographics make these user profiles especially relevant to intersection design. The 1990 census showed 19.8% of the Florida population was too young to get a driver's license and 18.3% was 65 and older, almost 40% combined. The nation is aging as boomers reach their fifties and Americans live longer. On Clearwater Beach, half the residents are aged 60 and older. In general, "The single greatest concern in accommodating older road users, both drivers and pedestrians, is the ability of these persons to safely maneuver through intersections."[6]

Bicyclists and skaters (especially novice skaters) have yet other user profiles[7] and present further challenge to intersection design.

Besides serving well the many categories of users, it was necessary that the project be compatible with and actually enhance the Beach District as a whole and strongly support the surrounding land uses, which are resort-business and resort-residential. If it were to add economic value to the island, it had to be an environmental and social asset. An additional benefit of a modern roundabout was that it would result in a net reduction in asphalt and impermeable surface.

The City considered several alternatives for replacement of the nine existing intersections: do nothing; add more turn lanes to the existing intersections (more asphalt); build a giant signalized T intersection; build a separated-grade intersection; or build a modern roundabout. The only intersection configuration that had the potential to serve all users well in the context of Clearwater Beach was a modern roundabout.

III. *REALITY CHECK:* ACHIEVING THE DESIGN OBJECTIVES

The Grand Opening of the Clearwater Beach Entryway Roundabout took place on December 21, 1999, just in time for the new millennium, to much fanfare. A crowd of 700 showed up to enjoy speeches, music, a parade and fireworks, while four media helicopters circled overhead. Rare it is for the opening of an intersection to be the occasion for such celebration.

Exactly one month after opening the project won First Place in the Infrastructure category in the Future of the Region Awards annual competition sponsored by the Tampa Bay Regional Planning Commission. "The Council's mission in recognizing excellence is to encourage future vision and cooperation within the community."[8]

Now that the roundabout has been operating for several months, how well is it achieving its ambitious design objectives? The following comments answer this question, based on experience to date (May, 2000).

The Clearwater Beach Entryway Roundabout project reached for as many as fourteen design objectives, elucidated below.

1. Create a signature project

ACHIEVED. By any measure, the project has transformed the appearance of the midsection of this tourist island, converting a collection of old buildings and parking lots into a spectacular centerpiece. Sited as it is at the midpoint juncture with the causeway, all traffic between the north and south halves of the island travels through the roundabout, as does all traffic between the island and the mainland via the causeway.

The project has attracted a tremendous amount of attention locally, which is spreading nationally, and there is little doubt it has instantly become the landmark which most signifies Clearwater Beach. Interesting to look at from any angle, including from above, photographs and other likenesses are expected to appear on all manner of tourist brochures and travelogues.

Predictably, the project has generated the controversy experienced by many high-profile, innovative projects that affect the general public, including other modern roundabouts in the United States.

However, the criticism has not subsided as much as expected by the six-month mark, however, and the reasons for that are examined below in the sections discussing Design Objectives 12 and 13.

2. Spur economic revitalization

ENCOURAGING SIGNS. Clearwater Beach "is probably the city's most valuable and defining asset. In fact, it supports our primary industry, tourism, which brings the city over $3,000,000 annually," money which would otherwise have to "come from citizen taxes to maintain the high quality of living".[9]

The project is projected to eventually attract some $100 million in private investment on Clearwater Beach. It will take time to realize this goal, but early inquiries by developers are encouraging. In combination with other City initiatives for the Beach district, the project is expected to attract new tourist dollar revenues, increase property values business revenues and establish a steady tax base.

3. Create a sense of arrival

ACHIEVED. The project was to become the gateway into Clearwater Beach and, as such, would have to visually signal to arriving motorists that they had reached their destination. Even though the sand, surf, clear water and motels are still a few blocks away, the desired effect would be for motorists at this point to drop their "getting-there" mentality and relax into a "laid-back" state of mind.

As westbound causeway travelers drive over the small Bridge #43 from the causeway to Clearwater Beach, they are greeted by monuments on both sides; the one on the right is a vertical monolith bearing the name *Clearwater Beach*; on the left is an abstract structure using slanting wires to invoke a sail and also the immensely popular Skyway Bridge across the mouth of Tampa Bay.

At the instant the westbound motorist crests Bridge 43, the view straight ahead is down a heavily landscaped grand boulevard with 12' median, lined on both sides with tall palm trees that lead the eye to a huge fountain 750' ahead.

4. Create a sense of place

ACHIEVED. To be successful, the project had to be more than a gateway to the Beach District and more than a pass-through between South Beach and North Beach. It needed to be an attraction in its own right, where people would pause to enjoy the ambience. This effect was achieved through the use of landscaping, pedestrian amenities, green space, and the focal point established by the large fountain in the roundabout central island.

The central island of the Clearwater Beach Entryway Roundabout is oval-shaped, 150’ by 180’. The $2 million fountain occupying the central island has three large concentric pool basins with (reclaimed) water overflowing their rims and finally cascading down a series of seven steps to a grated gutter at grade. From the middle of the central island there shoots upward a 40’ high column of water, surrounded by 37 smaller fountain nozzles, all powered by three 150-horsepower pumps via a 10” pipe. The bright sunlight typical of Clearwater Beach lights up the splashing water by day and uplighting illuminates the whole fountain by night.

The roundabout, pedestrian amenities and fountain focal point combine to give the area the strong identity that creates a sense of place.

5. Create a pedestrian-friendly environment

ACHIEVED. The project includes a large number of features to make the walking experience pleasant and easy.

Pedestrian amenities. The sidewalk system incorporated into the project includes a 10’ wide “super sidewalk” on the north side and a 15’ wide trail on the south side. The sidewalk surface is a special mix of shell and cement blended and smoothed to give a pleasing texture. All pedestrian ways are separated from motorized traffic by a 15’ wide landscaped buffer. The low vehicle speeds and good separation from pedestrians greatly reduces the noise and intrusiveness of motorized traffic into the pedestrian experience.

There are a number of benches and drinking fountains, and even a small plaza where one can safely pose for a photograph with the roundabout fountain in the background. Numerous small shops and eating places are in the immediate vicinity of the project, as well as a marina with charter boats and operators offering boat rides.

At night the whole area is illuminated with pleasant ambient lighting provided by ornate street lamps, uplighting on the many Medjool Date Palm trees, and uplighting on the huge fountain in the roundabout central island, all contributing to a sense of personal safety.

Traffic calming measures. Traffic calming isn’t just for residential neighborhoods anymore, but is increasingly being applied to major streets. In this project, slow vehicle speeds are achieved through a variety of design features.

Slow traffic is extremely important to pedestrian comfort and safety, because even moderate speeds are lethal to pedestrians. Struck at 20 mph, a pedestrian is only 15% likely to die, but at 30 mph her odds are three times worse, or 45%. At 40 mph, the rate is 85%.[10] And for every pedestrian fatality, there are about 15 injured pedestrians.

At the furthest distance, approaching drivers realize they must commence slowing because they can plainly see there is a large central island occupying the middle of the road. Drivers in the major traffic flow westbound from the mainland first set eyes on the spectacle at a distance of 800’ as they crest Bridge 43. Closer to the roundabout, the visual narrowing provided by the 10’ wide approach lanes with vertical curbs and ample landscaping further encourages approaching traffic to drive slowly.

Traffic speed is also keep low by a number of features of modern roundabouts.

Modern roundabout features. Modern roundabouts have numerous features that benefit pedestrians, including features that limit the speed of motorized traffic and provide for simple decision-making.[11]

As vehicles enter a modern roundabout they are first forced by the splitter island to turn right, then must turn left to follow the circulating lane around the central island. Circulating vehicles must turn right to exit a modern roundabout. These changes in horizontal alignment limit speeds, much as they do in traffic calming projects.

Drivers accelerate as they exit the roundabout, so the exit radii are kept tight to control the speed of vehicles approaching the pedestrian crosswalks. The tight exit radii thus benefit pedestrians but may also affect the rate of minor vehicle collisions and driver comfort, as discussed below under Design Objectives 12 and 13.

The roundabout drains outward, not inward to the central island, so the circulating lanes have a negative superelevation of 2% – the opposite of a highway curve that is banked to make changes in horizontal alignment comfortable at higher speeds. The result is that drivers can feel the centrifugal force above 17 mph or so, making it less comfortable to speed around the roundabout.

Even with all the pedestrian amenities, the greatest determinant of overall pedestrian comfort is still the points at which pedestrian flow comes into conflict with motorized traffic. Modern roundabout design treats these pedestrian/vehicle conflict points very differently than does conventional intersection design.

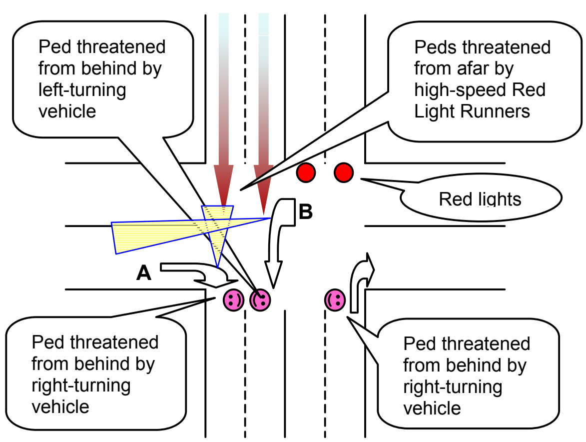
The number and nature of these conflict points have been altered substantially from the prior configuration. The original configuration of nine intersections had a total of 52 pedestrian/vehicle conflict points. The roundabout project has 22 such conflicts, a reduction of 58%. This means there are now only about two-fifths as many locations as there were for pedestrians to come into conflict with motorized vehicles. A diagram in the endnotes contrasts the two configurations.[12]

The pedestrian/vehicle conflict points in the new project are safer and more comfortable for pedestrians than the conflicts in the prior configuration because of a number of pedestrian-friendly features that can be built into modern roundabouts.

Pedestrians have to deal with only one direction of vehicular traffic flow at a time as they cross to the splitter island, which simplifies the crossing for both the pedestrian and the oncoming drivers. Pedestrians need look in only one direction – to their left – to watch for oncoming vehicles. Drivers aren't tasked with tracking oncoming or crossing vehicular traffic at the same time they must look out for crossing pedestrians, and drivers are looking ahead – not over their left shoulder – as they approach the crossing.

About half the pedestrian crossings are only one lane wide; the others are two lanes across.

Once they have crossed the first direction of flow of traffic, pedestrians have a pedestrian refuge in the splitter island where they can wait and watch for a comfortable gap in the opposite flow of vehicular traffic before completing their crossing.



Pedestrians at signalized intersections are under threat from several directions.
Drivers A and B are not looking at the pedestrians: the yellow triangles show Driver A is looking over her left shoulder, checking for oncoming motorized traffic; and Driver B is looking ahead, gauging the gap she is crossing in oncoming motorized traffic.

To the uninitiated, this sounds daunting – crossing through a moving traffic flow, so different from having vehicles stop for a red light at pedestrian crossings. However, at red lights many vehicles are *not* stopped – they are making turning movements and coming at pedestrians from the side and from behind, often at brisk speeds, driven by drivers who are looking out for oncoming vehicles, not pedestrians. And pedestrians must cross during the pedestrian crossing phase. At the roundabout, pedestrians simply wait for a comfortable gap before crossing. How long they wait is discussed below under Objective 6.

The pedestrian crossings are constructed with paver bricks for increased contrast of both texture and color. Concrete borders further set off the crossings, and at night lights embedded at grade along the borders glow, albeit not as brightly as desired. Beach-themed bollards at the ends of the crosswalks further add to the visual cues and contain down-lighting lamps. Pedestrians can stand safely and comfortably behind the bollards until they choose to cross.

The various contrast-enhancing features help mark the crossing as a special zone where pedestrians have a right to be, which both encourages drivers to respect the crossing and encourages pedestrians to cross in the marked crossings. Standard high-contrast pedestrian crossing signage completes the setting.

Informal observations indicate a very high rate of drivers yielding to pedestrians in the crosswalks or even poised to enter the crosswalks. This civil, highly desirable behavior on the part of drivers is attributed to the slow vehicle speeds and the strong demarcation of the crosswalks. Drivers are thought to be more willing to yield at low flow speeds, perhaps due to the ease of doing so, combined with a lower fear of being rear-ended by following traffic. Drivers are thought to be more willing to respect pedestrians in the roadway if the pedestrians clearly have a right to be there, and a well-demarcated crosswalk helps establish that right.

The only place in Clearwater with a higher rate of drivers yielding to pedestrians is two blocks away on Gulfview Avenue, which runs alongside the beach parking. There, the driver behavior is probably influenced by the overriding beach ambience, much as can be seen on Ft. Lauderdale Beach in Florida since it was streetscaped in the mid-90's.

Computer modeling during the design phase indicated that the average gap duration between vehicles on the south leg, Coronado Avenue, would be only about as long as the time it would take for pedestrians to cross, so a pedestrian-actuated signal was installed to assist pedestrians. However, a trial period with the signal flashing yellow demonstrated that pedestrians are having no difficulty crossing because drivers are yielding so well, and so the signal may not be needed. (Similar high rates of driver yield behavior are observed at the other crossings, which have no signals.)

Future pedestrian facilities.

At the eastern boundary of the project a pedestrian underpass was constructed under Bridge 43. This pedestrian walkway is actually a bridge itself, an open structure over the water and perpendicular to Bridge 43. At 750' from the roundabout, this walkway is too far away to serve pedestrians crossing the Causeway Boulevard leg of the roundabout.

Early in the design phase it was recognized that there would have to be a way for pedestrians to cross the causeway leg and that the volume and speed of traffic on the causeway would probably require a pedestrian-actuated signal.

There was no point in placing crosswalks anywhere except where pedestrians would use them, but it wasn't possible to determine the future pedestrian *desire lines* from previous patterns because so many of the previous pedestrian generators and attractors were removed for the project: about 120 parking places and a restaurant, civic center, library and police sub-station. The design solution was to place conduit for a signal along the Causeway Boulevard median to allow for future location flexibility, and then (when the project is open and operating) observe actual pedestrian behavior before deciding where to put the crossings.

A pedestrian-actuated signal on the Causeway Boulevard leg would also act as a metering signal, as discussed below under Objective 10.

Although the ambient lighting is sufficient for a sense of pedestrian safety, consideration is being given to adding streetlights at the crossings to make it easier for drivers to discern pedestrians in or near the crosswalks.

6. Provide good pedestrian Level Of Service

ACHIEVED. At a modern roundabout, pedestrians cross the vehicle travel lanes on marked crosswalks, timing their crossing to fit into the gaps between vehicles. How long they have to wait for a comfortable gap is a measure of the level of service they are experiencing.

Informal observations indicate that pedestrians are experiencing a very high level of service. Many pedestrians experience no delay at all and are able to cross immediately. Most are able to cross after a delay of no more than a few seconds. The very good rate of driver yield behavior, discussed above, is a big reason pedestrians are enjoying such good LOS.

Not all pedestrians are crossing in the crosswalks, of course, but informal observation indicates the usage is good and better than prior to the project (some locations had no crosswalks previously). The crosswalk usage is expected to improve further as the landscaping matures, making it less convenient to cut through the shrubbery. Fortunately, the low vehicle speeds make it reasonably safe to improperly cross outside the crosswalks.

One interesting aspect of modern roundabouts is observed during periods of heavy motorized traffic congestion. The pedestrian LOS actually improves, because pedestrians can easily cross the unidirectional creeping or halted traffic flow with safety and comfort. Motorists tend to avoid stopping astride the crosswalks, presumably because they are so well demarcated as pedestrian zones.

7. Create a bicycle-friendly environment

ACHIEVED. Bicyclists have a choice of using the roundabout roadway or the sidewalk system incorporated into the project.

Because motorized vehicle speeds in the circulating lanes are mostly in the 9-19 mph range, strong, competent bicyclists are easily using the roundabout by riding in the center of the roadway travel lane ("claiming the lane") and riding at the same speed as motorized traffic is traveling (legal in Florida).

However, bicyclists are encouraged instead to use the safer alternative provided by the wide sidewalks next to the roundabout, and to cross the roundabout legs on the same crosswalks as the pedestrians.

The 15' wide sidewalk on the south side is wide enough to be considered a trail. A new bridge for bicyclists, pedestrians and skaters will be constructed to span Mandalay Channel and connect to the trail running along the south side of Memorial Causeway. The structural elements, the large-scale aesthetics and the pedestrian-scale details can all be designed to complement the other gateway features and reinforce a sense of arrival for all visitors, motorized and non-motorized.

This new bridge will be entirely funded with $955,000 of Federal CMAQ money (Congestion Mitigation and Air Quality). The bridge competed successfully for CMAQ money because it is expected to be so heavily used as to significantly reduce the number of motorized trips to the beach.

At the east end of Memorial Causeway a new high-span bridge will be constructed which will include a trail lane separated from motorized traffic. On the mainland end of the new Memorial Causeway Bridge a trail will be constructed a few blocks to connect with the Pinellas Trail, a popular north-south trail 35 miles in length used by 10,000-12,000 persons weekly. Thus, the roundabout will be linked to the Pinellas Trail via the Memorial Causeway and two new bicycle-friendly bridges.

8. Nearly eliminate serious pedestrian crashes

PROBABLY ACHIEVED. Six months is too early to be conclusive, but the low vehicle speeds, excellent driver behavior and elimination of three-quarters of the vehicle/pedestrian conflict points indicate that this objective will be achieved.

9. Nearly eliminate minor pedestrian crashes

PROBABLY ACHIEVED. Again, six months is too early to be conclusive, but this objective probably has been achieved for the same reasons as Objective 8 above.

10. Provide good Level Of Service for motorized vehicles

ACHIEVED. The capability of the Clearwater Beach Entry Roundabout to move motorized traffic has exceeded all expectations.

There are several theoretical reasons for modern roundabouts to offer good capacity. Compared to conventional intersections, modern roundabouts have slow-moving traffic, simple decision-making and only about one-fourth the conflict points. These features make it practical for the traffic flow to operate with the fine-grained timing provided by individual drivers under ordinary yield control, which gives better efficiency than the coarse-grained timing provided by signal phases moving blocks of vehicles.

As a seasonal tourist beach destination, the beach street network experiences two levels of traffic loading: *normal conditions* and *overload conditions*. Normal conditions prevail year 'round, except during certain holiday periods.

Normal Conditions

Computer modeling using SIDRA in the early design phase predicted an overall roundabout design-hour LOS of A.[13] How has the roundabout performed in reality?

Like any intersection, the LOS for a roundabout can be calculated by computer, using software such as SIDRA, by entering turning movement counts as inputs to the program. But unlike conventional intersections, where collecting turning movement counts in the field is straightforward, collecting turning movements for roundabouts is tedious because it requires tracking each entering vehicle through the roundabout to see at which leg it exits. Perhaps the only practical way to do this with a large roundabout is to videotape the whole roundabout from high overhead and count the turning movements during playback. To date, no such study has been undertaken for this project.

When the roundabout is operating at or near free-flow, it *is* possible to estimate the LOS by simple observation. If a vehicle enters the roundabout with no delay and passes through it at normal roundabout speed, that vehicle experiences an LOS of A. Vehicles encountering very brief delays are experiencing an LOS of A or B. Hours of informal observation indicate that during normal conditions, most vehicles are experiencing a LOS of A or B most of the time. Stoppages in the approaches, exits and circulating lanes are usually very brief. Exiting vehicles are stopped mainly by pedestrians in the crosswalks. Vehicle queues backing up from crosswalks into the low-speed circulating lanes cause no problems and only very brief perturbations to circulating traffic.

A nearby 10-story hotel rooftop overlooking the project offers the perfect vantage point to observe it in its entirety, including the approaches. Watching the Clearwater Beach Entryway Roundabout operate under normal conditions is a phenomenon to behold, something akin to watching a giant horizontal waterwheel or perhaps the brass gears visible in the back of those old-fashioned table clocks with the glass dome cover.

Overload Conditions

Historically, overload conditions occur several times a year on Clearwater Beach: Spring Break, and the weekends of 4th of July, Labor Day and Thanksgiving. Spring Break lasts about five weeks until Easter. Spring Break 2000 came about three months after the project was opened. Ever since the days of the Beach Boys in the 60's, Spring Break traffic arriving at the Clearwater Beach has queued on the Causeway the two miles back to the mainland and often another mile inland.

Spring Break 2000 offered an excellent, extended opportunity to observe the roundabout operating and measure its performance during light, normal and overload traffic conditions. The opportunity was exploited for eleven days, with continuous observation for 12 hours each day, from 8 AM to 8 PM. Two technicians were posted atop the nearby 10-story hotel rooftop to count pedestrians. Two other technicians measured travel times by continuously driving six different routes through the roundabout, also for eleven straight 12-hour days.

Concurrently, traffic counters measured 24-hour traffic volumes at every roundabout entry and exit, and circulating traffic volume going from south to north.

All this voluminous data provided several revelations.

The first revelation was the magnitude of motorized traffic volume. The roundabout was designed for capacity based on a design hour volume of 3,655 vehicles per hour, and a weekend design hour volume of 3,885 vph with ADT of 33,300 on a week day and 39,500 on the weekend on Causeway Boulevard.[14] All design hour volumes were based on traffic counts taken only two years earlier in 1997.

This capacity was expected to be adequate for the foreseeable future, based on projections of a flat curve at 40,000 vpd in 2020 and beyond, by the Pinellas County Metropolitan Planning Organization.

On Friday, March 3, 2000, 58,456 vehicles passed through the roundabout, setting a record for modern roundabouts in the United States.

The second revelation was that during 12 of those 24 hours, 4,309 pedestrians also used the intersection, which makes this intersection like no other in the United States. A 24-hour pedestrian count would have yielded substantially higher numbers, considering the nocturnal vacationing lifestyle of the Spring Break clientele (high school and college students).

On Saturday, March 11, the 12-hour pedestrian count was up to 6,019 pedestrians, with 55,596 vehicles during the full 24 hours (no counts were taken of bicyclists and skaters).

These startling volumes are probably attributable to the combination of a booming economy and an unusually moderate winter.

Given these extreme circumstances, how did the Clearwater Beach Entryway Roundabout perform?

A third revelation was provided by the 1,014 trips driven by the technicians measuring travel times for six different routes through the roundabout. All the routes began and ended several blocks away on either side of the roundabout. As expected, this mass of data showed the roundabout flowing freely during light volume flows and minimal delay during normal volume flows.

Of greatest interest were the travel times during extreme overload conditions, the focus of attention during Spring Break 2000. Travel times previous to the roundabout were not recorded, but the emergency responders had decades of experience with getting emergency vehicles through during Spring Break. Likewise, the police had long experience leaving home or headquarters early enough to get to their beach posts in time for shift change. Their institutional memories, confirmed by long-time beach residents and business owners, were that during the heaviest Spring Break traffic it has always taken 30 minutes for the north-south routes and 90 minutes for the east-west routes.

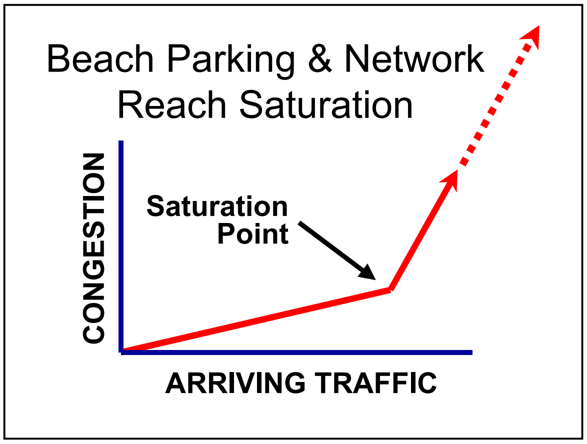
The fourth revelation was that the *maximum* travel time in the eleven-day period was 16.8 minutes for the north-south routes and 25.7 minutes for the east-west routes. The mean and median travel times were much shorter. This hard data was valuable to counteract public statements by persons claiming their travel times were much longer.

A fifth revelation was provided by observations from the nearby 10-story hotel rooftop. During previous Spring Breaks, it was not possible to see more than a small piece of the picture and traffic flow was observed piecemeal from the ground. With the construction of the roundabout several buildings were demolished and the more compact roundabout occupied the center area away from surrounding structures, so it became possible to observe the whole project at once from the hotel rooftop, including the approaches from many blocks away, even almost to the mainland two miles away. This vantage point contributed tremendously to comprehending the operation of the roundabout as traffic ebbed and flowed through light, normal and overload conditions and the flows shifted several times during the daily cycle.

The major traffic flow every day is the morning westbound causeway traffic traveling through the roundabout to South Beach. As the morning holiday traffic slowly built up, the queue at the causeway entry grew longer and longer, as expected, but traffic continued to flow smoothly.

Meanwhile, another phenomenon was occurring in the Beach street network, especially on South Beach. As traffic pours into the local streets and they approach saturation, traffic movement slows and congestion increases rapidly. As the parking on the Beach approaches saturation, there is a steep increase in *induced* traffic as motorists circulate searching for parking, and the congestion increase is amplified.

The net result is that holiday traffic arrives at a rate faster than the Beach can absorb it. That has been the case for decades, but it became too obvious to ignore when the roundabout replaced the previous connection system. The roundabout can deliver arriving traffic to the beach faster than the beach can absorb it, so the beach congestion builds that much faster. It was plain to see that when congestion on South Beach climbed,



Congestion builds steeply when the Beach street network and Beach parking reach saturation

traffic backed north up Gulfview Avenue, then north up Coronado Drive and through the roundabout, then east up the causeway for miles.

Spring Break 2000 Action Plans

Spring Break has always been a challenge for the Clearwater Police Department. Every year the PD beefs up its Beach District force and executes its Spring Break Action Plan, which calls for taking over the mid-island intersections and directing traffic manually.

Spring Break 2000 would require a new action plan.

Unlike previous years' action plans, which were always directed from the ground, the Beach District Commander set up his command, control and communications post on the nearby 10-story hotel rooftop, from where the whole scenario could be easily observed as it developed. When the backed-up South Beach traffic began to bog down the roundabout, the roundabout designer, Michael Wallwork[15], advised stopping the westbound traffic flow at the Causeway Boulevard entry to the roundabout. The order was radioed to the officers deployed on the ground, and in thirty seconds the roundabout was cleared up. The procedure was repeated as needed throughout the day, with most activations requiring 90 seconds to clear the roundabout. A new Action Plan was born.

Although the mainland traffic still queued back to the mainland, the causeway is the most desirable place to have a long queue, with its large storage capacity and scenic views. Queued traffic exhibits a more continual, dribbling, forward movement than the stop-wait-and-go pattern typical of queues for stoplights.

The one rule of modern roundabouts is that entering traffic yields to circulating traffic; or, put another way, circulating traffic has the right of way. A consequence of this simple rule is that once a major traffic flow is in the roundabout, it locks out other traffic until it exits; in this case, southbound North Beach traffic on Mandalay Avenue. When that situation developed, a second action plan was devised for it, equally successful as the first.

About five o'clock during Spring Break, beach-goers have had enough sun and surf and are ready for refreshments and dinner. A heavy northbound flow develops on Coronado Avenue going to North Beach and to the mainland via the causeway. A third action plan solved that problem, too. This action plan will likely work well during the summer months, too, when the daily 3 PM thunderstorms arrive to chase everyone from the beach at once.

The Clearwater Beach Entryway Roundabout performed so well in terms of capacity, even under the extreme conditions of Spring Break, that it was necessary to invoke an action plan only nine or ten times daily, and at that only on Saturdays and Sundays. The rest of the time the roundabout took care of itself.

The classic Spring Break Action Plan had been to man five intersections 8 hours a day, 7 days a week during Spring Break and included hiring an additional 18 Police Aides for traffic control to supplement the regular officers in the Beach District. Now only three Aides are needed and no intersections are manned.

Metering signal

The reason why an overload traffic flow can lock out traffic from other legs is lack of gaps in the overload traffic to permit other vehicles to enter. The police artificially created an extended gap by temporarily halting the overload traffic flow arriving from the mainland.

The automated equivalent would be to place a *metering signal* on Causeway Boulevard, to be triggered by a vehicle sensor loop in the pavement on southbound Mandalay Avenue at a distance away from the roundabout that is considered an acceptable queue length. When southbound Mandalay traffic backs up to the loop, the metering signal turns red, incoming causeway traffic stops entering the roundabout, the roundabout clears and southbound Mandalay traffic can enter the roundabout.

The metering signal can be combined with the needed pedestrian crosswalk on Causeway Boulevard and be actuated by pedestrians, as well as the vehicle loop. With frequent actuation of the metering signal by pedestrians, Mandalay traffic will seldom back up enough to trigger the signal. In this manner, a dynamic balance could be struck among the motorized users entering on Causeway Boulevard and Mandalay

Avenue and the pedestrian users crossing Causeway Boulevard.

Alternative modes to the Beach

In terms of capacity, the roundabout has done all that can be done to tie together North Beach, South Beach and the causeway. Beach parking and system capacity can be expanded only slightly. In short, there is plenty of room for more visitors on Clearwater Beach, but not for their cars.

Buses and trolleys would be entrained in the same causeway back-up. Free buses and water ferries were provided during Spring Break 2000 weekends, but lured only a handful of beach-goers away from driving in via the causeway. What's needed to ensure Clearwater Beach's fullest usage – and revenue generation – is a compellingly attractive alternative to the causeway.

Because of pending beach density and coastal construction line regulations, future beach hotel capacity is capped. So there is plenty of room on the beach for more visitors daytime and evenings, but not overnight.

Downtown Clearwater has also been targeted for development by Clearwater's *1C1F* vision. The volume of traffic State Road 60 now carries through downtown precludes creation of the quality pedestrian environment necessary to revitalized downtown. With construction of the new high-span Memorial Causeway Bridge, which links downtown to the causeway, SR 60 will bypass downtown and clear the way to re-invent downtown.

Elaborate downtown plans are in place for public spaces, cinema, residential land use, and especially, hotels and ample parking, the very elements in permanent short supply on the beach. In July, 2000, a referendum will decide whether the de Guardiola Company will invest $300 million in downtown Clearwater.

One long-standing dream[16] now being pursued seriously is to link downtown Clearwater and Clearwater Beach via some kind of modern guideway system, thereby bypassing the constrained causeway, beach network and beach parking. A monorail or other guideway would synergistically couple development in the two districts, so that initiatives in one reinforce the other. Downtown parking and rail passes could be subsidized by the private sector, just as parking stubs are now routinely stamped at restaurants and shops in many major U.S. cities.

Unlike the orthodox rationale for a guideway, a Bluff-to-Beach guideway would be justified on the basis of *future* development at both ends, to which it would contribute significantly, not solely on existing ridership, just as roads are universally built to both stimulate and serve future development.

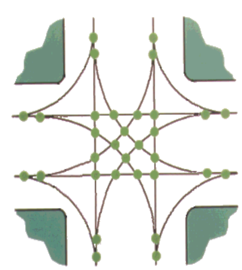
Downtown Clearwater sits on a bluff overlooking the Intracoastal Waterway. A Bluff-to-Beach guideway would be elevated leaving the bluff, rise 70' above the water next to (or part of) the high-span Memorial Bridge, continue west elevated or at grade on the causeway, then be elevated 20' to span Mandalay Channel and continue elevated to some terminus on the beach.

The view from an elevated position in any direction along this route is spectacular and guideway technology can now deliver a smooth, silent, enjoyable ride, as charmed visitors to the new Getty Museum in Los Angeles are discovering. This 10,000' guideway could be a demonstration project that enables envisioning a transportation modality hitherto impossible to imagine in the suburban sprawl that is Florida.

The State of Florida has granted the City $150,000 for the Preliminary Engineering study of this guideway concept.

11. Nearly elminate serious vehiclular crashes

LIKELY ACHIEVED. Although too early to be conclusive, there have been no serious vehicular crashes at the roundabout and it's reasonable to expect them to occur rarely, if ever.

Comparison of Vehicle/vehicle Conflict Points[17]	
Conventional 4-way Intersection	4-way Roundabout
	
32 vehicle/vehicle conflict points, many at high speeds and high impact angles	**8** vehicle/vehicle conflict points, all at low impact angles

There are three reasons to expect almost no serious vehicular crashes. First, the speeds are so low that there simply isn't much energy to disperse in a crash. Second, the opportunities for crashes are greatly reduced by the elimination of about three-quarters of the vehicle/vehicle conflict points. Third, and most important, the lethal conflict points have been eliminated, with the exception of rear-enders into vehicles stopped at the yield line. Head-on and T-bone collisions are eliminated.

12. Reduce minor vehicular crashes

TO BE ACHIEVED. The crash rate has gone up, not down. The crash rate at the roundabout is at least double the rate at the collection of streets and intersections it replaced. An accurate before/after comparison is impossible because of normal inconsistencies in collecting data for minor crashes; many are not reported in Florida, a no-fault insurance state, and for many no police record exists, not even a 911 call log entry, which itself has limited value for analysis.

All of the roundabout crashes are minor, low-speed collisions. So few warrant a police report that it was necessary to invent a "Sub-Threshold Incident Report" in order to capture collision diagrams for all incidents.

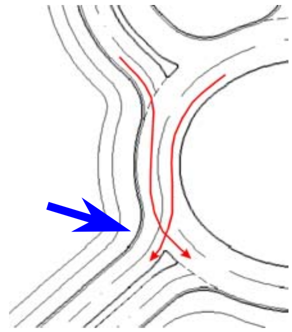
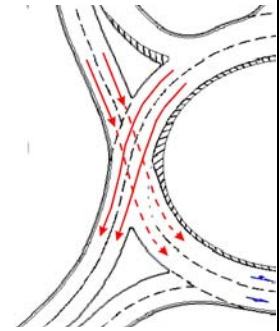
The diagrams revealed a clear-cut pattern of low-speed, low-angle merge collisions concentrated at the two exits which are two-lane exits (Coronado Drive and Causeway Boulevard).

Drivers are not resolving the conflicts at the two-lane exits successfully enough. A designer with extensive experience in fine-tuning roundabouts, Barry Crown,[18] was brought in to help analyze the situation and develop a solution.

Analysis

Some drivers in the outer circulating lane are continuing to circulate past the two-lane exit, using the outside lane, which is tantamount to cutting left across the left exiting lane. This maneuver works when there is no vehicle using that lane, same as a lane-change anywhere. But when there is simultaneously a vehicle in the inner circulating lane attempting to correctly exit using the left exiting lane, a merge collision can occur. This situation is shown on the left below.

Tweaking the Roundabout[19]

Existing Coronado Drive Exit Geometry	Proposed Modifications
	
The tight exit radii (fat arrow) successfully controls exit speeds to the benefit of down-stream pedestrians, but not all drivers are successfully resolving the exit conflict.	The *exit conflict* is replaced by the safer *entry conflict* and it is more obvious to drivers in the outer circulating lane that their lane exits here.

Tweaking the roundabout

The proposed solution involves modifying the exit geometry and pavement markings as shown on the right above to encourage drivers to use the roundabout correctly. The new geometry also combines the exit conflict with the safer entry conflict at the Mandalay entry.

A different modification is proposed for the two-lane exit to Causeway Boulevard, although it has some similarities to the Coronado Drive modification.

One major benefit of the proposed modifications would be that all the major traffic flows would proceed through the roundabout with no change of lanes. Drivers would simply select the correct lane for their destination before entering the roundabout, same as any other intersection. Advance signage would assist drivers in lane selection.

The existing tight exit radii has proved effective at controlling exit speeds, as intended, thereby improving safety and comfort for pedestrians at the crosswalks downstream from the exits. The proposed geometry loosens the exit radii and may result in increased exit speeds of 3-4 mph greater. Therefore, it is contemplated to take additional steps in order to retain the high comfort and safety now enjoyed by pedestrians using the crosswalks at the two-lane exits. These steps may involve giving additional prominence to the crossings, perhaps with special lighting or by raising them to become speed tables, so that exiting traffic notices them sooner and is discouraged from accelerating.

13. Create a comfortable driving experience

TO BE ACHIEVED. Numerous complaints have been received regarding the project, many of which concern the experience of driving through the roundabout. As expected, many drivers simply don't appreciate a novel intersection configuration and to others, it is all too reminiscent of the notorious high-speed rotaries and traffic circles in the Northeast, in spite of the low speeds and other major differences.

A few drivers seem not to like having to slow down, pay attention, and yield to pedestrians – but these behaviors are all desirable effects of good modern roundabout design. Some drivers find that the steps of the fountain produce an uncomfortable feeling of crowding or "canyon" effect and block too much of the field of view. The height of the steps and sight distances are within the recommendation contained in the forthcoming FHWA Roundabout Guide.

An big source of driving discomfort is the tight radii built into the design of the roundabout, especially at the exits. The purpose of the tight radii was to control exit speeds, for which they have been very effective. It's important to keep exit speeds down for the safety and comfort of pedestrians on the crosswalks, so this issue can be viewed as a straightforward trade-off of driver comfort versus pedestrian safety and comfort. Given the great volume of pedestrians and the fact that they are easily killed when struck at even moderate speeds, the decision was made to strike the balance in favor of the pedestrians.

By far the major source of driver discomfort is the ambiguity at the two exits which have two exiting lanes, as discussed in the previous section. It is anticipated that the same geometric modifications proposed to nearly eliminate the minor vehicle crashes at these two exits will also greatly reduce driver discomfort.

14. Improve air quality

ACHIEVED. While not a design objective per se, one unexpected benefit of the project was discovered during the early design phase. Motorized vehicles generate the most pollutants during deceleration, idle, and acceleration, all of which are greatly reduced during free-flow operation of a modern roundabout. Computer modeling using SIDRA[20] showed that the project would result in a reduction of 493,456 Kg of pollutants released to the atmosphere over the first 20 years. Since Pinellas County is at risk of being downgraded to Non-Attainment status by the Environmental Protection Agency, an emissions reduction of this magnitude is significant.

IV. CONCLUSION

The Clearwater Beach Entryway Roundabout is an ambitious project, as confirmed by the fourteen design objectives elucidated above. Seldom does an intersection design try so hard to serve so well so many conflicting interests.

In attempting to achieve the best balance among users, the project does not go as far as the "initial definition for smart, sensible, responsible, livable or sustainable growth" suggested by members of ITE's Smart Growth Task Force, which has proposed a "balanced system of transportation modes for livable neighborhoods (residential, commercial), in priority order: walk, bike, transit, goods and services movement vehicles, multi-occupant vehicles, single occupant vehicles."[21] The Comprehensive Plan for West Palm Beach, Florida, similarly codifies a transportation hierarchy with pedestrians at the top and single occupant vehicles at the bottom.[22] The project does, however, go further toward achieving balance among users than most large intersection projects.

This roundabout is perhaps already the most instrumented and most studied roundabout in the United States.

A reasonable assessment at six months is that twelve of the fourteen design objectives have been met.

It now appears clear why the two remaining design objectives are unmet and what must be done to achieve them. Absent underground utilities, it would be a simple matter of moving some curbs around and changing the pavement markings.

Whatever modifications are made, the follow-up data will reveal their effectiveness in reaching the goal of achieving all fourteen design objectives.

ILLUSTRATIONS

Below are a table and two diagrams, followed by the References.

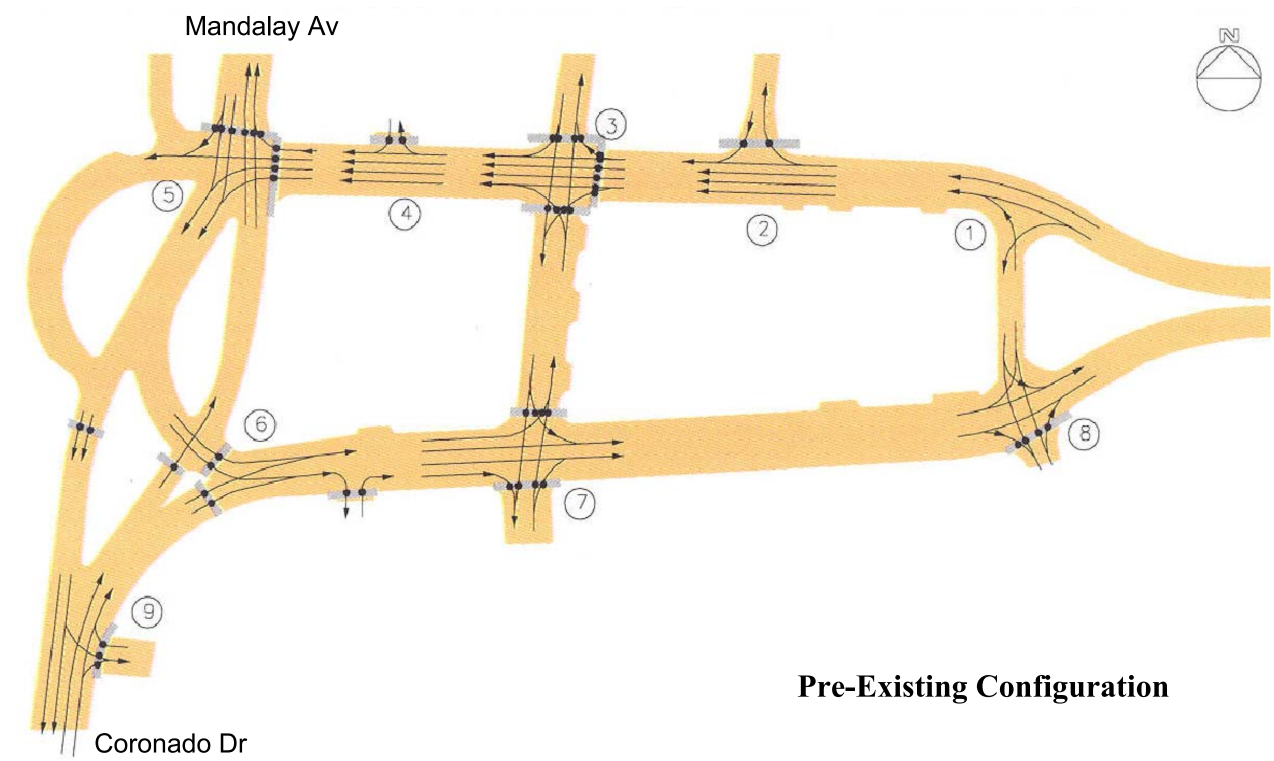
The table of Intersection Rules illustrates the simple decision-making environment of a modern roundabout by contrasting the rules for roundabouts with those for signalized intersections.

The table below compares drivers' rules for roundabouts and conventional signalized intersections.

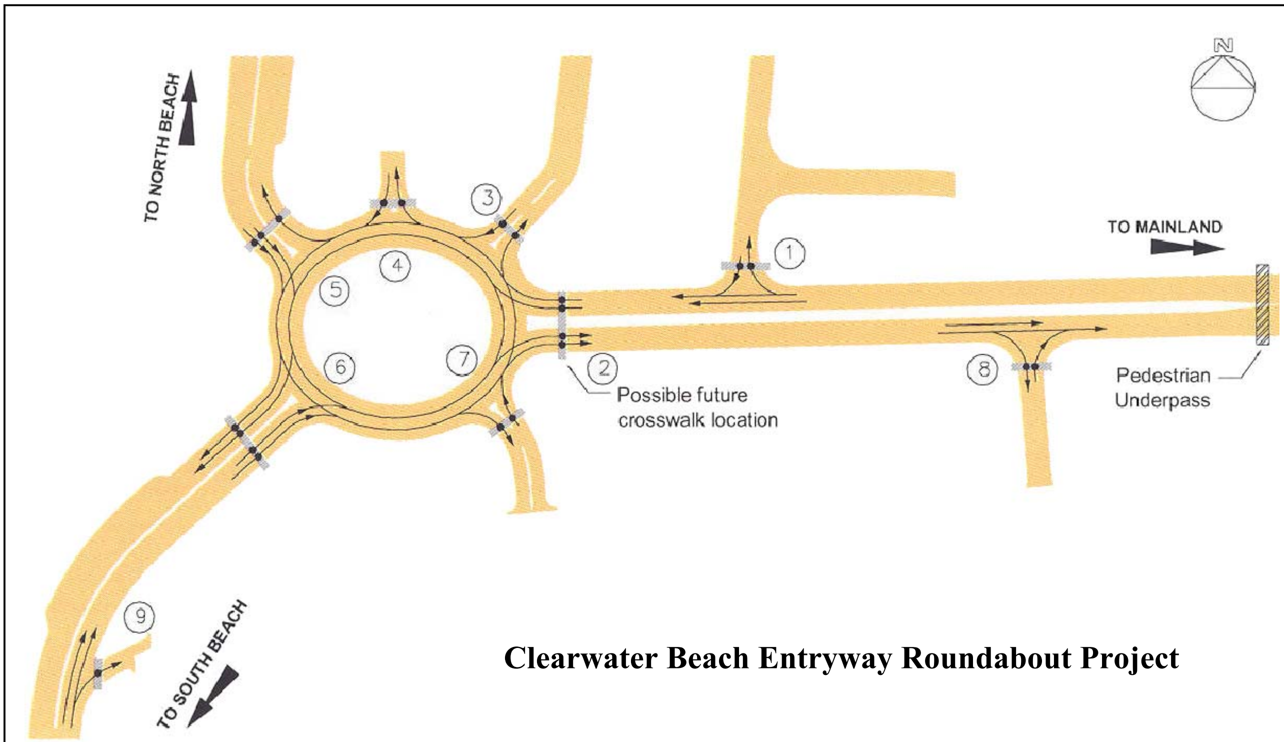
Intersection Rules	
Roundabout	**Signalized**
1. Yield to traffic already in the roundabout	1. If the signal is a **red ball**, come to a complete stop a) After stopping, you may turn right (legal in Florida, but not in all states) but must yield to oncoming traffic; except if the sign says "NO TURN ON RED", you cannot b) After stopping, you may turn left on red from a one-way street onto a one-way street (legal in Florida, but not in all states) but must yield to oncoming traffic 2. If the signal is a **green ball** a) you may go straight or turn right, but only if the way is clear – you must yield to vehicles still in the intersection b) you may turn left but must yield to oncoming traffic 3. If the signal is a **yellow ball** a) you may go straight or turn right b) you may turn left but must yield to oncoming traffic 4. If there is one signal head for several lanes, it applies to all those lanes; if there is a signal head for each lane, each lane is governed by its own signal head; and if there are multiple heads but not as many as there are lanes, generally a head centered above a lane governs that lane, a single head located above the line dividing two lanes governs both lanes, and a single head centered above three lanes governs all three lanes 5. If the signal for your lane is a **red arrow** pointing left or right, come to a complete stop a) After stopping, you may turn right on red but must yield to oncoming traffic (legal in Florida, but not in all states); except if the sign says "NO TURN ON RED", you cannot b) After stopping, you may turn left from a one-way street onto a one-way street (legal in Florida, but not in all states); except if the sign says "NO TURN ON RED", you cannot 6. If the signal for your lane is a **red arrow** pointing up, you may not go straight 7. If the signal for your lane is a **green arrow** pointing left or right, you may turn in the direction of the arrow, after yielding the right-of-way to vehicles within the intersection, even if the red light is burning at the same time 8. If the signal for your lane is a **green arrow** pointing up, you may go straight, after yielding the right-of-way to vehicles within the intersection, even if the red light is burning at the same time 9. If the signal for your lane is a **yellow arrow**, it means the same thing as the **yellow ball**, but applies only to movement in the direction of the arrow 10. If the signal is a **blinking red ball**, come to a complete stop and then enter the intersection, except you must yield to other vehicles already in the intersection 11. If the signal is a **blinking yellow ball**, enter the intersection with caution, except you must yield to other vehicles already in the intersection 12. If none of the bulbs on the signal head are illuminated (power outage), come to a complete stop and then enter the intersection with caution, except you must yield to other vehicles already in the intersection
Note: Vehicles in the roundabout *always* have the right-of-way	Note: Who has the right-of-way *changes* every few seconds as the phase sequence cycles

Pedestrian/Vehicle Conflict Points

The graphic below depicts pedestrian/vehicle conflicts before and after construction of the Clearwater Beach Entryway Roundabout



Pre-Existing Configuration



Clearwater Beach Entryway Roundabout Project

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[11] The table of Intersection Rules in the ILLUSTRATIONS section above illustrates the simple decision-making environment of modern roundabouts
[12] See the diagram of pedestrian/vehicle conflict points in the ILLUSTRATIONS section above
[13] *Gateway to the Beach Preliminary Engineering Report for Beach/Causeway Roundabout, November*, 1998, Florida Design Consultants, Inc., and Alternate Street Designs, P.A.
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