



SUBJECT Weaving in the Vicinity of an Approach	FINAL NUMBER AM 13-09(B)	EFFECTIVE DATE 05/15/2013	VALIDATION DATE 10/02/2014	SUPERSEDES or RESCINDS
TOPIC/PROGRAM Vehicle Weaving/Access Management	APPROVED SIGNATURE Original signed by: Larry McKinley, Access Management Program Manager			

PURPOSE

This Technical Services Bulletin provides guidance for understanding and applying OAR 734-051-4020 (3)(f) to existing connections and applications for new highway approaches. This guidance will help achieve greater statewide consistency in evaluating connections and approach applications for safety and operations concerns related to vehicle weaving

DEFINITIONS

“Approach” means a legally constructed public or private connection to the highway. A private approach must be recognized by the department as grandfathered or existing under a valid permit to operate.

“Connection” means an existing approach as defined in OAR 734-051-1070(9) or an unpermitted means of vehicular access to or from a state highway and an abutting private property, city street or county road. (OAR 734-051-0107)

“OAR” means Oregon Administrative Rule.

“ORS” means Oregon Revised Statutes.

“Peak Hour” means the highest one-hour volume observed on an urban roadway during a typical or average week, or the thirtieth (30th) highest hourly traffic volume on a rural roadway typically observed during a year.

“Weaving” refers to the movements that vehicles make when exiting an approach and then maneuvering across travel lanes to position the vehicle in the proper lane to make a turn at a downstream intersection or ramp.

GUIDANCE

This guidance is for use by the department’s Access Management staff and may be shared with members of the public. The guidance is for use as a screening level assessment of potential weaving concerns. No traffic analysis is required for this review.

Permit Specialists should coordinate with Access Management staff to confirm their evaluation is consistent with this guidance.

It is important to note that no weaving analysis is needed on two-lane highways when the following conditions apply: total two-way AADT is less than 5,000, approach ADT is less than or equal to 400, and crash rate is below 120 percent of the statewide crash rate.

Attachment A, *Weaving Distance for Approach Permitting*, provides specific details on data collection and general guidance in applying traffic engineering principles for use in determining potential weaving problems. There are two weave distance criteria, minimum and desirable. Adequacy of weave distance may be based on the minimum distance if speed and volume levels are below recommended thresholds. If thresholds are exceeded, adequacy is based on the desirable distance.

ODOT staff performing a more detailed review for the approach application should be familiar with the Analysis Procedures Manual (APM) section on Functional Area of an Intersection. This section includes procedures for identifying the factors impacting the approach location. The APM is available online at <http://www.oregon.gov/ODOT/TD/TP/pages/apm.aspx>.

BACKGROUND/REFERENCE

In earlier versions of OAR 734-051, safety factors for highway approaches were generally described as:

- Roadway Character
- Traffic Character
- Geometric Character
- Environmental Character
- Operational Character

The previous Division 051 did not quantify or set standards for these safety factors. This was problematic for customers who had no way of knowing how ODOT would make its determination. Senate Bill 264, which became law in June 2011, amended ORS 374 to establish six explicit criteria for safety and operations criteria that ODOT can consider in its permitting decisions. This bulletin covers one of those set forth in OAR 734-051-4020(3)(f):

3. Safety and Operations Concerns. *The department has the burden of proving any safety or highway operations concerns relied upon in the department's decision to require mitigation when it approves an application with mitigation or to deny an application. The department may deny an application where the applicant is unable to provide adequate improvements to mitigate documented safety or highway operations concerns and is required pursuant to OAR 734-051-3070. Safety or highway operations concerns that may be considered by the department are limited to (a) through (f):*

(f) Insufficient distance for weave movements made by vehicles exiting the proposed approach across multiple lanes in the vicinity of:

(A) Signalized intersections; or

(B) Roads classified as collectors or arterials; or

(C) On-ramps or off-ramps.

EXPLANATION

The primary purpose of the safety and operations concerns listed in OAR 734-051-4020(3) is to ensure that key safety and operational elements of a proposed approach are evaluated during the decision to approve, approve with mitigation, or deny an approach application. The evaluation of these concerns typically determines the location and mitigation requirements associated with approval of an approach application and may identify a significant safety problem that the applicant cannot or is unwilling to mitigate, resulting in ODOT's denial of the approach application.

ODOT staff is expected to work with the applicant to the extent possible to solve problems identified during the evaluation of safety factors, recognizing that the problems and solutions must be viewed in the context of practical design and balanced against other important considerations, including local community or government aspirations and economic development.

As indicated in OAR 734-051-4020(3), the department is responsible for proving that unique safety and highway operations concerns exist at or near the location of a proposed approach. This can be accomplished by observation, evaluation and review of existing records for the location of concern. Where potential issues are identified, data and analysis may also be needed. If a Traffic Impact Analysis (TIA) is required pursuant with OAR 734-051-3030(4), the TIA shall be scoped to include a safety and operations analysis per OAR 734-051-3030(5)(d) and the analysis must be sufficient to allow the department to assess safety and operational impacts.

Weaving, for the purposes of this Bulletin, occurs when vehicles exiting an approach must maneuver across travel lanes in order to turn from or exit the highway at a downstream intersection or ramp. Approaches that are located where sufficient distance for weaving maneuvers is not available can contribute to high speed differentials, violation of traffic laws, abrupt stops, and diagonal maneuvers across lanes, leading to increased crash potential and degraded intersection operations.

Assuming measurements indicate the potential for concerns with weaving, the Permit Specialist or individual taking measurements should involve a staff member experienced in engineering analysis to determine if the concern is significant. This evaluation would be site specific but could include traffic counts and other information necessary to confirm the issues associated with the location.

It is important to distinguish between how 734-051-4020(3) factors and design standards are used in the permitting process. Generally, the factors identified in

4020(3) are used in the process to identify where a problem exists or is expected to develop in association with an approach or where the approach could possibly exacerbate conditions.

Design standards are applied after approval of the approach application and during the development of the construction plans and specifications. Design standards are contained in various manuals and technical publications, such as the Highway Design Manual. Design standards are used to prepare construction plans and details (i.e., approach width, length of turn lanes, surfacing, etc.). It should be recognized that there is a correlation between the factors and design standards. They are not totally distinct from one another. For example, sight distance must be considered during the design of an approach or if the approach can only be approved as a right-in/right-out, the design of restricting the approach to a right-in/right-out must be evaluated. In some cases, it may be necessary to do some level of design prior to approval of an approach so as to understand how the approach will impact highway features or operations, site circulation or other important considerations. Generally speaking, 734-051-4020(3) factors are applied prior to approval of an application to determine if an approach can be approved at a specific location.

RESPONSIBILITIES

Department staff members in the following positions are responsible for carrying out the guidance in this Bulletin as it relates to their assigned duties and authority:

- Region Managers;
- District Managers;
- Region Access Management Engineers;
- Development Review Coordinators;
- Access Management Coordinators; and
- Permit Specialists.

ACTION REQUIRED

Implement this Bulletin upon the effective date.

SPECIAL INSTRUCTIONS

If problems develop while implementing this guidance or further clarification is needed, contact the Access Management Program Manager.

CONTACT INFORMATION

Title: Larry McKinley, Access Management Program Manager
Branch/Section: Technical Services / Access Management
Phone: 503-986-4216
E-mail: Larry.MCKINLEY@odot.state.or.us

Attachment A

Weaving Distance For Approach Permitting

Introduction

Weaving distance is one of the safety and operations concerns identified in OAR 734-051-4020(3). This guidance provides information on why weaving distance is important and instruction on how to determine if an approach meets the recommended distance for weaving. It also discusses what to do when an approach does not meet the criteria for weaving. Not meeting the weaving criteria does not necessarily mean that a safety or operations concern exists.

This guidance provides a quick initial assessment of whether or not weaving is a potential safety/operational concern. The examples provided do not necessarily address all potential weaving situations. Permit Specialists should coordinate with Access Management staff to confirm their assessment is consistent with this guidance.

Guidance

This guidance addresses the situation where a connection exists or is proposed to be located upstream of a nearby intersection or ramp. The guidance only applies to approaches in the vicinity of intersections that are signalized, or intersections with arterials, collectors and ramps. Weaving distance refers to the distance needed for a vehicle exiting an approach to maneuver across travel lanes and into position to make a turn at a downstream intersection or ramp. It is preferable that the vehicle not obstruct an adjacent lane while waiting to make the turn.

Ideally, the available distance for weaving should allow a vehicle to make weaving movements as prescribed by the Oregon Driver Manual. The Manual prescribes that the general rule for turning from an approach into the flow of traffic is to turn into the closest lane in the direction the driver wants to go. This means that upon exiting an approach, vehicles should turn into the closest lane in the desired direction of travel, followed by signaling and changing lanes until positioned in the proper lane to make the desired turn at the downstream intersection. The Manual also advises drivers to signal for a turn at least 100 feet before turning or making a lane change when the vehicle is moving in traffic. When the distance to accomplish these weaving maneuvers is not adequate, vehicles may make abrupt lane changes, not signal or signal improperly, cross multiple lanes in one movement, slow excessively, stop or partially block a through lane. These operational problems reduce the capacity of the mainline and increase the potential for crashes.

Weaving distance is an element of the functional area of an intersection¹. The upstream functional area of an intersection is comprised of the distance traveled by a driver during the perception-reaction time, plus the distance needed to change lanes and the queue length. Queue length in this guidance means the 95th percentile queue².

Collecting data can be very time consuming; therefore, once an application is received, the need for a weaving analysis should be discussed with the Region Access Management Engineer (RAME) or other qualified department staff. A preliminary review of the site should be done by viewing a current aerial of the area. The following data are typically needed:

- Posted speed
- Design vehicle
- Distance from centerline of connection to stop bar at downstream intersection or start of ramp taper
- Site Average Daily Traffic (ADT)
- Highway Annual Average Daily Traffic (AADT)
- Number of lane changes vehicle must make to get in position for downstream turn
- Urban or rural area
- 95 percentile queue length
- Identification of nearby collectors or arterials

Arterials or collectors are identified in Transportation System Plans (TSPs). County Geographic Information System (GIS) map sites and other internet mapping sites usually have aeriels and measuring tools that are adequate to perform a preliminary review. Other resources include the ODOT Digital Video Log and Highway Inventory Summary. If weaving needs to be evaluated, a field visit and measurements to all apparent points of interest may be required to ensure accurate results.

The weaving criterion is applicable where vehicles exiting the connection must cross at least one through-travel lane in order to turn at a downstream intersection or ramp. The exception is that *no weaving analysis is needed on two-lane highways with less than 5,000 AADT (two-way AADT total), approach ADT less than or equal to 400, and crash rate below 120 percent of the statewide crash rate.*

There are two weaving distance criteria used for evaluation: 1) minimum weaving distance and 2) desirable weaving distance. The minimum weaving distances in Table 2 apply when posted speed does not exceed 35 mph and volume levels are below the thresholds in Table 1. The desirable weaving distances in Tables 3 and 4 apply when the posted speed is above 35 mph or the volume thresholds in Table 2 are exceeded. The two criteria are explained below.

Minimum Weaving Distance

Thresholds are used to determine if the minimum weaving distance criterion may be used. The minimum weaving distance applies where both the posted speed is equal to or less than 35 mph, and both the site ADT and highway AADT are below the thresholds shown in **Table 1.**

Table 1: Volume Thresholds for Minimum Weaving Distance

Posted Speed <= 35 mph		
Site ADT	Maximum Highway AADT*	
	Right Turn From Approach	Left Turn From Approach
< = 400	24,000	10,000
401-1,000	22,000	9,000
1,001-2,000	19,000	7,000
2,001-3,000	17,000	6,000
3,001-4,000	15,000	5,000
4,001-5,000	14,000	3,000
> 5,000	**	**

* Highway AADT is the total two-way AADT.

**Desirable weaving distance applies.

For a couplet (one-way streets, highway AADT is the two-way AADT (includes the opposite direction).

For left turns from a couplet, use the right turn threshold.

The posted speed threshold of less than or equal to 35 mph was selected to minimize the risk of severe crashes. There is a direct link between speed and crash severity. As speeds increase, crash severity increases.

The minimum weaving distance volume thresholds were developed based on the availability of gaps and amount of delay for the vehicle exiting the connection that desires to turn directly into the far lane. The values assume a three-leg connection. If there is a connection aligned directly opposite the proposed approach, the desirable weaving distance should be used. The assumption is that if the Level of Service (LOS) is D or better and the volume to capacity (v/c) ratio is 0.70 or lower, sufficient gaps should be available to allow the driver to turn directly into the far lane without conflict with other vehicles. If the LOS is worse or the v/c ratio is higher, the driver will not be able to make this movement easily and therefore there needs to be greater weaving distance (desirable weaving distance) in order to merge with traffic one lane at a time.

If the threshold conditions are present, then it is necessary to accommodate the vehicle radius and length so that the vehicle can enter the desired lane to make the turn without partially blocking the adjacent through lane. Although ORS 811.355 requires a right turning driver to enter the right-hand lane closest to the curb or edge of the roadway, and ORS 811.340 requires a left turning driver to enter the left-hand

lane, there should generally not be a safety problem below the identified speed and volume thresholds.

If either the posted speed or volume thresholds are exceeded, the minimum distance is not applicable. Instead, the desirable weaving distance is used (see Desirable Weaving Distance section).

If the posted speed and the volume thresholds in Table 1 are not exceeded, the minimum weaving distances in Table 2 are applicable. This distance is measured from the center of the proposed approach to the back of queue or start of ramp taper (see Figure 1 below). The minimum weaving distance is based on accommodating the design vehicle's outside turning radius and length. This distance will enable the design vehicle to maneuver into the back of a queue and come to a stop without obstructing an adjacent lane. The queue length is determined from Technical Services Bulletin AM 13-08(B) on queuing.

Table 2 provides the recommended minimum distances based on typical design vehicle types. For other vehicle types or combinations such as other trucks, buses or RVs, the current edition AASHTO Green Book¹ is used to establish appropriate vehicle turn radius and length. For the purpose of this guidance, the design vehicle is the largest vehicle classification anticipated to exceed 5 percent of the total volume on the approach during the peak hour. The design vehicle does not include large vehicles that do not normally make their trips during the peak hour, such as at grocery stores, shopping centers or gas stations. Some examples of land uses with large design vehicles include manufacturing facilities, distribution centers and recreational sites (RVs, vehicles towing boats, etc.).

Table 2. Minimum Weaving Distance

Design Vehicle	Passenger Car	Single Unit Truck	WB-67 Truck
Distance from Proposed Approach to Back of Queue*	45 feet	75 feet	120 feet

* Where the queue in question is a left-turn lane, the distance is measured to either the back of queue or to the beginning of the 8-inch white stripe, whichever is greater

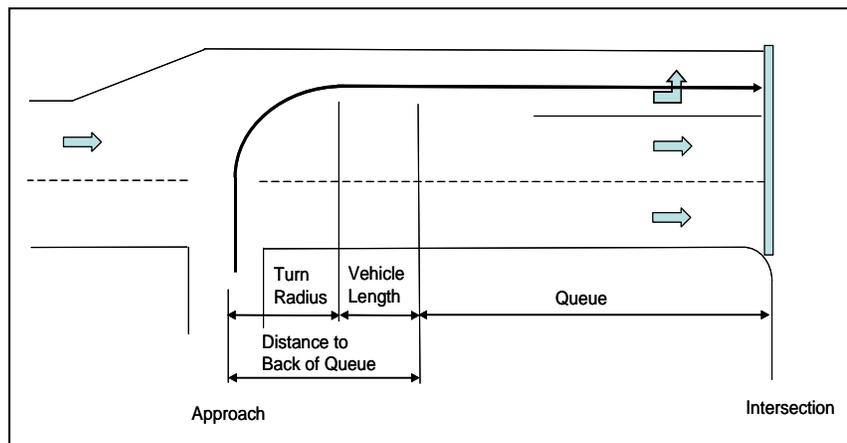
If the minimum weaving distance is applicable but the actual distance is less than the minimum distance, further evaluation is needed (see Further Evaluation section below).

^aA Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials (AASHTO)

Example 1 – measuring minimum weaving distance turning right from an approach to reach a downstream left-turn lane.

Evaluation of weaving distance is being made for a passenger car turning right from a proposed approach and crossing two through lanes in order to turn left at a downstream signalized intersection. See Figure 1 below. The highway AADT is 20,000, the site ADT is 350, and the posted speed is 35 mph. From the queue length evaluation, the distance from the proposed approach centerline to the back of queue is 75 feet.

Figure 1: Minimum Weaving Distance —
Right Turn from Proposed Approach to Downstream Left-Turn Lane



Since the posted speed is 35 mph, the speed criterion is met for minimum weaving distance. Using Table 1, the maximum highway AADT is found to be 24,000 for a right turn from an approach with less than 400 ADT. Since the actual AADT is 20,000, which is less than 24,000, the volume threshold is met. Therefore, the minimum weaving distance can be applied in this case.

Using Table 2, the minimum weaving distance from the center of the proposed approach to the back of queue is 45 feet. Since the actual distance of 75 feet exceeds 45 feet, the minimum distance is available so the weaving distance is sufficient. If the actual distance was 30 feet, then further evaluation would be needed.

Desirable Weaving Distance

Where the minimum volume thresholds in Table 2 are exceeded or the posted speed is above 35 mph, the desirable weaving distance applies. The desirable weaving distance is measured from the center of the proposed approach to the back of queue or start of ramp taper if the vehicle is destined to a ramp. The desirable weaving distance is determined from the number of lane changes (including turn lanes) and

the design vehicle type. The desirable weaving distance is based on the following driving tasks:

1. **Turning Movement.** This is the distance needed to complete a turn and position the vehicle in the closest lane in the direction of travel, as described previously for minimum weaving distance. One second of perception reaction time is also included in this distance prior to beginning the first lane change, with an assumed speed of 10 mph.
2. **Lane Change.** Lane changes may be required for a driver to maneuver into the proper lane to make the downstream turn. The lane change distance is the length required for a driver to make one or more lane changes. Unless traffic control signs or pavement markings indicate otherwise, ORS 811.355 and 811.340 require a right turning driver to enter the right-hand lane closest to the curb or edge of the roadway, and a left turning driver to enter the closest left-hand lane. The lane change distance is based on the speed of the vehicle changing lanes, which is assumed to be 15 mph for vehicles exiting an approach and desiring to turn or exit the highway at a location closely spaced downstream. Three seconds is assumed for a lane change in urban areas, four seconds in rural areas. For left turns exiting a proposed approach, the assumption is for a single-stage turn into the nearest through lane. A two-stage turn that first enters into a two-way left-turn lane, then into the nearest lane in the direction of travel would require an additional lane change.

The desirable weaving distance to the back of queue or start of ramp taper is the sum of the distances described above, with the lane change distance repeated for each required lane change.

The queue length is determined from the Technical Services Bulletin AM 13-08(B) on queuing. The desirable weaving distances are provided in Table 3 for an urban area and Table 4 for a rural area.

Table 3. Desirable Weaving Distance — Urban

Number of Lane Changes	Weaving Distance from Proposed Approach to Back of Queue or Start of Ramp Taper		
	Passenger Car	Single Unit Truck	WB-67 Truck
1	130 feet	160 feet	205 feet
2	195 feet	225 feet	270 feet
3	260 feet	290 feet	335 feet

Table 4. Desirable Weaving Distance — Rural

Number of Lane Changes	Weaving Distance from Proposed Approach to Back of Queue or Start of Ramp Taper		
	Passenger Car	Single Unit Truck	WB-67 Truck
1	150 feet	180 feet	225 feet
2	240 feet	270 feet	315 feet
3	325 feet	355 feet	400 feet

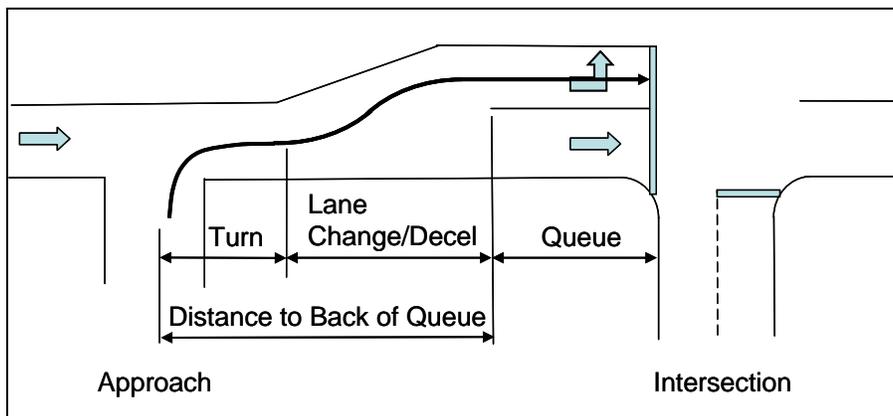
For other vehicle types or combinations such as other trucks, buses or RVs, further evaluation is needed.

Tables 3 and 4 require identifying whether the site is urban or rural, the design vehicle, and the number of lane changes the vehicle needs to make for a given weaving path. The following examples illustrate the application of this method.

Example 2 – Measuring desirable weaving distance turning right from an approach to reach a downstream left turn lane.

Evaluation of weaving distance is being made for a passenger car turning right and entering a left-turn lane at a downstream intersection. See Figure 2 below. The area is urban and the posted speed is 45 mph. The minimum weaving distance is not applicable because the posted speed exceeds 35 mph. The distance from the proposed approach centerline to the back of queue is measured (or estimated) at 100 feet.

Figure 2. Desirable Weaving Distance — Right Turn from Proposed Approach to Downstream Left Turn Lane



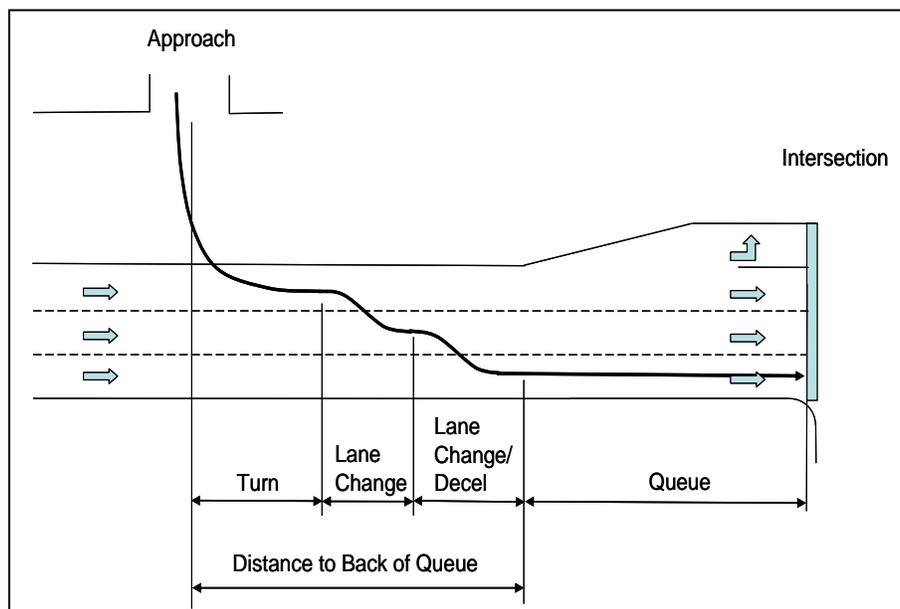
As shown in Figure 2, the weaving path requires one lane change. Applying Table 3 for an urban area with one lane change for a passenger car, the desirable weaving distance is 130 feet, measured from the proposed approach centerline to the back of

queue in the left turn lane. Since the actual distance of 100 is less than 130 feet, the available weaving distance is not sufficient, and further evaluation is needed. If the actual distance was equal to or greater than 130 feet, the available weaving distance would be sufficient.

Example 3 – Measuring desirable weaving distance turning left from an approach to reach a downstream right turn curb lane.

Evaluation of weaving distance is being made for a single unit (SU) truck turning left from a proposed approach, then maneuvering into the right turn lane at a downstream intersection. See Figure 3 below. The posted speed is 35 mph in an urban area. The site ADT is 1,000 and the highway AADT is 30,000. Since the posted speed does not exceed 35 mph, Table 1 can be used if the volume thresholds are not exceeded. However, Table 1 shows that the maximum highway AADT for to apply the minimum weaving distance is 9,000. Since the actual AADT is 30,000, the minimum weaving distance is not applicable. Therefore the desirable weaving distance is used.

**Figure 3. Desirable Weaving Distance —
Left Turn from Proposed Approach to Downstream Right Turn Curb Lane**

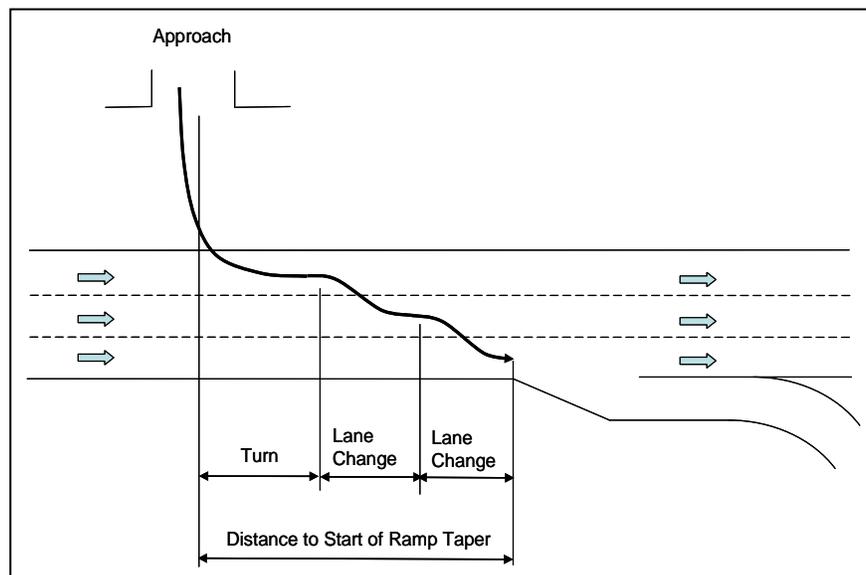


As shown in Figure 3, the weaving path includes two lane changes. Using Table 3 for an urban area with two lane changes and a SU truck, the desirable weaving distance is 225 feet, measured from the proposed approach centerline to the back of queue in the through lane.

Example 4. Measuring desirable weaving distance turning left from an approach to reach a downstream ramp.

Evaluation of weaving distance is being made for a single a WB-67 truck turning left from a proposed approach, then maneuvering to exit the highway at a ramp downstream. See Figure 4 below. The highway AADT exceeds the minimum weaving distance threshold. The area is rural.

Figure 4. Desirable Weaving Distance —
Left Turn from Proposed Approach to Downstream Ramp



Two lane changes are required. Using Table 4 for a rural area, making two lane changes in a WB-67 truck, the desirable weaving distance is 315 feet, measured from the proposed approach centerline to the start of the ramp taper.

Further Evaluation

Further evaluation is necessary where the actual weaving distance is less than the applicable minimum or desirable weaving distance. Assumptions differ from those listed above, such as:

- Four-leg connections (the minimum weaving distance thresholds assume there is no connection directly across on the other side of the highway)
- Design vehicles other than passenger car, SU truck or WB-67 truck
- Six-lane highways (the minimum weaving distance thresholds are based on two- and four-lane highways)
- A ramp enters the highway upstream of a proposed approach

The thresholds and weaving distances in this document are based on planning level assumptions. If the distances cannot be met, it may be necessary to collect site-specific

data and perform a more accurate operational analysis following procedures in the Analysis Procedures Manual (Chapters 3, 5, 7 and Addendum A).

Weaving distances less than those recommended in this Bulletin may be acceptable upon further evaluation by the RAME or other qualified staff. OAR 734-051 does not require processing a deviation to approve weaving distances less than those specified in this Bulletin.

Various factors should be considered when further evaluation is required by the RAME or other qualified staff, including:

- Signal queues that build and dissipate each cycle, allowing for vehicles to maneuver when queues are discharged. It may be appropriate to use less than the 95th percentile queue.
- Sufficient gaps are created by traffic signals, such as platooning of traffic on one-way streets.
- When an existing connection has no safety or operations concerns set forth in OAR 734-051-4020(3) and none are anticipated with the proposed increase in site ADT. For example, an existing connection with an absence of crash history may be acceptable where volumes are not anticipated to increase substantially and the location is not in a top 10 percent Safety Priority Index System (SPIS) segment
- If the evaluation is for an existing connection, observation may indicate vehicles are able to turn directly into the far lane without problems.
- If few vehicles are expected to weave, there is less risk and the use of minimum weaving distance may be acceptable.
- Alternate routes are available that reduce the frequency and need for weaving, for example within a downtown grid.
- The weaving distances in this Bulletin are based on the assumption that all of the site ADT uses the proposed approach. Multiple site connections or alternative access may reduce the demand for the weaving movement for a given site ADT.
- The department and the applicant agree on changes or a proposal that adequately address the safety or operation concerns associated with the weaving distance.
- Restriction of turning movements (signs, pork-chops, striping, medians). Such restrictions need to be analyzed to determine the effect caused by the redistribution of the trips.
- A lower posted speed may be warranted, lowering the potential crash severity.

References

1. *Functional Intersection Area - Discussion Paper No. 7*, January, 1996, Transportation Research Institute, Oregon State University:
<http://www.oregon.gov/ODOT/HWY/ACCESSMGT/docs/FnctlIntArea.pdf>
2. ODOT Highway Design Manual (HDM – 2003 English Manual) Chapter 9:
http://www.oregon.gov/ODOT/HWY/ENGSERVICES/Pages/hwy_manuals.aspx
3. ODOT Analysis Procedures Manual (APM) Addendum A, Functional Area of an Intersection: <http://www.oregon.gov/ODOT/TD/TP/APM/FA.pdf>
4. ODOT Highway Design Manual
5. Oregon Motor Vehicle Code Chapter 811:
https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2013ors811.html
6. Technical Services Bulletin AM 13-08(B): Queuing Evaluation for Approach Permitting