SECTION 5188 – ACHD ROUNDABOUT DESIGN GUIDE

Appendices

A - ACHD Fastest Path Procedure
B - ISPWC SD-701B (Roundabout Standard Curb Drawing)
C - Design Parameter Checklist Assistant

5188 ROUNDABOUTS

Roundabouts are gaining popularity across the United States as a safe, efficient means of controlling and accommodating intersection traffic. ACHD recognizes the need to develop a common approach to roundabout development in the County. To that end, ACHD has adopted a set of requirements for the development of roundabouts on roadways within the District's jurisdiction to serve as an aid to ACHD staff, city planners, design engineers, developers, and others as they consider and pursue roundabout solutions.

5188.1 Roundabout Design Guide Purpose

The ACHD Roundabout Design Guide provides detailed guidance needed by planners, analysts, designers, and reviewers to evaluate, design, review, and construct roundabouts within the jurisdiction of ACHD. The Design Guide is a supplement to the ACHD Section 5108 Roundabout Policy.

The standards identified in the Roundabout Policy may or may not apply to all situations and allowance has been made to consider design exceptions. Compliance with these standards does not relieve the responsibility to use sound professional engineering judgment or to comply with other local, state, or federal requirements. ACHD intends for these standards to assist, but not substitute for, competent work by design professionals.

5188.2 Roundabout Definition

ACHD Roundabout Policy Section 5108.2 defines the characteristics of a roundabout.

5188.3 Modifications and Addenda

The Design Guide will be updated administratively to include advances in the field of roundabout evaluation and design. The ACHD website will contain an email distribution list to notify users of updates and will contain the latest approved changes. The designer should check the website at www.achdidaho.org to verify they have the most current adopted version.

5188.4 Intersection Control Selection

A roundabout will be evaluated if the criterion identified in Roundabout Policy 5108.5 is met. Additionally, Roundabout Policy 5108.5 identifies the requirements of the roundabout evaluation. The FHWA Highway Safety Manual should be used for use in safety evaluation.

Roundabouts have been shown to function efficiently and safely under a wide range of conditions. In short, a roundabout can be constructed at any intersection where an efficient, safe, and appropriate design can be achieved. It is not practical to make specific, exhaustive lists of intersections or sets of conditions where roundabouts will and will not be allowed. The subsequent discussion is broken down into the following three general types of intersections to assist in determining whether or not a given intersection is a potentially suitable location for a roundabout:

- Intersections where roundabouts are generally inappropriate,
- Intersections where roundabouts may be particularly advantageous, and
- Intersections where additional analysis will likely be needed to assess the suitability of the site.

These citing guidelines provide a means of "screening" proposed roundabout intersections to determine whether or not it is reasonable to advance a roundabout solution to the alternatives development and evaluation phase of the project development process.

5188.4.1 Generally Inappropriate Intersections

The following is a list of situations where installing a roundabout is usually not desirable in Ada County:

1. Close Proximity

   The distance between the proposed roundabout and the next fully controlled intersection (existing or planned) does not meet the intersection spacing requirement in the ACHD Development Policy Manual. In this case, ACHD will determine which intersection takes precedence. If necessary, a design exception may be possible for the spacing between a roundabout and adjacent intersections based on site and traffic conditions. This should not be handled any differently than it is with signalized intersections, although the result may be different, given the difference in operating characteristics between signals and roundabouts.

2. Impractical Right-of-Way Cost

   The cost of right-of-way makes it impractical to obtain sufficient right-of-way for the type and size of roundabout required to meet the operational and safety needs of the intersection (e.g., developed downtown areas). The lifecycle-cost to lifecycle-benefit ratio is not favorable or the lifecycle cost is too high and not affordable.

3. Significant Grades

   If grades greater than 4% are unavoidable for the circulatory roadway, roundabouts can become impractical to maneuver efficiently and safely.

4. Extremely High Traffic Demand

   When traffic volumes through the intersection exceed the capacity of a two-lane roundabout (~50,000 total entering vehicles (TEV) ADT under ideal conditions) other traffic control should be considered as the complexities of three-lane roundabouts (and larger) reduce some of the safety benefits associated with roundabouts.

5188.4.2 Advantageous Intersections

The characteristics of roundabouts make them particularly attractive at certain intersections, due to their inherent efficiency and safety. The following paragraphs present examples of these intersection types.

1. High Crash Rate Intersections

   A roundabout can provide a possible solution for intersections that experience high crash rates or a high crash severity by reducing the number of conflict points where the paths of opposing vehicles intersect. Furthermore, collisions that occur at roundabouts involve low speeds and low angles of impact, and therefore, are less likely to result in serious injury for all road users. Pedestrian safety features include slower vehicle speeds, a more prominent crossing location prior to any vehicle-vehicle conflict points, and a refuge between directions of vehicular traffic. The procedures and guidance identified in the Highway Safety Manual (HSM) should be used in the safety evaluation. Safety evaluation is an important process to complete for any intersection improvement alternative.

2. Unconventional Intersection Geometry

   Conventional forms of traffic control are often less efficient than roundabouts at intersections with skewed angles, offset approaches, more than four approaches, or close intersection spacing. Roundabouts may be better suited for such intersections because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes makes them especially effective at “Y” or “T” junctions. A pair of closely spaced signalized or stop controlled intersections may be more efficient if reconstructed as a pair of roundabouts or as one multileg roundabout depending on traffic patterns.

3. Intersections with Increased Capacity Needs

   When considering methods to increase the capacity of an intersection, a roundabout is an alternative to stop signs and traffic signals. With conventional traffic signals, only alternating streams of vehicles are permitted to proceed through at one time, causing increased delay and a loss of capacity when the intersection clears between phases. In contrast, roundabouts allow vehicles to enter simultaneously from multiple approaches using short headways, reducing delay and increasing capacity. The only restriction on entering a roundabout is the availability of gaps in the circulating flow. The slow speeds within the roundabout allow drivers to safely select a gap that is relatively small. Traffic operation analysis generally finds that roundabouts produce less vehicular delay than traffic signals.

4. Intersections with Constrained Queue Storage

   Due to reduced delay and continuous flow at roundabouts, lengthy queues are generally less prevalent than at intersections with other types of traffic control. As a result, fewer lanes and/or shorter queue storage areas may be required.

5. Controlled Access Facilities

   Roundabouts can facilitate U-turns, which can be especially beneficial to facilities with raised medians and access control, allowing vehicles to access properties on the opposite side of the roadway.

6. Intersections where Approach Widening is Infeasible

   At some locations, widening one or more approaches to accommodate the needed number of lanes for a traffic signal installation is difficult or cost-prohibitive (e.g., widening a freeway interchange cross-street to provide turn-lanes may require a new bridge.) Roundabouts do not require exclusive turn lanes and can be advantageous under these circumstances.

7. Locations where Traffic Patterns are Uncertain

   Roundabouts can absorb changes in traffic patterns with less operational disruption than is experienced at traffic signals. This characteristic of roundabouts makes them particularly advantageous at locations where there is uncertainty regarding traffic patterns or traffic patterns are variable.

8. Intersections with Excessive Speeds

   Regulatory signage alone has been shown to be ineffective in controlling vehicle speeds. Speed control is dependent on enforcement, environment, and/or geometry. Roundabout geometry limits vehicle speeds by design and creates a subsequent “traffic calming” benefit.

9. “Gateway” Intersections

   While not usually a primary consideration when evaluating the appropriateness of a roundabout, the aesthetic benefits of roundabouts can be a factor in their selection. These aesthetic benefits may make gateway intersections, (e.g., university and residential development entrances, dividing lines between urban/rural areas, speed zone transition points, etc.) particularly appropriate sites for roundabouts, provided they are not inappropriate for the control of traffic at that location.

5188.4.3 Intersections Requiring Further Analysis

The following conditions raise concerns that might make a roundabout less desirable than other intersection control types and require additional evaluation before implementation.

1. Isolated Intersections in a Coordinated Signal Network

   The overall system may be better served with a signalized intersection to maintain progression and traffic control continuity for motorists. There may be situations where an intersection within a coordinated signal system requires a significantly different cycle length or is difficult to provide good progression through. If this intersection dictates operations of the coordinated system and reduces the overall efficiency, a roundabout may work within the system or allow it to be split into two coordinated networks, thus improving the efficiency of the entire network.

2. Significant Queues

   Queues from a downstream traffic control device or other constraint should not extend into the roundabout reducing or stopping the flow of vehicles in the circulatory roadway. A detailed queuing analysis or simulation should be conducted to determine the feasibility of the roundabout and possible remediation to reduce the queue lengths and impacts.

3. Unbalanced Traffic Flow

   A minor approach may back up due to a lack of gaps caused by a heavy flow of through and/or left-turning traffic on the major street. In addition, the dominant traffic movement may assume right-of-way and not yield when appropriate. It is also possible that the major movement may experience unnecessary delay.

4. High Pedestrian Activity

   Intersections where the predominant traffic is regularly comprised of pedestrians may be better served by another device that provides protected pedestrian crossings.

5. Utility Conflict

   Locations where there are major utility, irrigation, and/or drainage conflicts that could be more easily avoided with the installation of a different form of traffic control.

5188.5 Traffic Operations Analysis

Traffic analysis scenarios, result reporting, and acceptable threshold requirements are summarized in ACHD Roundabout Policy 5108.6.

To avoid overbuilding, a designer should evaluate the pros and cons of designing a roundabout with an anticipated volume-to-capacity ratio greater than 0.85, especially if the value is only slightly greater than 0.85. On a case-by-case basis the maximum V/C ratio may be permitted to be greater than 0.85 through a design exception to avoid over-building.

5188.6 Intersection Capacity Enhancement Phasing

ACHD Roundabout Policy Section 5108.7 identifies when an interim roundabout design shall be considered, the interim design construction options, and necessary features of an interim design and the interim design process.
It is generally undesirable to construct a multilane roundabout in locations where a single-lane roundabout would handle the traffic acceptably for many years. Where they can safely and efficiently handle the anticipated traffic, single-lane roundabouts are preferable to multilane roundabouts for the following reasons:

- Operational simplicity
- Better safety record
- During low-volume periods multilane roundabouts experience lower compliance with the signing and pavement markings, resulting in higher speeds.

In designing an expandable roundabout, the following issues should be considered:

- Expanding a “good” single-lane design does not necessarily result in a “good” multilane design. This is due to the fact that the issues associated with multilane design are much more complex, particularly with natural path.
- The design process should start with a good multilane roundabout layout (ultimate configuration) that addresses the issues of fastest path, path overlap, design vehicle accommodation, etc. Once the ultimate multilane layout is determined the designer can evaluate interim design options that may be constructed in phases.
- The initial single-lane, the ultimate multilane design, and any interim designs should be thoroughly analyzed to ensure proper operations and safety. The design should not short-change either the interim or the ultimate design’s operation or safety.
- A roundabout constructed for multilane operation and striped for single-lane use is not desired. Proper channelization for single-lane operation should be provided by physical improvements including curbs on both sides of all vehicle paths extending at least to the ends of the splitter islands, or farther if necessary, for positive physical control and guidance.
- Depending on the particulars of a given site, it may not be feasible to construct an expandable roundabout.

An initial or interim roundabout design can be conducted utilizing one of two basic schemes (building the full outside footprint and widening inward or building the final interior features and widening outward.) The advantages and disadvantages of the two schemes are summarized in the table below:

Scheme	*Advantages*	*Disadvantages*
Build Full Outside Footprint & Widen Inward	• Drainage features & sidewalks are built initially* • Full right-of-way needs taken care of up front* • Future expansion impacts islands and signing and striping only – no impacts to adjoining property*	• More widening on each leg – longer transitions • Higher initial cost* • Higher single lane circulating speed • Greater construction traffic conflicts
Build Final Interior Features & Widen Outward	• Lower initial cost* • Drainage facilities, sidewalks, & ultimate right-of-way can be obtained through development* • Lower single lane circulating speed • Less construction traffic conflicts	• Adjoining properties impacted twice instead of once* • Lack of pedestrian facilities* • Potentially higher ultimate costs if additional adjacent development occurs by the time the roundabout is expanded*

*Note: It is preferable to purchase all the right-of-way initially so that utilities and sidewalks can be placed at their final locations. Purchasing all the right-of-way up front negates the advantages and disadvantages that are based on right-of-way.

The determination as to which scheme is best for a given location should be made based on the individual project circumstances of budget, drainage issues, pedestrian traffic, aesthetic goals, public input, etc.

5188.7 Design Submittal and Review

ACHD Roundabout Policy Section 5108.8 identifies the design submittal requirements for all preliminary and final roundabout designs.

It is rare to produce an acceptable design on the first attempt. For developer submitted roundabout designs, review costs should be expected to be assessed similarly to any other development plan submittal. The first developer plan review fee covers an initial submittal plus one resubmittal in response to an ACHD generated comment letter. If all ACHD comments are not adequately addressed in the resubmittal, ACHD asses an additional fee to the developer for each subsequent submittal until deemed adequate per ACHD policies.

5188.8 Design Guidelines

Typical roadway or intersection design standards consist of minimum values for such design parameters as roadway width, shoulder width, centerline radius, curb return radius, vertical curve “K” values, design vehicle, etc. These minimum values provide the minimum acceptable design. Common belief is that use of greater values, where possible, results in a more conservative, “better” design. The idea is that if a certain amount of something (e.g., the number of approach lanes to an

intersection) is good, then more of it is better. Although some design philosophies, such as “context sensitive design,” have challenged that way of thinking, it is still the predominant approach used across the country.

Roundabout design requires a shift in the thought processes of both design itself and the establishment of design policies. Providing greater than optimum values for design parameters can be as bad as or worse than providing less than optimum values. For example, providing pavement widths, entry curve radii, and inscribed circle diameters that are larger than optimum will result in excessive speed and reductions in safety and efficiency. Also, proper design can’t be achieved by following a “cookbook” process and selecting standard values for design parameters. The nuances of roundabout design and operation are such that it is the combination of parameter values for a given site that will produce the desired result, not the individual values. This is sometimes referred to as taking a “holistic” approach to design. The different elements of the roundabout work in harmony to produce the desired operational efficiency and driver behavior. The “best” combination of parameter values will vary from site to site and even from one leg of the roundabout to another. This variation is due to differing traffic characteristics, topographic constraints, roadway function, etc.

Based on the discussion above, what follows are not prescriptive, hard standards for geometric layout. The intent is rather to provide guidance that a designer can use, in conjunction with his or her knowledge and expertise in roundabout design, to produce designs that avoid certain extremes deemed undesirable by ACHD. The intent is also to form the basis for the development of “sample” roundabout designs to assist ACHD in identifying right-of-way preservation needs for potential future roundabouts. The guidance presented here is not a substitute for designer experience, expertise, and engineering judgment.

Roundabout designers should be familiar with, and make use of, nationally accepted guidance documents. Examples of six such documents are the most current versions of the following:

- Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)
- A Policy on Geometric Design of Highways and Streets (AASHTO Green Book);
- Roundabouts: An Informational Guide (FHWA Roundabout Guide);
- NCHRP Report 572: Roundabouts in the United States;
- Technical Summary: Roundabouts (FHWA Roundabout Technical Summary); and
- Public Rights of Way Accessibility Guidelines (PROWAG).

5188.8.1 Design Parameters

The following table presents roundabout design guidelines for the primary parameters of concern and discusses the issues associated with them.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.1 Inscribed Circle Diameter	Several factors should be considered in selecting an inscribed circle diameter (ICD) to use for a given intersection. Prominent considerations are the number of lanes in the circulatory roadway, number of intersecting legs, angle of intersecting legs, traffic composition, and topographic constraints. Larger diameters can more easily accommodate multilane operation without path overlap issues, facilitate creating adequate horizontal deflection (slower entry speeds), and generally yield slightly greater capacities. However, they can also invite higher circulating speeds, are more costly to construct, and may have greater impacts to adjoining properties.	For intersections with legs at right angles and with no more than four legs, the ICD should generally fall within the ranges indicated below. Unusual site conditions may require the use of larger or smaller diameters. Dual-lane: 150-180 feet*. Single-lane: 100-130 feet*. **Note: These dimensions are approximate starting ranges for typical cases; they do not imply that a particular value is optimum at a specific location, or that the parameter is limited to these values.*
5188.8.1.2 Entry/Exit Geometry	In general, large radii on exits and smaller radii on entrances are desirable. A large exiting radius reduces exit crashes and improves visibility between exiting vehicles and crossing pedestrians. It also helps create a "left offset" condition on the approach increasing entry deflection. With a flat exit, the left offset can be achieved while maintaining adequate splitter island width for pedestrian refuge. ("Left offset" design may not be achievable or desirable at some roundabouts.) A smaller entry radius helps achieve the desired entry approach speed. For multilane roundabouts, natural path should be carefully considered and evaluated. Selection of design entry and exit radii should also consider the traffic needs and geometric constraints imposed by the specific site. Entry lane flares improve operational efficiency and capacity, and help to accommodate truck turning. However, entry flares combined with small central islands may not provide adequate horizontal deflection to achieve acceptable speeds.	Exit outside curb radius: 300 feet or larger*. Entry outside curb radius: 50-100 feet*. Entry taper: from existing approach lane width at beginning of taper to ~14-18 feet width for single-lane entries (25-30 feet for dual-lane entries) over ~50-100 feet of taper length*. **Note: These dimensions are approximate starting ranges for typical cases; they do not imply that a particular value is optimum at a specific location, or that the parameter is limited to these values.*
5188.8.1.3 Design Vehicle	Roundabouts should be designed to accommodate any vehicle type and size that regularly uses the intersection. In general, this "maximum" vehicle will vary from location to location and even between different turning movements in the same roundabout based on the adjacent land use and roadway function. It is incumbent on the designer to do background research to determine what vehicles must be accommodated at a particular location. A designer should weigh the pros (large vehicles can maneuver the roundabout more easily) and cons (smaller vehicles will have faster paths) of selecting a larger design vehicle.	WB-67 for principal arterial intersections, industrial areas, and access to industrial areas. WB-50 or larger for minor arterial intersections. BUS, fire truck, or larger for roadways in residential areas not intended to serve through traffic.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.4 Number and Assignment of Lanes	The number of entering, circulating, and exiting lanes at roundabouts has a pronounced effect on roundabout operation. In general, it is desirable to provide only the number of lanes that are needed to provide acceptable capacity. Fewer lanes provide less complex operation, which generally translates into improved safety. The number of approach lanes and their assignment should be determined on an approach-by-approach basis by a traffic operation analysis (traffic operation analysis is generally performed as a part of the alternatives analysis.) Not all approaches need to have the same number of lanes. It is desirable to design the roundabout for its anticipated ultimate lane configuration but to build an interim configuration with fewer lanes if traffic volumes allow. Refer to section 5188.6 for more detail.	ACHD Roundabout Policy Section 5108.9.1 defines the number and assignment of lanes requirements. Below are some "rules-of-thumb" regarding roundabout capacity. Note that the values are for a typical 4-leg intersection with legs at approximate right angles to each other. • TEV ADT <22,000 typically single-lane roundabout. • TEV ADT >27,000 and <39,000 typically two-lane roundabout. • TEV ADT >39,000 and <50,000 possible dual-lane roundabout but requires more analysis. • Sum of entering and circulating volume at merge point <1000 vehicles per hour (vph) typically requires one approach lane. • Sum of entering and circulating volume at merge point >1300 vph and <1800 vph typically requires two approach lanes. • Sum of entering and circulating volume at merge point >1800 vph typically requires a detailed analysis.
5188.8.1.5 Lane Continuity	The number of circulating lanes is driven by the number of approach lanes and their assignment. Some portions of the circulatory roadway may have more lanes than others. Similarly, the number of exit lanes on a given leg is driven by the entry lane configuration of the approaches and the circulatory roadway design. Attention should be paid to issues of lane balance and continuity in considering the number of lanes for each portion of the roundabout. If a multilane roundabout design provides too much separation between entries and subsequent exits, entering vehicles may enter next to circulating traffic that intends to exit at the next leg, rather than crossing the path of exiting and circulating vehicles. This can create conflicts at the exit point between exiting and circulating vehicles. Please see FHWA Roundabout Technical Summary Figures 14 and 15 for more detail.	ACHD Roundabout Policy Section 5108.9.2 defines the lane continuity requirements.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.6 Bypass Lanes	Bypass lanes provide additional capacity to a roundabout without adding circulating lanes. By reducing the number of entry lanes at the circulatory roadway, bypass lanes can also help minimize the entry fastest path speeds and minimize natural path issues. Impacts to pedestrian and bicycle users, and right-of-way requirements should be carefully considered when evaluating bypass lanes. Pedestrian crosswalks across bypass lanes should be provided in locations where vehicles have low speeds and pedestrians are visible. An appropriately sized and ADA compliant refuge area should be provided for pedestrians inside of the bypass lane. There are two types of bypass lanes. One type must yield to the traffic in the exit approach lane and the other type has an exclusive receiving lane on the exit approach which may or may not merge downstream. Yielding bypass lanes have lower capacity than free or merge bypass lanes. At the yield point, the bypass lane should intersect with the exit approach at an angle that allows the driver to see oncoming conflicting traffic easily.	Determine appropriateness of a bypass lane and its type as necessary. Bypass merge lanes should be designed to AASHTO guidelines. Refer to 5188.6.1.14 for pedestrian refuge area size and location requirements.
5188.8.1.7 Splitter Islands	Splitter islands provide a refuge for pedestrians and some bicyclists, creating a two-stage crossing maneuver such that pedestrians only deal with one direction of vehicular traffic at a time. This is a feature that helps give roundabouts the safety record they enjoy. Splitter islands also provide physical and visual separation between the entering and exiting traffic. They define the curvilinear path to be traversed by vehicles approaching the yield line to enter the roundabout. This physical definition, or "channelization," of the approach further encourages vehicles to follow the path intended for them, rather than ignore striping and follow a straightened path. Splitter islands help control the speeds of vehicles entering the roundabout. The length of the splitter can vary significantly based on the geometry of the roundabout, the roadway and land use environment, and the approach speed. Splitter islands should be at least as far back from the circulatory roadway such that it impacts the fastest path control offset point. For approaches on high speed facilities, the splitter islands should be at least 200 feet long and provide a comfortable deceleration length. Additionally, the splitter island should extend beyond the end of the exit curve to assist with the paths of exiting vehicles. Splitter islands that are wide at the edge of the circulatory roadway provide somewhat improved capacity because the increased separation between the entrance and the upstream exit aids the entering driver in determining early whether an upstream vehicle will continue in the circulatory roadway or exit. This allows the driver to accept a gap and enter traffic when he may not otherwise know that gap is going to open up until it's too late to take advantage of it.	ACHD Roundabout Policy Section 5108.9.3.2 identifies the splitter island requirements. The landscaping issue of whether and to what extent plant material, rocks, art, and/or hardscape is used should be resolved through the cost sharing policy. Refer to 5188.6.1.14 for pedestrian refuge area size and location requirements.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.8 Central Island	Landscaping, berming, and other visual obstructions within the central island can limit sight distance to just what is needed for safe merging, diverging, and stopping. Sight distance can be managed through landscaping to help control speeds and limit crashes. The roundabout design should consider the provision of irrigation water and power to the central island for the landscaping and lighting. When selecting items to place in a roundabout central island, it is important to consider the following: • Overly complex pieces are likely to distract the driver's attention and are therefore undesirable. • The pieces should not encourage pedestrians to venture to the island. It is desirable for the center island to contain features with sufficient vertical relief to provide a visual cue to approaching motorists that they need to slow down. At a minimum the island should be mounded. If the central island will require vehicle access for maintenance a pullout for maintenance vehicles should be considered to avoid impacting traffic operations.	ACHD Roundabout Policy Section 5108.9.3.3 identifies the central island requirements. The landscaping issue of whether and to what extent plant material, rocks, art, and/or hardscape is used should be resolved through the cost sharing policy.
5188.8.1.9 Design Speed	Guidance from the FHWA Guide and NCHRP Report 572 should be used to determine the fastest paths and expected speeds. The fastest path tracks the center of a car and should be at least 5 feet from any curb. The precise path is a series of tangential spiral curves. The fastest paths and corresponding speeds are controlled by a combination of the roundabout diameter, entry and exit approach geometry, vehicular acceleration, and cross-slope. The relationship between curve radius, cross-slope, and speed is detailed in the AASHTO "Green Book." It is important to minimize the differences in speeds of the various vehicles using the roundabout.	ACHD Roundabout Policy Section 5108.9.4 defines a fastest path, identifies a procedure to estimate fastest paths, and the fastest path speed threshold requirements. Appendix A summarizes the ACHD fastest path procedure and outlines each step in detail.
5188.8.1.10 Natural Path	Roundabout design should encourage vehicles to naturally stay in their assigned lane at a comfortable speed rather than be directed at a curb or an adjacent lane to maximize safety and enhance operations. The key principal in determining the natural path of a vehicle is to remember that they cannot change their direction or speed instantaneously. Natural paths should not encroach on each other or on curbs. Encroachment can be caused by angle points, flat spots, or arcs shorter than three passenger car lengths that drivers tend to smooth out by cutting corners.	ACHD Roundabout Policy Section 5108.9.5 defines natural path. Outlines the requirements of an analysis procedure, and identifies its requirements.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.11 Roadway Width	The roadway should not be wider than is necessary. Wide pavements increase construction and maintenance costs and decrease the safety of the roundabout by encouraging higher speeds. The width of the roadway should be adequate to accommodate the wheel paths of all movements for all design vehicles except semis (typically a bus or fire truck is the critical design vehicle.) For multilane roundabouts, design vehicles should be selected for side-by-side lane analysis to ensure vehicles can travel side-by-side through a roundabout without their swept paths colliding. A roundabout should have a consistent circulatory roadway width so that right-turns are made tangent to the inscribed circle diameter. If the circulatory roadway width is widened more than a couple feet to accommodate a right-turning vehicle it begins to negatively impact the performance of the roundabout by creating a large open paved area that can be confusing to drivers and increase fastest path speeds.	ACHD Roundabout Policy Section 5108.9.6 defines wheel and swept paths, identifies a procedure to analyze them, and states their threshold requirements. If an intersection is expected to experience a significant portion of the design vehicle, a greater clearance width should be considered. Refer to 5188.8.1.3 for guidance on the selection of appropriate design vehicles. Circulating lane: ~1-2 feet wider than the entry lane at the yield line*. **Note: These dimensions are approximate starting ranges for typical cases; they do not imply that a particular value is optimum at a specific location, or that the parameter is limited to these values.*
5188.8.1.12 Truck Apron	The roadway width is designed to accommodate the wheel paths of all design vehicles except semis. The additional off-tracking experienced by semi-trailers is handled through the use of truck aprons. A truck apron is usually needed around the center of a single-lane roundabout. Sometimes a truck apron is used on the outside of a roundabout to accommodate tight right turns. The truck apron width is determined by the off-tracking distance from the roadway. The truck apron is raised above the adjoining pavement to discourage passenger vehicles from “short-cutting” across the apron. A mountable/traversable curb should be used between the roadway and the truck apron. The apron should also be constructed of colored/textured concrete or pavers to provide contrast with the roadway surface and pedestrian and bicycle facilities so general users realize it is not for their use.	ACHD Roundabout Policy Section 5108.9.7 defines a truck apron and states the truck apron standards. The size of a truck apron is determined by a wheel path analysis as identified in ACHD Roundabout Policy Section 5108.9.6. If an intersection is expected to experience a significant portion of the design vehicle, a greater clearance width should be considered. Should be constructed to accommodate additional semi-trailer (e.g., WB-50 and WB-67) off-tracking.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.13 Pedestrian Facilities	Pedestrian facilities should be designed in a way that provides for the safety of these users. They should be designed in a way that discourages pedestrian crossings to the central island; therefore, crosswalks and pedestrian ramps oriented toward the central island should not be provided. Pedestrian crosswalks should consider total walking distance, exposure area to vehicles, visibility, sight distance, and positive guidance. In the future, PROWAG may require pedestrian crossings of multiple lanes to be signalized. All multilane roundabouts should consider this possibility and the resulting need for additional traffic control such as a pedestrian hybrid beacon. Providing a buffer between the sidewalks and curbs around the exterior of the roundabout encourages pedestrians to cross at appropriate locations (i.e., the crosswalk), helps to discourage crossings to the central island, enhances pedestrian safety and comfort, and provides a high visibility location for critical signage. Separating crosswalks from the yield lines allows drivers to deal with crossing pedestrians independently from the vehicle merge points and turning movements. This allows drivers to focus their attention on the pedestrians, thereby improving pedestrian safety. The use of the splitter island as a refuge allows pedestrians to make the crossing as a series of one-way traffic crossings, rather than a longer crossing of two-way traffic further aiding pedestrian safety.	ACHD Roundabout Policy Section 5108.9.8 identifies the sidewalk, crosswalk, refuge area, and buffer requirements. Buffers equal to 5 feet or greater in width are desired. The landscaping issue of whether and to what extent plant material, rocks, art, and/or hardscape is used should be resolved through the cost sharing policy.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.14 Bicycle Facilities	Bicycle facilities should be designed in a way that provides for the safety of these users. When bicycle lanes or shoulders are provided along approaching roadways, they should be terminated prior to the roundabout. At the termination point, bicyclists choose whether they will proceed through the roundabout in the same manner as a motor vehicle (in which case they move to the center of the vehicular lane and claim it as their own as they proceed through) or exit the roadway and cross as a pedestrian. Ramps (or curb openings to a shared-use path) provided at the ends of the bike lanes and shoulders allow cyclists who choose the latter option to access the pedestrian facilities. These bicycle ramps should be separate from the pedestrian ramps and located further from the circulatory roadway than the pedestrian crossing facilities. Bicycle ramps should be provided at angles easily maneuverable by the bicyclists (ideally parallel to bike lane/shoulder) and should not direct bicyclists into the motor traffic travel lane. The MUTCD does not permit bicycle lanes within the circulatory roadway of a roundabout. Between bicycle ramps the mixed-use path may need to exceed the typical sidewalk width of five feet to accommodate the anticipated pedestrian and bicycle activity. Some factors that should be evaluated when considering the width of this area include the presence of bicycle facilities, the presence of a continuous sidewalk connection, pedestrian volume, bicycle volume, and the bicyclist and pedestrian travel behavior and directionality.	ACHD Roundabout Policy Section 5108.9.9 states the bike lane/shoulder termination and mixed-use path standards at roundabouts.
5188.8.1.15 Vertical Alignment	The roadway, aprons, and hard-surfaced islands should be sloped to provide for adequate drainage. The most common guidance on drainage is to slope the circulating roadway away from the central island at a 2% slope. Three reasons are generally used to justify this practice. The first is that by sloping away from the central island, the island can more readily be seen by approaching vehicles. The second reason is that sloping the roadway away from the island creates a negative superelevation which helps to control speeds. Truck aprons must also be sloped. They are commonly sloped outward at the same slope as the circulatory roadway. The third reason is because then no drainage facilities are required in the central island of the roundabout. If grades greater than 4% are unavoidable special care should be given to the efficiency and safety of the roundabout design. Significant down slopes can make yielding and stopping more difficult. Roundabouts located on crest vertical curves with steep approaches can compromise motorist sight lines and a roundabout may violate their expectancy.	ACHD Roundabout Policy Section 5108.9.10 identifies the vertical alignment standards at roundabouts and ACHD Roundabout Policy Section 5108.8.3.1 defines the deliverable requirements for grading plans.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.16 Sight Distance	It is important that an appropriate amount of intersection sight distance be provided to drivers as they approach the yield line on a roundabout entry. The concept of "sight triangles" as discussed in the AASHTO "Green Book" is applicable to roundabouts with some adaptation: • Driver position for measuring sight distance (i.e. "decision point") is approximately 50 feet from the yield line. • The length of the conflicting leg's sight "triangle" should be measured along the curvilinear path of travel, not as a straight line. • Sight distances significantly in excess of the minimums encourage higher approach speeds and are therefore undesirable. However, limited sight distance cannot take the place of good geometry in reducing entry speeds. As with other types of roadway facilities, adequate stopping sight distance should be provided throughout the roundabout. Care should also be taken to provide appropriate sight distance between drivers and pedestrians, including pedestrians at the side of the road who have not yet entered the crosswalk. Diagrams in the FHWA Guide as well as other publications can be useful to the designer in analyzing the sight distance issues. The designer should recognize that there are various speeds governing sight requirements in a roundabout (i.e., approach, entry, circulating, and exit). Care should be taken to ensure that the correct speed is used for each element of the analysis.	ACHD Roundabout Policy Section 5108.9.11 identifies the requirements for analyzing intersection and stopping sight distance. In addition, the intersection decision point and critical headway values are specified. ACHD Roundabout Policy Section 5108.8.3.4 defines the deliverable requirements for landscaping which is determined by sight distance calculations.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.17 Signing & Striping	While there is considerable variation in roundabout markings around the country, the latest edition of the MUTCD most closely reflects the current state of the practice and is a critical resource for roundabout signing and striping design. Chapter 2B provides information regarding regulatory signs, Chapter 2C provides information on warning signs, and Chapter 2D provides guidance for guide signs at roundabouts. In addition, Chapter 3C provides direction solely regarding roundabout markings. All required signs and pavement markings as identified in the MUTCD should be included in the roundabout design. Optional signing and striping should be considered on a case-by-case basis. It is important to clearly communicate necessary information to motorists without overloading them with too much information. Generally, yield lines, "YIELD text markings, and optional lane striping next to curbs, are not desired. Secondary yield signs are only included when necessary (e.g., multilane entry or limited yield point visibility.) ACHD prefers use of the fish-hook arrows instead of the normal arrows as they more closely reflect the driving pattern of roundabouts. Diagrammatic signs can be helpful for irregular intersections.	ACHD Roundabout Policy Section 5108.9.12 identifies the signing and striping standards at roundabouts.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.18 Illumination	Proper illumination at roundabouts achieves the following objectives: • Provide adequate lighting for pedestrians so that they can be seen by approaching motorists. • Provide lighting for route guidance. All movements in roundabouts are turning movements. A driver's headlights therefore do not point in the direction a driver needs to be looking. Luminaires are needed to overcome this. • Provide perception of the presence of a roundabout for approaching motorists in dark/low light conditions. The target value aids in slowing motorists as they approach the roundabout. An adequate amount of lighting should be furnished, and it should be placed strategically to accomplish all of the objectives. It is also important to not provide too much light at the intersection as compared to the intersecting roadways such that driver's eyes are unable to adjust sufficiently to the light/dark transition. All decision points should be well-illuminated. The light poles should be placed in locations that illuminate pedestrians and signage rather than make them appear as shadows. The Illuminating Engineering Society (IES) publication, *Design Guide for Roundabout Lighting*, and the FHWA Roundabout Guide are helpful resources for illumination design of roundabouts.	ACHD Roundabout Policy Section 5108.9.13 identifies the illumination standards at roundabouts.
5188.8.1.19 Curbs	Mountable curbs should be provided between the roadway and truck aprons. Mountable curbs should provide adequate deflection and deter passenger cars from driving over them; however, they should also not create a situation where trucks might tip over or bottom out. All other curbs should not be mountable except if a portion is rolled for a driveway access.	ACHD Roundabout Policy Section 5108.9.14 identifies the curb standards at roundabouts. Appendix B contains a copy of the ISPWC SD-701B drawing that illustrates curb standards at roundabouts for reference.

Design Parameter	***Discussion***	***Design Guidance***
5188.8.1.20 Access Control	As with other types of intersection traffic control devices, it is desirable to keep driveway approaches as far away from roundabouts as possible. Taking advantage of the ease of making U-turns at roundabouts allows a corner parcel with right-in-right-out driveways on both streets to be fully accessible to and from all directions. In fact, all that is needed to achieve full accessibility is a one-way driveway from the street into the parcel on the exit side of the roundabout and a one-way driveway out from the parcel onto the street on the entrance side. Low-volume driveways, such as single-family homes, can be placed as close to the roundabout intersection as would be allowed for other intersection types. Where it is necessary to provide full access to a driveway, the driveway should be kept beyond the ends of the splitter islands. When it is unavoidable, driveways should be right-in/right-out only if they are located within the areas where left-turn access is blocked by a splitter island. Direct driveway access to the circulatory roadway is not desirable and should only be considered as a last resort if it can be designed properly. A direct access driveway to the circulatory roadway is preferred over a full access driveway cut through a splitter island. Proper design includes a sidewalk and rolled mountable curb so it does not look like an exit and should provide a way for vehicles to turn around in the driveway to prevent backing into the roundabout. Similar to signalized and stop controlled intersections, access control for roundabouts should be consistent with ACHD's access management guidelines.	ACHD Roundabout Policy Section 5108.9.15 identifies the access control standards for roundabouts. Refer to ACHD Policy section 7200 – Technical Requirements for additional access control standards.

Appendix C contains a checklist assistant to help roundabout designers and reviewers ensure critical design parameters are not overlooked.

5188.9 Design Exceptions

ACHD Roundabout Policy Section 5108.10 states the design exception standard requirements. The circumstances should dictate whether the final determination on a design exception will be made by the project team, a deputy director, or the Commissioners. For instance, a technical deviation decision may potentially be made by a project team and an intersection control decision may be made by the Commissioners.

Appendices:
1 – ACHD Fastest Path Procedure
2 – ISPWC SD-701B (Roundabout Standard Curb Drawing)
3 – Design Parameter Checklist Assistant