Part 600 Interchanges and Grade Separations

Section 601 Introduction

Interchanges and grade separations are an integral part of freeways, and also a feature of certain other facilities in select locations and contexts. Much has been learned about how interchanges operate and the role they play in safety and efficiency of our roadway network. Some features of earlier generations of freeways and other facilities have proven to be problematic or have become obsolete as the demands on them have grown. Several ODOT facilities started with a mix of interchanges and at-grade intersections, over time changing to fully access controlled highways. Some still have a mix of interchanges and at-grade intersections. In some cases, very early versions of grade separated facilities (Harbor Drive and Interstate Avenue in Portland) have been changed into at-grade arterial roadways, with vestiges of the original still in service. Valuable insights have been gained from these transitional facilities. Most of those insights have been incorporated into ODOT standards and practices over time. Detailed explanations of current standards and practices are provided in each Section.

Interchange contexts can vary widely, from simple rural locations to complex urban systems and large freeway to freeway connections. A wide variety of interchange forms have been used over the last several decades. There are some design features, however, that are common to all interchanges no matter the context.

Part 600 of the HDM provides specific guidance on design and planning for interchanges and grade separations on ODOT facilities. Design criteria and standard practices have been developed (and continue to be refined) as operational, safety, and constructability experience has increased. Key design and planning considerations are discussed in detail. Recognizing that in many (if not most) situations, it isn’t practical (or in some cases possible) to meet full standards, Part 600 includes discussion of the tradeoffs involved when working on existing facilities. Also included are numerous design aids and example applications of design criteria and practices in typical situations.

601.1 Documentation and Approval Font Key

Text within this part is presented in specific fonts that show the required documentation and/or approval if the design does not meet the requirements shown. Table 600-1 shows the four text fonts used, along with their descriptions. The text in figures, tables, exhibits, equations, footnotes, endnotes, and captions typically does not utilize the font key.

Table 600-1: Font Key

Font	Documentation	Approver
Bold text	Design Exceptions	State Roadway Engineer (SRE) and for some projects FHWA
Bold Italics text	Design Decisions Document	Region with Tech Expert input or other approver as described
Italics Text	Document decisions	Engineer of Record (EOR)
General Text (Not bold or italics)	N/A	N/A

Bold Text - Some standards appear in a bold font style. A design exception is required to justify and document not meeting a standard that appears in bold. The State Roadway Engineer (SRE) gives formal approval, and FHWA approves as required. See 601.2 for a description of design standards. In the case of 3R clear zone approvals and local agency projects off the state highway system, design exceptions can be approved by someone other than the State Roadway Engineer (see sections 402 and 1003.5).

Bold Italics Text - Both standards and guidelines may appear in a bold italics font style. While a formal design exception is not required when not meeting a standard or guideline that appears in bold italics, document and justify the decisions made by the Engineer of Record in decision documents or other engineering reports. When not meeting a standard or guideline that appears in bold italics, region approval with input from Technical Experts, or other approval as described in the HDM, is required. For urban projects, formally record decisions via the Urban Design Concurrence Document in the Design Decision portion. The Urban Design Concurrence document is located on the Highway Design Manual website. See 601.2 and 601.3 for descriptions of design standards and guidelines.

Italics Text - Design decisions that require documentation appear in italic font style in design parameters sections. While a formal design exception is not required, document the design decisions made by the Engineer of Record in decision documents or other engineering reports. See 601.3 and 601.4.

General Text - Any informational statement that does not convey any degree of mandate, recommendation, authorization, prohibition, or enforceable condition. The remaining text in the manual is general text and may include supporting information, background discussion, commentary, explanations, information about design process or procedures, description of methods, or potential considerations and all other general discussion. General text statements do not include any special text formatting. General text may be used to inform and support design exception requests, particularly where narrative explanations show best practices or methods of design that support the requested design exception.

601.2 Standards

A standard is a statement of required, mandatory, or specifically prohibitive practice regarding a roadway geometric feature or appurtenance. The verb "provide" is typically used. The adjective "required" is typically used in figures to illustrate Standard statements. The verbs "should" and "may" are not used in Standard statements. The adjectives "recommended" and "optional" are only used in Standard statements to describe recommended or optional design features as they relate to required design features. Standard statements are sometimes modified by Best Practices (see 601.4).

601.3 Guidelines

A guideline is a statement of recommended practice in typical situations. The verb "should" is typically used. The adjective "recommended" is typically used in figures to illustrate Guideline statements. The verbs "provide" and "may" are not used in Guideline statements. The adjectives "required" and "optional" are only used in Guideline statements to describe required or optional design features as they relate to recommended design features. Guideline statements are sometimes modified by Best Practices (see 601.4).

601.4 Best Practices

A Best Practice is a statement of practice that is a permissive condition and carries no requirement or recommendation. Best Practice statements sometimes contain allowable ranges within a Standard or Guideline statement. The verb "may" is typically used. The adjective "optional" is typically used in figures to illustrate Best Practice statements. The verbs "shall" and "should" are not used in Best Practice statements. The adjectives "required" and "recommended" are only used in Best Practice statements to describe required or recommended design features as they relate to optional design features.

601.5 Definitions

Definitions of some basic terms and ODOT specific terminology is appropriate. The following terms are commonly used in the context of Interchange Planning and Design.

At-Grade Intersection -	An intersection of two roadways at the same level, typically featuring stop control, roundabout control, or traffic signal control.
Grade Separation -	A roadway that is carried at a different level than a through roadway. They may be part of an interchange, or a standalone feature.

Interchange - A system of interconnecting roadways in conjunction with one or more grade separations that provides for movement of traffic between two or more roadways or highways at different levels.

Freeway - An arterial roadway with full control of access. It's intended to provide high levels of safety and efficiency in moving high volumes of traffic at high speeds. Access to a Freeway is only by way of entrance and exit ramp roadways.

Ramp - In the context of interchanges, a ramp is a connecting roadway between different level roadways. They feature full access control and perform the key function of transitioning to/ from higher speeds to lower speeds or a full stop.

FHWA - Federal Highway Administration

Access Modification Request - A formal document submitted by ODOT to FHWA regarding modified access to the Interstate System. FHWA approval is required for implementing those changes.

Interchange Area Management Plan (IAMP) - An ODOT process that is intended to provide engineering and access management guidance for new and existing interchanges. It is developed in conjunction with local officials and public input. Planned improvements, expected operational characteristics and high level environmental evaluations are part of the final document, which when approved by the Oregon Transportation Commission, becomes an amendment to the Oregon Highway Plan. Future improvements, projects, and management decisions are informed and guided by the IAMP.

Mainline - In the freeway and interchange context, the mainline is the primary or through roadway (such as an Interstate) being served by the interchange

Crossroad - The primary roadway intersecting the through roadway by way of grade separation and ramp roadways. The crossroad may be a State Highway or local jurisdiction roadway. In the interchange area, the crossroad must take into account the local context and the necessary interchange functions.

Auxiliary Lane - An Auxiliary Lane is defined as the portion (normally a full lane) adjoining the through lanes for speed change, turning, storage for turning, weaving maneuvers, truck climbing, or other purposes that supplement through traffic movements. They are typically used for relatively short section of a roadway, such as between two closely spaced interchanges.

Speed Change Lane - The portion of a ramp roadway used for speed matching, gap identification and merging maneuvers (entrances) or deceleration to appropriate speeds or a stop (exits). ODOT uses parallel type entrances and tapered type exits. Standard ramp configurations in the HDM provide the necessary/appropriate speed change lengths.

Section 602 General Information

There are three types of roadway intersections: intersections at-grade, grade separations without exit or entrance ramps, and interchanges. Each of these has specific characteristics and applications. Each is appropriate to use in the proper context. The strongly preferred approach for system planning is to use consistent control features and not mix at-grade intersections with grade separated interchanges. Grade separations without ramps are sometimes necessary on at-grade facilities due to terrain, development patterns, or the need to maintain appropriate spacing of adjacent intersections. When this approach is considered, the completeness of the supporting local road network (local roads or frontage roads for example) must also be considered; strong consideration must be given to including those elements that are missing or incomplete as part of the roadway work.

In some very unusual situations, intersections at-grade and interchanges can be used together, with appropriate spacing and other criteria being applied. However, this needs to be very carefully evaluated regarding safety and operations and implemented with exceptional care. Mixing of controls create uncertainty and confusion for roadway users (driver expectations). If users are accustomed to seeing a facility that is accessed by way of interchanges, an at-grade intersection is out of context.

An example of this is the incremental development of OR 217 (Beaverton-Tigard Highway). Although interchanges were planned at several locations, they were not built during initial construction in the mid-1960s - they had interim at-grade intersections with signals. Shortly after the facility was opened, the operational and safety issues became very apparent. Access was eventually handled by completing the remaining interchanges in the late 1970s; close interchange spacing and some confusing connections created additional ongoing issues. The highway is also affected by limited local parallel facilities.

Design and planning practitioners need to keep in mind that using an inappropriate solution for a specific context can lead to serious safety and operational issues. This section discusses both general considerations and specific design features for interchange and grade separation facilities in a variety of contexts.

Interchanges require major investments and typically have significant impact on the natural and built environments. The decision to use an interchange as a transportation solution requires adequate study, including traffic analysis, geometric design, and environmental/land use impacts. To work properly, an interchange needs to fit into the context of the roadway system, the surrounding area, and be supported by an adequate network of local facilities. When these features, for whatever reason, are not feasible, a new interchange is not advisable.

Basic interchange forms (diamond, partial cloverleaf, etc.) have inherent strengths, weaknesses and tradeoffs when they are applied. Section 603 has discussion and examples of various basic forms and issues to consider when working in both planning and design. Variations are too numerous to list; experience has taught us that it is advisable to stick with the basic forms in most cases. Striving to provide clear, simple, and familiar patterns for drivers is the best practice. When it's deemed appropriate, basic forms can be modified to fit the immediate context.

Existing interchanges often have operational and safety issues to consider as well. Much of our freeway system was designed and initially built in the late 1950s and early 1960s. Although they were deemed appropriate at the time, decisions were made without the benefit of operational experience we now enjoy. Common problem areas on these facilities include close spacing to adjacent interchanges, inadequate speed change areas, queue storage issues, crossroads that have deficient capacity, tight geometry that restricts sight lines or operations, and inadequate weaving areas on the mainline.

Close interchange spacing is often a root cause of other problems, such as speed change and weaving issues. Solutions for these types of problems are commonly expensive and difficult to implement. Existing facilities normally can't avoid these problems, unless there is a willingness to remove an interchange (although the grade separation structure may remain) or some connections. Adding frontage roads and grade separations without ramps often helps to maintain or improve the local road network around the interchange, but these come with a cost as well. When new interchanges are considered, designers and planners need to adhere to the spacing and design guidelines provided in Part 600.

Particularly during planning efforts, it is important to not default to minimum design values. Defaulting to minimums may entirely preclude future options for managing problems or make them more costly and impactful. When working in fully developed areas, compromises are normally unavoidable, at least for some elements. Designers should always look for opportunities, however, to provide as many incremental improvements as possible within the context of the work. Where greater uncertainty exists, planning for future needs should always allow for as much flexibility as is reasonable. Alternatives need to be evaluated to an appropriate level of detail to understand the implications of these basic decisions.

ODOT has several example facilities that have made provision for future needs. Some were originally built to accommodate future construction which has since taken place, and others have made provision for work yet to be done. Examples include:

- The four laning of OR 22 between Joseph Street interchange and Stayton interchange (several grade separation structures dating back to 1960).

- I-205 in Portland made provision for a future system of busways and slip ramps in some areas, and some of that space was ultimately used for Light Rail Transit.
- OR 140 in Klamath Falls has an interchange at Washburn Way; the structure overhead was constructed to provide for a four-lane section on the highway, even though the highway is currently two lanes.
- I-5 in Salem is configured with sufficient median width to allow for possible future needs.
- The recently constructed two-lane Phase 1 of the Newberg-Dundee Bypass has also made provision for future needs.

Designers and planners must remember that any interchange, no matter how simple or basic, functions as a unit. The various components each have their functions and features to make the facility work. While the interchange always needs to make appropriate accommodation for the context in which it is present, it still needs to be able to function as a discrete piece of the overall system.

602.1 Warrants for Interchanges and Grade Separations

Interchanges are integral features of freeways and are adaptable for solving safety, operational, and traffic congestion problems on other types of facilities provided that adequate access management features are present. They can vary from single ramps connecting between local facilities and arterials to large and complex arrangements connecting two or more highways or freeways. Grade separations without ramps are also integral features on freeways. They also can provide significant system benefits to other facilities. Since a wide variety of factors come into play at each location, specific warrants for justifying an interchange cannot be conclusively stated. There are several conditions that need to be considered when deciding whether to use an interchange as a transportation solution. These include:

1. Design Designation – Fully Access Controlled Facilities, e.g.
2. Reduction of Bottlenecks or Congestion
3. Reduction of Crash Frequency and Severity
4. Site Topography
5. Traffic Volume
6. Road User Benefits – Cost of Delays and Congestion, e.g.

Chapter 10 of the AASHTO *“Policy on Geometric Design of Highways and Streets – 2018”*, page 10-3 to 10-5 has a detailed discussion on things to consider for each interchange warrant. Warrants pertaining to grade separations are also located in that section

602.2 Interchange Spacing

Interchanges are expensive to build and to upgrade. Therefore, it is critical that they operate as efficiently as possible. Interchange spacing and access control should be an integral part of interchange planning and design. With the high number of vehicles and demand in an urban area, the interchange spacing for urban freeways is less than the spacing for rural interchanges. Minimum spacing for an added interchange is 3 miles in urban areas and for rural areas it is 6 miles. The spacing is measured from crossroad to crossroad.

See OAR 734, Division 51 for additional guidance on other Interstate and Non-Interstate interchange spacing criteria. Coordinate with the Region Access Management Engineer (RAME) on interchange and ramp spacing during planning and project development.

Table 600-2 shows the spacing standards for interchanges for freeway and non-freeway locations. The spacing shown is based upon crossroad to crossroad centerline distance. **Provide crossroad to crossroad spacing for new interchanges according to the values listed.**

Table 600-2: Freeway and Non-Freeway Interchange Spacing

Access Management Classification	Area	Interchange Spacing
Freeways Interstate and Non-Interstate	Urban Rural	3 miles 6 miles
Non-Freeways Expressways, Statewide, Regional, and District Highways	Urban Rural	1.9 miles 3 miles

NOTES:

Spacing distance is measured from crossroad to crossroad.

A design exception is required if interchange spacing standards are not met for new interchanges.

When long range plans call for new interchanges or converting grade separations into interchanges, new interchange criteria apply. A design exception is required where spacing standards are not met. The DE needs to be prepared by internal or external staff making the proposal.

Existing interchanges that do not meet current spacing standards do not require a design exception. *Interchange ramp spacing guidelines (explained in OAR Chapter 734, Division 51) apply and need to be considered during project development. An operational and safety analysis needs to be completed.* This analysis is prepared by ODOT or external staff doing the project work.

FHWA Interstate Access Modification approval is required for added or modified access to Interstate highways. The policy requires specific items to be addressed in a formal submittal document, known as an Interstate Access Modification Request (IMR for short). This document is prepared by ODOT or by others delegated to do so. Details on the policy are available online at: Interstate Access Policy - Interstate System - Design - Federal Highway Administration (dot.gov). Other ODOT jurisdiction highways (including freeways) are not subject to the FHWA policy; approvals in those cases are internal to ODOT.

602.3 Access Control at Interchanges

Access spacing along the crossroad in an interchange area is equally important as the interchange spacing. Spacing and operation of accesses and intersections adjacent to the ramp terminal are key part of how well service interchanges can serve their function. Recurring problems are often present in facilities operating at or near capacity. Poorly performing intersections, inadequate progression between them, and the effects of turning moves at accesses create conditions which potentially back traffic onto the freeway.

Access management is one of the most valuable tools ODOT has in preserving the existing transportation system and addressing safety issues. It allows balancing between land access and preserving the movement of traffic in a safe and efficient manner.

Access spacing standards have been developed that are dependent on the type of area adjacent to the freeway interchange. Urban areas have two types of area, fully developed and urban. A fully developed interchange management area occurs when 85 percent or more of the parcels along the developable frontage are developed at urban densities and many have driveways connecting to the crossroad. Fully developed areas are also characterized by slower speeds. Urban interchange management areas are areas within an urban growth boundary that are not fully developed. OAR 734, Division 51 and the OHP provide information and spacing requirements for interchanges and interchange management areas at urban and rural locations.

At new interchanges with new crossroads, provide access control in the interchange area consistent with the following:

1. At all rural and suburban/urban fringe area interchanges, access shall be controlled a minimum distance of 1320 feet from the centerline of the ramp. The access control shall be applied equally to both sides of the crossroad. No reservations of access are allowed within these access controlled areas. No private access is allowed across from the interchange ramp terminal.
2. All other urban interchange areas should also be access controlled for 1320 feet from the centerline of the ramp. In many existing urban interchange environments however, this distance will be very difficult to achieve due to the built-up environment surrounding the interchange. In these situations, provide access control for a minimum distance of 750 feet. This controlled section applies equally to both sides of the crossroad and shall not include any reservations of access. No private access is allowed across from the interchange ramp terminal.

When a new interchange is added to an existing crossroad, full standard spacing is often not feasible. ***In those situations, every effort needs to be made to move in the direction of meeting the full spacing criteria.*** Often it is necessary to do added traffic analysis to support decision making. Investing in this level of improvement makes it very important to understand how the system will operate, both at opening and over time with the non-standard features.

When appropriate, exceptions from the above criteria need to be developed through a deviation process associated with interchange access management area planning. This is not a design exception, but rather a part of the project's Access Management Plan. It is developed by the project team in conjunction with the Region Access Management Engineer as part of the project's decision making records. OAR 734, Division 51 provides information and rules involving access management for road connections to state highways. Potential justifications for not obtaining the minimum access control may include but are not limited to:

1. The cost of obtaining the access rights far exceeds the benefits.
2. Existing development patterns make it difficult and costly to provide alternative access routes such as frontage roads, combined access, or completing local roadway networks.
3. Topographical constraints make it impractical to achieve the desired spacings.

Exceptions from the access control standards for new interchanges with new crossroads will generally not be approved. In these situations, the standards should be achievable at a reasonable cost and impact. Only extreme cost or environmental impacts may justify an exception. Substantial inability to meet access criteria may in itself be sufficient reason to dismiss a new interchange alternative.

In those situations and contexts where meeting full spacing standards is not possible, every effort needs to be made to move in the direction of the standard. Exceptions and deviations are nearly always necessary in fully developed and urban areas. Many rural locations have significant terrain constraints that preclude full standards. Recognizing these facts, it's still important to document the reasons for not meeting the criteria, both in planning and project development.

Also remember that additional guidance on access management at interchanges can be found in the Oregon Highway Plan and OAR 734, Division 51.

602.4 Interchange Area Management Plans (IAMPs)

An Interchange Area Management Plan (IAMP) is an ODOT long term (20+ years) transportation facility plan that focuses on solutions that manage transportation and land use decisions over a period of time at an interchange. An IAMP is a valuable tool in protecting the long term function and operations of an interchange.

The ODOT Interchange Area Management Plan Guidelines provide additional information on IAMPs and are maintained by the Planning Unit of ODOT's Policy, Data, and Analysis Division. They are Facility Plans and as such require approval from the ODOT Chief Engineer or designated representative. Completed IAMPs are adopted by the Oregon Transportation Commission and become amendments to the Oregon Highway Plan.

IAMPs involve many local and state interested parties. The purpose of an IAMP includes the following objectives:

1. Protect the state and local investment in major facilities;
2. Establish the desired function of interchanges;

3. Protect the function of interchanges by maximizing the capacity of the interchanges for safe movement from the mainline highway facility;
4. Balance the need for efficient interstate and state travel with local use;
5. Preserve and improve safety of existing interchanges;
6. Provide safe and efficient operation between connecting roadways;
7. Adequately protect interchanges from unintended and unexpected development while accommodating planned community development;
8. Manage the existing interchange capacity and new capacity provided through improved interchange improvements;
9. Establish how future land use and transportation decisions will be coordinated in interchange areas between ODOT and the local governments;
10. Minimize impacts to farm and forest lands and other resource lands around rural interchanges in accordance with adopted Statewide Planning Goals;

602.5 Traffic Studies

Appropriate levels of traffic analysis are necessary for decision making and design on interchanges. This is the case regardless of the type of work (new construction or upgrading/modifying existing facilities). Traffic studies should be requested as early in the development of the design as possible, and the appropriate level of analysis detail determined at that time. Typical requests for analysis include peak hour volumes, turning movements, capacity (Volume/Capacity ratios), storage lengths and levels of service. Analysis for weaving sections, storage lengths, and spacing should also be done as needed. **Analysis shall be considered on the basis of a 20-year design life after construction of the project.** There are also situations where sensitivity analysis is needed. An example of this is estimating when traffic volumes or V/C ratios are expected to reach certain levels. This information helps to inform planning and future facility needs, which in turn can also inform current project efforts. Providing flexibility for future needs is always desirable.

602.6 Design Reviews and Approvals

Prior to the location and design stage, ODOT and FHWA approval must be obtained for the reconstruction, reconfiguration, adding an interchange, or adding new access points to an existing interchange on the Interstate system. Depending on the level of interchange detail, FHWA approval is obtained at the Division Office for new or revised access on the Interstate System, except for Freeway to Freeway and partial interchanges, which require consultation with FHWA Headquarters staff in Washington D.C. The approval procedures are submitted to and processed through the Technical Services Roadway Engineering Unit. Justification for new or modified access is based on a number of factors, including roadway system analysis, traffic studies, interchange spacing, cost/benefit ratio, etc. The HDM and following documents provide the basis of interchange planning and design process:

- AASHTO "A Policy on Geometric Design of Highways and Streets - 2018"
- AASHTO "A Policy on Design Standards-Interstate System - 2016"
- FHWA Policy Statement on Additional Interchanges to the Interstate System – May 22, 2017 Revision
- The "Oregon Highway Plan - 1999" ("OHP"), plus amendments.
- Oregon Administrative Rules (OAR) Chapter 734, Division 51.

New or modified interchanges on non-Interstate facilities do not require FHWA approval. These proposals do require coordination between Region Technical Center design staff and Roadway Engineering Section Interchange Engineers. The same fundamental principles apply as in evaluation of Interstate access.

602.6.1 Standard Interchange Layout Sheets

The proposed interchange design (new or modified) may be prepared on the Standard Interchange Layout Sheet to serve as the documentation of basic design features for the interchange. Draft copies are submitted to the Interchange Engineers in the Technical Services Roadway Engineering Unit, Transportation Planning Analysis Unit (or Region Traffic), and the Bridge Engineering Section for review. The Standard Interchange Layout Sheet, when developed, is normally developed by the Design Acceptance stage of project development, at least in draft form. Guidelines for preparation of the Standard Interchange Layout Sheet are available from the Technical Services Roadway Engineering Unit Interchange Engineers.

Section 603 Guiding Principles for Interchange Planning and Design

603.1 Route Continuity

The concept of Route Continuity refers to providing a clear directional path along the entire length of a designated route on the principal highway mainline. *Through drivers, especially those not familiar with a route, should be provided with a continuous through path on which it is not necessary to change lanes to continue on that route.* Applying this principle simplifies the driving task because it reduces lane changes and allows for simpler signing. It makes navigating unfamiliar routes easier and reduces the number of tasks drivers need to deal with at any given time. Operationally, fewer lane changes often helps to reduce congestion on the main route.

Route continuity applies to entire systems of roadways, but interchange (or series of interchanges) design features are used to provide for it. A practical aspect of route continuity is that interchange configurations and designs should favor the through route instead of heavy volume connections. Heavier movements can be accommodated with more generous geometry, more direct connections and auxiliary lanes. The net result may be that for an interchange to provide good route continuity more grade separating structures are needed. The effects of poor route continuity are more pronounced when a route goes through an urban area or on a bypass, but they still apply in other contexts.

Some locations have overlapping routes on a single roadway. In some situations, this feature is relatively simple (a US route that overlaps with an Interstate in a rural area, e.g.). In urban areas the issues are usually more complicated. Signing is more complex and weaving sections are needed in many cases. It is important to establish relative priority of the Routes (Interstate, US, State Route, e.g.). The priority Route should be given primary consideration in design (such as I-84/US 395 between Exits 188 and 209). ***When the relative priorities are essentially equal, the heavier volume route may be given design priority.*** This may not always be the case, such as two Interstates where one is a through Route and the other is a spur or looping Route (such as I-5 and I-205 or I-405). ***The primary Interstate Route should have priority in that case.*** Not all existing facilities are configured in line with this guidance - it may be infeasible in some situations.

Appropriate levels of traffic analysis, evaluation of constructability, and identifying other major constraints are needed to determine if operational/safety/incident response issues are problematic enough to warrant correction.

AASHTO's "*A Policy on Geometric Design of Highways and Streets -2018*", Section 10.9.5.5, pages 10-83 to 10-85 has a more detailed discussion of Route Continuity and Overlapping Routes, and includes illustrative examples.

603.2 Basic Number of Lanes

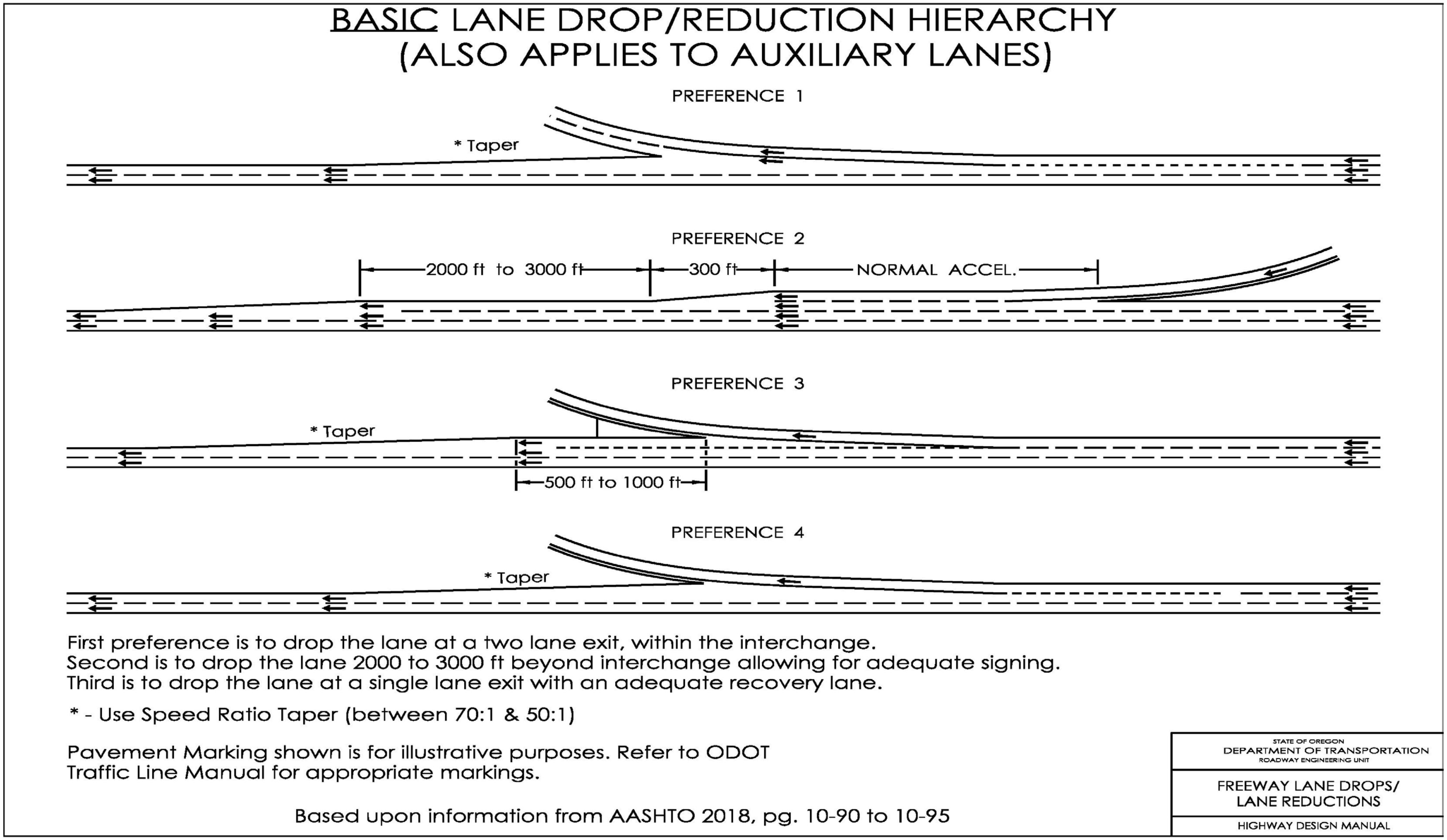
A basic lane is simply a through travel lane that continues for a specified distance along a highway route. For example, an **Interstate route has a minimum of four basic lanes (two in each direction) over its entire length.** The basic number of lanes is maintained over a significant length of the route based on the capacity needs of that section. A typical situation where the number of basic lanes varies is a through route that traverses a major urban area. Basic lanes are added and terminated at locations where volumes and system considerations make it appropriate. Localized variations in traffic volume, such as weaving areas between interchanges, do not change the basic number of lanes. These variations are handled by introducing auxiliary lanes, or in some cases Collector-Distributor roadways. (See 603.6 for discussion).

It is very important in systems planning to identify the appropriate number of basic lanes and their logical termini. AASHTO's "A Policy on Geometric Design of Highways and Streets - 2018", pages 10-86 and 10-87, discusses the concept of Basic Number of Lanes and includes a schematic (Figure 10-51) that illustrates the idea clearly. This concept is closely associated with the principles of Route Continuity and Lane Balance.

The freeway systems in Oregon were mostly planned and built between the late 1950s and early 1970s. Some of these concepts were not well defined in that era. Many of the facilities were built with minimal (or no) room allowed for future improvements. Decisions to invest in major improvements or to add capacity are not just engineering choices. The impact to the natural and man-made environment, budgets, future planning objectives, and the communities nearby generally require compromises from "ideal" solutions. While it may not be feasible to provide all the exact guidance around Route Continuity, Lane Balance, and the Basic Number of Lanes, designers need to seek every opportunity to provide for future flexibility with the updated infrastructure.

When basic through lanes are suddenly added or dropped on a facility in an unexpected manner, it often leads to confusion for users – especially those who are unfamiliar with the area. Adding a basic lane is usually not as problematic – it typically happens at major entrance ramps. Lane drops should be clearly visible to approaching users, preferably on flat horizontal alignment and grade. They should occur at places that make sense to drivers and are as free as possible from other features that place demands on drivers' attention. *Reductions in the basic number of lanes should only be done when overall traffic demand on the route drops significantly.* Examples of this include the outer edge of a major metro area, a major system interchange, or a series of service exits that remove enough demand so that the basic lane is no longer necessary. Figure 600-1 shows, in order of preference, typical configurations for dropping a basic lane.

Figure 600-1: Freeway Lane Reductions



603.3 Lane Balance

To realize efficient traffic operation through an interchange, there should be a balance in the number of traffic lanes on the highway and ramps. Design traffic volumes and capacity analysis determine the number of lanes to be used on the highway and on the ramps, but the number of lanes for some sections should be increased to ease operation from one roadway to another. See AASHTO's "A Policy on Geometric Design of Highways and Streets - 2018", pages: 10-87 to 10-90 for additional information regarding Lane Balance. Several figures are provided that illustrate the concept. Lane balance should be checked after the minimum number is determined for each roadway on the basis of the following principles:

- ***The number of lanes beyond the merging of two traffic streams should not be less than the sum of all traffic lanes on the merging roadways minus one but may be equal to the sum of all traffic lanes on the merging roadways.***
- ***For exits, the number of approach lanes on the highway should be equal to the number of lanes on the highway beyond the exit plus the number of lanes on the exit, minus one.***
- For entrance ramps bringing two lanes of traffic onto a highway, the road beyond the ramp entrance should be at least one lane wider than the road approaching the entrance. These types of entrances are often where an added basic lane begins, but not always. **The parallel design for two lane entrance ramps shall be used (see Figure 600-16 for details) in any case. Any exception from this standard requires approval by the State Roadway Engineer.** ODOT operational experience with tapered (aka "instant on") entrance connections has not been positive, particularly with two lane ramps. Exceptions are strongly discouraged.

603.4 Weaving Sections

Weaving sections occur when entrance ramps are closely followed by exit ramps, and an auxiliary lane is utilized. Such areas present special design problems due to the concentrated lane changing maneuvers of merging and diverging traffic. The development of the design involves the following factors: desired mobility standard; length; number of lanes; traffic volumes; weaving and non-weaving vehicles; and average speed. Auxiliary lane lengths generally will be below access management spacing standards and may require a deviation. Design guidance may be obtained from AASHTO's "A Policy on Geometric Design of Highways and Streets – 2018", ODOT Analysis Procedures Manual and from the Highway Capacity Manual.

Consult with the Transportation Planning Analysis Unit and Region Traffic staff for data and direction on the design of each weaving section and the location of consecutive entrance and exit ramps.

As a preliminary guide, the minimum distance between a freeway entrance and exit ramp at separate interchanges is one mile for urban freeways and two miles for rural freeway (see OAR 734, Division 51 guidelines). **Provide a minimum distance between successive freeway entrance and exit ramp terminals of 1000 feet. Provide a minimum distance for a single exit followed by a secondary exit or split of 800 feet. See Figure 600-2 for minimum spacing distances, for additional details and other ramp terminal configurations. Ramp spacing dimension is measured from painted nose to painted nose. Design exceptions from the minimum standard spacing must be obtained from the State Roadway Engineer.**

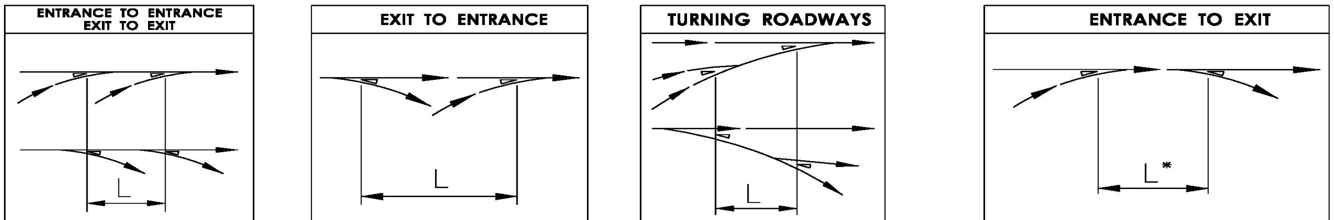
Where the distance between an entrance terminal and an exit terminal is 2500 feet or less, the interim space generally becomes a weaving section and must be analyzed for required length and design by the Transportation Planning Analysis Unit, Regional Traffic staff, or others designated to do the appropriate analysis. *Where the distance is 1500 feet or less, an auxiliary lane may be introduced.*

Collector-Distributor roads can also be used to reduce traffic friction from multiple entrance and exit connections on the same side of the freeway, thereby permitting more uniform speeds and smoother operations on the through traffic lanes. More guidance on Collector-Distributor roads is provided in Section 603.6.

Figure 600-2: Minimum Ramp Terminal Spacing

RECOMMENDED MINIMUM RAMP TERMINAL SPACING (ft.)

(BASED UPON OPERATIONAL EXPERIENCE AND NEED FOR FLEXIBILITY)



ENTRANCE TO ENTRANCE / EXIT TO EXIT

GUIDELINES	FULL FREEWAY	C-D ROAD OR FWY. DIST.
DESIRABLE	1500	1200
ADEQUATE	1200	1000
MINIMUM	1000	800

EXIT TO ENTRANCE

GUIDELINES	FULL FREEWAY	C-D ROAD OR FWY. DIST.
DESIRABLE	750	600
ADEQUATE	600	500
MINIMUM	500	400

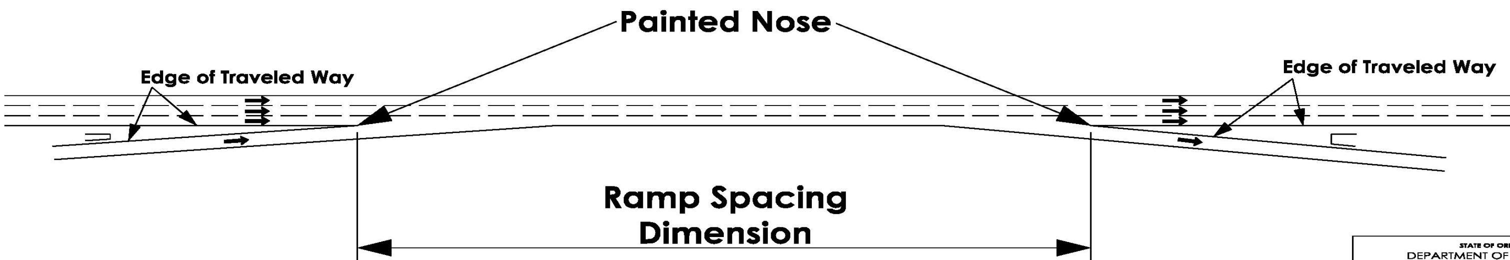
TURNING ROADWAYS

GUIDELINES	SYSTEM INTCHG.	SERVICE INTCHG.
DESIRABLE	1200	1000
ADEQUATE	1000	800
MINIMUM	800	600

ENTRANCE TO EXIT

GUIDELINES	SYSTEM TO SERVICE INTERCHANGE		SERVICE TO SERVICE INTERCHANGE		GUIDELINES
	FULL FREEWAY	C-D RD. OR FWY. DIST.	FULL FREEWAY.	C-D RD. OR FWY. DIST.	
DESIRABLE	3000	2000	2000	1500	DESIRABLE
ADEQUATE	2500	1800	1800	1200	ADEQUATE
MINIMUM	2000	1600	1600	1000	MINIMUM

* TRAFFIC ANALYSIS IS NEEDED TO VERIFY THAT OPERATIONAL NEEDS ARE ACCOMMODATED. ANALYSIS NEEDS TO MEET CRITERIA FROM THE ODOT ANALYSIS PROCEDURES MANUAL AND THE CURRENT HIGHWAY CAPACITY MANUAL.



STATE OF OREGON
DEPARTMENT OF TRANSPORTATION
ROADWAY ENGINEERING UNIT

RAMP TERMINAL SPACING

HIGHWAY DESIGN MANUAL

603.5 Auxiliary Lanes

Auxiliary lanes are introduced adjacent to through lanes for limited distances for specific operational or capacity reasons. They are used to provide lane balance, facilitate weaving maneuvers, and help smooth out flow in through lanes. A typical application is to provide an added lane on the mainline between closely spaced interchanges.

Auxiliary lanes have the same width as through lanes. Shoulders adjacent to auxiliary lanes should be the same width as the remainder of the corridor (typically 10 feet or more), **with a minimum width of eight feet (plus 2 feet if longitudinal barrier is present). Auxiliary lane drops at exits shall be configured according to the details in Figure 600-14.**

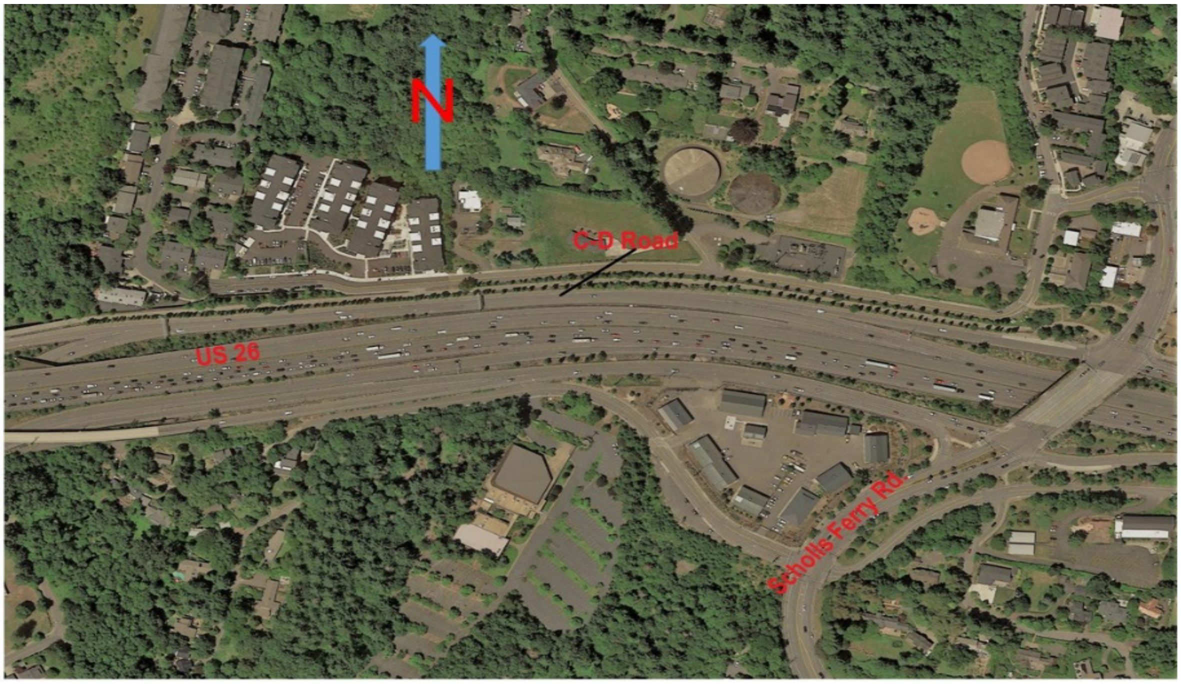
603.6 Collector-Distributor (C-D) Roads

C-D roads are introduced to freeway systems to eliminate weaving directly on mainline through lanes. They are physically separated from the through roadway and connect to it by way of slip ramps. They may be provided within a single interchange, between two adjacent interchanges, or even continuously between several interchanges of a freeway segment. Ramp connections occur on the C-D road, which then conveys traffic to the mainline lanes.

C-D roads are one-way facilities similar to frontage roads except that access to abutting property is not permitted. ***The design speed of the C-D can be less than the through roadway, although it's preferred to keep that differential to no more than 10 mph***. They may have single lane or more commonly, multi-lane configurations. **Typical cross sections for C-D roads use the ODOT standard ramp dimensions as shown in Figure 600-32.** The outer separation between edges of travelled way should be a minimum of 20 feet (preferably 30 feet) with an appropriate barrier separating the two roadways. Slip ramp connections to or from the through lanes are configured the same as any other exit or entrance ramp.

Figure 600-3 shows a C-D road system on a freeway in Portland. A two lane exit from the freeway forms the backbone, which also serves as a directional connection to an urban arterial highway. Local access ramps enter and leave from the C-D road rather than the freeway mainline.

Figure 600-3: Collector Distributor System (US 26 Sylvan Interchange - Portland)



603.7 Grade Separation Structure Considerations

In all cases, provide vertical clearance on interchange structures in accordance with Part 300 guidelines. Along with the selection of interchange form, the grade separation structure should consider vertical clearance requirements and mobility concerns.

As interchange structure options are explored (both with existing and new bridges), vertical clearance requirements for the interchange and the corridor, along with alternate “up and over” options, should be considered. Some interchange forms do not provide for direct “up and over” movement where larger oversized freight vehicles can exit the freeway and then return to the freeway at the same interchange (usually due to the oversized load being impacted by the existing interchange structure vertical clearance). They also need to provide for adequate sight lines. Particularly at depressed interchanges, structure elements can impair sight lines for traffic stopped at ramps. The appropriate sight lines to consider for design are usually based on Stopping Sight Distance, (SSD) or Intersection Sight Distance (ISD). The roadway context (urban or rural, higher or lower speed), type of intersection traffic control and geometry at the ramp intersections all need to be considered when determining which sight distance case to apply. Skewed ramp intersections and abrupt vertical curves can make it difficult to achieve sight distance goals. Shoulder widening or flaring the corners of structures may be needed to achieve SSD, so early coordination with structural designers is important. Use the “C” Table on Figure 600-23 as a guide for minimum requirements.

Although it is often appropriate to provide Intersection Sight Distance (ISD) at the intersections, this is sometimes difficult to achieve on existing facilities. When the ramp intersection is stop controlled, using ISD is the most appropriate treatment. Designers should refer to "*A Policy on Geometric Design of Highways and Streets – 2018*"- Sections 3.2 and 9.5 for guidance on selecting the most appropriate sight distance case to use. Designers should also consider using ISD at signal or roundabout controlled intersections. **SSD for the design speed of the crossroad is the minimum to be provided in all cases.**

Structure layout needs to consider future needs for both the through road and the crossroad. This normally means two things. First, the clear opening underneath the structure needs to accommodate the "ultimate" typical section envisioned for the facility (future lane additions, e.g.). Secondly, grades on the structure should also allow for future widening without restricting vertical clearance. It is also important to check sight lines on long flyover and viaduct structures. The combination of horizontal and vertical curvature and superelevation transitions can sometimes result in sight line limitations. Bridge rails can also limit sight lines. Geometric designers need to coordinate with structure designers to arrive at appropriate solutions, since it's normally impractical to widen these structures to allow for added sight distance.

Refer to AASHTO's "A Policy on Geometric Design of Highways and Streets – 2018" - Chapter 10 for detailed discussion on grade separation design.

Section 604 Interchange Types and Forms

Regardless of the type of facility, it is very important that the basic form of the interchanges fits the basic function it is expected to perform. Inappropriate applications can lead to early obsolescence and safety issues.

There are two basic types of interchanges – "System" and "Service". System interchanges connect two or more freeways. The focus is on providing free flow and higher speed connections to facilitate mobility. System interchange examples in Oregon include I-5/I-205 in Tualatin, I-84/I-82 near Hermiston, and I-5/I-105/OR 126 in Eugene-Springfield. Service interchanges connect freeways (or other expressways) to local facilities. Mobility is also an important function of service interchanges, but it needs to be balanced with the need to get access to the surrounding area and the rest of the local roadway network. The majority of ODOT interchanges are service types.

The selection of interchange form should take into account vertical clearance requirements and mobility concerns. Some interchange forms do not provide for a direct "up and over" movement where larger oversized freight vehicles can exit the freeway and then return to the freeway at the same interchange (usually due to the oversized load being impacted by the existing vertical clearance at the interchange structure). As interchange options are explored, vertical clearance requirements for the interchange and the corridor, along with alternate “up and over” options, should be considered.

A preliminary layout of guide signing is a very useful tool when comparing interchange alternatives. The sign plan may help to identify potential confusion points for drivers navigating the facility and helps to show where design features might cause operational problems. A sign concept should be developed for each alternative considered during early stages of design.

Figure 600-4 illustrates basic system interchange forms. System interchanges are often complex and need to be customized to local conditions. Because of this, they may not fit exactly to the basic forms shown. ODOT has relatively few system interchanges on its facilities, and the majority of them are in the Portland Metro area.

Figure 600-5 illustrates basic service interchange forms. They tend to be much simpler in configuration. With very few exceptions, service interchanges provide for all moves to and from the main facility. Figure 600-6 shows compact service forms. ODOT has not used the compact forms extensively, but they are considered proven concepts (when applied in the proper context).

In a few cases, system movements are provided within the confines of a service interchange, such as the I-5/Chemawa Rd/Salem Parkway and Canby/Charbonneau/Wilsonville-Hubbard Highway interchanges. A standard diamond interchange is “superimposed” over a directional Y (See Figure 600-7). For these types, additional care must be taken with respect to spacing between consecutive ramps, lane balance, guide signing, the length of speed change lanes, and providing for driver expectations. Each of these areas are discussed in more detail later in this chapter.

A few non-freeway interchange forms are shown in Figure 600-8. These types of solutions are not appropriate for Interstates or other freeways.

Figure 600-9 shows interchange forms for specialized situations. ODOT has used the Trumpet form in a few locations. It is suitable for connecting two highways as a low level system interchange, and as a service type. The Three-Level diamond is appropriate for connecting two limited access facilities, using a third level to handle turning movements through at-grade intersections, completely separate from thru moves. It too can serve as a low level system type connection. It may be adaptable in non-freeway situations where adequate access control is provided on both facilities. ODOT has not used this form, but it is used in several midwestern states and in Texas.

Partial interchanges (1/2 diamond or “Y”) have sometimes been used in less developed areas to connect local roads or bypassed routes that have no access to other highways. These are limited applications, and usually consist of a pair of interchanges. Examples include I-84 Exits 313/317 (Encina/Pleasant Valley) in Region 5, and I-5 Exits 76A & 76B (Wolf Creek) in Region 3. Partial interchanges tend to violate driver expectations, and thus can lead to operational and safety problems, especially for unfamiliar users. Drivers using service interchanges expect to be able to exit and enter the highway at the same location. FHWA policy strongly discourages the use of partial interchanges on the Interstate system.

Less than "full movement" interchanges may be considered on a case-by-case basis for applications requiring special access for managed lanes (e.g., Transit, HOV or HOT lanes) or major Park and Ride Lots. The same logic applies to non-Interstate facilities. Contact the ODOT Interchange Engineer for guidance.

Each situation and context have unique characteristics, so it is not possible to say which interchange form is most appropriate for all situations. In general, it is best to avoid using configurations that require heavy left turn demands to go through standard signalized intersections. The exceptions to this are the Single Point and Diverging Diamond forms, where the left turns are handled in a way that works better with through traffic. Also, it is good practice to use the simplest interchange form that will meet expected demands. Driver expectancy is key – drivers should be presented with clear choices and the fewest number of decisions necessary to navigate the interchange (or series of interchanges). Details for Single Point intersection layout are found in Figure 600-23 and Figure 600-24.

Full cloverleaf interchanges have operational issues that make their use problematic, even when Collector-Distributor (C-D) roads are used. The key problem is that loop ramps on the same side of the through roadway have significant safety and operational problems. Loop ramps generally have tight curvature (25 – 30 mph). The speed differentials between entering and exiting traffic combined with relatively short weaving/speed change lanes are a serious safety concern. C-D roads (discussed in detail in 603.6) can provide some limited benefits by removing the weaving and speed change maneuvers from the mainline. Traffic congestion on the C-D facility can also reach levels where backups onto freeway mainlines occur – thus rendering the C-D facility obsolete. These issues make it highly preferable to use other interchange forms**; ODOT will not approve the use of full or ¾ cloverleafs in any context.**

Partial Cloverleafs with loops in opposite quadrants are considered acceptable, although exit loop configurations have additional issues. Loop ramps of necessity are designed with sharper curves and require longer speed change lanes. Exit loops on the far side of a crossroad can have sight lines obscured by fills, or in the case of depressed interchanges, the mainline profile. Areas prone to regular freezing conditions may see more issues with vehicles sliding off loop ramps. **Transitions to exit loops on downgrades require longer spirals and the loop itself needs to have a minimum radius of 191′ (30° curve).** The area beyond the exit loop gore needs to be kept as free of obstructions as possible and should be contour graded.

There are cases where loop ramps on the same side of the crossroad work adequately. They are not configured as free-flowing ramps, but rather as "T" intersections in a Folded Diamond configuration. Figure 600-10 depicts I-84 Exit 261 (OR 82 Wallowa Lake Hwy.) in La Grande; a good example of the concept.

Figure 600-4: Examples of System Interchange Forms

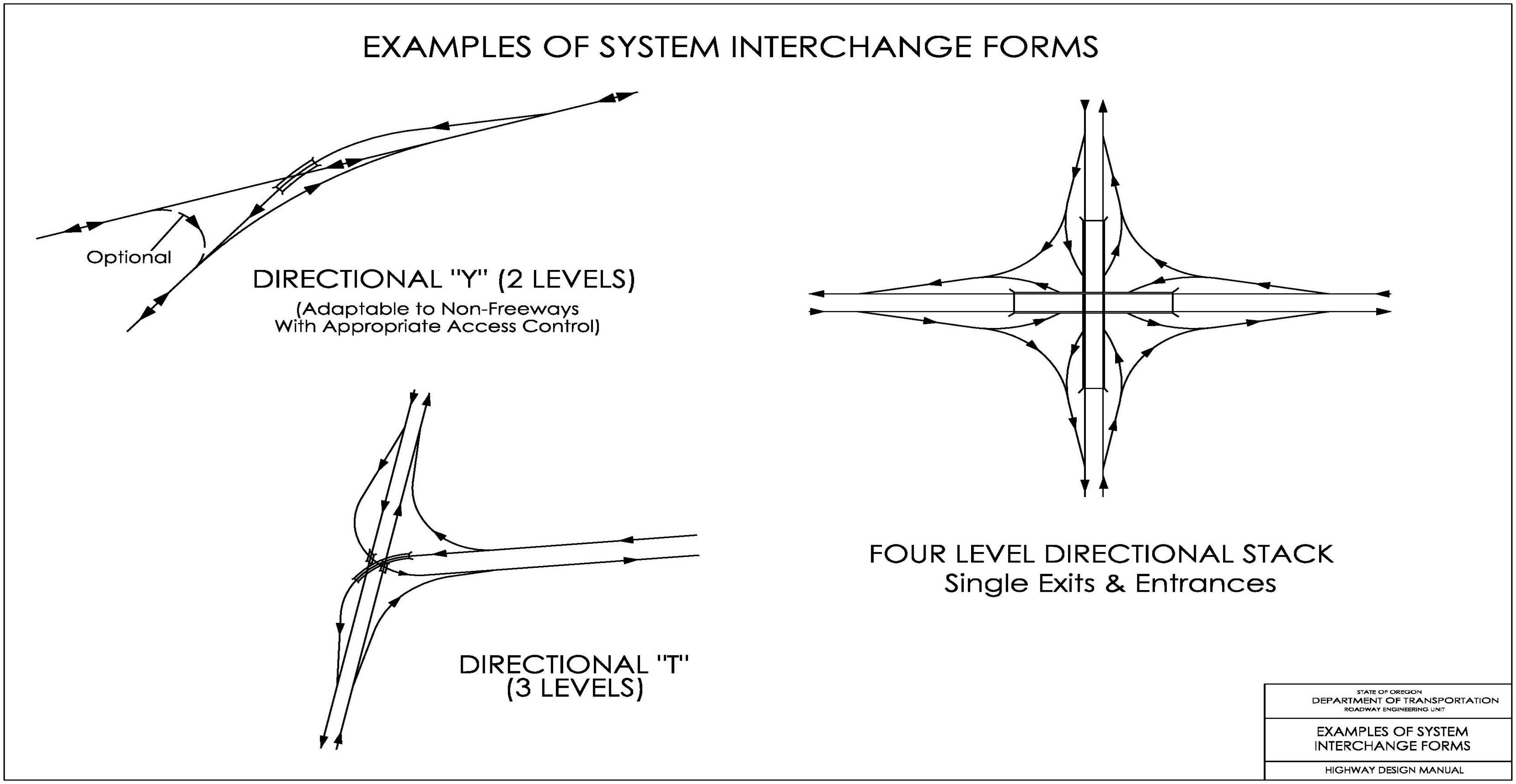


Figure 600-5: Common Service Interchange Forms

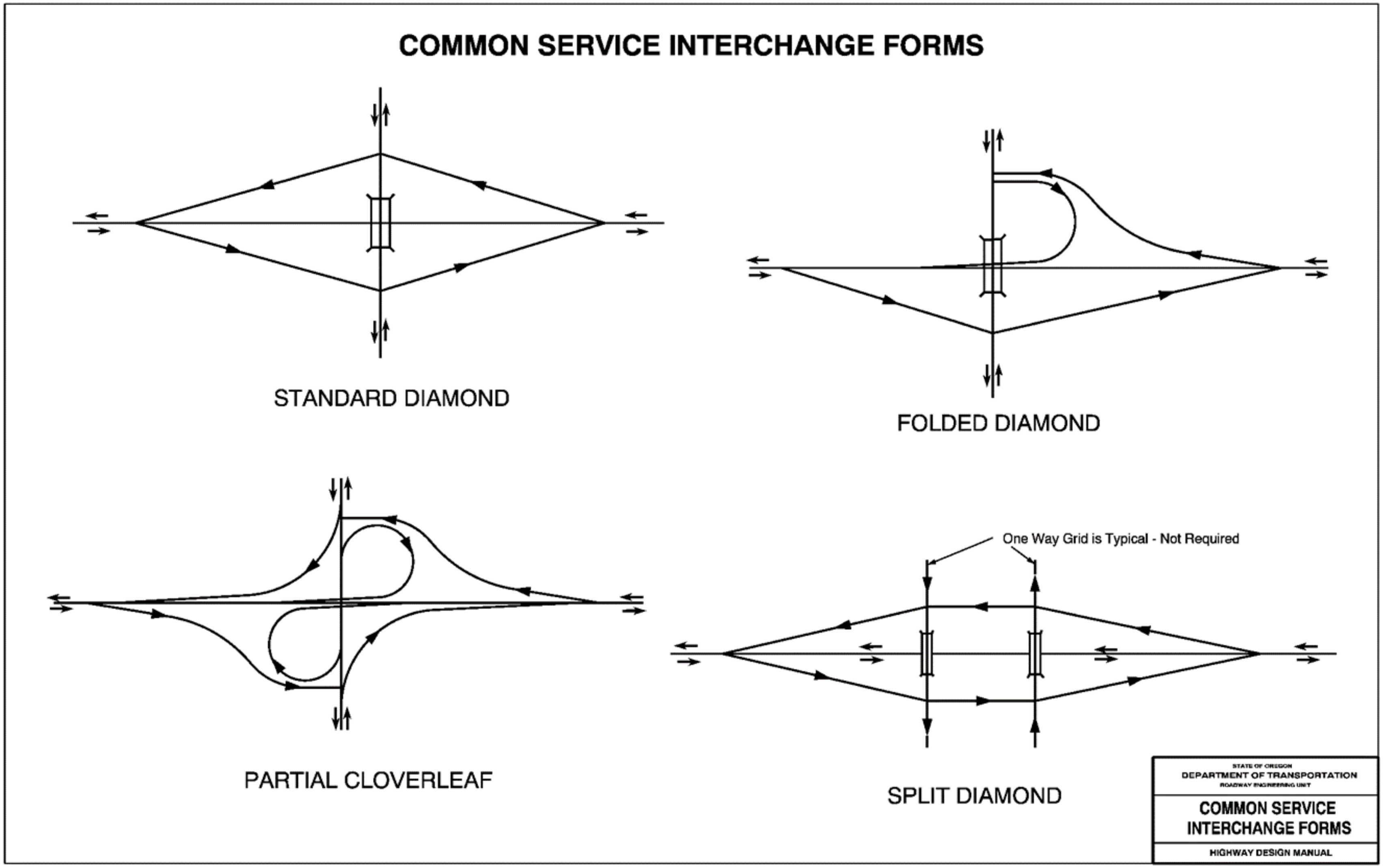


Figure 600-6: Examples of Compact Diamond Interchange Forms

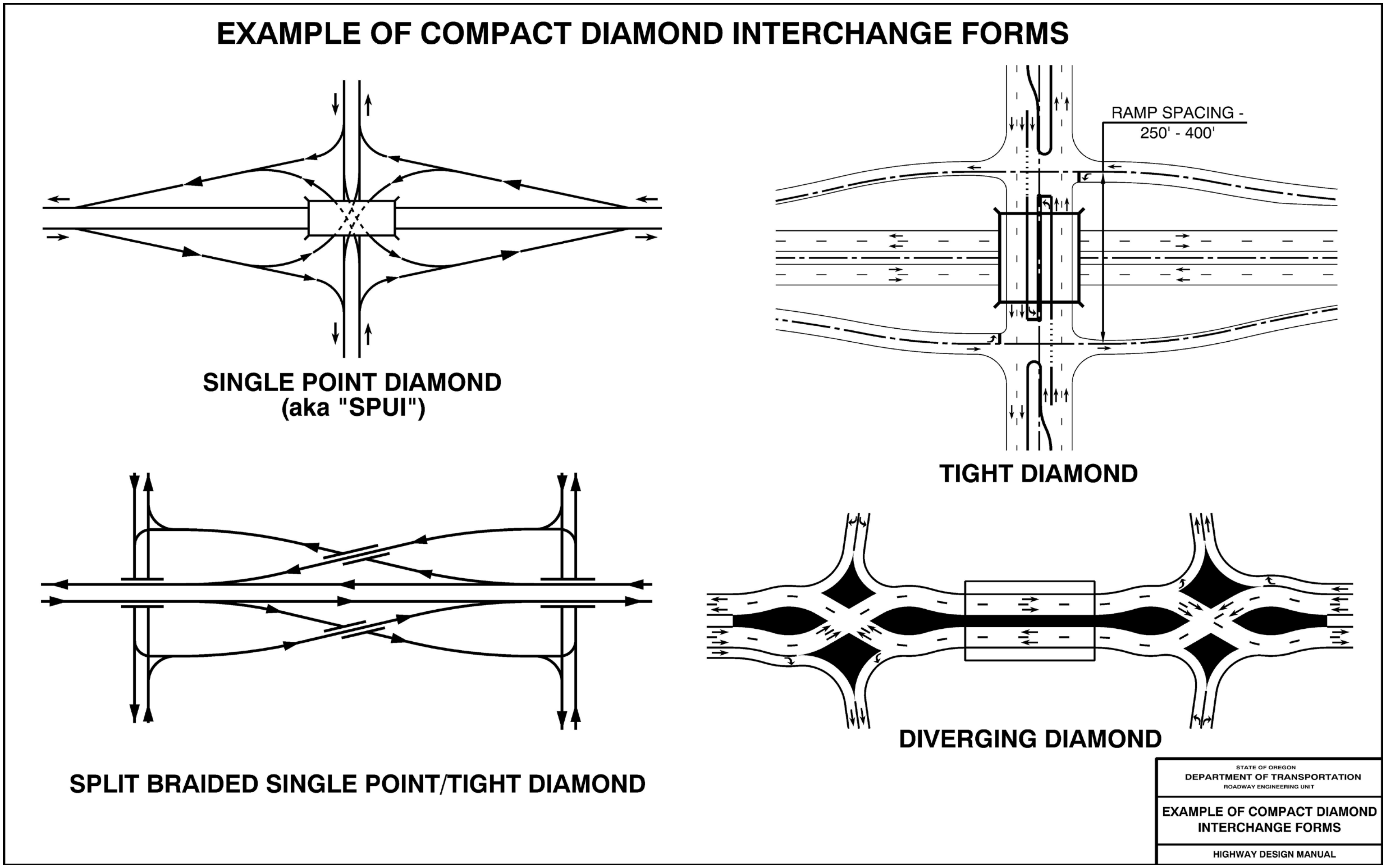


Figure 600-7: Superimposed Interchange in Keizer, OR (I-5 Exit 260)

Figure 600-8: Non-Freeway Interchange Forms

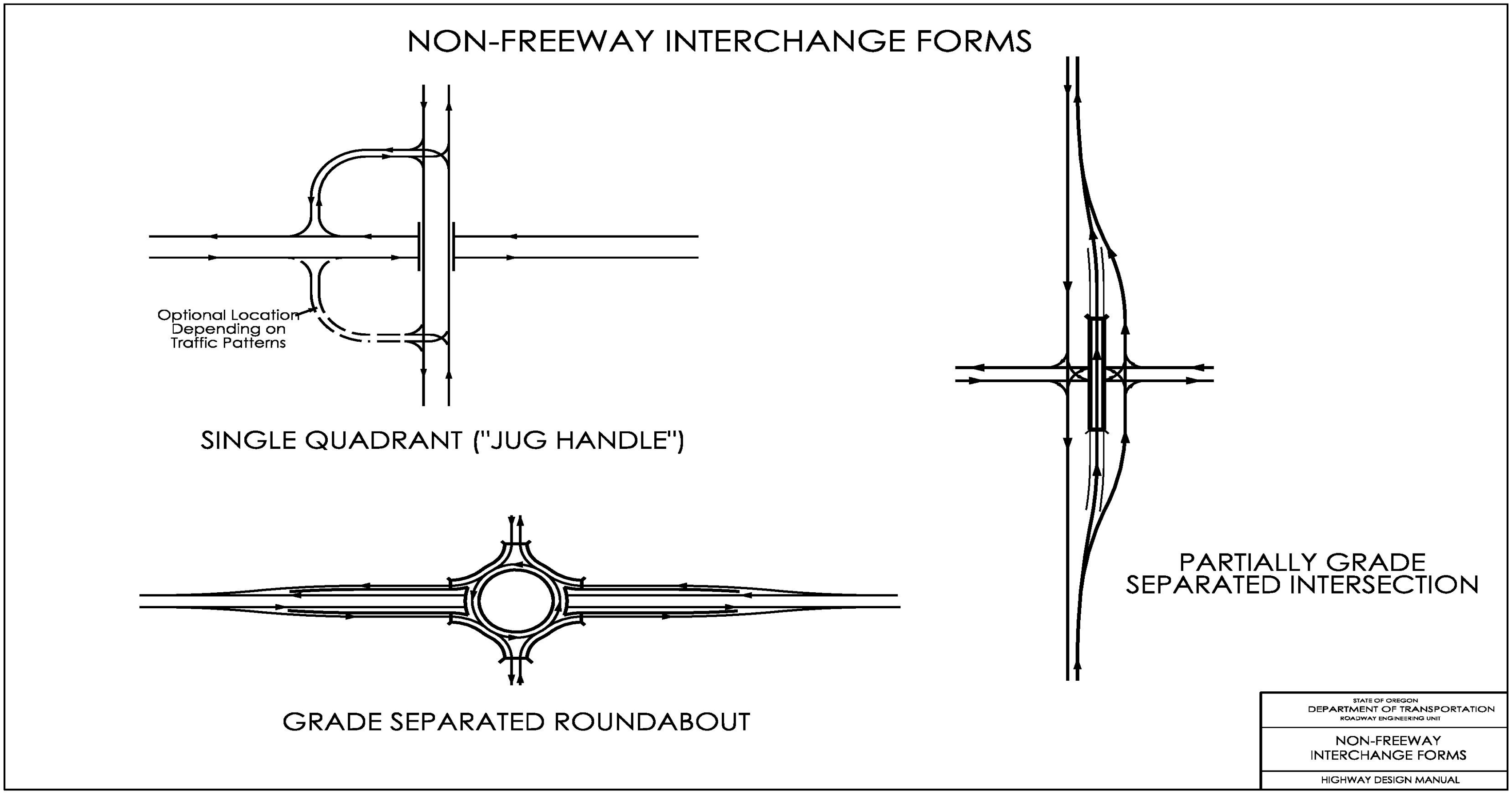


Figure 600-9: Examples of Specialized Interchange Forms

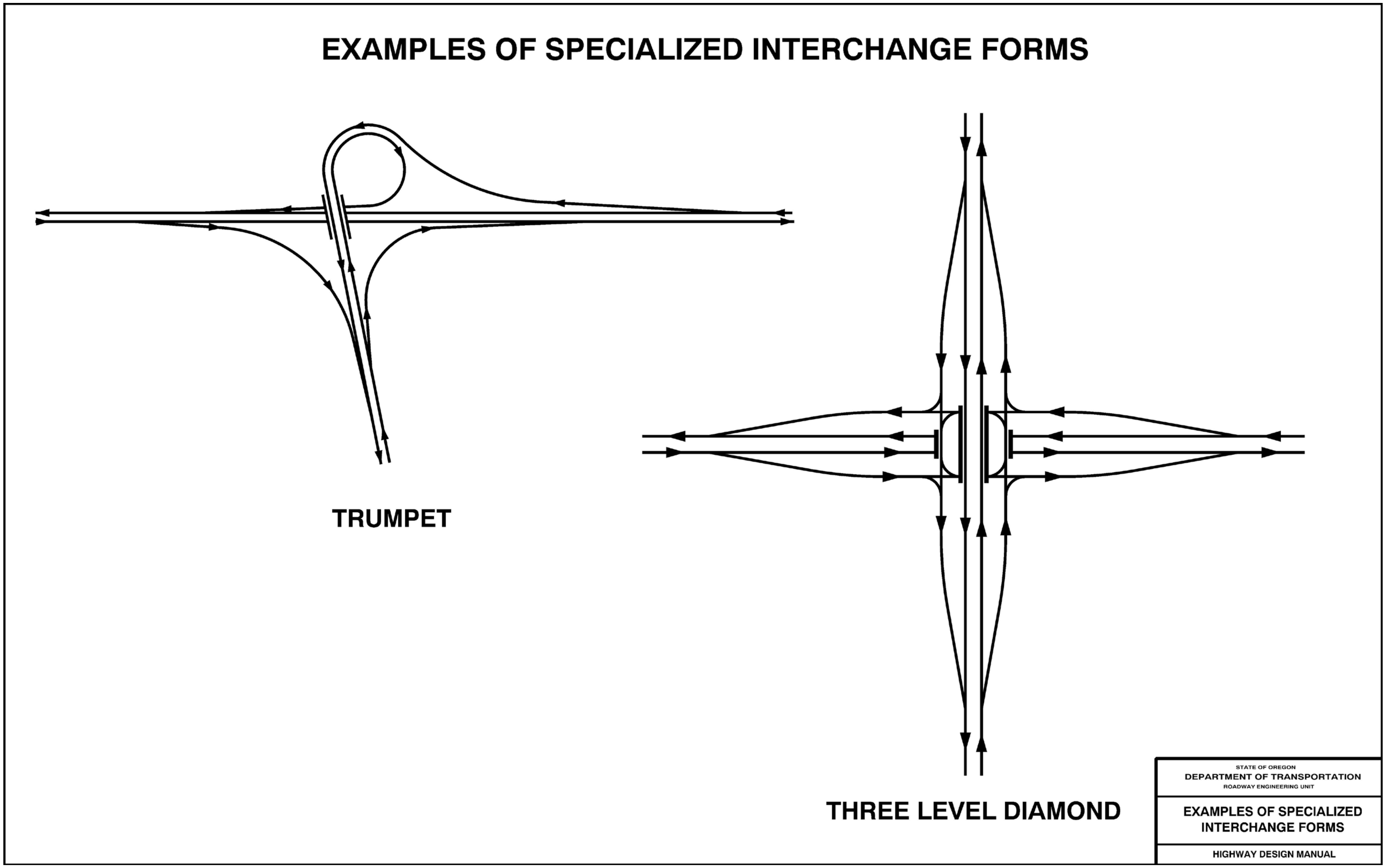


Figure 600-10: I-84 Exit 261 in La Grande

Several features and issues are common to all types of interchanges. These items are important to consider in all contexts. New or Existing facilities, Freeway or Non-Freeway, Urban, Rural or Transitional Areas - these features must be evaluated for all projects.

Common elements include:

1. Clear Sight Lines (vertical & horizontal)
2. Interchange Form – appropriate for traffic types and patterns
3. Appropriate Horizontal/Vertical Geometry
4. Adequate Speed Change Lanes
5. Driver Expectancy/Positive Guidance – adequate perception/reaction distances for typical maneuvers – all exits/entrances to the right of through traffic
6. Design Vehicle Offtracking
7. Adequate Storage for Vehicle Queues
8. Bike, Pedestrian and Transit Needs (accessibility features under the ADA for site arrival and destinations points)
9. Adequate Accommodation for Signing
10. Long Range Planning Vision for the Interchange – including the crossroad facility
11. Adaptability/Flexibility for Changing Needs Over Time

“Ideal” designs are typically not possible, especially in retrofit situations and in fully developed areas. In retrofit situations evaluating deficiencies and making tradeoffs is necessary. Designers must still consider the key features and how to make safety and operational improvements whenever possible. Tools such as the Highway Safety Manual, Interactive Highway Safety Design Model (IHSDM) and FHWA’s Interchange Safety Analysis Tool – Enhanced (ISAT-E) are available to help in evaluations. ODOT Interchange Engineer and the State Traffic Safety Engineer are available to help in using tools and providing guidance on tradeoff situations.

Section 605 Interchange Geometric Design

605.1 Crossroad Design

Parts 200, 300, 800, and 900, discuss typical section and other design elements for roadways. Crossroad design, including nearby intersections, is an integral part of the overall interchange, regardless of whose jurisdiction the road falls under. The local context for the crossroad must also be considered during design and planning efforts. Deficient crossroads often create safety and operational issues, such as vehicle queues extending back to freeway thru lanes on exit ramps. In developed areas, crossroad characteristics are largely set, and the changes need to maintain the interchange functions will require tradeoffs in the design. New interchange layouts generally have more flexibility, but need to provide good profiles, intersection design, and appropriate access management. Retrofit designs, especially in developed areas, need to carefully consider identified design and operational issues and make appropriate accommodation. In all contexts, essential information for crossroad design includes traffic volumes and queue lengths, crash history and analysis, clearly defined project goals, and clear understanding (agreed to by appropriate parties) of the crossroad context.

605.2 Interchange Ramp Design

An interchange ramp is a connecting roadway that provides for movement between grade separated roadways as part of an interchange. Well planned and designed ramps are important to the proper functioning of interchanges, which in turn are a key feature of well-planned and designed access controlled highways. Because interchange ramps are the transition roadway between high speed, free flowing traffic and the local road system, they need to accommodate the various things drivers are dealing with at that point. That functional transition needs to guide design decisions in all contexts. Designs that require drivers to deal with too much information or maneuvering in a short time span will often have operational and safety problems. Another significant problem is queuing on interchange exit ramps, sometimes extending to the mainline. Queue length is a function of interchange ramp intersection operations, in turn a function of crossroad operations. The point to remember is that interchanges work as a system, and each part of that system that struggles to function will create issues for the rest of the system.

Interchange ramps consist of three discrete elements and functions:

1. The Speed Change Area (including the gores).
2. The Main Transition Area (sometimes called the “Main Curve”, although it may be on tangent alignment).
3. The Terminal Area – which is in some ways an extension of the intersection with the crossroad.

Each discrete piece of the ramp has design features intended to accommodate typical things drivers are dealing with in that area. Interchange exit ramps that experience significant queuing will limit the speed change area’s ability to function well. Peak hour mainline speeds may be significantly less than off-peak speeds, so the speed change function is somewhat mitigated. The speed change on entrances is likewise altered during peak hours. Finding gaps and safely making the entry maneuver becomes more difficult; the length of the parallel portion of the interchange ramp needs to not only meet minimums but be as long as possible.

The Main Transition portion of the interchange ramp needs to provide for a smooth, “stepped down” driving path. This approach provides for a smooth and logical transition from freeway speeds and conditions to the situation where drivers are dealing with an at grade intersection. Stepping speeds down makes sense to users and is relatively easy to negotiate. Although stopping sight distance is the minimum criteria, every effort should be made to improve on this – decision sight distance being the goal. ***When the HDM makes reference to Design Speed on interchange ramps, it is referring to the Main Transition Area. The main transition area should have a design speed of between 50 and (preferably) 70 to 85 percent of the mainline.*** (See Figure 600-11.)

Terminal Areas should continue the “stepped down” approach for design speed (between 50 and 85 percent of the main transition curve). Refer to Figure 600-11, Figure 600-13, and Figure 600-14. Terminal curves have their own set of standard spiral lengths and superelevation rates; these are shown in Figure 600-25.

In cases where interchange ramps connect two freeways in a System Interchange, the Terminal Area is replaced with a second Speed Change Area - an exit at the leading end and entrance at the trailing end. **Two lane entrance ramps are designed according to the information in Figure 600-16.**

Oregon uses parallel type entrance ramps only. **Tapered entrances are not permitted**. **ODOT uses a tapered configuration for both single and multi-lane exits**. In certain multi-lane exit situations it is appropriate to provide an auxiliary parallel deceleration area next to the outermost through lane. An example of this is the two lane SB exit at the I-5/OR 22 (Mission St.) interchange in Salem (Exit 253).

Figure 600-11: Discrete Areas of Typical Ramps

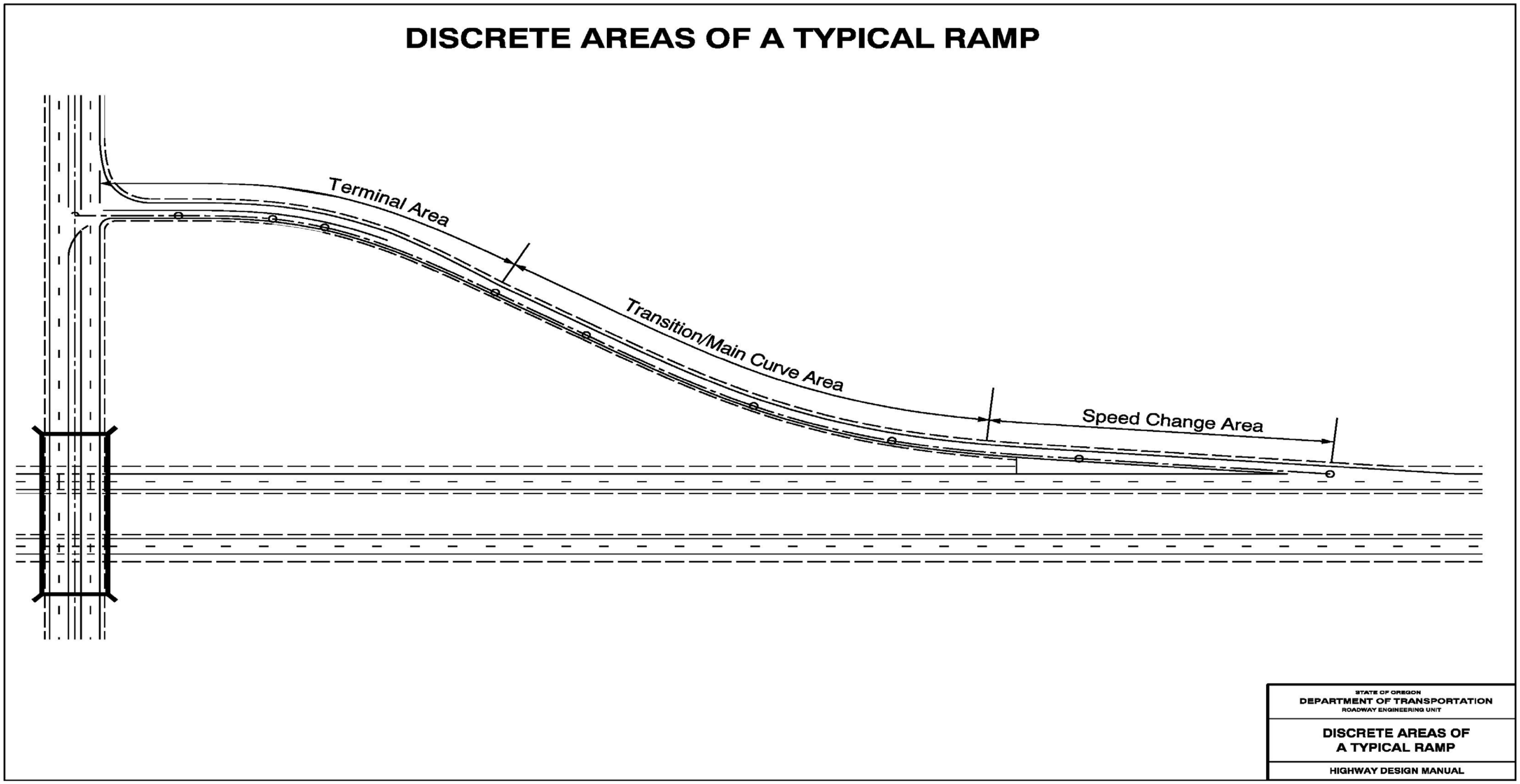


Figure 600-12 illustrates examples of different types of interchange ramps. Some types are only appropriate for non-freeway applications. Assuming adequate access control is in place, the other types can be adapted for non-freeway use as well.

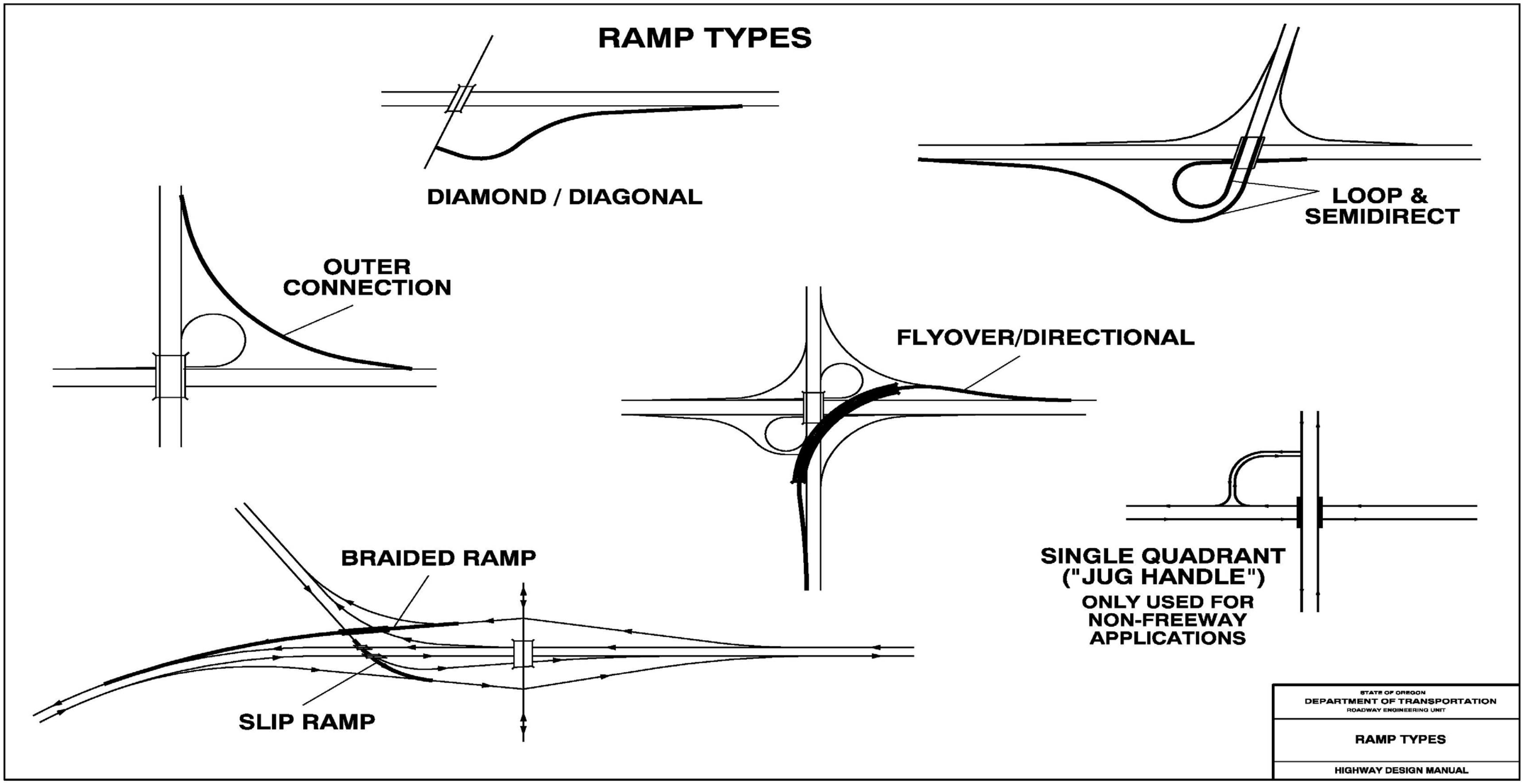
Interchange ramp designs need to provide flexibility for the future. This doesn't mean over-designing, just making sure that there is flexibility to deal with changing needs. Providing additional deceleration length and at least 100' of tangent on the horizontal alignment between the main curve and the terminal curve will often help in this regard. Designing to bare minimums often leads to operational and safety issues. Another consideration is an interchange where future lanes may be added to the right. Interchange ramp gores in these situations should be developed to fit the future condition so that the interchange ramp itself would not have to be rebuilt. The interim condition will provide added speed change length.

For interchange ramps, provide for adequate speed change length, sufficient storage for vehicles stopped on the ramp, suitable intersection design and control at the cross-road, sight distances, and standard geometry. Each of these elements needs to be checked to make sure they will be adequate and appropriate for expected operations. For additional information on ramp terminal intersections, see Section 605.8. Coordinate with the Interchange Engineers in Technical Services Roadway Engineering Unit when questions arise.

As a minimum the speed change length shall be long enough for traffic to stop before reaching the end of 95 percent queue length on the ramp. Provide for deceleration to a complete stop from mainline design speed. Coordinate with signal detection locations and operations to allow vehicle queues to clear.

Interchange ramp terminal intersection design and controls have a significant impact on the safety and efficiency of the entire interchange. If interchange ramp intersections and nearby intersections are not able to manage the traffic demands at an appropriate level, it can quickly lead to queues building up on interchange exit ramps and the cross street. This can occur because of deficient geometric design or intersection controls that are inappropriate for the context. Geometric issues are normally easy to identify but sometimes difficult to correct, especially in more fully developed areas. Evaluation of the intersection controls should be done in a timely enough manner to be incorporated into project scoping efforts.

Figure 600-12: Ramp Types



605.3 Interchange Ramp Design Speed

Interchange ramp design speed normally varies from 50 percent (minimum) to 85 percent (desirable) of the freeway speed, except for interchange loop ramps, which are usually designed to 25 or 30 mph. Design speed applies to the interchange ramp proper and not to the terminals and speed change areas, which are relative to the speed of the highway involved. The design speed influences the horizontal and vertical curvature of the ramp, and the length of speed change lanes. Table 600-3 below can be used to determine the appropriate ramp design speed. Ramp capacity is also influenced by the design speed. (See Table 600-4).

Table 600-3: Ramp Design Speed

Highway Design Speed (mph)	Desirable Ramp Design Speed (mph)	Minimum Ramp Design Speed (mph)
50	45	25
55	45	*30
60	50	*30
65	55	*35
70	60	*35

NOTE:

* Loop Ramp Design Speed shall not be less than 25 **mph (36°, 159.15′ Radius). When a loop ramp exits the mainline on a downgrade, the minimum degree of curve should be 30° (190.99′ Radius) and the spiral at the entry end should be at least 300 feet long.** ***Loop radii are seldom greater than a 30 mph design (24°, 238.73′ Radius). The footprint for larger radii curves often becomes impractical (or infeasible) in areas that have even modest levels of development.***

See Figure 600-35 and Figure 600-36 for Loop Alignment details.

Table 600-4: Single Lane Ramp Capacity

Approximate Ideal Service Flow Rates for Single Lane Ramps (Passenger Cars Per Hour)				
LOS	Ramp Design Speed (mph)			
	21 - 30	31 - 40	41 – 50	Over 50
A	*	*	*	600
B	*	*	900	900
C	*	1100	1250	1300
D	1200	1350	1550	1600
E	1450	1600	1650	1700
F	Variable	Variable	Variable	Variable

* Level of service not obtainable due to restricted design speed.

NOTE: For two lane ramps, multiply the values in the table by:

1.8 for 21 - 30 mph

1.9 for 31 - 40 mph

2.0 for 41 mph or over

605.4 Speed Change Lanes

ODOT uses tapered type exit and parallel type entrance configurations. Tapered exits fit the direct path most drivers use during the exit maneuver and give them a clear indication of the point where the exit departs from the through roadway. Parallel interchange entrance ramps provide an added lane of sufficient length to aid in gap acceptance and merging. The actual merging maneuver is similar to changing lanes to the left. The gore area is configured the same for all entrances. The length of the parallel portion varies to account for speed changing and the effects of longitudinal grades. **Figure 600-13 and Figure 600-14 show the ODOT standard for interchange ramp acceleration and deceleration lanes, and dimensions for gore areas. Information on making adjustments for grades is also shown on those two figures. Figure 600-15 shows the details for consecutive entrances at the same interchange (typical in partial cloverleaf interchanges). Figure 600-16 shows details for two lane parallel entrances.**

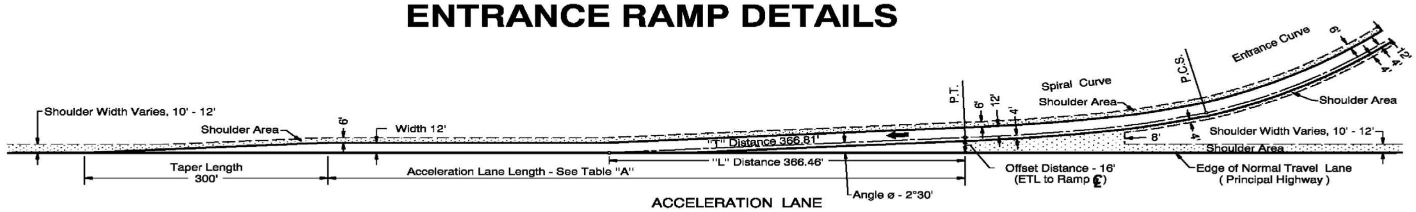
The deceleration and acceleration characteristics of trucks are quite different from the typical passenger vehicle. *When there is significant truck traffic (over 20 trucks with 4 or more axles per hour), the minimum deceleration design lengths for trucks should be consistent with Figure 600-14*. Due to the longer acceleration requirements, it is normally not practical for acceleration lanes to be designed for large trucks. Instead, all types of vehicles should be considered in the design of interchange ramps. When significant truck traffic is present, as much parallel acceleration length as is reasonable should be added to the minimum values listed in Figure 600-13.

Standard gore area details are shown on Figure 600-13 and Figure 600-14, including minimum acceleration and deceleration lengths. Since gore areas (especially exit gores) are important decision points for drivers, their layout and dimensions can directly affect safety. Gores should present drivers with a clear and easily understood view of how to transition from the mainline to the ramp (or vice-versa). Non-standard elements are not necessarily unsafe; many existing ramps have non-standard features and are not experiencing significant safety issues. Each situation needs to be evaluated for its potential effects on safety and operations and documented in a Design Exception.

Tradeoffs requiring non-standard features in gore design are unavoidable in some situations, even on new ramps. Examples of this include exits on elevated structures, bridge columns in the gore, or tightly constrained urban facilities. In these types of situations, the key elements for helping drivers make safe transitions are the deceleration (or acceleration) distance, adequate room in the gore for impact attenuators (or traffic separators), and pavement cross slopes in the gore area. Non-standard features cannot compromise these elements. Refer to AASHTO “A Policy on Geometric Design of Highways and Streets” – Chapter 10 for more information on gore design.

Figure 600-13: Entrance Ramp Details

ENTRANCE RAMP DETAILS



ACCELERATION LANE

TABLE "A"
MINIMUM ACCELERATION LANE LENGTHS

Design Speed of Turning Curve (mph)	25	30	35	40	45	50+
Minimum Curve Radius (ft.)	160	230	320	430	555	695
Design Speed of Highway (mph)	TOTAL LENGTH OF ACCELERATION LANE (WITHOUT TAPER) Length (ft.)					
40	540	540	540	540	540	540
45	540	540	540	540	540	540
50	550	540	540	540	540	540
55	780	670	550	540	540	540
60	1020	910	800	550	540	540
65	1220	1120	1000	770	*600	*540
70	1420	1350	1230	1000	820	*580

* Desirable length is **750'**, this allows additional decision time for picking gaps.

TABLE "B"
RATIO OF LENGTH OF ACCELERATION LANES
ON MAINLINE GRADES TO LENGTH ON LEVEL

Design Speed of Highway (mph)	Design Speed of Turning Roadway (mph) 25	30	35	40	45	50	ALL Speeds
	3% to 5% Upgrade						3% to 5% Down
40	1.30	1.30	1.20	1.00	1.00	1.00	0.70*
45	1.30	1.35	1.30	1.00	1.00	1.00	0.65*
50	1.35	1.40	1.40	1.40	1.35	1.00	0.65*
55	1.40	1.45	1.45	1.45	1.45	1.00	0.65*
60	1.45	1.50	1.50	1.50	1.55	1.60	0.60*
65	1.50	1.55	1.55	1.60	1.65	1.70	0.60*
70	1.55	1.60	1.65	1.70	1.75	1.80	0.60*
	5% and over Upgrade						5% and over Down
40	1.50	1.50	1.50	1.00	1.00	1.00	0.60*
45	1.55	1.60	1.65	1.00	1.00	1.00	0.60*
50	1.60	1.70	1.80	1.90	1.45	1.00	0.55*
55	1.70	1.80	1.90	2.05	2.15	1.00	0.55*
60	1.80	1.90	2.05	2.20	2.35	2.50	0.50*
65	1.95	2.05	2.20	2.40	2.60	2.75	0.50*
70	2.10	2.20	2.40	2.60	2.80	3.00	0.50*

* If the ratio from Table "B" yields a length less than 540', use 540' as the minimum acceleration lane length. The desirable length is 750', this allows additional decision time for picking gaps.

ENTRANCE CURVES & SPIRALS

Ramp Design Speed (mph)	Degree of Curve	Radius (ft)	e (%)	Spiral Length (ft.)	Spiral Parts "a" Value	Spiral Parts "S" Value
70	1° 00'	5729.58	3.5	200	0.5	1.0
	2° 00'	2864.79	6.5	200	1.0	2.0
	3° 00'	1909.86	8	240	1.25	3.6
65	4° 00'	1432.39	9	240	1.667	4.8
60	5° 00'	1145.92	9.5	250	2.0	6.25
55	6° 00'	954.93	10	240	2.5	7.2
50	7° 00'	818.51	10.5	240	2.917	8.4
	8° 00'	716.20	10.5	250	3.2	10.0
45	10° 00'	572.96	11	250	4.0	12.5
40	12° 00'	477.46	11.5	240	5.0	14.4
	14° 00'	409.26	11.5	200	7.0	14.0
35	16° 00'	358.10	12	200	8.0	16.0
	18° 00'	318.31	12	200	9.0	18.0
30	20° 00'	286.48	12	200	10.0	20.0
	24° 00'	238.73	12	200	12.0	24.0
25	30° 00'	190.99	12	200	15.0	30.0
	36° 00'	159.15	12	200	18.0	36.0

EXAMPLE:

Find: Adjusted Acceleration Lane Length
Given: Principal Highway design speed 70 mph
Turning Highway design speed 30 mph
Meeting on a 5% upgrade

Solution: From Table "A" acceleration lane length = 1350'
From Table "B" ratio on upgrade = 2.20
Adjusted acceleration lane length = 1350' x 2.20 = 2970'

Note: If adjusted acceleration lane length appears impractical, a merge analysis should be performed. Lengthening of acceleration lane length may be necessary due to high truck volumes.

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ENTRANCE RAMP DETAILS

HIGHWAY DESIGN MANUAL

Figure 600-14: Exit Ramp Details

EXIT RAMP DETAILS

EXAMPLE 1:

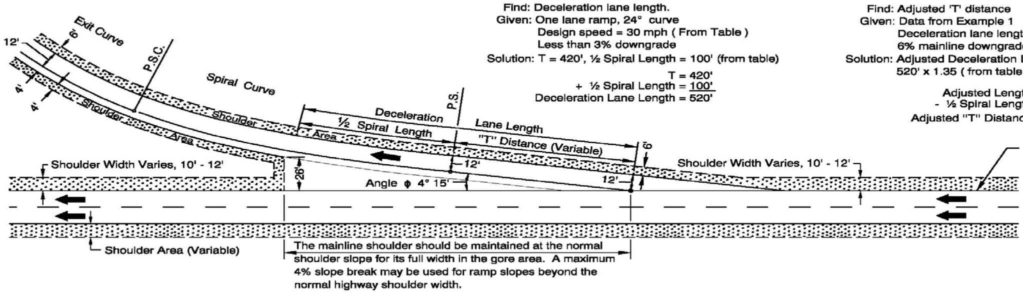
Find: Deceleration lane length.
Given: One lane ramp, 24° curve
Design speed = 30 mph (From Table)
Less than 3% downgrade
Solution: T = 420', ½ Spiral Length = 100' (from table)

T = 420'
+ ½ Spiral Length = 100'
Deceleration Lane Length = 520'

EXAMPLE 2:

Find: Adjusted 'T' distance
Given: Data from Example 1
Deceleration lane length (calculated in Example 1) = 520'
6% mainline downgrade.
Solution: Adjusted Deceleration Lane length =
520' x 1.35 (from table) = 702' (round to 705')

Adjusted Length = 705'
- ½ Spiral Length = 100'
Adjusted "T" Distance = 605'



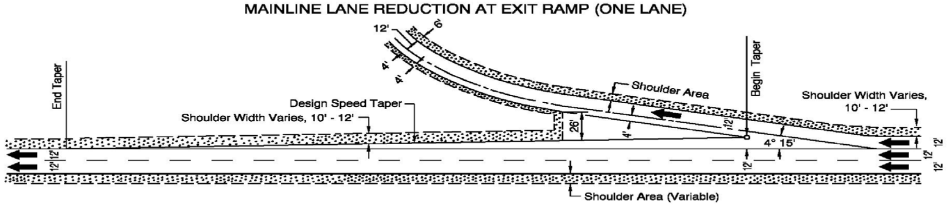
MINIMUM DECELERATION LANE LENGTHS (1 LANE)

Design Speed of Highway (mph)	Design Speed of Turning Curve (mph)					
	25	30	35	40	45	50
	DECELERATION LENGTHS (ft.)					
40	235	185	155	-	-	-
45	295	250	220	-	-	-
50	355	315	285	225	175	-
55	410	380	350	285	235	-
60	460	430	405	350	300	240
65	500	470	440	390	340	280
70	550	520	490	440	390	340

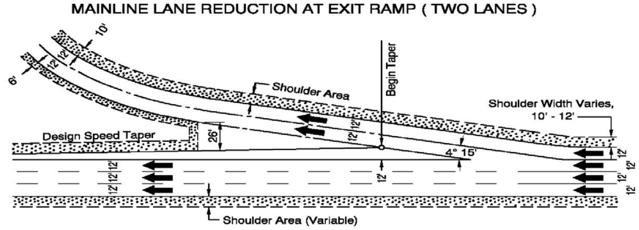
Ratio of Length of Deceleration Lanes on Mainline Grade to Length on Level		
Grade	Down	Up
3% to 5%	1 .20	0.9
5% and over	1 .35	0.8

NOTE: Adjust "T" Distance to the length required to give adjusted deceleration lane length.

MAINLINE LANE REDUCTION AT EXIT RAMP (ONE LANE)



MAINLINE LANE REDUCTION AT EXIT RAMP (TWO LANES)



EXIT CURVES & SPIRALS

Ramp Design Speed (mph)	Degree of Curve	Radius (ft)	e (%)	1 LANE (Highway Design Speed 70 mph) Spiral Length (ft.)	1 LANE Spiral Parts "a" Value	1 LANE Spiral Parts "S" Value	1 LANE "T"* Distance (ft.)	1 LANE "T" TRUCK Distance (ft.)	2 LANE (Highway Design Speed 70 mph) Spiral Length (ft.)	2 LANE Spiral Parts "a" Value	2 LANE Spiral Parts "S" Value	2 LANE "T"* Distance (ft.)	2 LANE "T" TRUCK Distance (ft.)
70	1° 00'	5729.58	3.5	200	0.5	1.0	240	340	300	0.333	1.5	300	400
	2° 00'	2864.79	6.5	200	1.0	2.0	240	340	300	0.667	3.0	300	400
	3° 00'	1909.86	8	240	1.25	3.6	220	320	360	0.833	5.4	300	370
65	4° 00'	1432.39	9	240	1.667	4.8	220	320	360	1.111	7.2	300	370
60	5° 00'	1145.92	9.5	250	2.0	6.25	215	315	375	1.333	9.375	300	365
55	6° 00'	954.93	10	240	2.5	7.2	220	320	360	1.667	10.8	300	370
50	7° 00'	818.51	10.5	240	2.917	8.4	220	400	360	1.944	12.6	300	450
	8° 00'	716.20	10.5	250	3.2	10.0	215	395	375	2.133	15.0	300	445
45	10° 00'	572.96	11	250	4.0	12.5	265	470	375	2.667	18.75	315	520
40	12° 00'	477.46	11.5	240	5.0	14.4	320	545	360	3.333	21.6	370	595
	14° 00'	409.26	11.5	200	7.0	14.0	340	565	300	4.667	21.0	400	625
35	16° 00'	358.10	12	200	8.0	16.0	390	650	300	5.333	24.0	450	710
	18° 00'	318.31	12	200	9.0	18.0	390	650	300	6.0	27.0	450	710
30	20° 00'	286.48	12	200	10.0	20.0	420	700	250	8.0	25.0	505	785
	24° 00'	238.73	12	200	12.0	24.0	420	700	240	10.0	28.8	510	790
25	30° 00'	190.99	12	200	15.0	30.0	450	745	240	12.5	36.0	540	835
	36° 00'	159.15	12	200	18.0	36.0	450	745	240	15.0	43.2	540	835

* "T" distance is based upon spiral length shown. Variations in spiral lengths will cause change in "T" distance. If spiral length is shortened, then lengthen "T" distance for minimum deceleration length. "T" should be increased if high truck volumes are present on the ramp. "T" truck distance to be used with high truck volumes.

Contact the Roadway Engineering Unit for assistance on any portion of this drawing.

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EXIT RAMP DETAILS

HIGHWAY DESIGN MANUAL

Figure 600-15: Consecutive Entrance Ramps

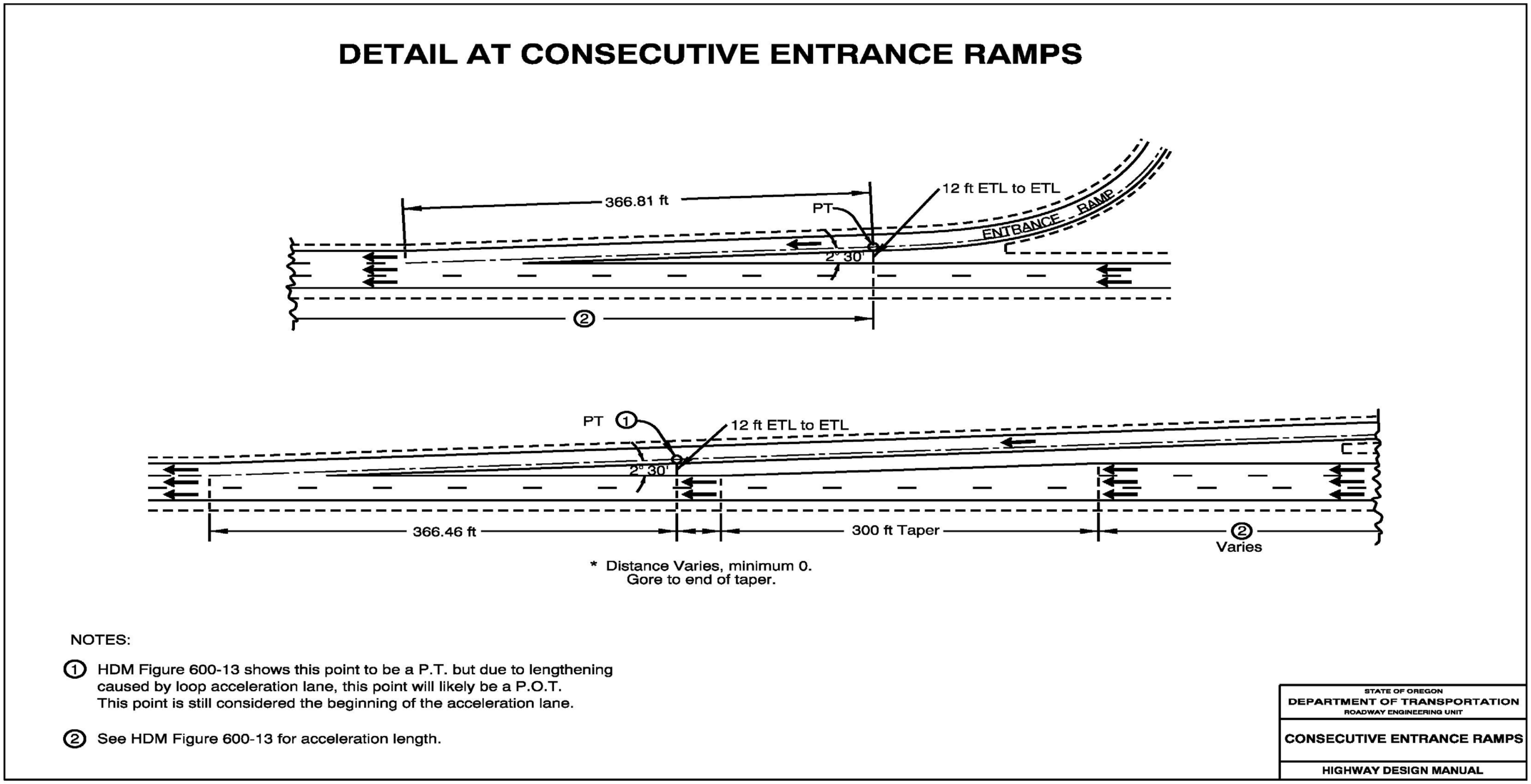

Figure 600-16: Two-Lane Parallel Entrance Ramp

TWO-LANE PARALLEL ENTRANCE RAMP DETAIL

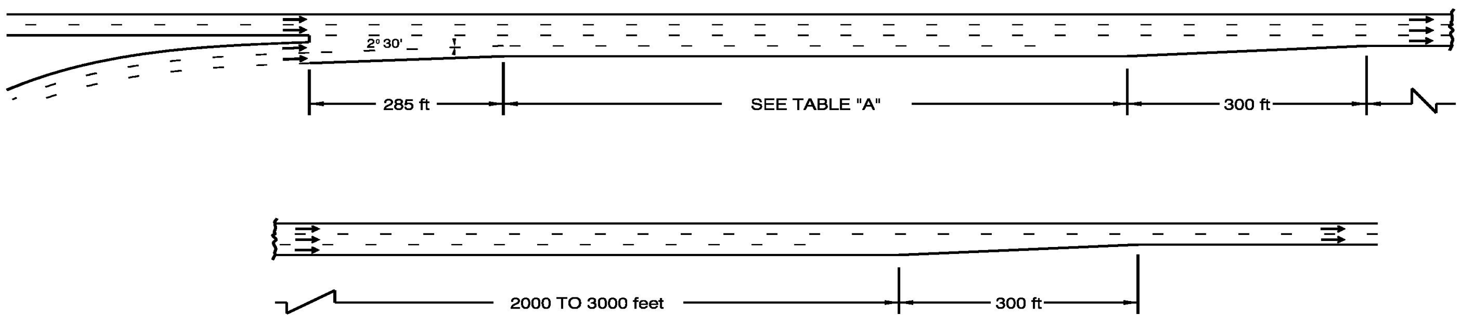

TABLE "A"

Design Speed of Turning Curve	25	30	35	40	45	50 +
Minimum Curve Radius in feet	160	230	320	430	555	695
Design Speed of Highway mph	TOTAL LENGTH OF ACCELERATION LANE (WITHOUT TAPER) Length in feet					
45	540	540	540	540	540	540
50	550	540	540	540	540	540
55	780	670	550	540	540	540
60	1020	910	800	* 550	540	540
65	1220	1120	1000	770	* 600	* 540
70	1420	1350	1230	1000	820	* 580

* Where possible minimum length for design should be 750 feet ; this allows additional decision time for picking gaps.

NOTE: This is the standard two lane ramp configuration.

Two-Lane Tapered Entrances are NOT Considered Acceptable Configurations.

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TWO-LANE PARALLEL ENTRANCE RAMP

HIGHWAY DESIGN MANUAL

605.5 Horizontal Alignment

The main curve (the curve immediately following the exit taper or preceding the entrance taper) should conform to the desirable ramp design speed, with maximum degrees of curvature shown in Table 600-5. Variations of this will require adjustments to the exit taper or acceleration lane length. Ramp alignments use standard spiral lengths that are different from those used for open road design. See Figure 600-13, Figure 600-14, and Figure 600-16 for ramp spiral data. Ramp Terminal Curve spirals also have unique values, shown in Figure 600-25.

Table 600-5: Maximum Degree of Curvature and Sight Distance on Interchange Ramps

Design Element	Design Speed of Ramp (mph)							
	25	30	35	40	45	50	55	60
Maximum Design Degree of Curvature	36°	26°	19°	14°	10°30′	8°15′	6°30′	5°
Stopping Sight Distance (feet)	159	200	250	305	360	425	495	570

The layout of the interchange is influenced by the skew and horizontal alignment of the crossroad. The skew of the crossroad to the highway should be as close to 90 degrees as possible. The use of horizontal curves on either highway through the interchange should be avoided. However, there are numerous existing interchanges on ODOT highways that include horizontal curves. It is often not practical or necessary to remove these features, unless significant safety issues have been documented that relate directly to the curved alignment. Even in those cases, there are often alternatives for solving problems that don't require major roadway realignments.

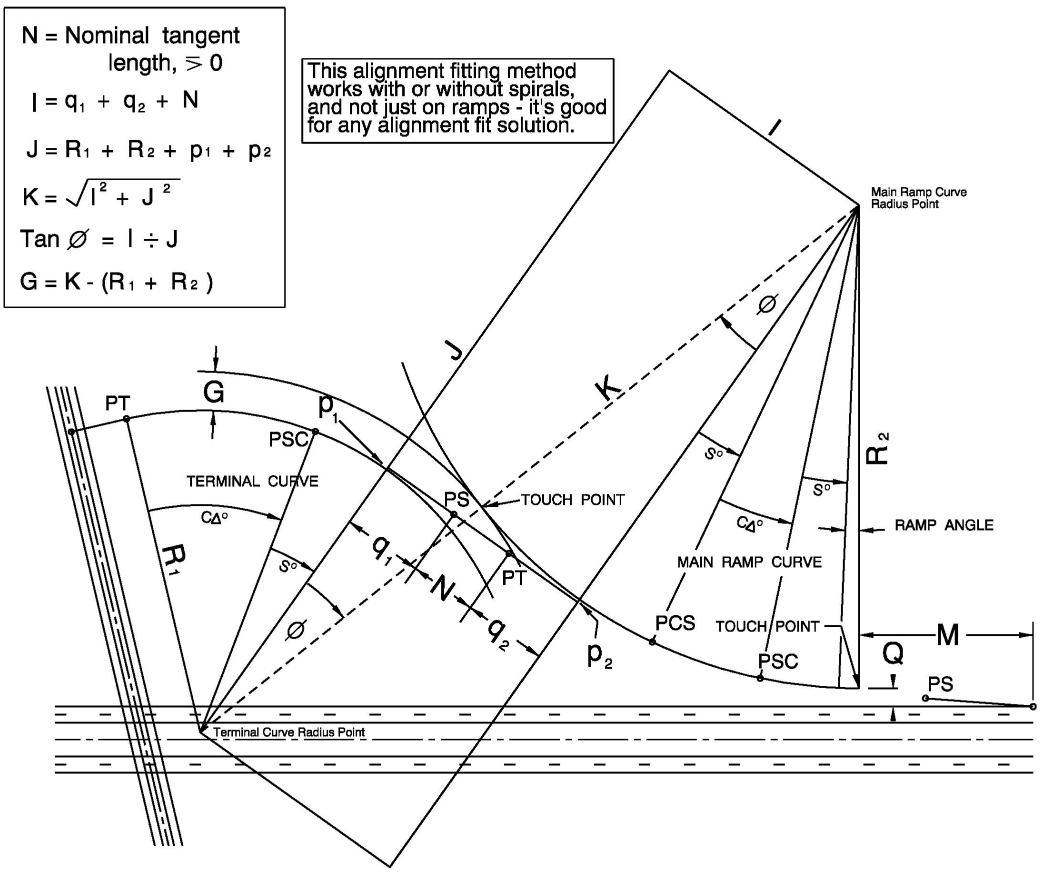
When one way, one-lane ramps exceed 1500 feet in length, consider adding a second lane to relieve congestion caused by slow moving or stalled vehicles. Steep grades and/or a high percentage of trucks may require an added lane on shorter ramps.

Typical horizontal entrance and exit details for the connection to the main highway can be found in Figure 600-13 and Figure 600-14. Ramp terminals are desirably perpendicular to the crossroad as shown on Figure 600-24. Various acceptable configurations for terminal area horizontal geometry are shown on Figure 600-24. Ramp terminal alignments that have spirals at one end only (the entering end on exit ramps and the trailing end on entrance ramps) do not require design exceptions. The first two Options are the most desirable, with Option 2 being common practice. Using Option 3 or Option 4 on Figure 600-25 is generally discouraged when developing new ramp alignments – contact the ODOT Interchange Engineer for guidance.

Designers need to keep in mind that roadside barriers and bridge ends can create sight distance restrictions for the ramp intersections. The appropriate sight distance (Stopping or Intersection) application needs to be determined, each location needs to be evaluated to clearly identify and prioritize problems and the potential solutions. The following figures (Figure 600-17 thru Figure 600-19) include numerous design aids and tools for fitting alignments. The Roadway Engineering Unit can provide guidance on the application of these tools.

Figure 600-17: Ramp Alignment Fitting

RAMP CURVE FITTING DETAIL



A.) Establish the location of the ramp terminal intersection with the crossroad. Refer to HDM Figure 600-23 (Diamond Interchange - Terminal Ramp Spread) and HDM Figure 600-24 (Detail at Ramp & Crossroad Intersection). When Loop Ramps are present refer to HDM Figures 600-36 & 600-37 (Loop Fitting Data), HDM Figure 600-34 (Partial Cloverleaf Intersection Detail) and Figure 600-35 (Folded Diamond Terminal Detail) to fix terminal location.

B.) Choose curves and tangency between them appropriate for the individual situation. Normally the Terminal Curve is designed to between 50 and 75% of the Main Curve design speed. The Main Curve design speed should be between 70 and 85% of the Thru Roadway design speed. The tangent length between curves is variable - strive for 100'.

C.) Having established the ramp terminal, and appropriate ramp curves, the next steps are:

1.) Establish radius point of terminal curve.

2.) Look up values for p_1 & q_1 from HDM Fig. 600-25 (for the Terminal Curve) and p_2 & q_2 from HDM Figure 600-18/600-19 (For the Main Ramp Curve). Q & M are also found in Figure 600-18/600-19.

3.) Compute value of "K".

4a.) Establish touch points for main ramp curve from the formula "K - R = distance from radius point of terminal curve" and "Q = distance from edge of travel lane".

4b.) Establish radius point of main ramp curve "K" distance from radius point of terminal curve and "Q + R_2" from edge of travel lane.

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RAMP CURVE FITTING DETAIL

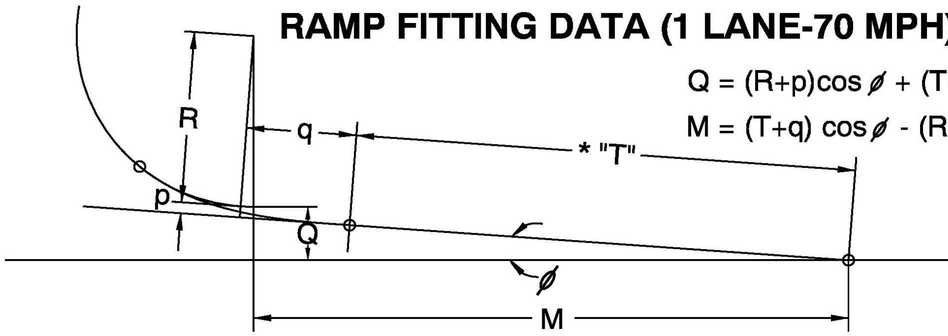
HIGHWAY DESIGN MANUAL

Figure 600-18: Alignment Fitting Data 70 MPH

RAMP FITTING DATA (1 LANE-70 MPH)

$Q = (R+p)\cos\phi + (T+q)\sin\phi - R$

$M = (T+q)\cos\phi - (R+p)\sin\phi$



RAMP FITTING DATA @ HIGHWAY DESIGN SPEED 70 MPH									EXIT ∅ = 4°15'			ENTRANCE ∅ = 2°30', T= 366.81		
mph	D	R	L	e %	a	S°	p	q	*T	Q	M	Q	M	Accel
70	1	5729.58	200	3.5	0.50	1.00	0.2909	99.9990	240	9.7316	-85.5679	15.1992	216.4307	580
70	2	2864.79	200	6.5	1.00	2.00	0.5818	99.9959	240	17.8991	126.7127	18.2163	341.3753	580
70	3	1909.86	240	8.0	1.25	3.60	1.2565	119.9842	220	21.1970	197.4194	20.6711	402.9686	580
70	3°15'	1762.95	240	8.5	1.35	3.90	1.3611	119.9815	220	21.7051	208.2964	20.9154	409.3695	580
65	3.5	1637.02	240	9.0	1.46	4.20	1.4658	119.9785	220	22.1556	217.6178	21.1397	414.8547	580
65	3.75	1527.89	240	9.0	1.56	4.50	1.5705	119.9753	220	22.5598	225.6946	21.3480	419.6074	580
65	4	1432.39	240	9.0	1.67	4.80	1.6751	119.9719	220	22.9265	232.7603	21.5433	423.7648	580
60	4.25	1348.14	250	9.5	1.70	5.31	1.9311	124.9642	215	23.4129	238.9779	22.0970	432.4164	580
60	4.5	1273.24	250	9.5	1.80	5.63	2.0446	124.9599	215	23.7317	244.5156	22.2815	435.6741	580
60	4.75	1206.23	250	9.5	1.90	5.94	2.1581	124.9553	215	24.0288	249.4689	22.4585	438.5876	580
60	5	1145.92	250	9.5	2.00	6.25	2.2716	124.9504	215	24.3075	253.9252	22.6290	441.2085	580
55	5.5	1041.74	250	10.0	2.20	6.88	2.4985	124.9400	215	24.8195	261.6182	22.9545	445.7323	580
55	6	954.93	240	10.0	2.50	7.20	2.5119	119.9369	220	25.0713	268.0476	22.8322	444.5199	580
55	6.5	881.47	240	10.0	2.71	7.80	2.7209	119.9259	220	25.4809	273.4649	23.1104	447.7040	580
50	7	818.51	240	10.5	2.92	8.40	2.9299	119.9141	220	25.8616	278.1036	23.3787	450.4294	580
50	7.5	763.94	250	10.5	3.00	9.38	3.4056	124.8885	215	26.4841	282.0868	24.1228	457.7586	580
50	8	716.20	250	10.5	3.20	10.00	3.6321	124.8732	215	26.8402	285.5931	24.3939	459.8161	580
45	8.5	674.07	250	11.0	3.40	10.63	3.8586	124.8569	265	30.8861	338.5447	24.6596	461.6275	820
45	9	636.62	250	11.0	3.60	11.25	4.0850	124.8395	265	31.2136	341.2859	24.9206	463.2338	820
45	9.5	603.11	250	11.0	3.80	11.88	4.3113	124.8212	265	31.5300	343.7340	25.1777	464.6672	820
45	10	572.96	250	11.0	4.00	12.50	4.5374	124.8019	265	31.8370	345.9328	25.4315	465.9534	820
45	10.5	545.67	250	11.0	4.20	13.13	4.7635	124.7817	265	32.1360	347.9177	25.6825	467.1134	820
40	11	520.87	250	11.5	4.40	13.75	4.9894	124.7604	315	36.1333	399.5805	25.9308	468.1642	1000
40	12	477.46	240	11.5	5.00	14.40	5.0152	119.7478	320	36.2775	402.7827	25.7793	465.0486	1000
40	13	440.74	200	11.5	6.50	13.00	3.7746	99.8286	340	35.1473	405.6771	23.7060	446.8046	1000
40	14	409.26	200	11.5	7.00	14.00	4.0638	99.8013	340	35.5202	407.9615	24.0236	448.1378	1000
35	15	381.97	200	12.0	7.50	15.00	4.3527	99.7720	390	39.5866	459.7953	24.3370	449.2860	1230
35	16	358.10	200	12.0	8.00	16.00	4.6413	99.7406	390	39.9377	461.5118	24.6466	450.2834	1230
35	17	337.03	200	12.0	8.50	17.00	4.9296	99.7073	390	40.2807	463.0183	24.9533	451.1564	1230
35	18	318.31	200	12.0	9.00	18.00	5.2176	99.6719	390	40.6168	464.3493	25.2573	451.9252	1230
35	19	301.56	200	12.0	9.50	19.00	5.5052	99.6346	390	40.9469	465.5323	25.5590	452.6061	1230
30	20	286.48	200	12.0	10.00	20.00	5.7925	99.5952	420	43.4952	496.5066	25.8586	453.2120	1350
30	22	260.44	200	12.0	11.00	22.00	6.3659	99.5106	420	44.1324	498.3098	26.4526	454.2384	1350
30	24	238.73	200	12.0	12.00	24.00	6.9377	99.4180	420	44.7555	499.7834	27.0405	455.0676	1350
30	26	220.37	200	12.0	13.00	26.00	7.5077	99.3175	420	45.3669	501.0019	27.6230	455.7434	1350
25	28	204.63	200	12.0	14.00	28.00	8.0758	99.2092	450	48.1919	531.9358	28.2007	456.2970	1420
25	30	190.99	200	12.0	15.00	30.00	8.6417	99.0931	450	48.7852	532.7891	28.7741	456.7514	1420
25	34	168.52	200	12.0	17.00	34.00	9.7667	98.8376	450	49.9500	534.1161	29.9083	457.4272	1420
25	36	159.15	200	12.0	18.00	36.00	10.3256	98.6984	450	50.5227	534.6296	30.4694	457.6721	1420

* NOTE: Where exit ramp "T" distances are variable for grades in excess of 3% see HDM Figure 600-14 to calculate "T" distance.

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RAMP FITTING DATA (1 LANE - 70 MPH)

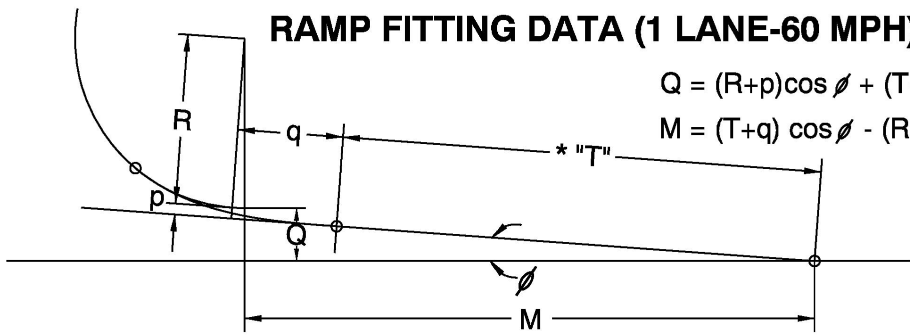
HIGHWAY DESIGN MANUAL

Figure 600-19: Alignment Fitting Data 60 MPH

RAMP FITTING DATA (1 LANE-60 MPH)

$$Q = (R+p)\cos\phi + (T+q)\sin\phi - R$$

$$M = (T+q)\cos\phi - (R+p)\sin\phi$$



RAMP FITTING DATA @ HIGHWAY DESIGN SPEED 60 MPH									EXIT ϕ = 4° 15'			ENTRANCE ϕ = 2°30', T= 366.81		
Ramp Curve (mph)	D	R	L	e %	a	S°	p	q	*T	Q	M	Q	M	Min. Accel
70	1	5729.58	200	3.5	0.50	1.00	0.2909	99.9990	140	2.3208	-185.2929	15.1992	216.4307	*540
70	2	2864.79	200	6.5	1.00	2.00	0.5818	99.9959	140	10.4882	26.9877	18.2163	341.3753	*540
70	3	1909.86	240	8.0	1.25	3.60	1.2565	119.9842	120	13.7861	97.6944	20.6711	402.9686	*540
70	3°15'	1762.95	240	8.5	1.35	3.90	1.3611	119.9815	120	14.2943	108.5713	20.9154	409.3695	*540
65	3.5	1637.02	240	9.0	1.46	4.20	1.4658	119.9785	120	14.7447	117.8927	21.1397	414.8547	*540
65	3.75	1527.89	240	9.0	1.56	4.50	1.5705	119.9753	120	15.1489	125.9696	21.3480	419.6074	*540
65	4	1432.39	240	9.0	1.67	4.80	1.6751	119.9719	120	15.5156	133.0353	21.5433	423.7648	*540
60	4.25	1348.14	250	9.5	1.70	5.31	1.9311	124.9642	115	16.0020	139.2529	22.0970	432.4164	*540
60	4.5	1273.24	250	9.5	1.80	5.63	2.0446	124.9599	115	16.3209	144.7906	22.2815	435.6741	*540
60	4.75	1206.23	250	9.5	1.90	5.94	2.1581	124.9553	115	16.6180	149.7438	22.4585	438.5876	*540
60	5	1145.92	250	9.5	2.00	6.25	2.2716	124.9504	115	16.8967	154.2002	22.6290	441.2085	*540
55	5.5	1041.74	250	10.0	2.20	6.88	2.4985	124.9400	115	17.4087	161.8932	22.9545	445.7323	*540
55	6	954.93	240	10.0	2.50	7.20	2.5119	119.9369	120	17.6604	168.3225	22.8322	444.5199	*540
55	6.5	881.47	240	10.0	2.71	7.80	2.7209	119.9259	120	18.0701	173.7398	23.1104	447.7040	*540
50	7	818.51	240	10.5	2.92	8.40	2.9299	119.9141	120	18.4508	178.3786	23.3787	450.4294	*540
50	7.5	763.94	250	10.5	3.00	9.38	3.4056	124.8885	115	19.0733	182.3618	24.1228	457.7586	*540
50	8	716.20	250	10.5	3.20	10.00	3.6321	124.8732	115	19.4294	185.8681	24.3939	459.8161	*540
45	8.5	674.07	250	11.0	3.40	10.63	3.8586	124.8569	150	22.3637	223.8609	24.6596	461.6275	*540
45	9	636.62	250	11.0	3.60	11.25	4.0850	124.8395	150	22.6911	226.6021	24.9206	463.2338	*540
45	9.5	603.11	250	11.0	3.80	11.88	4.3113	124.8212	150	23.0075	229.0502	25.1777	464.6672	*540
45	10	572.96	250	11.0	4.00	12.50	4.5374	124.8019	150	23.3146	231.2490	25.4315	465.9534	*540
45	10.5	545.67	250	11.0	4.20	13.13	4.7635	124.7817	150	23.6135	233.2340	25.6825	467.1134	*540
40	11	520.87	250	11.5	4.40	13.75	4.9894	124.7604	225	29.4636	309.8279	25.9308	468.1642	*550
40	12	477.46	240	11.5	5.00	14.40	5.0152	119.7478	230	29.6078	313.0302	25.7793	465.0486	*550
40	13	440.74	200	11.5	6.50	13.00	3.7746	99.8286	250	28.4776	315.9246	23.7060	446.8046	*550
40	14	409.26	200	11.5	7.00	14.00	4.0638	99.8013	250	28.8505	318.2090	24.0236	448.1378	*550
35	15	381.97	200	12.0	7.50	15.00	4.3527	99.7720	305	33.2874	375.0290	24.3370	449.2860	*800
35	16	358.10	200	12.0	8.00	16.00	4.6413	99.7406	305	33.6385	376.7456	24.6466	450.2834	*800
35	17	337.03	200	12.0	8.50	17.00	4.9296	99.7073	305	33.9815	378.2520	24.9533	451.1564	*800
35	18	318.31	200	12.0	9.00	18.00	5.2176	99.6719	305	34.3176	379.5830	25.2573	451.9252	*800
35	19	301.56	200	12.0	9.50	19.00	5.5052	99.6346	305	34.6477	380.7660	25.5590	452.6061	*800
30	20	286.48	200	12.0	10.00	20.00	5.7925	99.5952	330	36.8255	406.7541	25.8586	453.2120	*910
30	22	260.44	200	12.0	11.00	22.00	6.3659	99.5106	330	37.4627	408.5572	26.4526	454.2384	*910
30	24	238.73	200	12.0	12.00	24.00	6.9377	99.4180	330	38.0857	410.0309	27.0405	455.0676	*910
30	26	220.37	200	12.0	13.00	26.00	7.5077	99.3175	330	38.6972	411.2494	27.6230	455.7434	*910
25	28	204.63	200	12.0	14.00	28.00	8.0758	99.2092	360	41.5222	442.1833	28.2007	456.2970	*1020
25	30	190.99	200	12.0	15.00	30.00	8.6417	99.0931	360	42.1155	443.0366	28.7741	456.7514	*1020
25	34	168.52	200	12.0	17.00	34.00	9.7667	98.8376	360	43.2803	444.3636	29.9083	457.4272	*1020
25	36	159.15	200	12.0	18.00	36.00	10.3256	98.6984	360	43.8530	444.8771	30.4694	457.6721	*1020

NOTE: Where exit ramp "T" distances are variable (for grades in excess of 3%) see HDM Figure 600-14 to calculate "T" distance.

NON-STANDARD -
USING 60 MPH DESIGN SPEED AS A BASIS FOR SPEED CHANGE AREAS REQUIRES AGREEMENT BETWEEN REGION AND TECH SERVICES ROADWAY MANAGERS.

STATE OF OREGON
DEPARTMENT OF TRANSPORTATION
ROADWAY ENGINEERING UNIT

RAMP FITTING DATA (1 LANE - 60 MPH)

HIGHWAY DESIGN MANUAL

Special treatments are used in cases where ramps connect to the mainline on curves. Figure 600-20 and Figure 600-21 provide guidance on developing curved ramp horizontal alignments. The intent of these configurations is to approximate the conditions where ramps merge or diverge on tangent alignments. Additional information is also located at the end of Part 600. The figures at the end of Part 600 provide guidance for specific cases and recommended configurations are shown. In many of these cases it is necessary to use spiral segments to deal with compound horizontal curves. Details on spiral segments are presented in Part 200 of this manual.

Superelevation at curved ramps is generally controlled by the mainline cross slope throughout the gore area. When curved ramps reach the “physical nose” (see Figure 600-14) the ramp and mainline become separate roadways. Ramp cross slopes become mostly independent. Designers must keep in mind the need for smooth cross slope transitions through this area. Development of these transitions will often not fit neatly calculated mathematical or runoff chart solutions. Using multiple line profiles (based on traveled way edges) that approximate precise solutions will normally provide adequate results.

Figure 600-22 is intended as a guide for typical cross slope transitions at ramps. Detailed guidance for developing super transitions at curved ramp connections is provided in AASHTO 2018 – Section 9.6.4. Although the discussion is about turning roadways at intersections, the basic ideas are also applicable for interchange ramps (keeping in mind the higher speed transitions). Often, it’s necessary to use cross slope breaks in gore areas to provide suitable transitions. Table 9-18 in AASHTO lists suggested maximum cross slope breaks in various situations; **ODOT’s standard for freeways and expressways is to limit cross slope breaks to four percent.** Minimal horizontal alignment, especially on ramps, often has a negative impact on vertical alignment as well. Designers need to pay careful attention to the combined effects of horizontal and vertical geometry. In fully developed areas it is often infeasible to change the crossroad profile, but ramps may have more flexibility. A general discussion on horizontal alignments for roadways can be found in Section 200.

Figure 600-20: Entrance Ramps on Curves

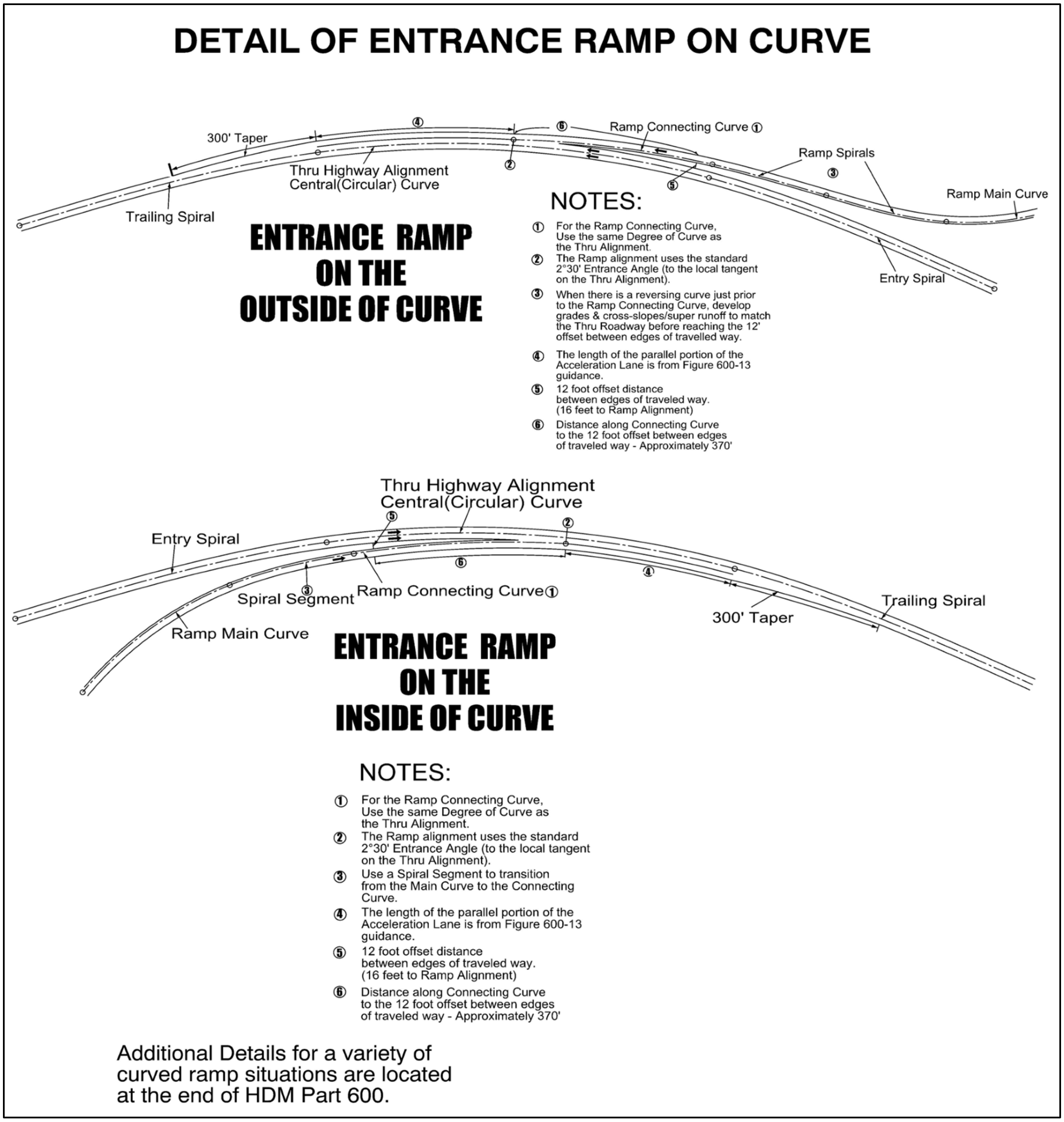
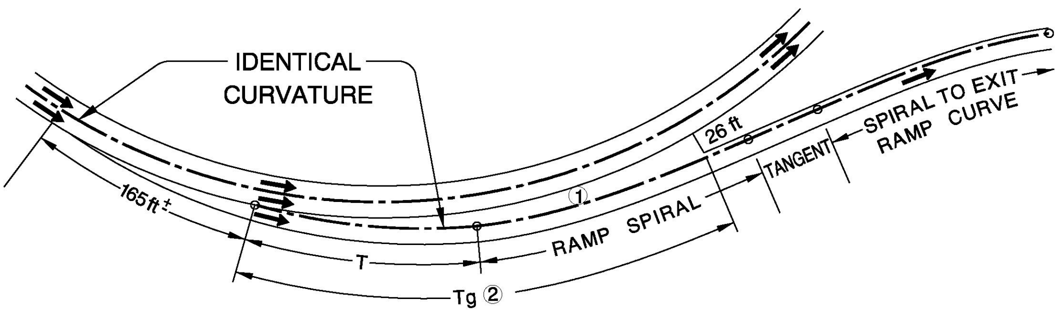


Figure 600-21: Exit Ramps on Curves

DETAIL OF EXIT RAMP ON CURVE



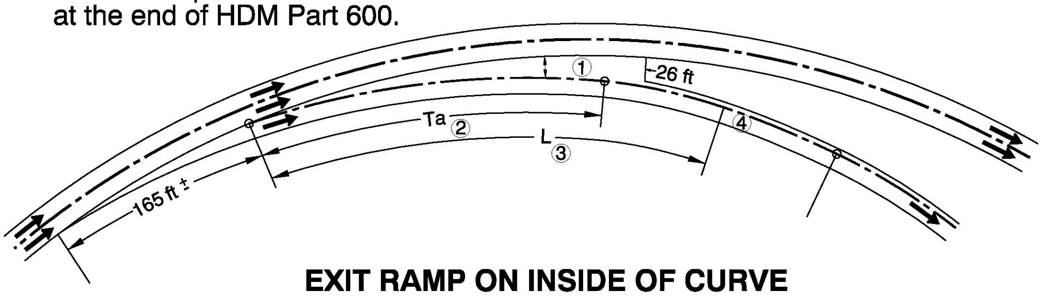
NOTE:

The theory behind this is to emulate a tangent condition for the entire configuration.

1. This angle is to be 4° 15' to local tangent.
2. 'Tg' should approximate distance from takeoff to gore on tangent section (approximately 405 ft)

EXIT RAMP ON OUTSIDE OF CURVE

Additional Details for a variety of curved ramp situations are located at the end of HDM Part 600.



EXIT RAMP ON INSIDE OF CURVE

NOTES:

① This angle is to be 4° 15' to local tangent.

② 'Ta' distance will be the 'T' distance from table for exit curve plus the difference between the length of spiral specified for the exit curve and the length of the spiral segment.

EXAMPLE:

Given: 3° mainline curve, 12° exit curve
with 240 ft Sp. A = 5.0, & T = 320 ft
'Ta' = 320 ft + 240 ft (Sp.) - 150 (Sp. Seg.) = 410 ft

③ "L" deceleration lane length is the "T" distance from the table for exit curve plus ½ length of spiral normally used. To adjust "Ta" for grade correction using above data see example.

EXAMPLE:

Given: T = 320 ft, Ta = 410 ft, ½ Sp. = 120 ft
grade = 4%, factor = 1.2

320 ft (T) + 120 ft (½ Sp.) = 440 ft x 1.2 = 528 ft (round to 530)

"Ta" = 530 ft - 440 ft + 410ft = 500 ft

④ Use spiral segment to join exit curve to curve of deceleration lane, which is the same as the mainline curve. The "a" value may vary between designated "a" values for exit curve and deceleration curve, preferably the greater.

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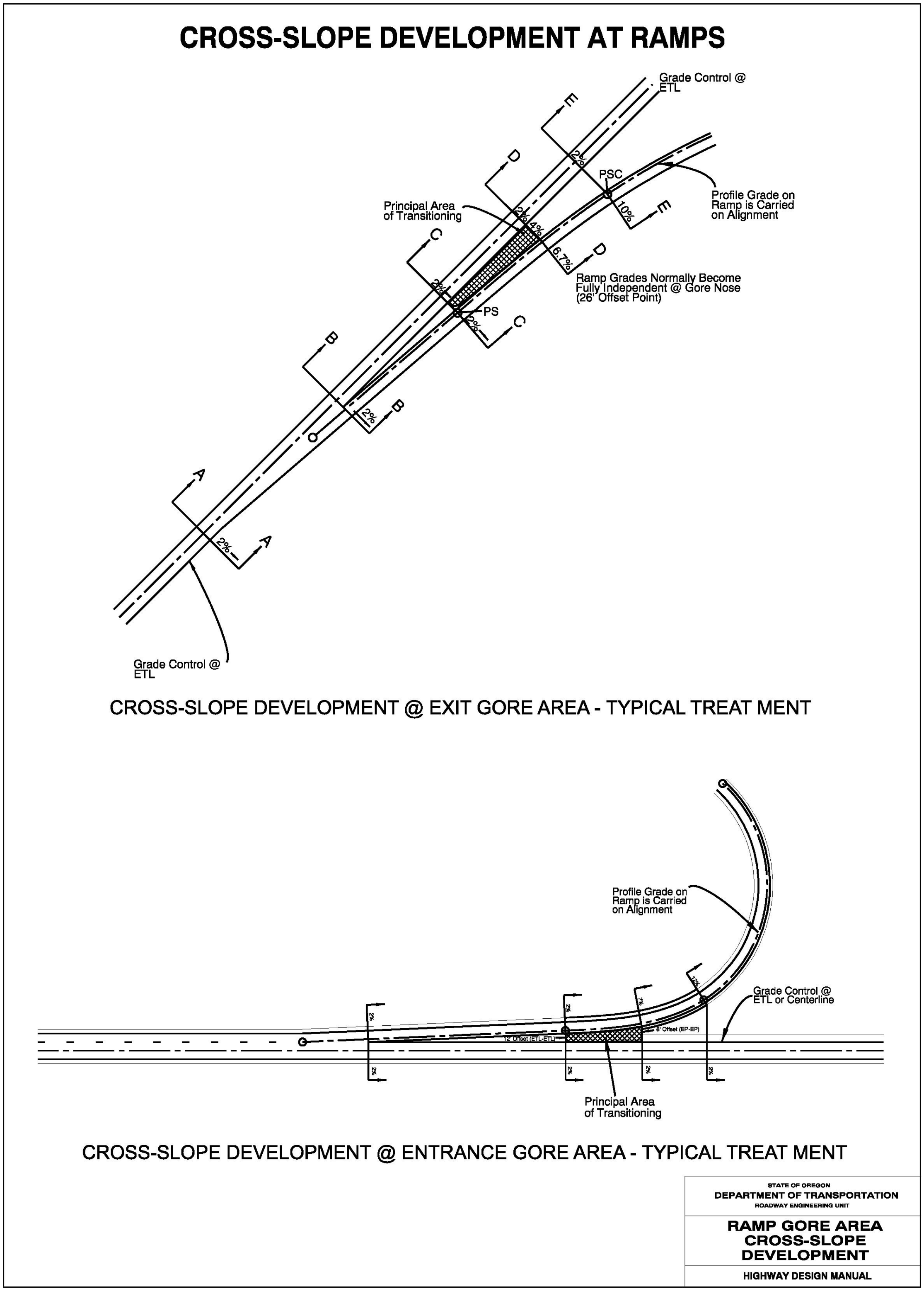
ROADWAY ENGINEERING UNIT

EXIT RAMPS ON CURVES

HIGHWAY DESIGN MANUAL

Figure 600-22: Cross Slope Development at Gore Areas



605.6 Vertical Alignment

Ramp grades should be as flat as possible. (See Table 600-6) Steep grades at the terminal area may have significant operational effects, especially for large vehicles. ***Where ramp traffic has a significant percentage of heavy trucks or buses, 3 percent or 4 percent approach gradients are strongly preferred. The grades at the landing area (where the ramp meets the crossroad) should match the cross-slope on the crossing road, preferably close to 2 percent.*** Vertical alignments and clearances for the crossroad and ramps should be designed in accordance with Part 200 guidelines. Ramp profile grades are normally carried at the horizontal alignment.

Table 600-6: Maximum Grades for Ramps

Design Speed (mph)	Ascending Grades %		Descending Grades %	
	Desirable	Maximum	Desirable	Maximum
25-30	5	7	7	8
35-40	4	6	6	7
45-50	3	5	5	6

Except in special cases, descending grades on exit ramps should be the same as the ascending grades. Depressed interchanges are the most common situation where this would apply. Exits on downgrades require added deceleration length, and steeper grades increase this requirement. Steeper grades also make it more difficult to provide an appropriate vertical curve in the gore area, thus the recommendation for keeping the descending exit grades similar to the ascending. In certain special cases grades can vary from the standard as appropriate. Examples of special cases would be an outer connection on a partial cloverleaf or system interchange, or entrance ramps in mountainous terrain. These ramps do not have to account for stopped vehicles in a queue (although they still need to provide SSD and appropriate vertical curves), so there is greater flexibility in the profile design. **Ramp grades steeper than the standard need to be documented in a design exception**. Contact the ODOT Interchange Engineer for guidance in unusual situations.

Ramp profiles in gore area need to be developed to match the mainline profile adequately, in order to minimize cross slope variations in that area. It is preferable to develop grades in gore areas based on the mainline profile up to the point where gore paving ends (refer to Figure 600-13 and Figure 600-14 for details). The ramp profile can become independent at that point. In constrained situations it may be necessary to vary from this practice. *Significant cross slope breaks can create problems for vehicles traversing the gore area, especially at exits, so the profile always needs to match mainline to the extent possible in each situation.*

Ramp grades have significant operational impacts, but it's equally important to provide adequate sight distance along the entire length of the ramp. When the crossroad is over the main facility, the ascending exits and descending entrances generally have fewer problems, provided they have sufficient length and good horizontal alignment. Sight line limitations are often found on depressed interchanges (crossroad under), both on ramps at the gore area and at the intersection with the crossroad. Sight distances at exit and entrance gore areas require careful evaluation, as these are higher speed conflict areas. The vertical alignment at the terminal end of a ramp may also have adverse impacts on sight lines. A profile that includes a relatively steep grade at the terminal end affects not only sight lines, but startup and stopping operations, which in turn affects the sight distance needed for safe operation.

Partial cloverleaf ramp arrangements may create sight line restrictions as well, in the area where the outer ramp wraps around the loop. The combined effects of horizontal and vertical alignment and the ramp cross section need to be carefully evaluated in all cases. Horizontal and vertical sight lines both need to be checked for obstructions.

In situations where it is impractical to make significant changes to the profile, sight lines should take priority over specific gradient controls. **Design exceptions are necessary when either or both of these criteria aren’t met. As a minimum, exit ramp profiles shall provide appropriate stopping sight distance to expected vehicle queues.** *Exit profiles, especially at depressed interchanges, need to provide appropriate sight distance in the gore area.*

605.7 Ramp Terminal Curves

Ramp terminal curves are the portion of a ramp where it meets the crossroad. In some respects, these are a part of the intersection with the crossroad. Sometimes there is no horizontal curve present, but the same principles and thought process need to be followed as with curved terminal areas.

Terminal curves (where a ramp terminates at a crossroad) are generally sharper than the main curve, varying with the conditions. Ramp Terminal areas are typically designed to between 50 percent (minimum) and 85 percent of the main ramp curve speed.

605.8 Ramp Terminal Intersections

The separation or "spread" between ramp terminal intersections on the crossroad should be adequate to allow for standard median channelization if left turns are required. **Figure 600-23 gives minimum spread distances for a basic diamond interchange at various design speeds.** Particular attention should be paid to adequate vertical and horizontal sight distance at the ramp terminals. Design elements such as barrier, protective screening, superelevation rates, and landscaping can have an impact on the sight distance of ramp terminals. Exit ramp and entrance ramp terminals on the crossroad should be offset to encourage drivers to use the entrance ramp and to discourage wrong way moves. Figure 600-24 and Figure 600-25 provide details on exit and entrance ramp terminal intersection design. AASHTO “A Policy on Geometric Design of

Highways and Streets-2018"- Chapter 10, pages 10-98 to 10-102, discusses issues and possible mitigations to help discourage wrong-way entry. Wrong-way potential can be minimized by using conventional, easily recognized intersection and interchange layout, clear pavement markings, and proper signing.

Due to the crossroad grade often being averse to a normal superelevation for terminal curves and the fact that traffic is slowing to stop at the crossroad, ramp terminal curves seldom are fully superelevated and may not be superelevated at all. Therefore, the need for spirals, particularly standard length ramp spirals, is diminished and sometimes eliminated on terminal curves. While spirals may not be required for superelevation transition, their use is always beneficial for leading traffic smoothly into the terminal curve. *The ramp terminal curve superelevation rate is typically one-half the full superelevation rate for that curve.* Refer to Figure 600-25 for spiral length and superelevation details on Terminal Curves. Contact the ODOT Interchange Engineer for guidance as needed.

Ramp terminals on many existing facilities do not meet the "X-X Minimum" distance shown in Figure 600-23. Achieving this target distance is often not feasible, particularly in fully developed areas. Designers need to work with traffic analysis staff to determine the range of options for dealing with anticipated left turn demand on the crossroad. It may be necessary to widen a structure to provide additional turn lanes for storage (along with widening of ramps to receive the added lane). In some cases, it may be necessary to reconfigure the interchange to a more compact form, such as a Tight Diamond or Single Point. Oftentimes at existing interchanges, these values are difficult or infeasible to achieve. Sight lines and intersection features still need to be considered. **Design exceptions are necessary when SSD can't be provided at ramp intersections.**

On the other hand, where interchanges are in remote locations with very little traffic demand, the need for accommodating turn lanes is practically non-existent. In those cases, the chief control is sight lines (as shown in Figure 600-23, Table C). The type of traffic control at the intersection guides in the selection of the most appropriate case to use – Stopping Sight Distance for the crossroad design speed being the minimum. Designers should consider whether it is appropriate to provide Intersection Sight Distance, although in many situations this may prove impractical. Each individual situation must be evaluated to determine the appropriate sight distance condition that will control for design.

In cases where the crossroad is on a horizontal curve, added caution is necessary. Superelevated crossroads introduce awkward breaks in the cross-slope that have serious operational and safety implications, especially when there are significant numbers of trucks present. Horizontal curves can also make it more difficult to provide appropriate sight lines. Crossroad alignments should therefore be as close to tangent alignment as possible.

Refer to Part 500 of this manual and AASHTO "A Policy on Geometric Design of Highways and Streets-2018"- Chapter 9 for detailed discussion on intersection design and Intersection Sight Distance.

Figure 600-23: Interchange Ramp Spread

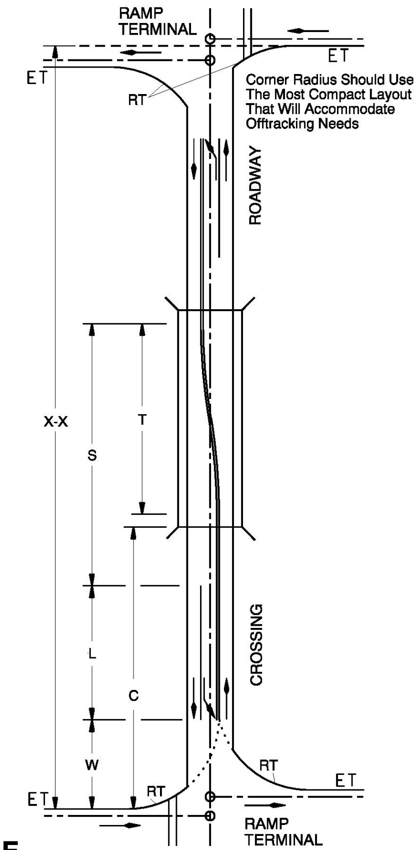
DIAMOND INTERCHANGE - TERMINAL RAMP SPREAD

CHANNELIZATION DIMENSIONS

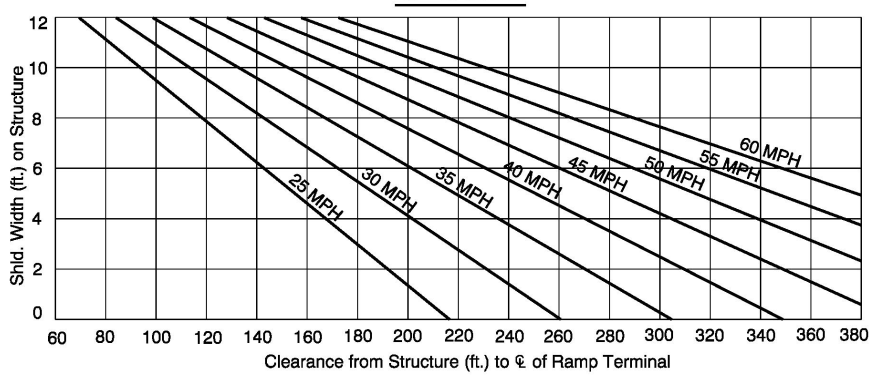
MPH	R (ft.)	T (ft.)	*S (ft.)	L min. (ft.)	X-X MIN 3-Lane	X-X MIN 5-Lane
25	195	100	155	100	610	510
30	195	100	155	100	610	510
35	250	110	155	100	600	520
40	305	120	200	100	680	590
45	370	135	250	100	765	675
50	435	145	305	150	965	875
55	510	160	360	150	1060	970
60	595	170	425	150	1180	1090
65	680	180	495	150	1310	1220
70	680	180	570	150	1460	1370

GLOSSARY OF TERMS

MPH = Design speed of crossing roadway.
R = Radius of reversing curve.
T = Length of reversing curve.
S = Stopping sight distance for a speed 10 mph less than the Design Speed. (Based on 2018 AASHTO, Table 3-1)
L = Length of storage determined by storage analysis - Minimums shown.
W = 100' for 3-lane @ 90° in tangent section. 55' for 5-lane @ 90° in tangent section. W determined by where turning vehicle's off-track crosses edge of left-turn lane (See figure right). This is where stop bar should be placed.
X-X = Minimum distance between the left edges of travel of the ramp terminals (see diagram right). X-X = 2(W+L+S)-T ; where S ≥ T. Else X-X = 2(W+L)+T.
C = Combined horizontal and vertical sight distance clearance from the structure. Typically 200 feet or more.
RT = Ramp terminal radii should accommodate a WB-67 Interstate Design Vehicle (IDV). Two Centered radii should be used to satisfy this requirement.
ET = Edge of Travel



'C' TABLE



'C' TABLE NOTES

1) 'C' Table values are based on the appropriate vertical curve and horizontal stopping sight distance values for the design speed in a tangent section.
2) Clearance calculations do not include sidewalks; as there may or may not be barrier separation from the roadway. Barriers must be used when the cross-road design speed is 45 mph or greater.

ORIGINAL SOURCE: ODOT PRELIMINARY DESIGN

STATE OF OREGON
DEPARTMENT OF TRANSPORTATION
ROADWAY ENGINEERING UNIT

INTERCHANGE RAMP SPREAD

HIGHWAY DESIGN MANUAL

Figure 600-24: Detail at Ramp/Crossroad Intersection

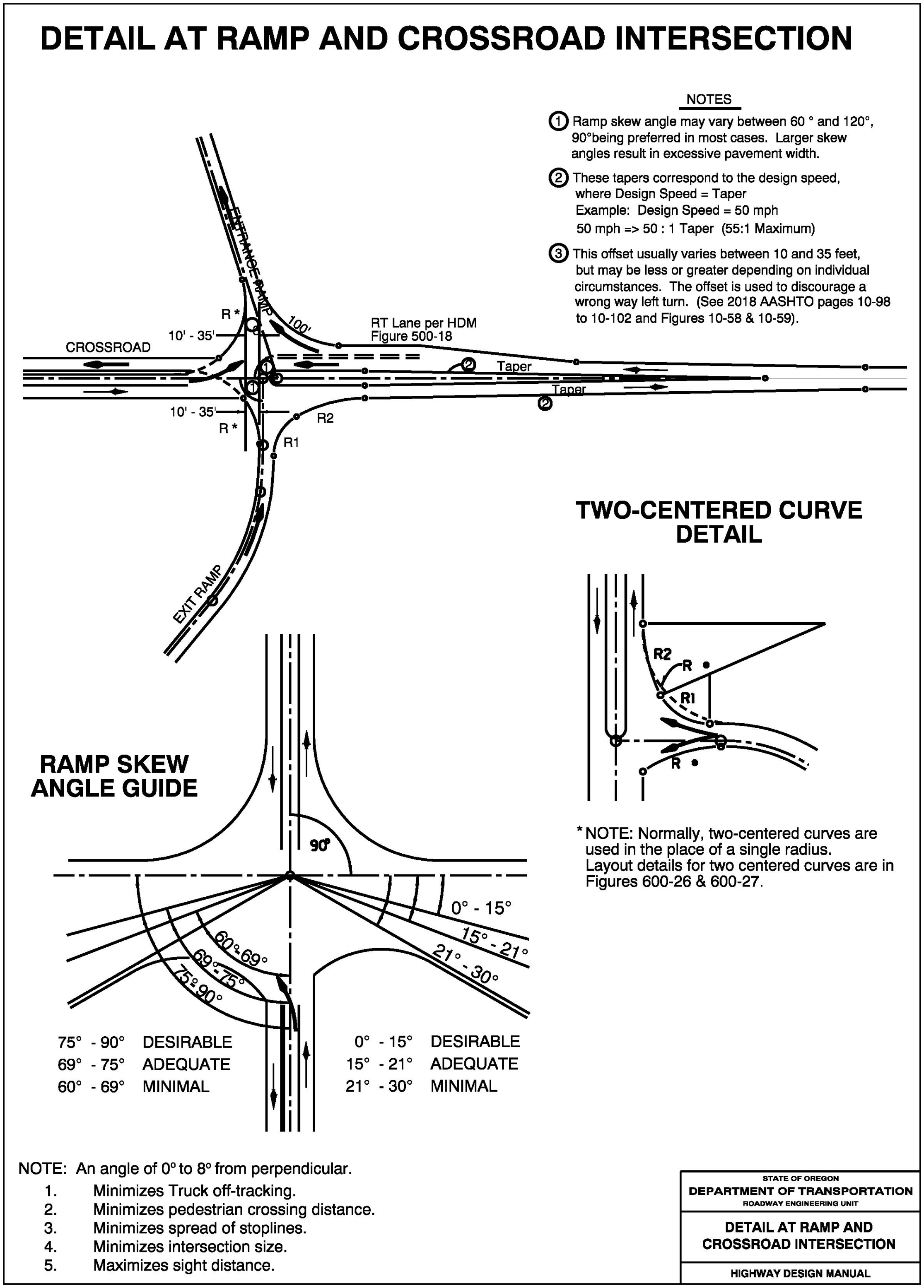
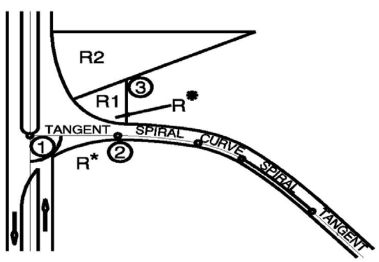
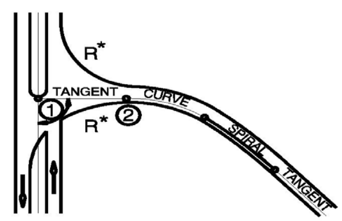


Figure 600-25: Terminal Curve Design Option

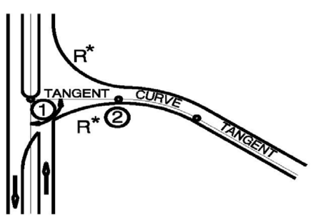
ACCEPTABLE TERMINAL CURVE DESIGNS
in descending order of preferrence



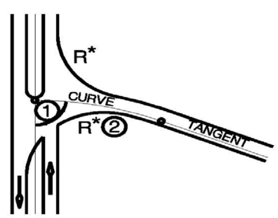
OPTION 1



OPTION 2



OPTION 3

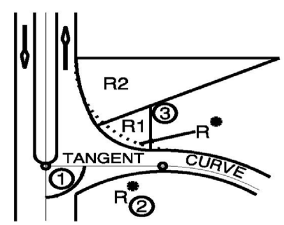


OPTION 4

TERMINAL CURVE SPIRAL DATA (ONE LANE)

Curve	Sp. length	e %	a	S°	p	q	x	y
1°	100	1.75	1	0.5	0.0727	49.9999	99.9992	0.2909
2°	100	3.25	2	1	0.1454	49.9995	99.9970	0.5818
3°	120	4	2.5	1.8	0.3141	59.9980	119.9882	1.2565
4°	120	4.5	3.3333	2.4	0.4189	59.9965	119.9789	1.6753
5°	125	4.75	4	3.1250	0.5681	62.4938	124.9628	2.2721
6°	120	5	5	3.6	0.6282	59.9921	119.9526	2.5126
7°	120	5.25	5.8333	4.2	0.7329	59.9893	119.9355	2.9310
8°	125	5.25	6.4	5	0.9088	62.4841	124.9048	3.6341
10°	125	5.5	8	6.25	1.1358	62.4752	124.8513	4.5413
12°	120	5.75	10	7.2	1.2559	59.9684	119.8106	5.0209
14°	100	5.75	14	7	1.0176	49.9751	99.8508	4.0681
16°	100	6	16	8	1.1627	49.9675	99.8052	4.6477
18°	100	6	18	9	1.3078	49.9589	99.7535	5.2268
20°	100	6	20	10	1.4529	49.9493	99.6958	5.8051
24°	100	6	24	12	1.7426	49.9270	99.5622	6.9595
30°	100	6	30	15	2.1763	49.8860	99.3168	8.6840
36°	100	6	36	18	2.6088	49.8360	99.0175	10.3984

Spiral lengths are based on using ½ of standard superelevation.
Use on terminal curves only.



TERMINAL CURVE NOTES

1. This angle may vary between 60° and 120°; where 90° is desirable in most cases.
2. To minimize intersection opening ramp curve should end near tangency of the variable crossing radius.
3. A two-centered curve design should be used to optimize intersection area and accommodate truck off-tracking.

* TWO-CENTERED CURVE DETAIL

Two-centered curves should be used in place of a single radius.
See HDM Figures 600-26 & 600-27 for additional details.

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RAMP TERMINAL CURVE DESIGN

HIGHWAY DESIGN MANUAL

Freeway ramp terminals, and intersections pre-approved for interstate trucks shown on Route Map 7 at major truck use locations, shall accommodate the current Interstate Design Vehicle (WB-67).

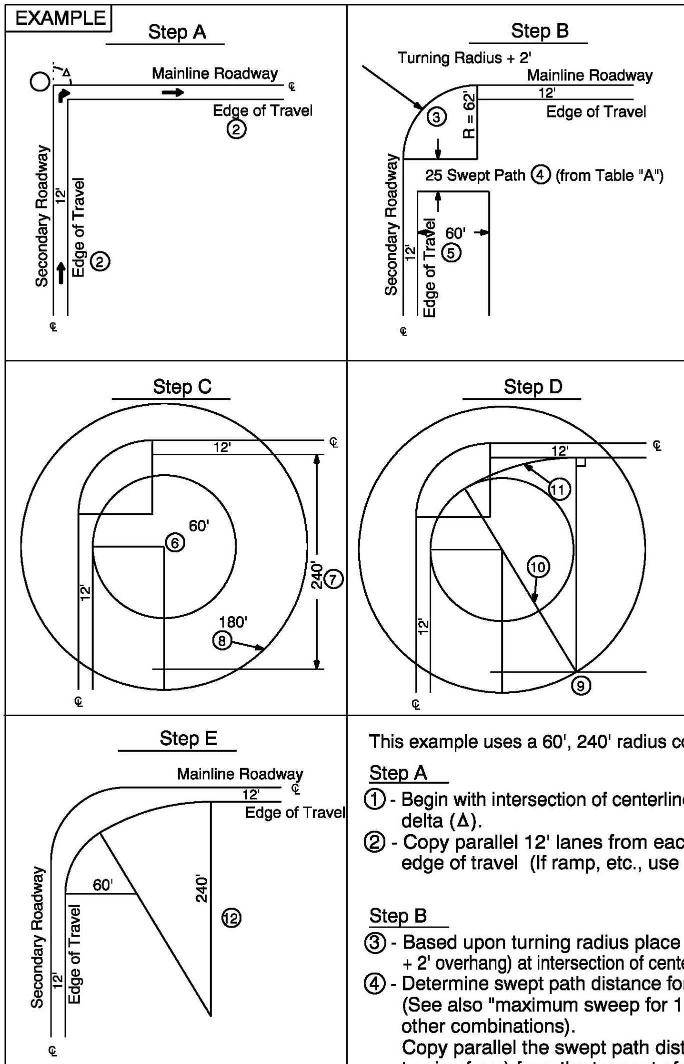
Route Map 7 can be found at: [**https://www.oregon.gov/odot/Forms/Motcarr/8104.pdf**](https://www.oregon.gov/odot/Forms/Motcarr/8104.pdf)

Other intersections that have known large truck usage should also be designed to accommodate the current Interstate Design Vehicle. Computer and CADD generated wheel paths of the design vehicle should be used to determine adequate clearances. This is particularly important when determining stop lines for left turn bays and when designing double left turns and two lane loop ramps.

Interstate Design Vehicle swept path requirements can also be found on Figure 600-28. Typically, two centered curves are used at ramp terminals due to the benefits of matching the turning characteristics of large vehicles. Two centered curves assist in reducing the crossing distance at ramp terminals while accommodating the turning requirements of the design vehicle. Figure 600-26 and Figure 600-27 have detailed helps on developing two-centered curves.

Figure 600-26: Two Centered Corner Graphical Solution

EXAMPLE



Note: Table "A" based on Interstate Design Vehicle 3S2, C-75, WB-67.

TABLE "A"

60' Turning Radius	
Delta	Swept Path Distance + 2'
60°	25.0
75°	27.3
90°	29.3
105°	31.0
120°	32.3

This will only work with a minimum 12' lane and 2' shoulder.

The 60',240' radius curve combination will work in most situtations.
If the turning area or turning radius needs to be changed, then use Autoturn turning template and lay in minimum curves.

If in a curb section, this should be checked with truck turning software to ensure that it does not encroach on the curb, walks, and ADA ramps.

This example uses a 60', 240' radius compound curvature, assuming a 60' turning radius.

Step A

① - Begin with intersection of centerlines (left edge of travel) to determine delta (Δ).
② - Copy parallel 12' lanes from each centerline to determine right edge of travel (If ramp, etc., use appropriate offset).

Step B

③ - Based upon turning radius place a 62' arc (60' turning radius + 2' overhang) at intersection of centerlines and determine radius point.
④ - Determine swept path distance for radius and delta from TABLE "A". (See also "maximum sweep for 1989 Interstate Design Vehicle" for other combinations).
Copy parallel the swept path distance (along the roadway you are turning from) from the tangent of the 62' radius curve.
⑤ - Copy parallel 60' (This distance is the radius of intial two centered curves) from the right edge of travel of the roadway you are turning from and intersect with swept path distance.

Step C

⑥ - Place a 60' radius circle at intersection of Step B No. ⑤ .
⑦ - Copy parallel a line 240' from mainline roadway edge of travel. (this distance is the radius of the 240' transition offtrack curve).
⑧ - Place a 180' circle at ⑥ (this is the difference in offtracking curves (240'-60').

Step D

⑨ - Establish point ⑨ by intersecting line ⑦ with the radius of step ⑧.
⑩ - Place line from point ⑨ passing thru point ⑥ and intersect 60' radius circle.
⑪ - Construct a 240' radius arc for transition offtrack curve.

Step E

⑫ - The two centered curves are completed.

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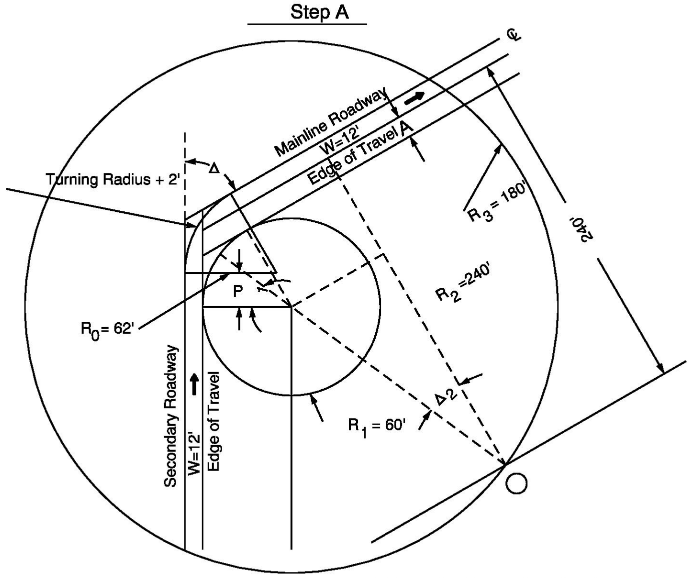
GRAPHICAL SOLUTION
TWO-CENTERED
CORNER RADII

HIGHWAY DESIGN MANUAL

Figure 600-27: Two Centered Corner Mathematical Layout

TWO CENTERED CURVE LAYOUT

Step A



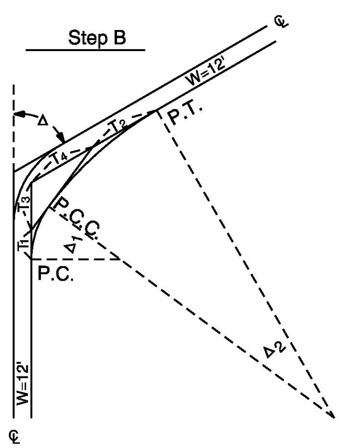
This method uses a 60', 240' radius compound curvature, assuming a 60' turning radius.

The 60', 240' radius curve combination will work in most situtations.

If the turning area or turning radius needs to be changed, then use truck turning software and lay in minimum curves.

If in a curb section, this should be checked with truck turning software to ensure that it does not encroach on the curb, walks, and ADA ramps.

Step B



Follow the illustration for the graphic method for layout of the two centered curves. Step A will be done using these equations below to calculate point ⑨.

A = distance at right angle parallel from edge of travel to 60' radius curve.

P = Swept Path + 2'

W = Lane width

R = Radius

R = R - R

Step A

1) $$A = \left(P + \left[(R_0 - R_1)\ \text{Tan}\frac{\Delta}{2}\right] - \frac{\quad}{\text{Tan}\Delta}\right)\text{Sin}\,\Delta = 14.9186'$$

2) $$\Delta_2 = \text{arc Cos}\ \frac{R - (R + A)}{\quad} = 23\ 29'\ 30''$$

$$\Delta_1 = \Delta - \Delta$$

Step B

1) $$T_1 = R_1 \tan\frac{\Delta_1}{2}$$

2) $$T_2 = R_2 \tan\frac{\Delta_2}{2}$$

3) $$T_3 = (T_1 + T_2)\frac{\text{Sin}\,\Delta_2}{\text{Sin}\,(180 - \Delta)}$$

4) $$T = T_3 \frac{\text{Sin}\,\Delta_1}{\text{Sin}\,\Delta_2}$$

$T_1 + T_3$ = distance from intersection of edge of travel to P.C. of initial two centered curve.

$T_2 + T_4$ = distance from intersection of edge of travel to P.T. of final two centered curve.

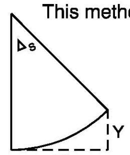
Note: Table "A" based on Interstate Design Vehicle 3S2, C-75, WB-67.

TABLE "A"

60' Turning Radius	
Delta	Swept Path Distance + 2'
Δ	P
60°	25.0
75°	27.3
90°	29.3
105°	31.0
120°	32.3

TANGENT LAYOUT OF CURVE

This method will allow to layout curves, if obstructions prevent setting radius points.



$$Y = R - \sqrt{R^2 - X^2}, \quad R - R\,\text{COS}\,\Delta_s$$

$$X = \sqrt{2RY - Y^2}, \quad R\,\text{SIN}\,\Delta_s$$

$$R = (X^2 + Y^2) - 2Y$$

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Ramp intersection design simultaneously needs to provide for design vehicle movements, pedestrian and bike crossings, good lines of sight, and appropriate traffic control devices. Transit stops are also a consideration, primarily in urban contexts.

As mentioned above, care needs to be taken to minimize wrong-way movement potential. Minimizing the skew angle will normally help in dealing with these issues, but other geometric design and lower cost measures are available to help minimize wrong way potential. Studies have consistently shown that impaired and older drivers are overrepresented in wrong way type incidents. Measures to reduce risk need to account for this. Although it's often not possible to determine precisely where drivers make mistakes, certain interchange forms, such as partial service interchanges, non-freeway directional interchanges, and cloverleafs/folded diamonds with exit loops, may create driver confusion and increase wrong way risks. Reconfiguring interchanges is often costly and sometimes infeasible. Lower cost measures, such as increased lighting, lane extension markings (providing more positive guidance), oversize and low mounted "Do Not Enter" and "Wrong Way" signs, and the use of raised traffic separators are demonstrated effective countermeasures. Providing decision sight distance and appropriate signing in advance of the maneuver area can help reduce risks as well. The use of roundabout intersection control when appropriate is also a proven wrong way movement countermeasure. Refer to AASHTO "A Policy on Geometric Design of Highways and Streets-2018" - Pages 10-98 thru 10-102 for examples and more detailed discussion of how geometric design can help reduce wrong way movements. When designing partial cloverleaf and folded diamond intersections with crossroads, these ideas are especially helpful.

Ramp intersection design also needs to make appropriate accommodation for bicycles, pedestrians, and transit use (when applicable). HDM Parts 800 and 900 have detailed discussion on bike and pedestrian design. Refer to Part 700 for discussion of Public Transportation design. Each individual situation needs to be evaluated to determine the most appropriate solutions to apply. Coordination between all disciplines involved, preferably early in design, is important for getting good results. All of these considerations need to be balanced with the need to keep the intersection to a manageable size, and to accommodate the expected demand at an acceptable level.

Figure 600-29 and Figure 600-30 provide details on intersection layout at Single Point interchanges. The details apply for both overcrossing and undercrossing situations. Contact the ODOT Interchange Engineer for guidaince.

Figure 600-28: Maximum Interstate Design Vehicle (I.D.V.) Swept Path

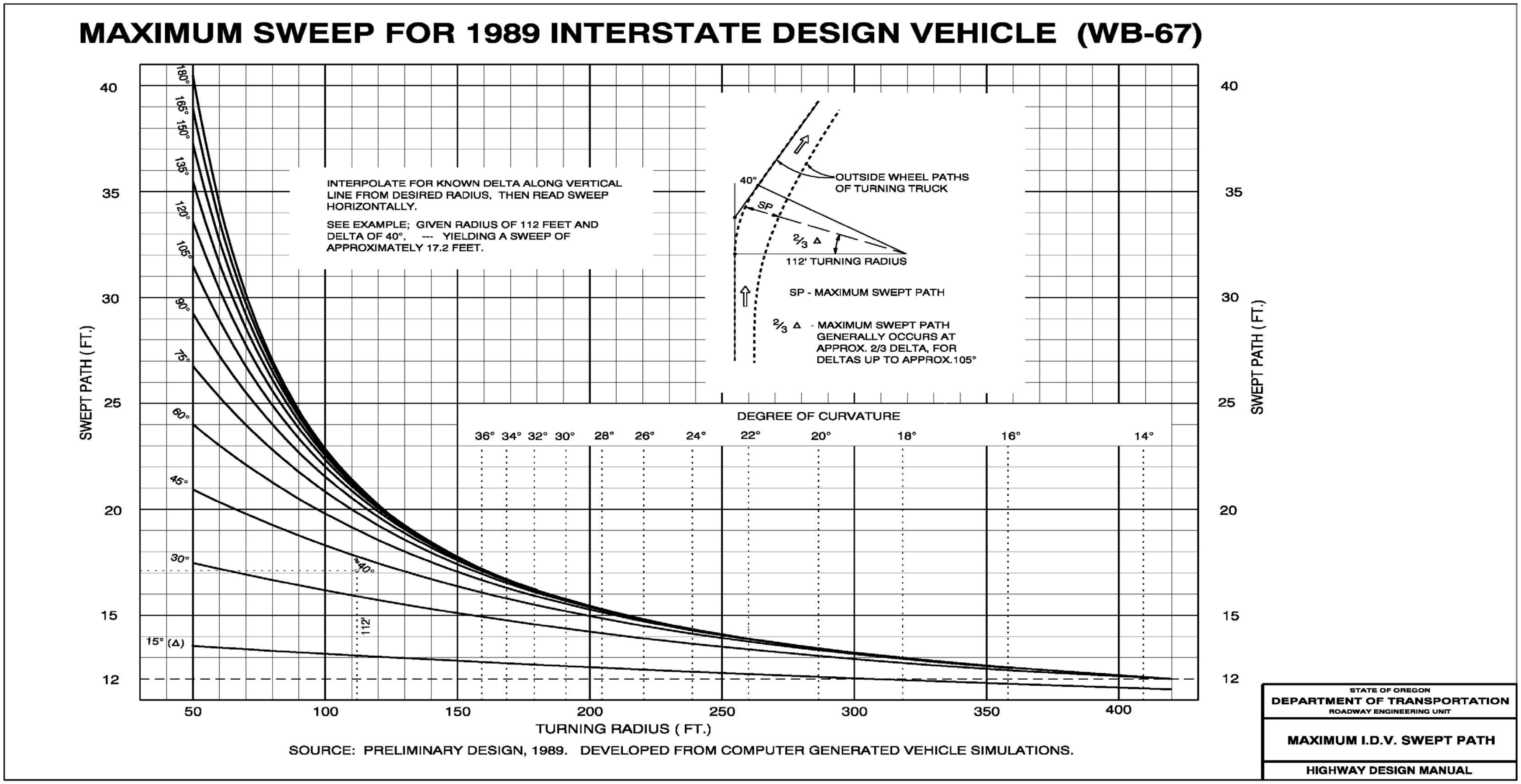


Figure 600-29: Minimal Single Point Intersection Details

MINIMUM DESIGN VALUES FOR SINGLE POINT INTERSECTION

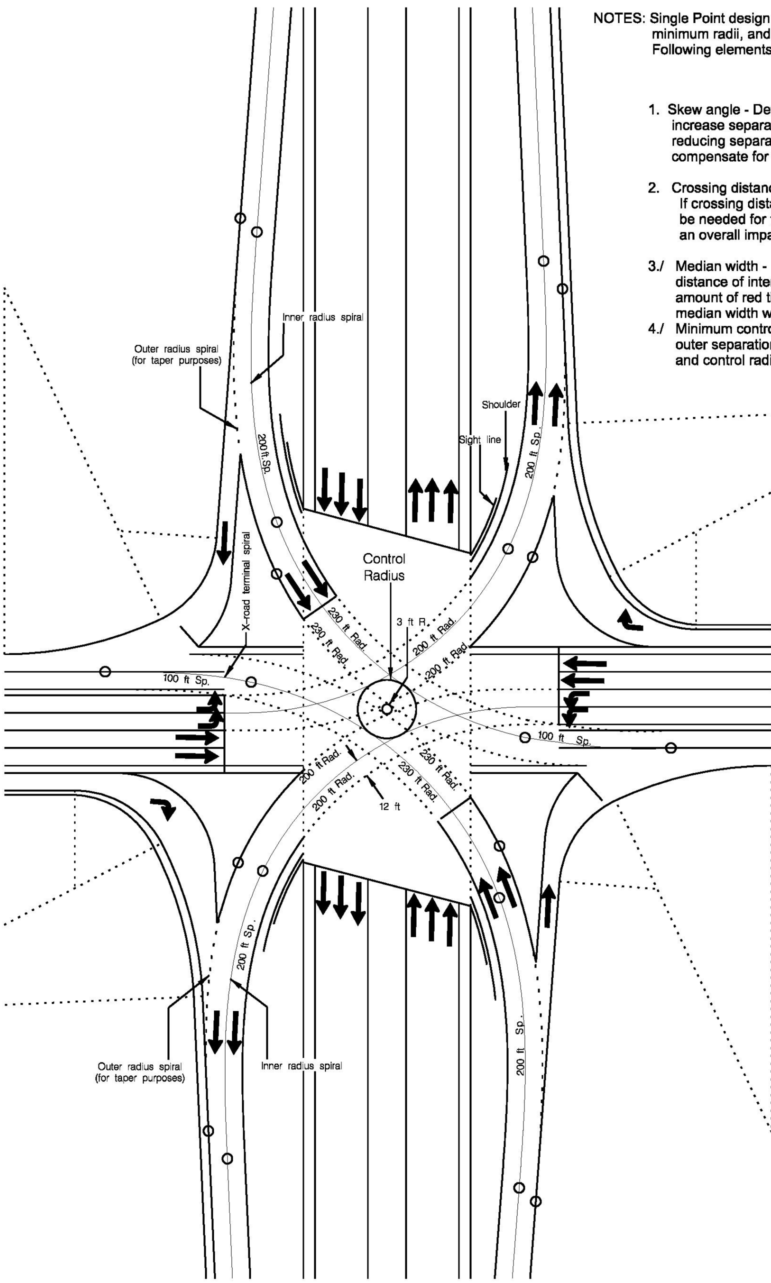
NOTES: Single Point design based on 90 degree intersection angle, minimum radii, and no superelevation.
Following elements are critical to proper design:

1. Skew angle - Deviation from 90 degree skew angle will increase separation between some ramps and mainline while reducing separation on other ramps(Radii must change to compensate for separation).

2. Crossing distance - Critical to coordinate with traffic analysis. If crossing distance is too great, additional red time may be needed for traffic to clear intersection. This may have an overall impact on the effectiveness of the design.

3./ Median width - Increased median width will allow crossing distance of intersection to be reduced. This will assist in amount of red time needed to clear intersection. Minimum median width will cause maximum crossing distance.

4./ Minimum control radii (15 ft -12 ft lane width, 3 ft outer separation) - Ramp curvature will affect swept path and control radii.



MINIMUM VALUES FOR DESIGN

Design Speed	Stopping Sight Distance	Inner X-road Radius	Inner X-road Terminal Spiral	Outer X-road Radius	Inner Ramp Radius	Outer Ramp Radius	Truck Sweep	Control Radius
25 mph	150 ft	200 ft	100 ft	200 ft	230 ft	230 ft	15.5 ft	20 ft

Length of inner radius spirals on outside terminals are 200 ft.
Length of outer radius spirals on outside terminals are determined by measured "p" distance.
Inside lanes are all 12 ft.

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MINIMUM DESIGN VALUES FOR SINGLE POINT INTERSECTION

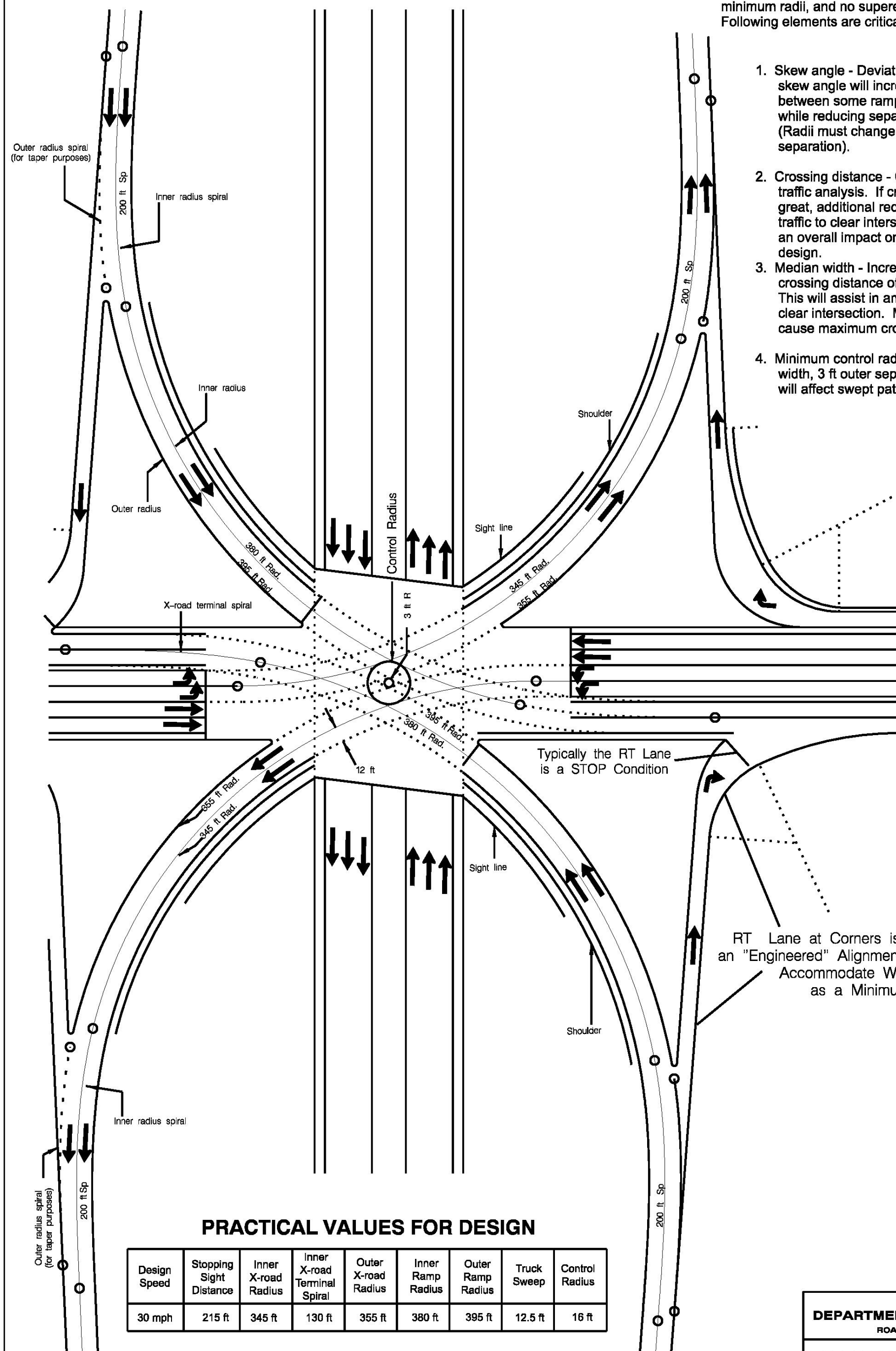
HIGHWAY DESIGN MANUAL

Figure 600-30: Preferred Single Point Intersection Details

PREFERRED DESIGN VALUES FOR SINGLE POINT INTERSECTION

NOTES: Single Point Layout based on 90 degree intersection angle, minimum radii, and no superelevation.
Following elements are critical to proper design:

1. Skew angle - Deviation from 90 degree skew angle will increase separation between some ramps and mainline while reducing separation on other ramps (Radii must change to compensate for separation).
2. Crossing distance - Critical to coordinate with traffic analysis. If crossing distance is too great, additional red time may be needed for traffic to clear intersection. This may have an overall impact on the effectiveness of the design.
3. Median width - Increased median width will allow crossing distance of intersection to be reduced. This will assist in amount of red time needed to clear intersection. Minimum median width will cause maximum crossing distance.
4. Minimum control radii (15 feet-12 ft lane width, 3 ft outer separation) - Ramp curvature will affect swept path and control radii.



PRACTICAL VALUES FOR DESIGN

Design Speed	Stopping Sight Distance	Inner X-road Radius	Inner X-road Terminal Spiral	Outer X-road Radius	Inner Ramp Radius	Outer Ramp Radius	Truck Sweep	Control Radius
30 mph	215 ft	345 ft	130 ft	355 ft	380 ft	395 ft	12.5 ft	16 ft

Length of inner radius spirals on outside terminals are 200 ft.
Length of outer radius spirals on outside terminals are determined by measured "p" distance.
Inside lanes are all 12 ft.

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PREFERRED DESIGN VALUES FOR SINGLE POINT INTERSECTION

HIGHWAY DESIGN MANUAL

605.9 Ramp Meters

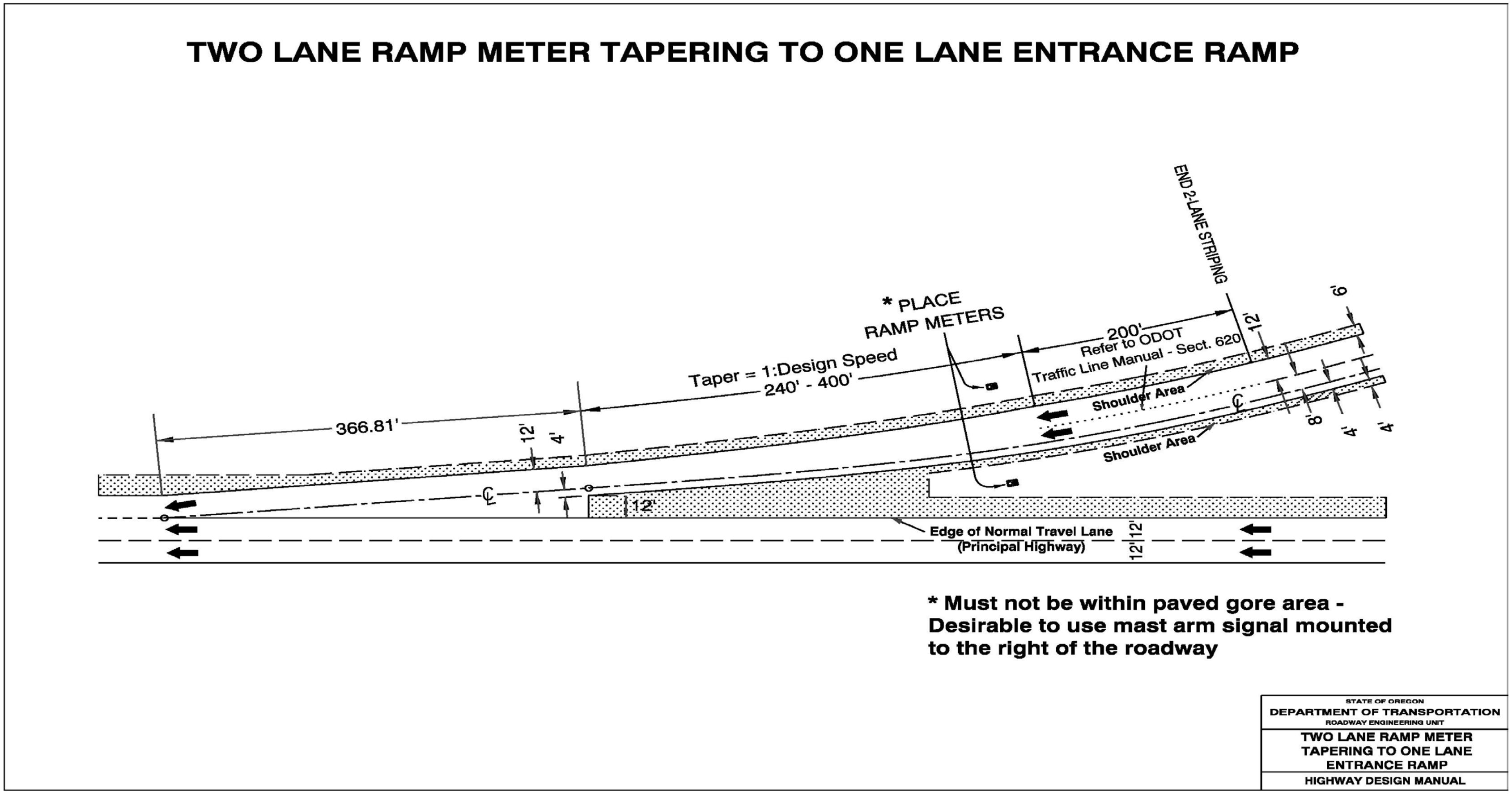
In highly congested areas, typically urban, the use of ramp meters may be beneficial to freeway traffic operations. Ramp meters reduce merge area turbulence and regulate total freeway flow through downstream bottlenecks. ***The Technical Services Traffic-Roadway Section should be contacted when ramp meters are being considered in the project development process***. In addition, there are geometric and safety issues with the design of the ramps and placement of the ramp meter signals that should be considered in the design.

Ramp meters can be installed on single lane or two lane entrance ramps. Ramp meters should not be installed on ramps connecting freeways to freeways, as those types of ramps are designed to operate as free flow ramps. Where ramp meters are installed on a single lane entrance ramp, the ramp design shall be consistent with the appropriate design for 4R/New Construction for Freeway or Non-Freeway Ramps found in Figure 600-13 and Figure 600-14. **Metered ramp acceleration lanes shall, as a minimum, meet the values in Table "A" of Figure 600-13.** This may require lengthening existing acceleration lanes that don't meet current criteria.

In a 3R project, installation of a two lane ramp meter on a single lane ramp should be built to 4R/New Construction standards (the ramp should be widened to full two lane ramp standards). In constrained areas, an evaluation should be made to determine if the existing one lane ramp should be widened to two full standard lanes or if the existing one lane ramp width can be retrofitted for installation of two ramp meters. **Single lane ramps retrofitted for two lane ramp meters require a design exception.** The ramp meter signals should be located just prior to the paved edge of the ramp gore area. Figure 600-31 details the proper location and typical section for a two lane tapered to one lane parallel entrance ramp meter.

It is important to locate the ramp meter signals outside of the freeway clear zone. It is equally important that queued vehicles not be stopped within that same clear zone. Following the guidance in Figure 600-31 should yield a design that meets that requirement. Flat entrance curves may have some design issues, since the more gradual convergence of the roadways has a longer paved gore area. Each location where a ramp meter is considered needs to be checked to verify the clear zone. For further information contact the Roadway Engineering Section Interchange Engineers.

Figure 600-31: Two-Lane Ramp Meter with Tapering to One-lane Entrance Ramp



605.10 Freeway Ramp Typical Sections

The number of lanes at the actual exit or entry point determines how a ramp is categorized. Single lane ramps that taper to multiple lanes after exiting are still considered one lane – standard shoulders for one-lane ramps are appropriate. Some entrance ramps include added lanes and then taper to a single lane prior to actual freeway entry – again these are considered single lane ramps. Figure 600-32 shows standard dimensions for freeway ramps.

Standard single-lane freeway ramps are 26 feet wide. The 26′ width provides for continued operation if a stalled heavy vehicle or maintenance activity requires using some of the width, although a large truck offtracking in relatively sharp ramp curves can make this more difficult. **When roadside barriers are introduced, the right shoulder is widened by 2 feet.** The left shoulder is normally not widened when barriers are used.

If an additional lane is being added to the ramp, it will normally only require adding eight feet of width – enough to get two 12 foot wide travel lanes. **If multiple lanes are needed, they should all be a minimum of 12 feet wide.** More width may be needed to accommodate truck offtracking on relatively sharp curvature. **Use a taper rate of at least 10:1 when adding the width.** The width can be added either to the left or right of the horizontal alignment as appropriate. Evaluate truck offtracking as part of the ramp design process.

Two lane interchange ramps are normally only used at system interchanges, although there are a few two lane loop connections on ODOT facilities that use two lane criteria. **Two-lane ramps consist of two 12 foot wide lanes, ten foot right and 6 foot left shoulders for a total of 40 feet width.** ***Two lane loops may need additional width for offtracking.*** Two lane entrance and exit ramps at service interchanges normally use single lane ramp shoulders. When standard shoulders are provided and barriers are present on two-lane ramps, no additional shoulder width is normally necessary (apart from the 2-foot "e" distance to right side barriers). When tighter horizontal geometry requires extra width for truck offtracking (as on loop ramps), or horizontal sight lines are restricted, more width may be necessary. The horizontal alignment for two-lane ramps is carried on the center of the traveled way (on the skip stripe between the two lanes). If more lanes are added past the gore, the location of the horizontal alignment remains the in the same place.

Non-freeway ramps can take different forms and may have slightly reduced typical cross section dimensions. **Refer to Figure 600-33 for those dimensions.** The horizontal alignment in that case is carried 2 feet from the left edge of traveled way. **As with freeway style ramps, add 2 feet (also referred to as "e" distance) to the right shoulder width when roadside barriers are present, but not to the left shoulder.**

Many non-freeway ramps are basically the same configuration as the freeway style with slightly reduced cross sectional dimensions. Jug-handle style ramps often have two-way operations and require a physical separator between directions of travel. Concrete median barrier is often not appropriate for this situation. A raised traffic separator (as shown in Standard Drawing RD706) is often preferable. Each direction of travel on jug handle ramps needs to be the same width as shown in Figure 600-33 (22′ total).

Figure 600-32: Freeway Ramps Standard Typical Sections

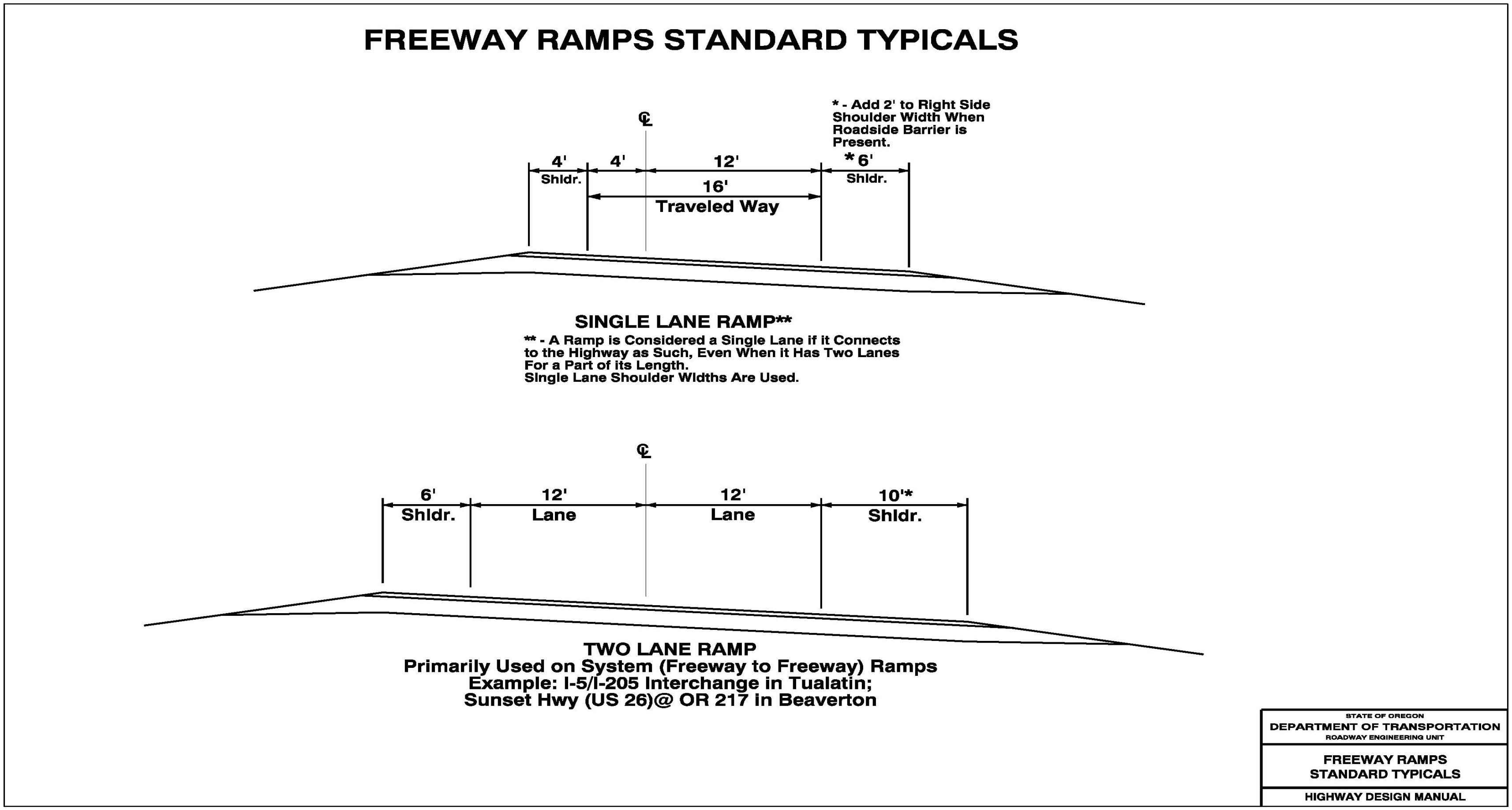
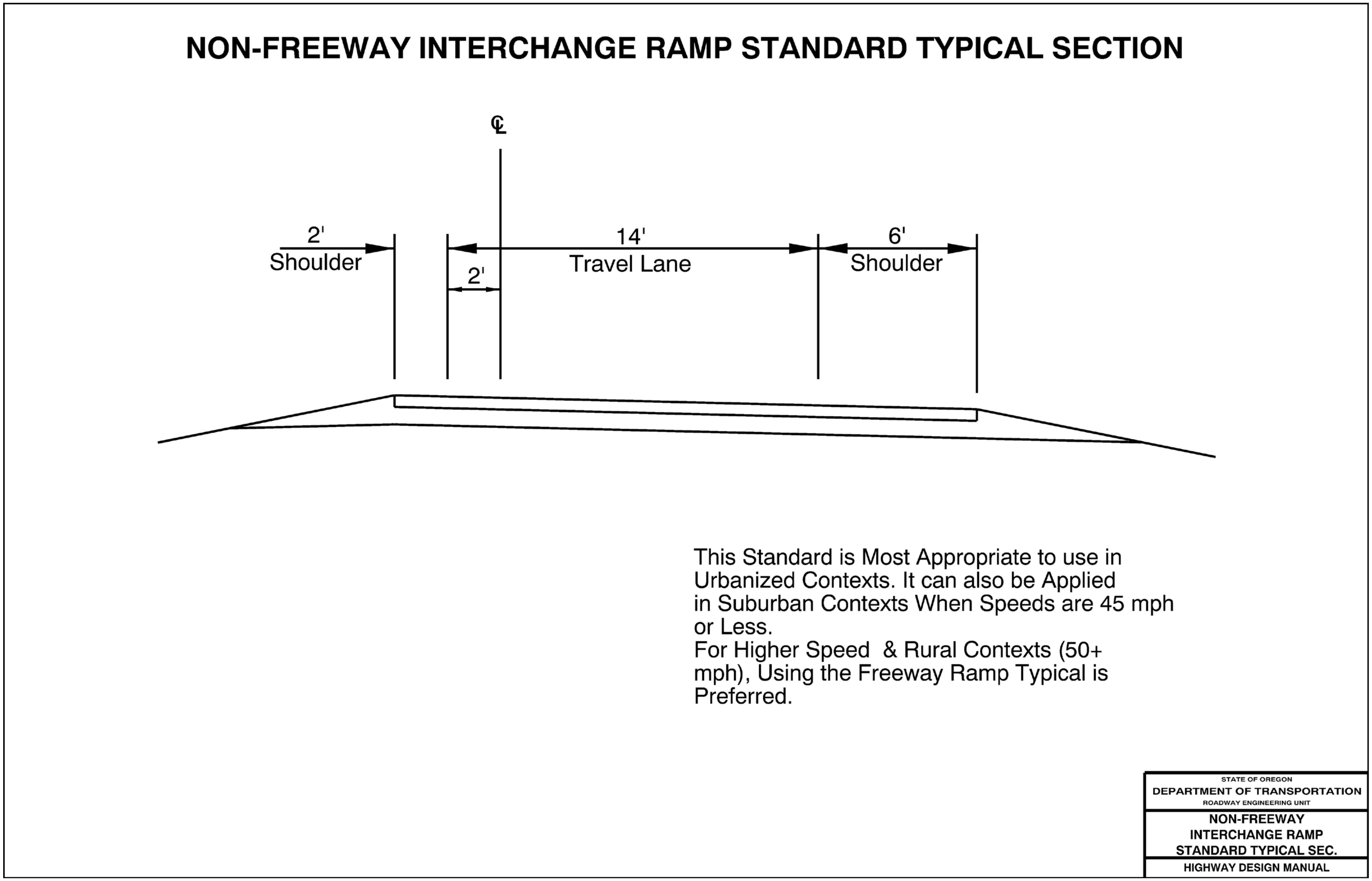


Figure 600-33: Non-Freeway Interchange Ramp Typical Section



605.11 Loop Ramps

Loop ramps should be as large as practical and with a minimum of a 36 degree curve. When designing an exit loop ramp where the crossroad is below the freeway, the maximum degree of curve is 30 degrees, and using spirals longer than the standard is recommended. Details for fitting loop ramp horizontal alignments are located in Figure 600-36 and Figure 600-37. Loop ramp connections usually come parallel to the crossroad using a spiral rather than an angled connection but can also terminate at a regular intersection. Figure 600-34 and Figure 600-35 show details for loop intersections at crossroads.

Adjacent loop ramps on the same side of the freeway are not usually permitted unless the weaving section is carried on a Collector-Distributor (C-D) road. Free flowing Loop ramps on the same side of the crossroad are discouraged due to the short weaving section normally available between them.

Loop ramp intersections with the crossroad must make appropriate provision for bicycle and pedestrian traffic. For rural interchanges the configuration shown in Figure 600-34 is typically the appropriate design. In urban or urbanizing areas, the treatment in Figure 600-35 is normally the most appropriate configuration. Each location must be evaluated for the most appropriate treatment to use, based on current and projected traffic conditions, the physical constraints on the roadway design, and other factors such as potential land use changes in the interchange area. HDM Part 800 and 900 provide guidance for various design situations. Contact the ODOT Bicycle and Pedestrian Design Engineer for additional guidance.

Loop exit ramps have issues that make their use undesirable in some situations. Deceleration areas need to be substantially longer due to tight radii on the ramps, especially on downgrades. When the loop is located beyond a grade separation structure and fills, it is not as visible to approaching users. Increasing the length of the structure to provide greater visibility can create longer spans (or more short spans with barriers) and can be costly. Significant superelevation is needed on the sharper curves, and this can create problems in areas with snow and ice. Trucks also have more issues negotiating the sharper curves. When loops exit on a downgrade, such as in a depressed interchange, many of the above issues can combine to create operational problems. When considering new interchanges, designs that include loop exits should be used with caution. Existing loop exits need to be evaluated to make sure they sufficiently provide for the above concerns. It may not be feasible to deal with every issue, but opportunities for making incremental improvements should always be sought.

Figure 600-34: Partial Cloverleaf Intersection Detail

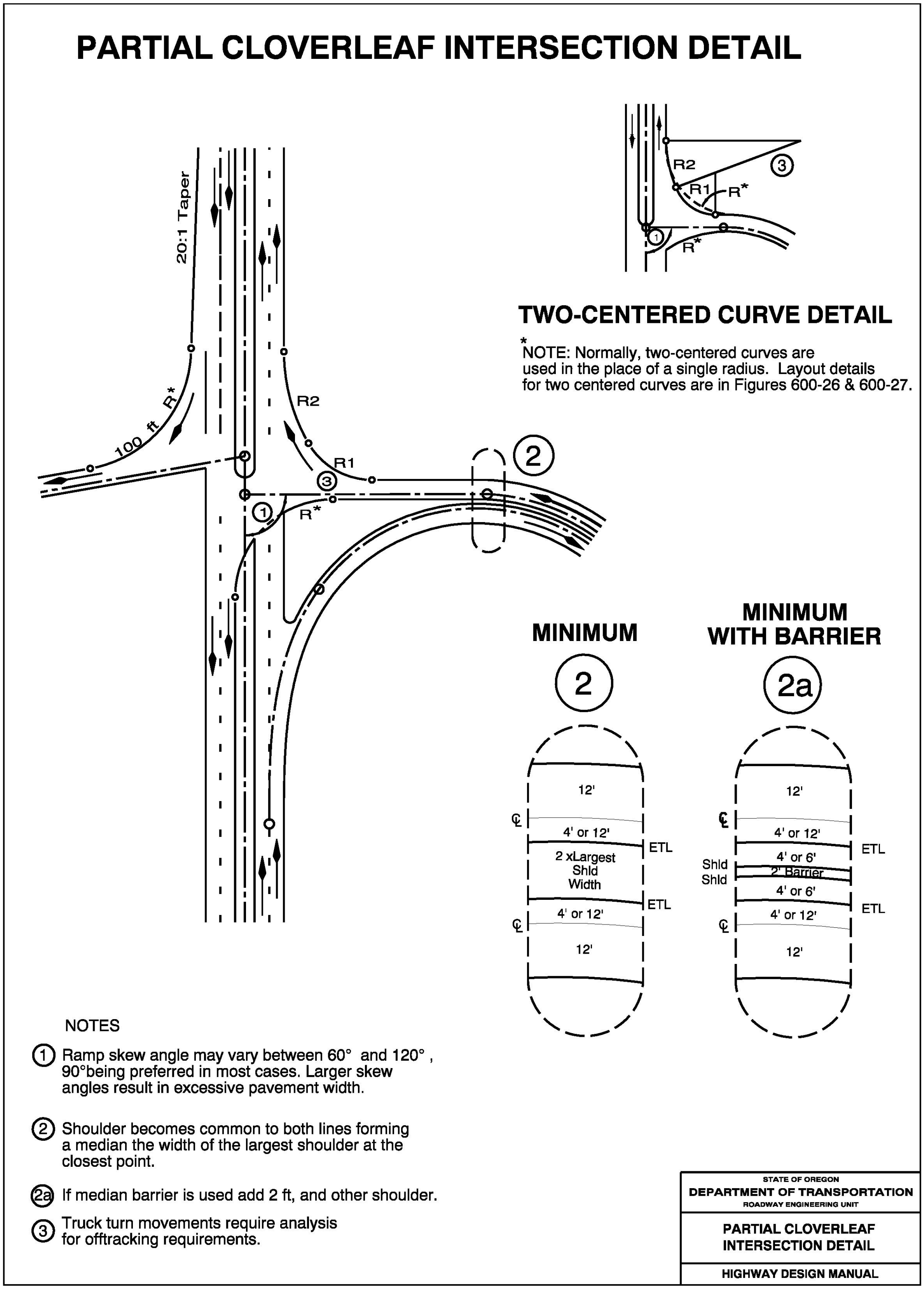


Figure 600-35: Folded Diamond Terminal Detail

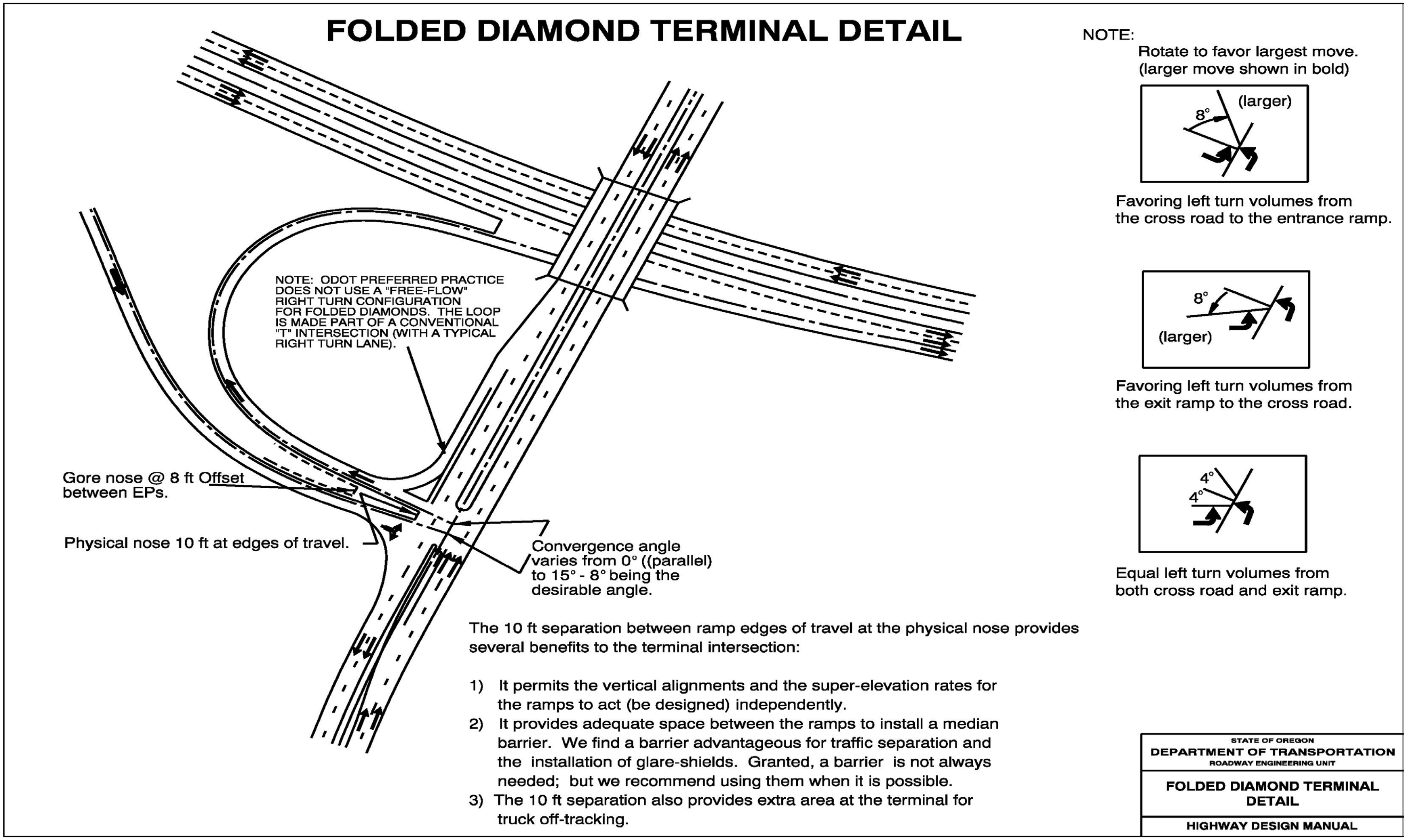
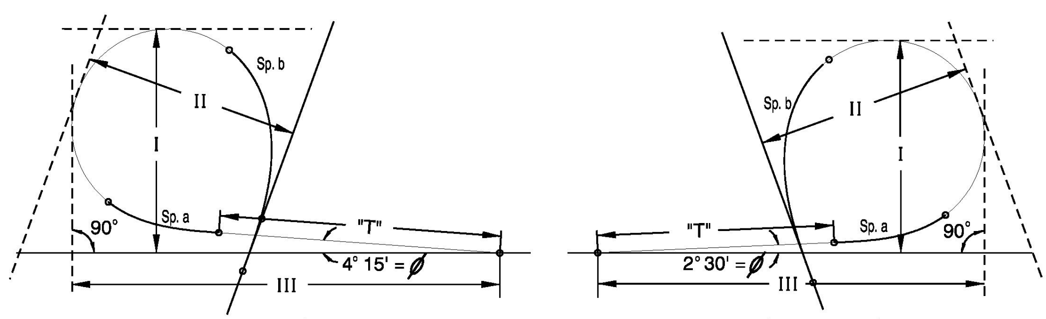


Figure 600-36: Loop Fitting Data (Single Lane)

LOOP FITTING DATA (1 LANE)

EXIT LOOP

ENTRANCE LOOP



I = (R+p)cos Ø + (T+q)sin Ø + R   II = 2R + p_b III = (T+q)cos Ø - (R+p)sin Ø + R

Highway Design Speed=70 mph															
								EXIT				ENTRANCE			
SPEED MPH	CURVE RADIUS	Sp. a LENGTH	p_a	q_a	Sp. b LENGTH	p_b	q_b	* "T"	I	II	III	"T"	I	II	III
30	238.73	200	6.9377	99.4180	400	27.2356	195.4112	420	522.2203	504.7005	738.5158	366.81	504.5053	504.7005	693.8000
25	220.37	200	7.5077	99.3175	400	29.3778	194.6327	450	488.3270	470.1146	751.2878	366.81	468.3598	470.1146	676.1118
25	204.63	200	8.0758	99.2092	400	31.4902	193.7978	450	457.4475	440.7458	736.5636	366.81	437.4563	440.7458	660.9248
25	190.99	200	8.6417	99.0931	400	33.5708	192.9079	450	430.7571	415.5427	723.7750	366.81	410.7459	415.5427	647.7373
25	179.05	200	9.2054	98.9692	400	35.6177	191.9644	450	407.4696	393.7163	712.5577	366.81	387.4418	393.7163	636.1730
25	168.52	200	9.7667	98.8376	400	37.6291	190.9687	450	386.9840	374.6631	702.6331	366.81	366.9423	374.6631	625.9442
25	159.15	200	10.3256	98.6984	400	39.6030	189.9224	450	368.8326	357.9129	693.7846	366.81	348.7793	357.9129	616.8270

** Minimum deceleration lengths for exit ramps with heavy truck volumes								
					EXIT			
SPEED MPH	CURVE RADIUS	Sp. a LENGTH	p_a	q_a	* "T"	I	II	III
30	238.73	200	6.9377	99.4180	700	542.9707	504.7005	1017.7459
25	220.37	200	7.5077	99.3175	745	510.1890	470.1146	1045.4766
25	204.63	200	8.0758	99.2092	745	479.3095	440.7458	1030.7524
25	190.99	200	8.6417	99.0931	745	452.6191	415.5427	1017.9638
25	179.05	200	9.2054	98.9692	745	429.3316	393.7163	1006.7465
25	168.52	200	9.7667	98.8376	745	408.8460	374.6631	996.8219
25	159.15	200	10.3256	98.6984	745	390.6946	357.9129	987.9734

NOTES:

* Exit Loop "T" Distances variable for grades in excess of 3%.

** Consideration for use should be given whenever truck volumes reach or exceed 6 trucks per hour.
A 36° exit loop is considered very minimal for design; using 30° or flatter is highly desirable. A 30°curve (or flatter) is required on exit loops on a downgrade.

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LOOP FITTING DATA (1 LANE)

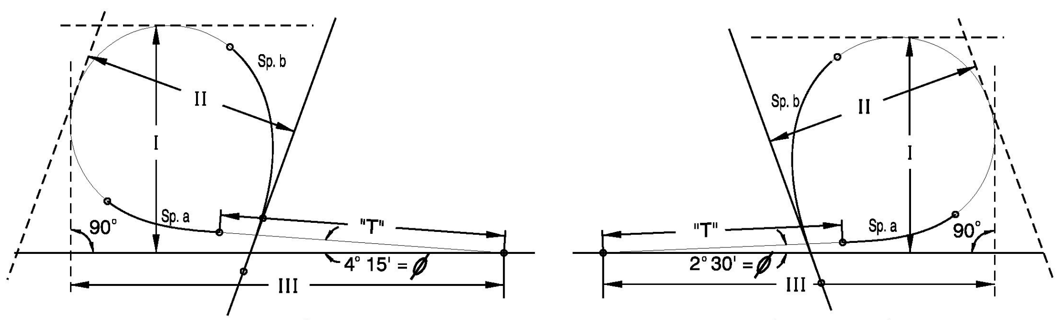
HIGHWAY DESIGN MANUAL

Figure 600-37: Loop Fitting Data (Two Lane)

LOOP FITTING DATA (2 LANE)

EXIT LOOP

ENTRANCE LOOP



$I = (R+p)\cos\phi + (T+q)\sin\phi + R$

$II = 2R + p_b$

$III = (T+q)\cos\phi - (R+p)\sin\phi + R$

Highway Design Speed=70 mph															
								EXIT				ENTRANCE			
SPEED MPH	CURVE RADIUS	Sp. a LENGTH	p_a	q_a	Sp. b LENGTH	p_b	q_b	* "T"	I	II	III	"T"	I	II	III
30	238.73	240	9.9629	118.9964	400	27.2356	195.4112	510	533.3578	504.7005	847.5688	550.2141	516.3816	504.7005	896.4580
25	220.37	240	10.7762	118.8236	400	29.3778	194.6327	540	499.7018	470.1146	860.2506	550.2141	480.4760	470.1146	878.6869
25	204.63	240	11.5856	118.6375	400	31.4902	193.7978	540	469.0573	440.7458	845.4309	550.2141	449.8103	440.7458	863.4117
25	190.99	240	12.3907	118.4381	400	33.5708	192.9079	540	442.5992	415.5427	832.5415	550.2141	423.3352	415.5427	850.1306
25	179.05	240	13.1911	118.2255	400	35.6177	191.9644	540	419.5412	393.7163	821.2182	550.2141	400.2637	393.7163	838.4673
25	168.52	240	13.9867	118.0000	400	37.6291	190.9687	540	399.2822	374.6631	811.1825	550.2141	379.9941	374.6631	828.1344
25	159.15	240	14.7771	117.7616	400	39.6030	189.9224	540	381.3544	357.9129	802.2180	550.2141	362.0581	357.9129	818.9081

** Minimum deceleration lengths for exit ramps with heavy truck volumes								
					EXIT			
SPEED MPH	CURVE RADIUS	Sp. a LENGTH	p_a	q_a	* "T"	I	II	III
30	238.73	240	9.9629	118.9964	790	554.1082	504.7005	1126.7988
25	220.37	240	10.7762	118.8236	835	521.5638	470.1146	1154.4394
25	204.63	240	11.5856	118.6375	835	490.9193	440.7458	1139.6197
25	190.99	240	12.3907	118.4381	835	464.4612	415.5427	1126.7303
25	179.05	240	13.1911	118.2255	835	441.4032	393.7163	1115.4070
25	168.52	240	13.9867	118.0000	835	421.1442	374.6631	1105.3714
25	159.15	240	14.7771	117.7616	835	403.2164	357.9129	1096.4068

NOTES:

* Exit Loop "T" Distances variable for grades in excess of 3%.

** Consideration for use should be given whenever truck volumes reach or exceed 6 trucks per hour.

A 36° (R-159.15') exit loop is considered very minimal for design; using 30° (R-190.99') or flatter is highly desirable.

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LOOP FITTING DATA (2 LANE)

HIGHWAY DESIGN MANUAL

605.12 Frontage Roads and Outer Separations

The area between the traveled ways of a through traffic roadway and a frontage road or street is called the outer separation. **Outer separations shall be a minimum of 33 feet (desirably 40 feet)** between edge of travel lanes for one way frontage roads with traffic proceeding in the same direction as the adjacent freeway or expressway traffic. **A minimum of 40 feet (desirably 50 feet)** is the required outer separations for frontage roads having two way traffic. **These same minimums also apply between ramps and frontage roads**. *Screening of headlight glare should be used on frontage roads with two way traffic or traffic opposing the main roadway or ramp traffic.* These outer separation requirements should not be confused with the ramp terminal and roadway spacing standards (OAR Section 734-051 criteria).

A thorough study should be made to determine appropriate widths of outer separations on ground level freeways. The outer separation should be as wide as can be economically attained to provide a safe buffer zone (see AASHTO's "A Policy on Geometric Design of Highways and Streets – 2018", page 8-5).

At intersections on major streets and on expressways, outer separations shall be minimum of 40 feet (desirably 65 feet) to provide room for turning movements.

Intersections of roads or streets with a crossroad having a structure shall be located 200 feet or more from the end of the structure to improve sight distance for vehicles on the intersecting facilities, unless the intersections are signalized. This applies to grade separations without ramps (non-interchanges). Spacing to crossroad intersections (including frontage roads) in the vicinity of interchanges is subject to OAR Chapter 734-051 criteria.

Section 606 Non-Freeway Interchange Design

606.1 General

The types of interchange designs on highways other than freeways are quite varied. They can range from freeway designs to intersection right in/out jug handles. Many of the design standards for freeway interchange design are also applicable to non-freeway interchange design. Unless otherwise noted below, the freeway design standards generally apply to non-freeway designs as well. However, other design elements and issues related to non-freeway design are discussed below.

606.2 Interchange Spacing

Table 600-2 shows the access spacing standards for non-freeway locations. The spacing shown is measured crossroad to crossroad centerline distance. Other access management spacing standards such as the distance between the ramp terminal and the first approach or first full intersection, and the distance between start and end of tapers of adjacent interchanges need to comply with the OAR Chapter 734-051 spacing standards or obtain a spacing deviation, approved by the Region Access Management Engineer (RAME).

606.3 Design Speed

As with freeway style interchanges, the design speed of the ramps should be between 50 percent and 85 percent of the design speed of the mainline. **However, the ramp design speed should not be below 25 mph. In certain fully urbanized contexts, a lower design speed might be considered, but a design exception is required.**

606.4 Typical Section

The design of the crossroad should be the same as for freeways. The ramp cross sections may be different, however. Non-freeway ramp sections *can use the typical section shown in Figure 600-33 when using "jug handle' style designs.* This configuration is most appropriate in urban and suburban context, where speeds are 45 mph or less. Facilities that are grade separated in those contexts can consider using the non-freeway section as well; operational analysis needs to be done to verify that using this section is appropriate. Large volumes of freight vehicles (e.g.) may indicate that the non-freeway section is not adequate. **If the interchange is a more typical open road type design or in a rural context, or the speeds are 50+ mph, use the regular freeway ramp typical section.**

606.5 Access Control

In addition to controlling access at the ramp terminals at the crossroad, access control along the mainline needs to be acquired upstream and downstream of the deceleration and acceleration lanes. Access needs to be controlled one mile (urban)/two miles (rural) in advance of a deceleration lane and one mile (urban)/two miles (rural) downstream of an acceleration lane. Achieving the access spacing may be very difficult on already developed existing roadways and often requires a spacing deviation. OAR Chapter 734-051 contains information on access management requirements.

606.6 Deceleration Lanes

All exit ramps for non-freeway interchanges require a deceleration lane. The deceleration lane can be a freeway style exit taper with gore area, or an intersection right turn deceleration lane. Either option is adequate for loop ramp or jug handle style ramps. Interchanges that look like a standard diamond should use freeway style deceleration design.

606.7 Acceleration Lanes

The decision to use acceleration lanes will vary depending upon the speed of the highway, ramp volume, highway volume, number of lanes, level of service, and the highway roadside culture downstream from the ramp.

Acceleration lanes should generally only be used when merging with a multilane highway. Only where safety is not compromised, could acceleration lanes be considered on two lane two-way roadways. Safety can be compromised when intersections or road approaches are located in the area of the acceleration lane (even on multi-lane facilities), or if the length of the lane is inappropriate for the specific situation. Acceleration lanes that are longer than necessary may encourage their use as a passing section, while those that are too short will probably not be used effectively. ***Where acceleration lanes are used, they should conform to the lengths shown on Figure 600-13.*** Non-freeway acceleration lanes may or may not use the entrance angle design associated with freeway interchanges. Consistency among ramps and throughout sections should be maintained as much as possible. If the exit ramps utilize an exit angle, the following acceleration lane should use the entrance angle. However, each interchange and ramp needs to be evaluated separately to determine the appropriate design. Typically, if the facility uses a “freeway style” interchange, exit and entrance angles should be used. “Jughandle style” interchanges should use parallel deceleration and acceleration ramps. Refer to Figure 600-8 for examples of non-freeway interchange designs.

Acceleration lanes for at-grade intersections that are not associated with non-freeway interchange design shall follow the requirements outlined in Part 500 of this manual.

606.8 Transitional and Combination Type Facilities

Facilities that are transitioning from at-grade to grade separated connections require special attention. Mixing of at-grade and interchange type controls can create safety and operational problems. An example of this situation is when an at-grade intersection is located near the end of an interchange acceleration lane, setting up conflicting speed/lane change maneuvers.

It is also very undesirable to have an at-grade intersection in between two interchanges, even those with jughandle style ramps. It is preferable to proceed with grade separating and adding ramps in a more “linear” fashion, adding the grade separations from one intersection to the next in progression. Traffic demand, existing development, and other factors can make this approach impractical. Consideration must always be given to the likely operational and safety effects of transitioning a corridor in a non-linear fashion. Tables 6 and 7 in OAR Chapter 734-051 give minimum spacing criteria to guide on planning and design for non-freeway facilities. A basic purpose of these criteria is to provide for safe operating conditions.

As a practical matter, meeting these criteria may require developing frontage road systems for local access. It may suffice to complete missing elements of the local road network (where terrain and existing development allow for it). Grade separations without ramps spaced at regular intervals provide for connectivity across the main facility.

Long-term planning for transitioning facilities should consider the need for and impact of future improvements. An example of this is the future conversion of a jughandle type interchange to a standard freeway style set of ramps. In cases where it is expected that a grade separation might be converted to an interchange, adequate spacing between other features is necessary.

Coordination between planning and project development is very important in this context. Good communication can help to minimize difficult, expensive, and sometimes ineffective afterthought fixes. Planners and engineers must strive to get a common understanding of problems, needs, and constraints from each other’s viewpoint.

Figure 600-38: Non-Freeway Interchange Example

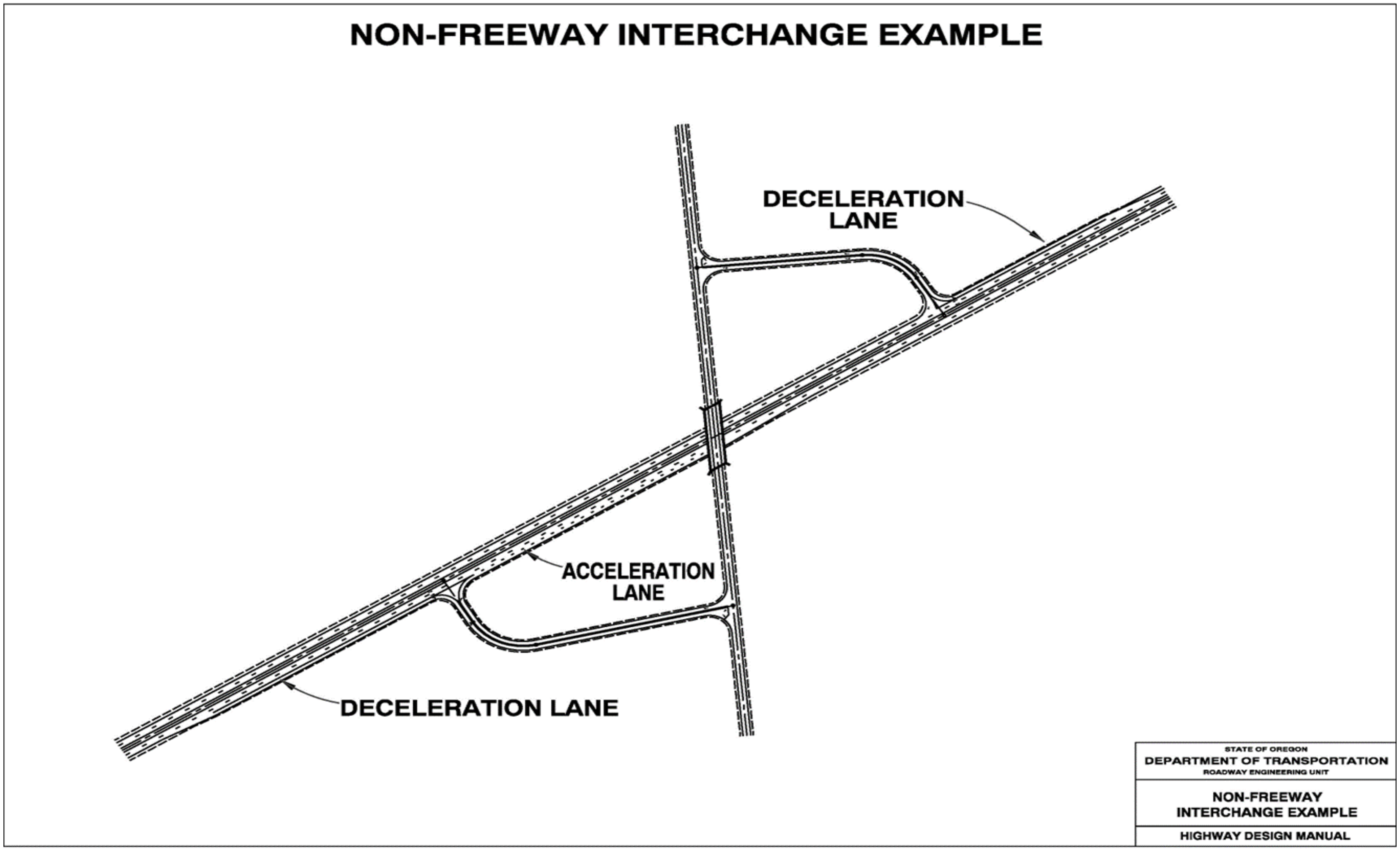
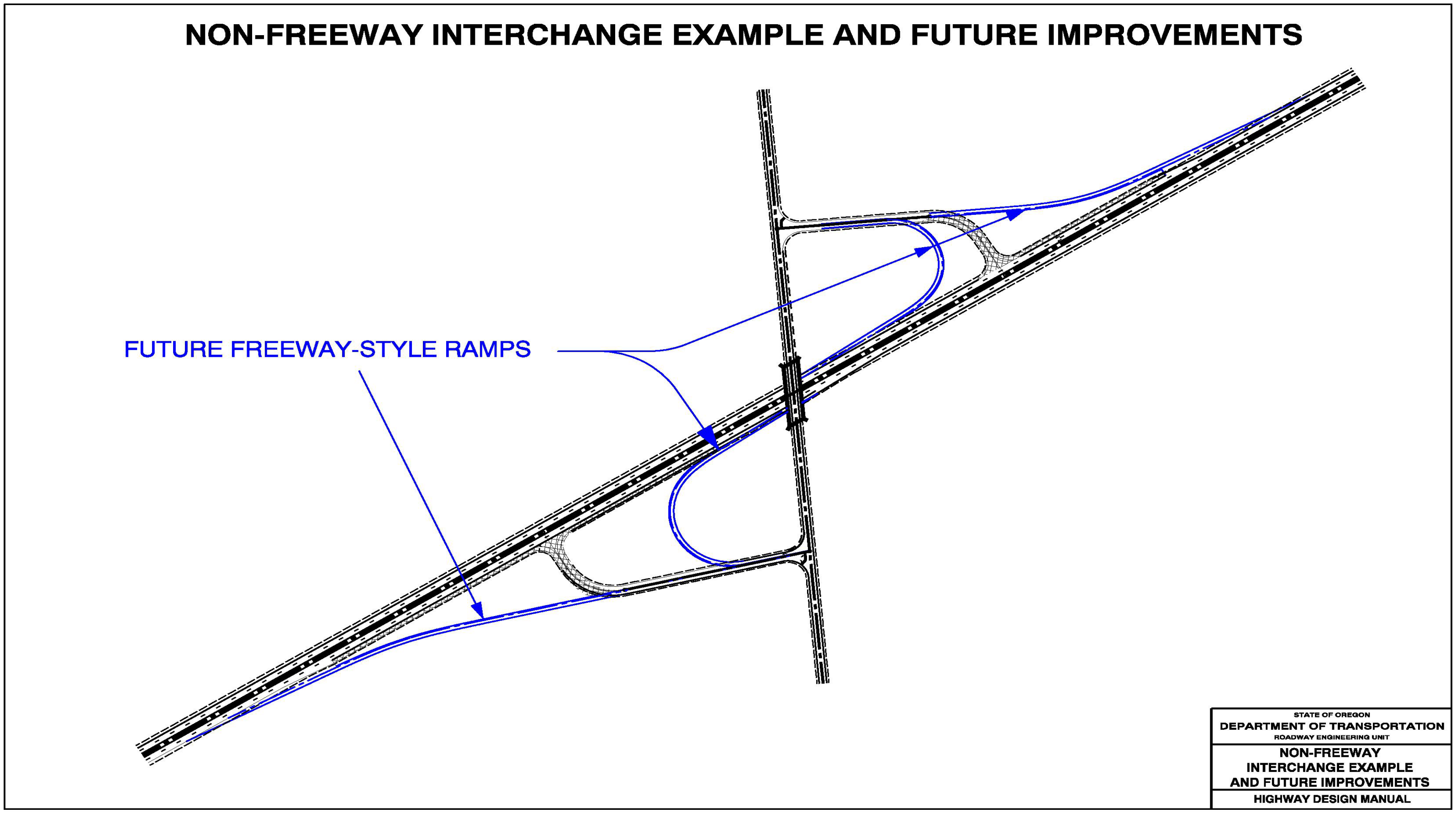


Figure 600-39: Non-Freeway Interchange Example and Future Improvements



Section 607 Accommodating Bicycles and Pedestrians

Bicycle and pedestrian movements must be accommodated through interchanges, even in rural locations. Even in urban or suburban areas where sidewalks are in place, the existing accommodations may not be suitable for current needs. It is equally important to develop the design for bikes and pedestrians as well as vehicles. Some interchange configurations (such as the Single Point or Diverging Diamond) require multi-stage crossings and refuge islands. Occasionally it is necessary to provide separated facilities through complex interchanges. Overhead illumination may also be needed. Each discipline involved in the design (geometry, traffic, structure) needs to coordinate to ensure the needs of various users are met.

The primary conflict points for these modes are at the ramp intersections. Refer to Part 500 (Intersections), 800 and 900 (bicycles-pedestrians-ADA) of this manual for detailed guidance on how to treat these areas.

For all interchange projects, designers should coordinate with the ODOT Bicycle and Pedestrian Design Engineer, Region Active Transportation Liaisons, and the ODOT Interchange Engineer. The combined effects of interchange operations and the context in which the interchange is located can be complex and needs a careful review.

Section 608 References and Design Aids

AASHTO "A Policy on Geometric Design of Highways and Streets - 2018"

AASHTO "A Policy on Design Standards-Interstate System - 2016"

FHWA Policy Statement on Additional Interchanges to the Interstate System – May 22, 2017 Revision

The "Oregon Highway Plan - 1999" ("OHP"), plus amendments.

Oregon Administrative Rules (OAR) Chapter 734, Division 51.

AASHTO *"A Policy on Geometric Design of Highways and Streets-2018"*- Chapter 10, pages 10-82 to 10-87

Chapter 10 of the AASHTO *"Policy on Geometric Design of Highways and Streets – 2018"*, page 10-3 to 10-5 has a detailed discussion on things to consider for each interchange warrant.

Tables 6 and 7 in OAR Chapter 734-051 give minimum spacing criteria to guide on planning and design for non-freeway facilities.

Figure 600-40: Design Aid 1 - Exit on Inside of Curve – Case A

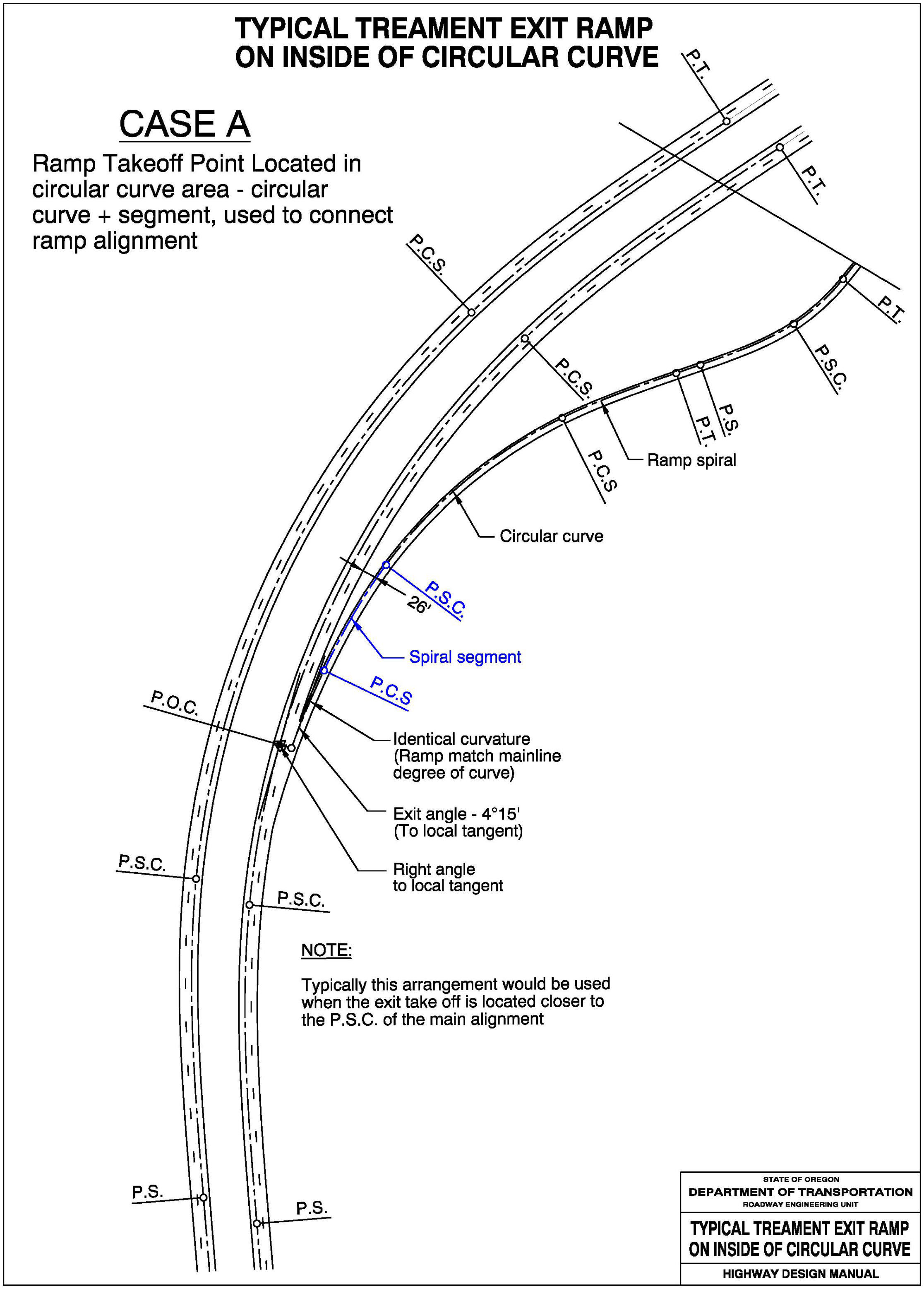


Figure 600-41: Design Aid 2 – Exit on Inside of Curve Case B

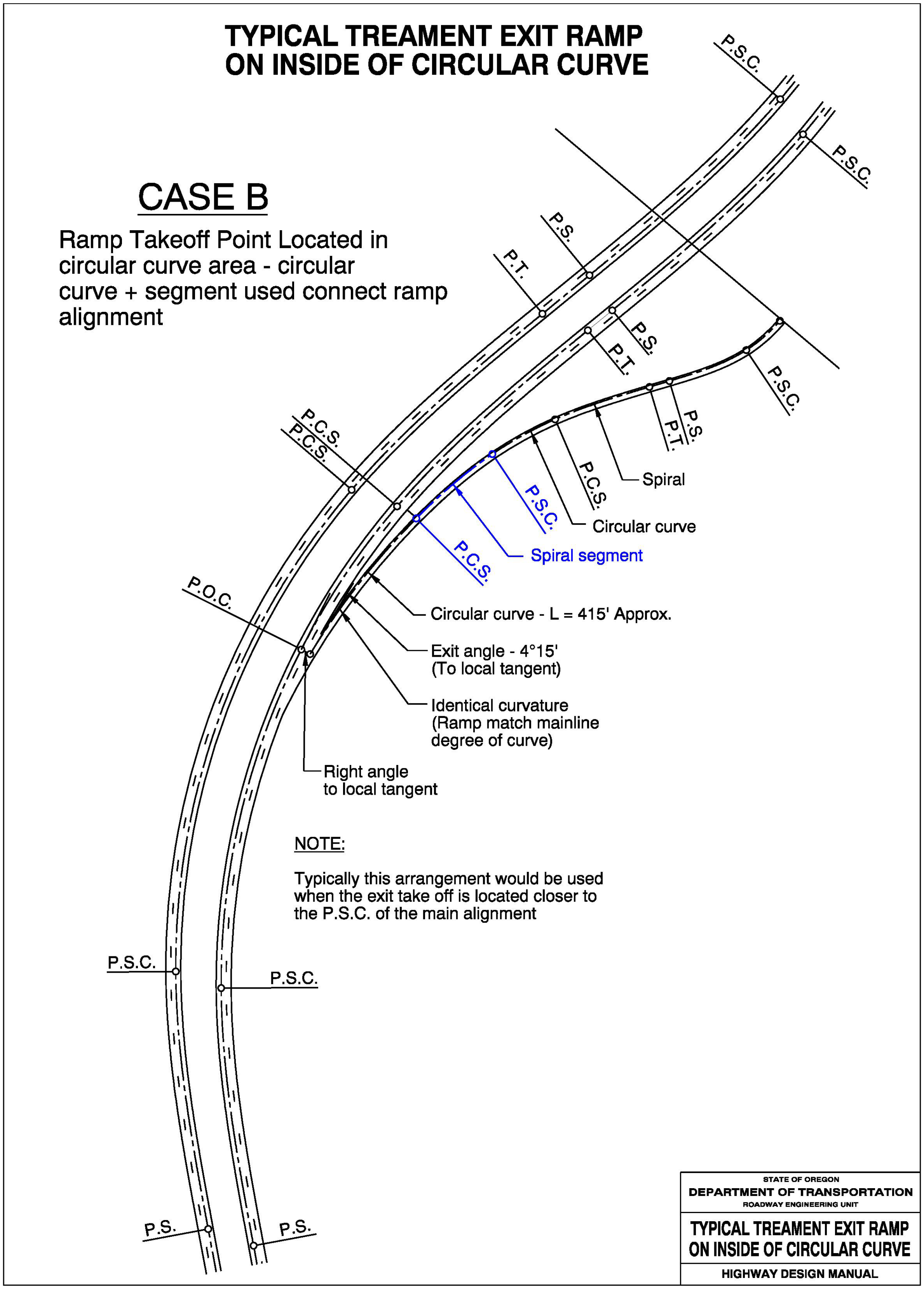


Figure 600-42: Design Aid 3 - Exit from Inside of Curve in Leading Spiral Area

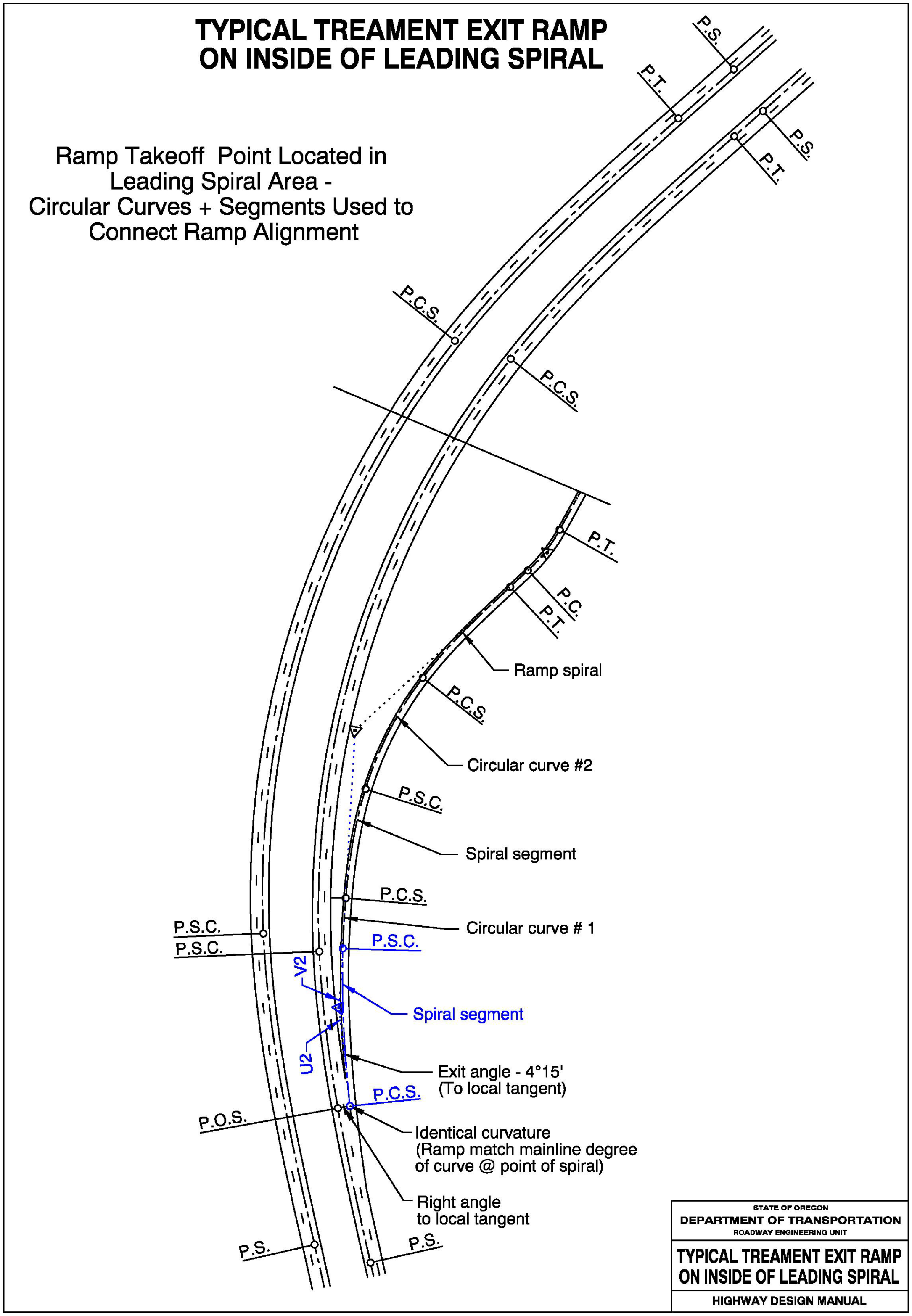


Figure 600-43: Design Aid 4 -Exit from Inside of Curve in Trailing Spiral Area

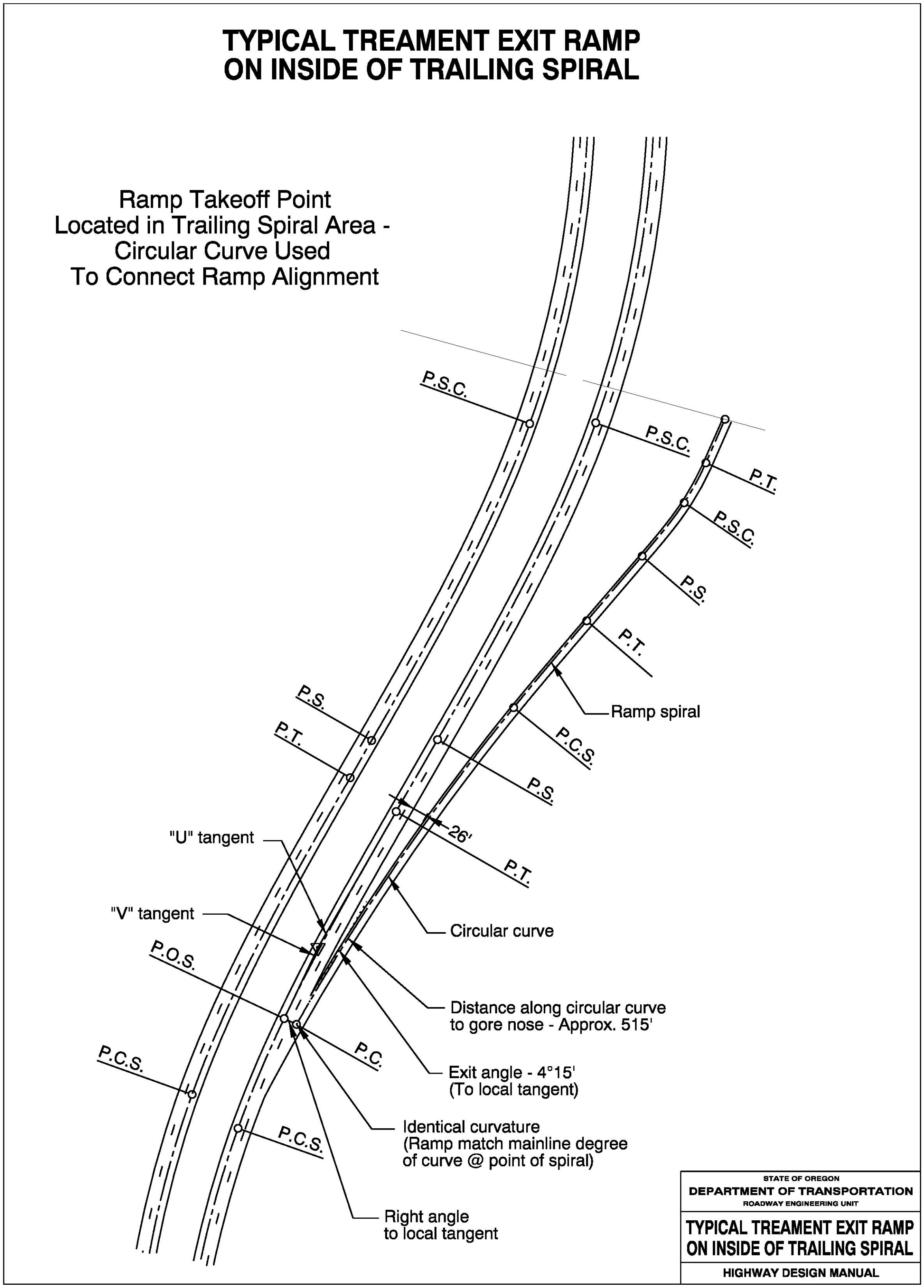


Figure 600-44: Design Aid 5 -Exit from Outside of Circular Curve

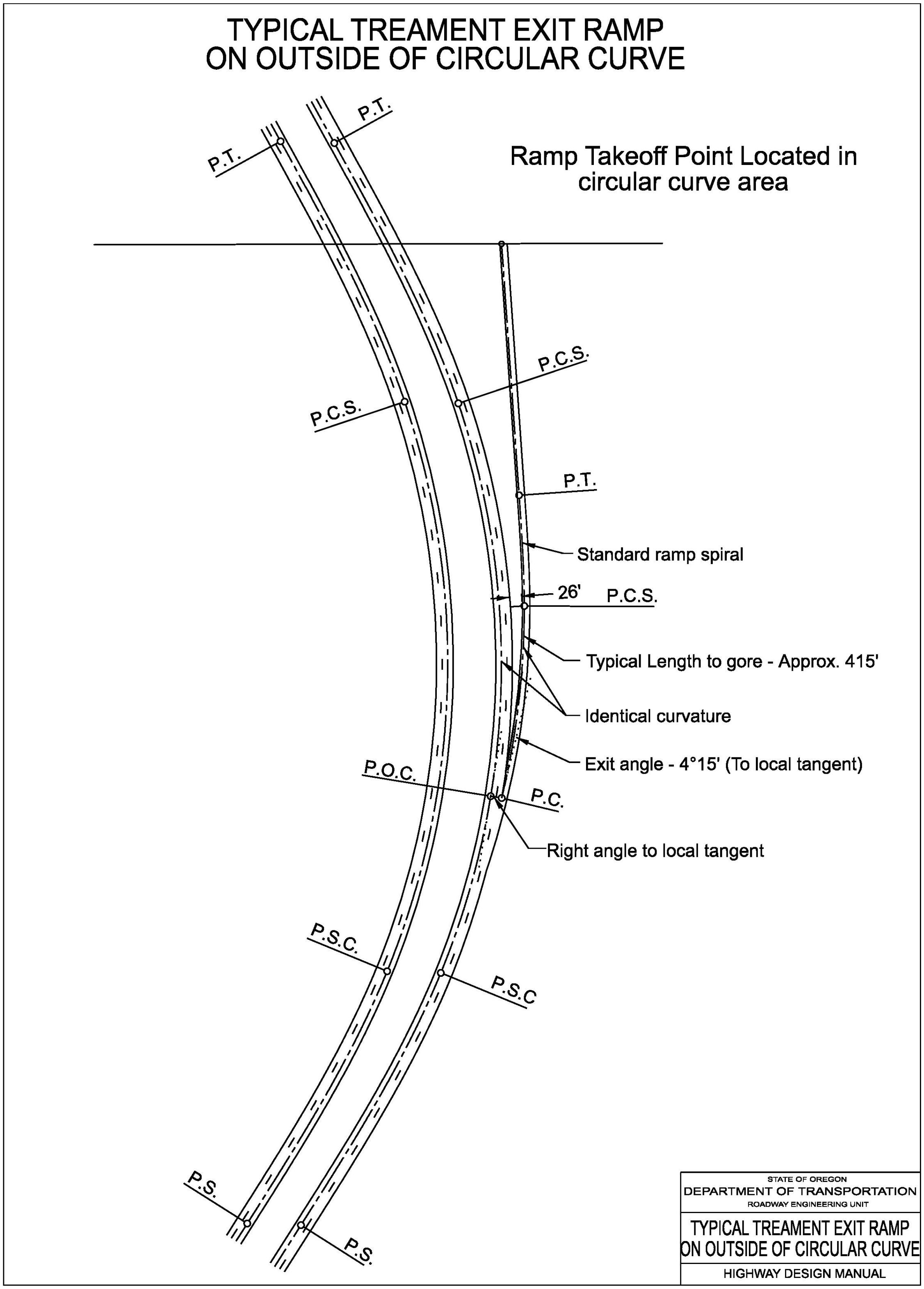


Figure 600-45: Design Aid 6 Exit on Outside of Curve in Leading Spiral Area

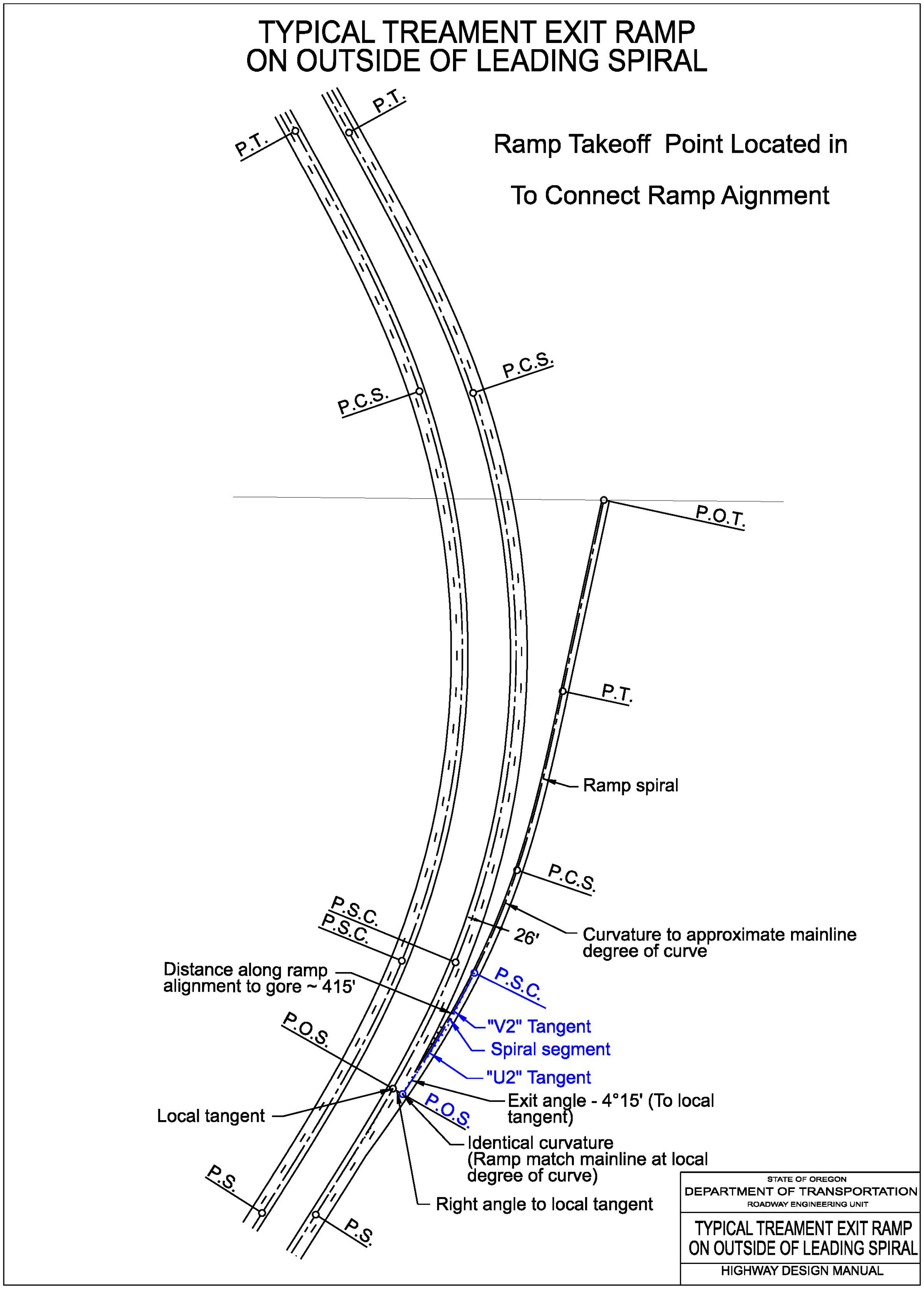


Figure 600-46: Design Aid 7 -Exit from Outside of Curve in Trailing Spiral Area

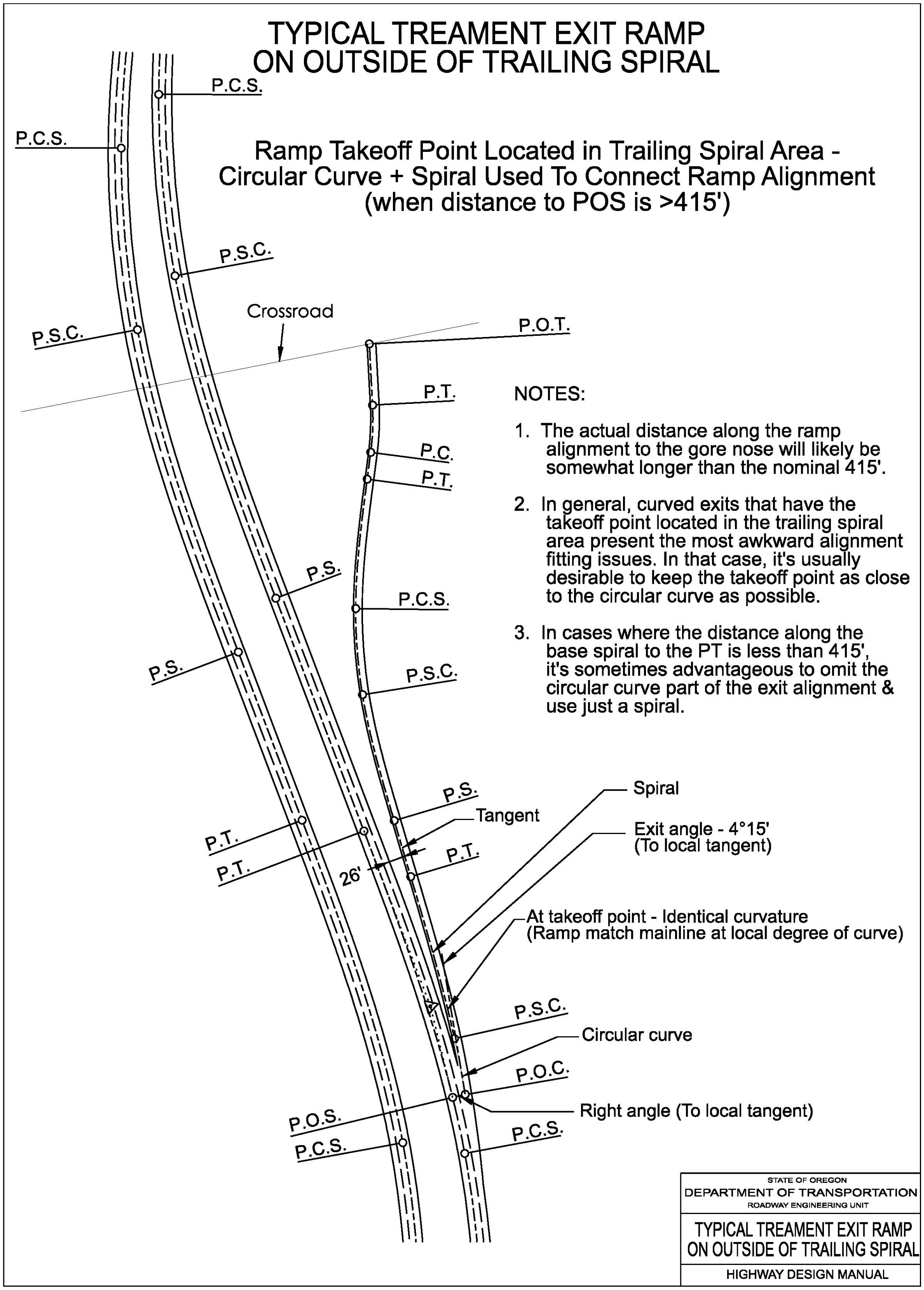


Figure 600-47: Design Aid 8 – Entrance on the Inside of a Circular Curve Area

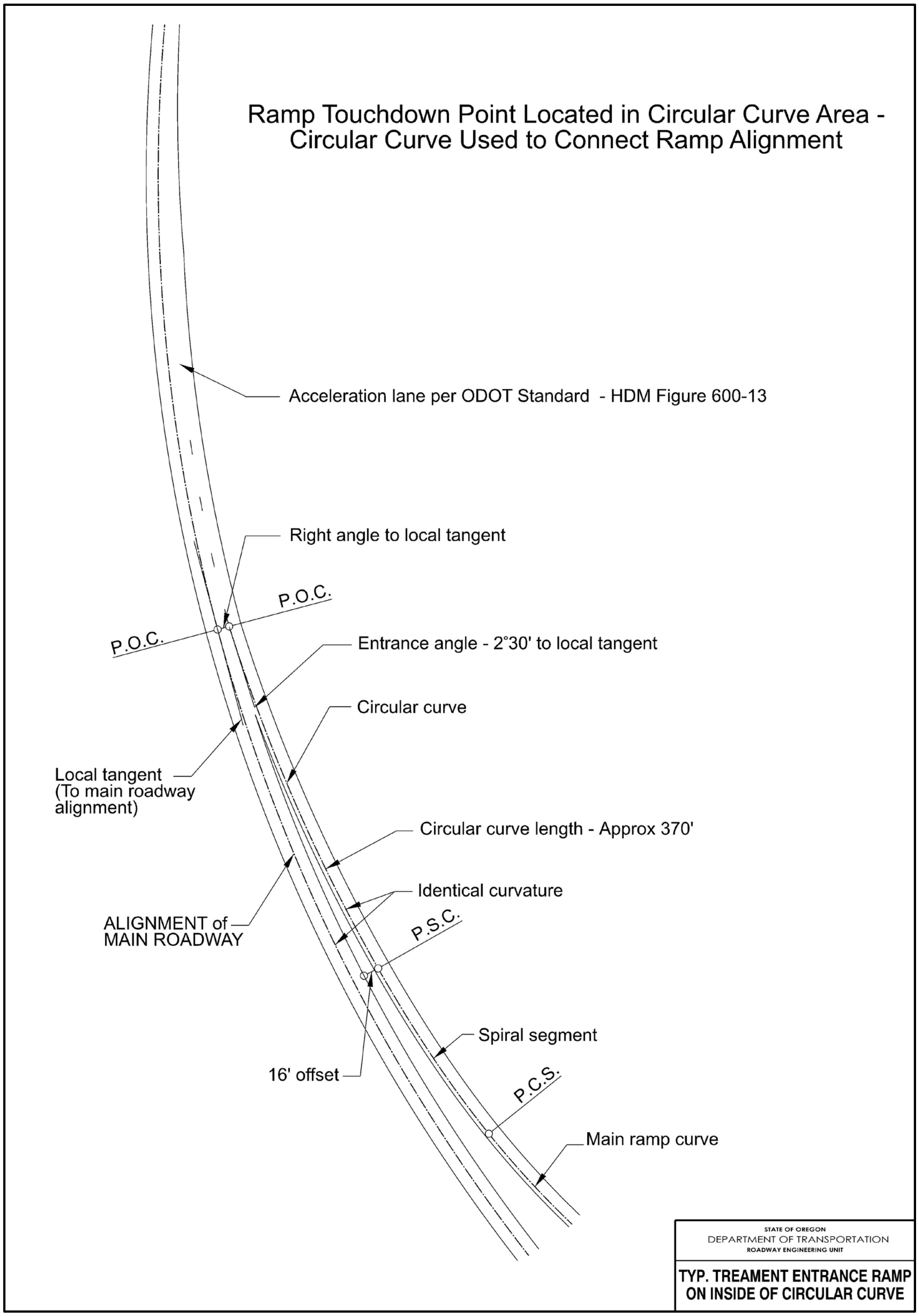


Figure 600-48: Design Aid 9 –Entrance on the Inside of the Leading Spiral Area

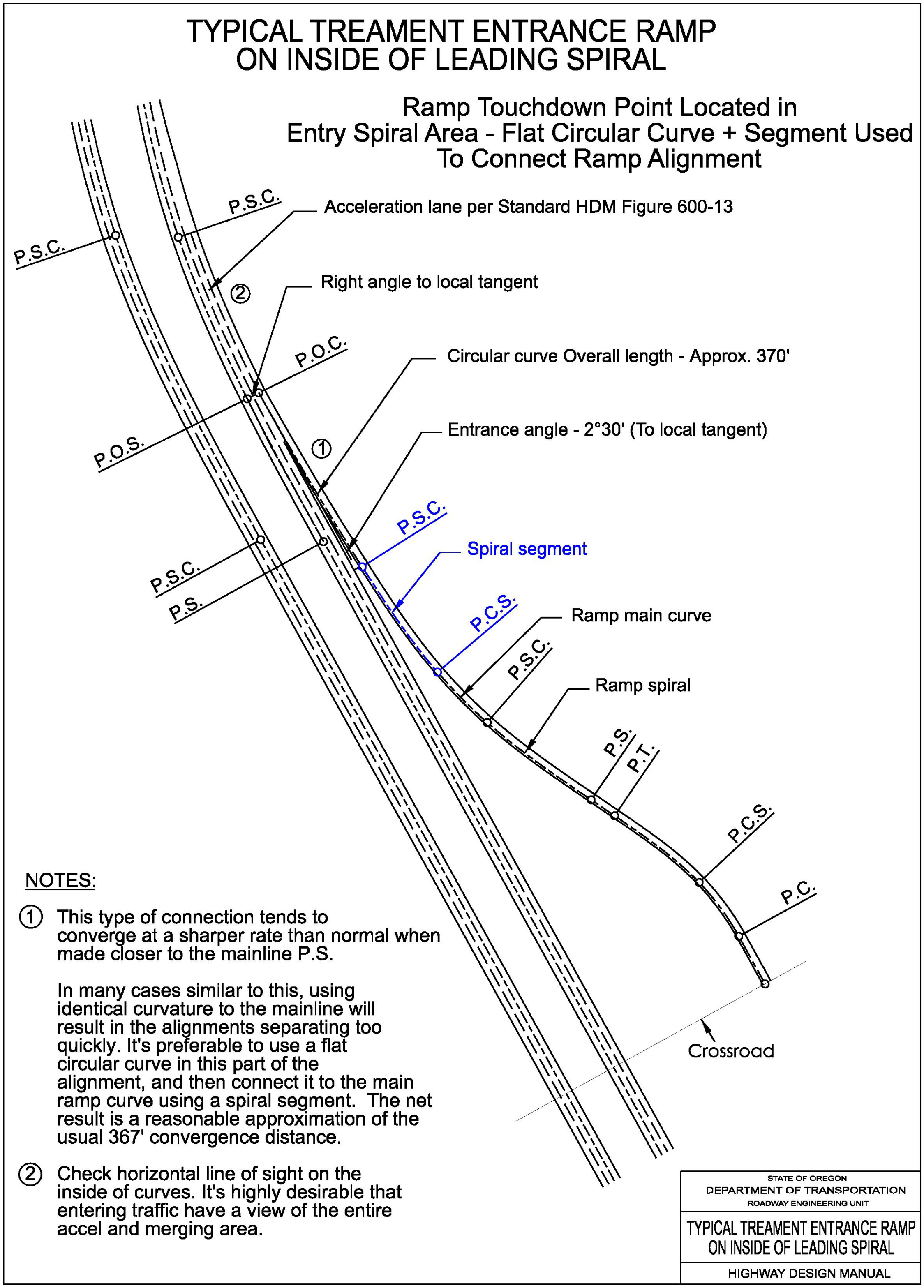


Figure 600-49: Design Aid 10 – Entrance on Inside in the Trailing Curve Area

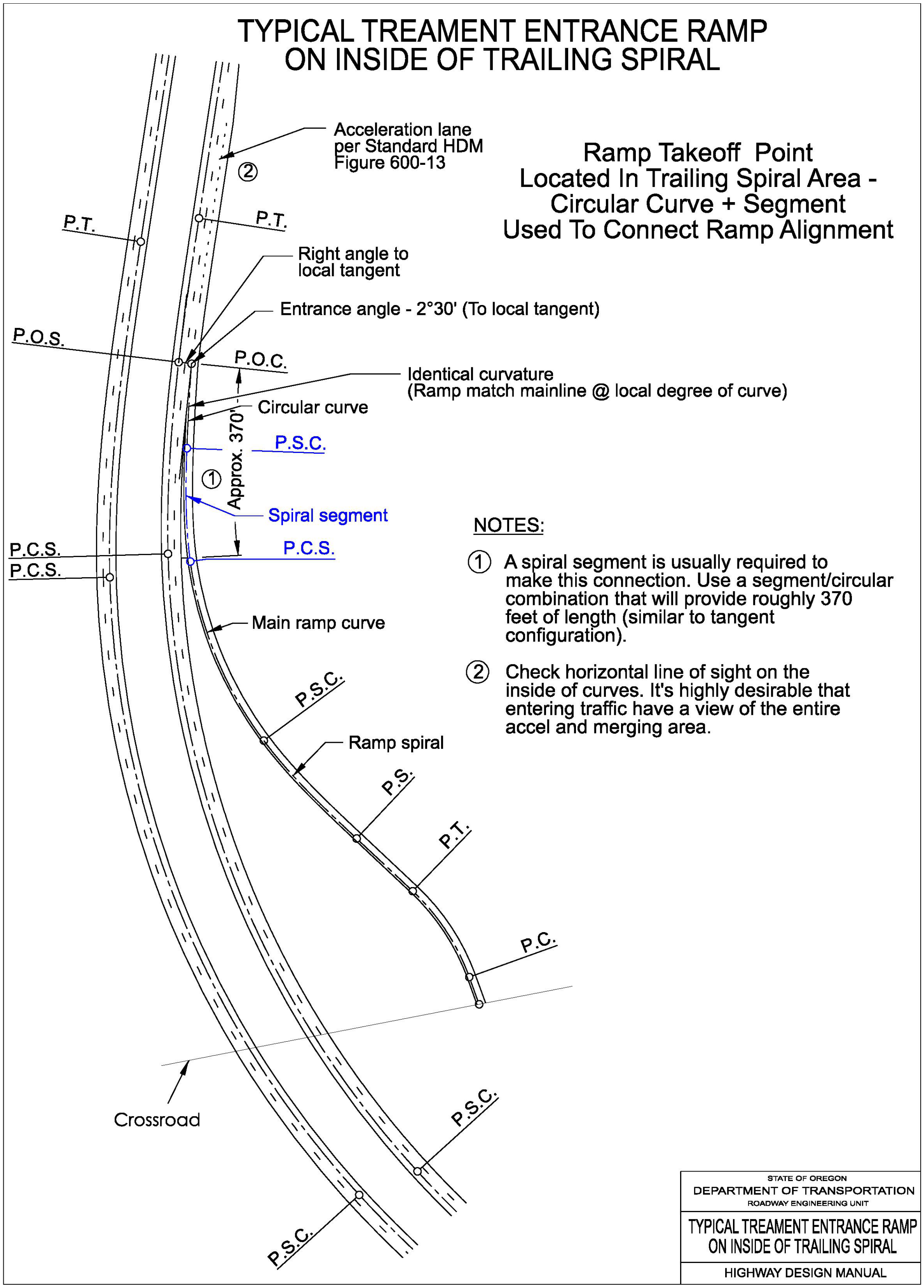


Figure 600-50: Design Aid 11 –Entrance on the Outside in Circular Curve Area

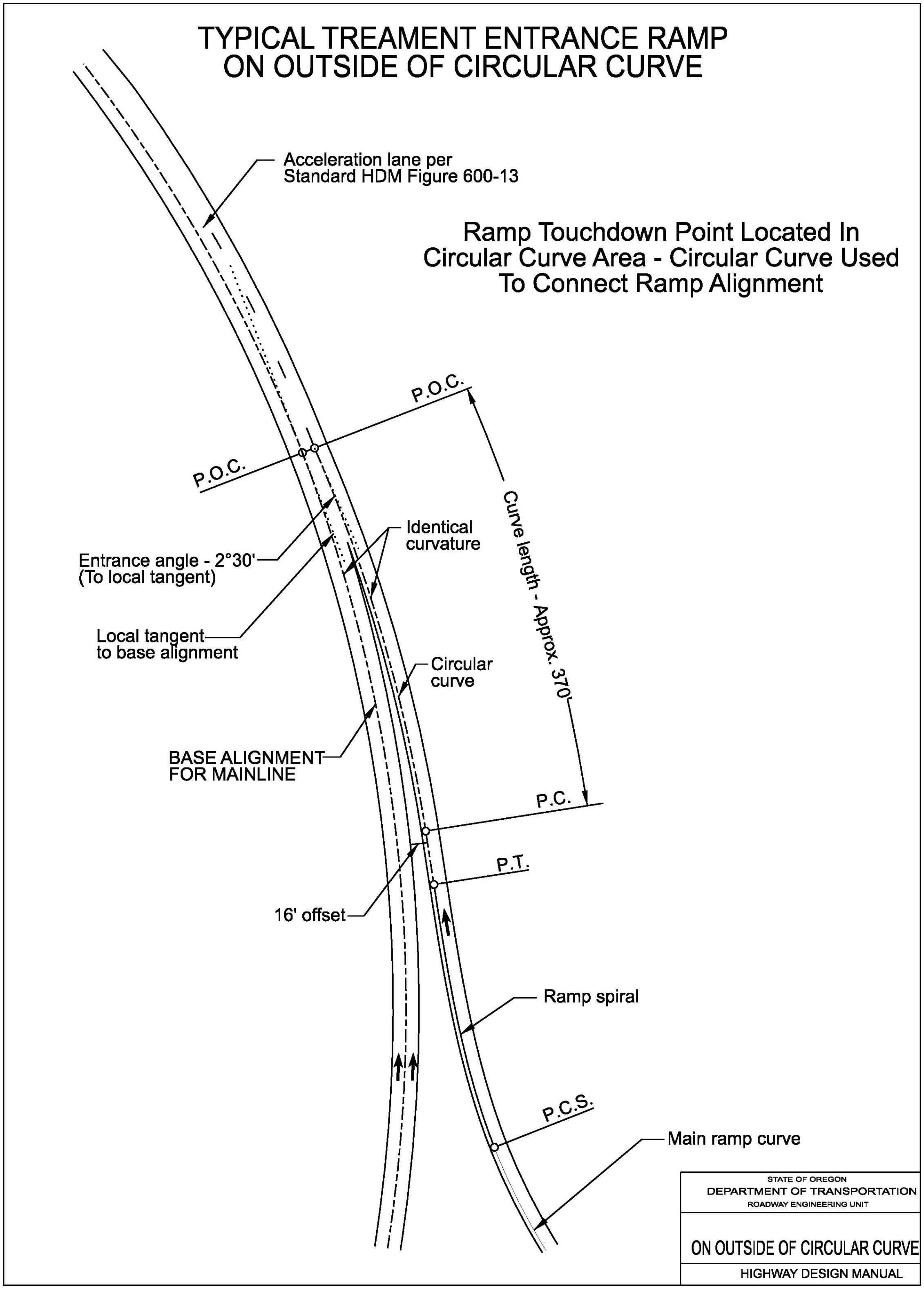


Figure 600-51: Design Aid 12 Entrance on Outside in Leading Spiral Area

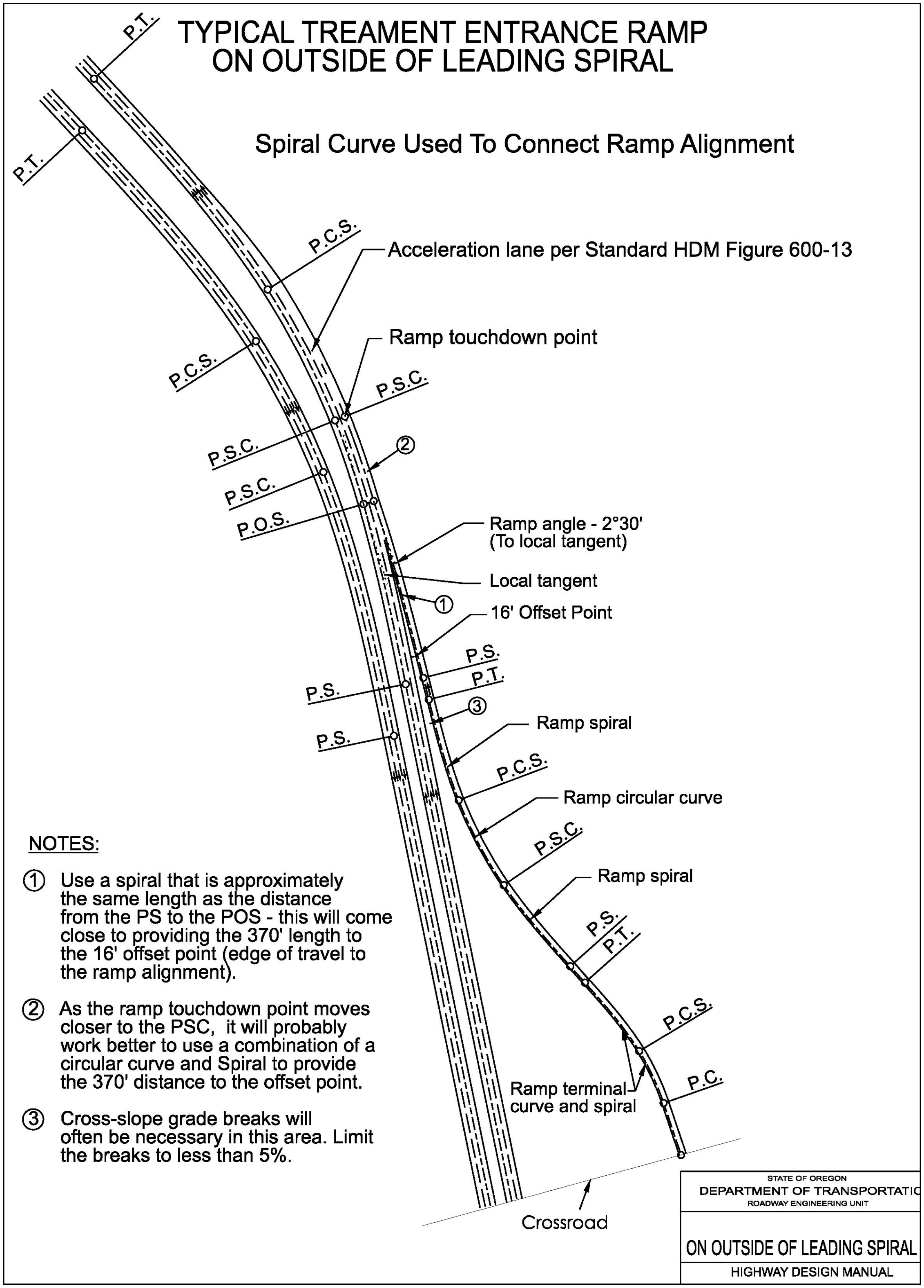


Figure 600-52: Design Aid 13 Entrance on Outside in Trailing Spiral Area