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NCHRP SYNTHESIS 332

Access Management on Crossroads in the Vicinity of Interchanges

A Synthesis of Highway Practice

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Planning and Administration, Transportation Law, Highway and Facility Design, and Highway Operations, Capacity, and Traffic Control

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Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

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FOREWORD

*By Staff
Transportation
Research Board*

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

Information exists on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, “Synthesis of Information Related to Highway Problems,” searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

The synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This report of the Transportation Research Board focuses on the current practices relating to access location and design on crossroads in the vicinity of interchanges. It identifies standards and strategies used on new interchanges and on the retrofit of existing interchanges. In addition to a discussion of some of the planning, operation, and design practices for new and retrofit projects, several case studies are provided illustrating how various transportation agencies (states, provinces, toll authorities, and local) have dealt with access locations on interchange crossroads. Among the topics discussed are spacing standards, factors influencing access location, spacing measurement, and access management techniques for interchange crossroads.

Information for this synthesis report was derived from a literature search, on-line questionnaire responses from various departments of transportation, a review of additional materials provided by the agencies, and follow-up interviews with agency contacts.

A panel of experts in the subject area guided the work of organizing and evaluating the collected data and reviewed the final synthesis report. A consultant was engaged to collect and synthesize the information and to write this report. Both the consultant and the members of the oversight panel are acknowledged on the title page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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Gary Sokolow, Transportation Planner, Florida Department of Transportation; and Eric Tabacek, Chief, Traffic Development and Support Division, Maryland State Highway Administration.

This study was managed by Jon Williams, Manager, Synthesis Studies, who worked with the consultant, the Topic Panel, and the Project 20-5 Committee in the development and review of the report. Assistance in project scope development was provided by Donna Vlasak, Senior Program Officer. Don Tippman was responsible for editing and production. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Crawford F. Jencks, Manager, National Cooperative Highway Research Program, assisted the NCHRP 20-5 Committee and the Synthesis staff.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance are appreciated.

ACCESS MANAGEMENT ON CROSSROADS IN THE VICINITY OF INTERCHANGES

SUMMARY

The primary focus of this synthesis is to document and summarize current practices relating to access location and design on crossroads in the vicinity of interchanges. In addition, this synthesis was designed to identify standards and strategies used on new interchanges and on the retrofit of existing interchanges. Each element of this synthesis is described in the following paragraphs.

The synthesis includes a summary of literature on the current research and publications available in the area of access management on crossroads in the vicinity of interchanges. Within the discussion, the synthesis also provides additional resources to help readers obtain specific information about the planning, operational, and design elements associated with locating access points in the vicinity of interchanges. Discussion of the literature review pertains to access management policies, summarizes various impacts of access management techniques, and addresses some of the tools for implementing an access management program.

In addition, the synthesis provides a summary of the strategies employed by various state departments of transportation, toll agencies, and other road authorities to manage access to and from crossroads in the vicinity of interchanges. The information presented is primarily based on questionnaire responses received from the various agencies, a review of additional materials provided by the agencies, and follow-up telephone interviews with the agency contacts. Based on these efforts, the synthesis includes a discussion on the survey questionnaire and design; survey responses and findings; agencies' access management programs; spacing standards on interchange crossroads; factors influencing access location on interchange crossroads; spacing measurement on interchange crossroads; access management techniques for interchange crossroads; and planning, operation, and design practices for new and retrofit interchange projects.

In addition to a discussion of some of the planning, operation, and design practices for new and retrofit interchange projects, the synthesis provides several case studies illustrating how various transportation agencies have dealt with access locations on interchange crossroads through new and retrofit interchange projects. Based on the responses from the survey questionnaires sent to various agencies throughout North America, and on follow-up interviews, eight case studies are summarized within the synthesis.

Although significant research has been conducted and much information has been collected on the benefits of managing and locating access points outside of interchange terminals, there are still impediments that continue to limit the ability of transportation professionals to successfully implement these practices. These impediments can be and have been overcome by agencies that have solid access management legislation and/or regulations, and that employ integrated processes to plan, design, operate, and maintain interchange facilities and the downstream access location points on their crossroads.

INTRODUCTION

BACKGROUND

Interchanges are a crucial component of the freeway and highway system. They provide access to and have become focal points of urban, suburban, and rural areas. The concentration of traffic in interchange vicinities stimulates land development activity. This situation often results in multiple driveways on the crossroad in close proximity to the interchange. Frequently, operational and safety problems occur when driveways and intersections are spaced too closely to the interchange terminals. Examples of these problems include increased congestion, significant weaving, increased crash rates, and the need for complex signal timing (1). Mitigation measures applied in the past to address these issues often consisted of roadway widening to increase the capacity of the crossroad and the construction of frontage and backage roads to alleviate congestion. Both measures often require additional right-of-way and may lead to more congestion. These solutions frequently only temporarily address the problem; furthermore, neither is conducive to creating a safe environment for pedestrians and bicyclists. Access management provides an alternative to protect the longevity of the interchange and crossroad.

The locating and controlling of access points on crossroads upstream and downstream of interchange terminals has been researched and considered ever since the first interchange in North America was constructed in 1928 in Woodbridge, New Jersey (Figure 1). The control of access has continued to the present as state departments of transportation (DOTs), toll authorities, ministries of transportation, and other roadway agencies have developed or are in the process of developing comprehensive access management programs to protect public investments in grade-separated interchanges.

The purpose of an access management program is to balance the required mobility of a roadway facility with the accessibility needs of the adjacent land uses. Crossroads in the vicinity of interchanges require a high level of mobility to prevent congestion on the crossroad from queuing onto the interchange ramps. Controlling access on crossroads near interchanges has the benefit of minimizing congestion, reducing crash rates, simplifying driving tasks, and improving pedestrian and bicyclist safety. Not properly managing access on crossroads within the interchange influence area may cause the premature failure of an interchange. In addition, it may cause significant impairment of crossroad and freeway main-line safety and operations.

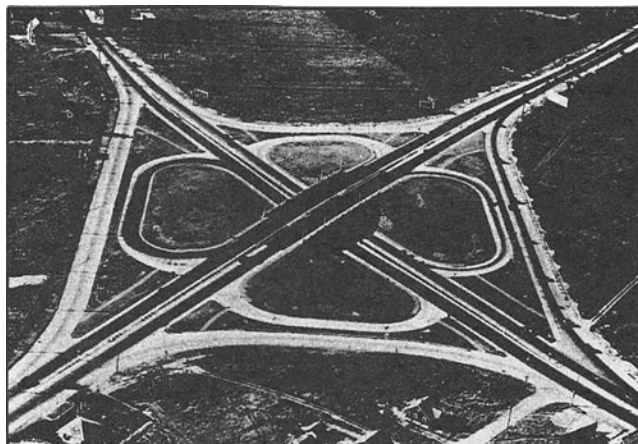


FIGURE 1 Cloverleaf interchange in Woodbridge, New Jersey (2).

Retrofit access management techniques can be employed to remedy poor crossroad operations. Although there are operational and safety benefits associated with controlling access on crossroads, retrofit access management techniques can lead to circuitous routes to reach certain properties, reduced access to local businesses, a concentration of left-turn and U-turn vehicular movements at select intersections, and increased driver confusion.

REPORT FOCUS AND OBJECTIVES

Interchanges are significant capital investments that need to operate safely and efficiently, because they often provide gateways to major activity centers and developments. To maintain the operations of interchanges, it is important to preserve the operations of the crossroad in the vicinity of these interchanges. Poorly located access connections on interchange crossroads can contribute to severe congestion and potentially high crash rates on the crossroad and the interchange. Access management practices on crossroads vary widely from state to state and throughout North America. This synthesis documents and summarizes the current state of the practice in locating and controlling access on crossroads in the vicinity of interchanges. It does so through a literature review and a survey of states, provinces, toll authorities, and local agencies. Specific objectives of the synthesis included the following:

- Describe, analyze, and synthesize pertinent literature;
- Summarize access management practices by states, provinces, toll authorities, and local agencies; and

- Provide case studies that illustrate access management practices and examples where access location and design were improved by retrofit of the interchange and crossroad.

ORGANIZATION OF THE SYNTHESIS

To fully address the current state of practice and issues related to access management on interchange crossroads, this synthesis report has been divided into five chapters, the contents of which can be described as follows:

- Chapter one provides a brief introduction to access management on crossroads in the vicinity of interchanges. In addition, this section highlights the report focus and summarizes the report organization.
- Chapter two addresses current literature on the state of the practice of access management on crossroads in the vicinity of interchanges. This discussion is based on the literature review conducted as part of the synthesis effort and provides additional references to help readers obtain specific information on the planning, operational, and design elements associated with locating access points in the vicinity of interchanges. This chapter includes a summary of recommended access spacing and design considerations that various agencies have suggested, consideration of alternate access concepts, a discussion on the impacts of access management practices, and insights into developing an interchange access management program.
- Chapter three addresses the existing agency programs for access management on crossroads near interchanges. It documents the design of the survey questionnaire that was distributed to agencies throughout North America, and includes a summary of responses and a comparative analysis on various techniques and programs used by the responding agencies and organizations. Specific issues addressed include an overview of the agencies' access management programs; standard spacing on interchange crossroads; access management techniques used on crossroads; and planning, operation, and design practices for new and retrofit interchange projects.
- Chapter four provides several case studies to demonstrate the specific benefits and potential problems associated with various planning, operation, and design techniques; programs; and guidelines associated with locating access points on interchange crossroads. In addition, a summary of lessons learned from these specific projects is provided.
- Chapter five presents a final discussion of findings based on the literature review, survey questionnaire responses, and case studies. In particular, this chapter highlights the general practices, access spacing standards, access control techniques, and results of new and retrofit interchange projects. The synthesis report is completed with conclusions and suggestions for further research.

LITERATURE REVIEW

This chapter provides a summary of literature on the current research and publications available in the area of access management on crossroads in the vicinity of interchanges. The information in this chapter is based on the literature review conducted as part of the synthesis effort and provides additional resources to help readers obtain specific information on the planning, operational, and design elements associated with locating access points in the vicinity of interchanges. The chapter is divided into three sections: (1) a review of access management policies in North America, (2) impacts of access management techniques, and (3) tools for implementing an access management program.

A list of definitions has been provided in the Glossary to aid in the discussion of current access management policies and practices on interchange crossroads.

Over the past several decades, a substantial amount of research has been conducted on access management. Beginning in 1993, the biennial TRB National Conferences on Access Management have facilitated the research and education on access management. In addition, other national and state conferences have provided a forum for the discussion and sharing of knowledge.

ACCESS MANAGEMENT POLICY REVIEW

A lack of access management on crossroads in the vicinity of interchanges can result in safety and operational deficiencies that compromise the integrity of these facilities. To protect the public investment and prolong the life of these facilities, agencies throughout North America have established or are in the process of establishing comprehensive access management programs. The primary components of these programs vary from agency to agency and include a variety of policy, design, and operational guidelines and regulative standards. A summary of several techniques employed by agencies is provided in Table 1.

The remainder of this section addresses the current state of the practice for the following access management and design techniques: access spacing standards, corner clearances, service roads, use of medians, and other example policies.

Access Spacing Standards

Within access spacing standards implemented by various jurisdictions, there are often three elements affecting the management of access on crossroads in the vicinity of interchanges. They pertain to the appropriate spacing of interchanges along highways or major roadways, the distance from an interchange along the crossroad in which access should be controlled (i.e., restricted or eliminated), and the appropriate spacing of public and private accesses along the crossroad.

There are a number of publications that provide guidance at the national level with regard to the distance from the interchange ramps in which access should be controlled on the crossroad. These publications include suggested spacing between the interchange ramp and the first right-in/right-out access, the first unsignalized full access, and the first signalized intersection.

According to AASHTO's *A Policy on Geometric Design of Highways and Streets (Green Book)* (4), "the appropriate degree of access control or access management depends on the type and importance of an arterial. Anticipation of future land use is a critical factor in determining the degree of access control. Provision of access management is vital to the concept of an arterial route if it is to provide the service life for which it is designed." According to that document, at an interchange with free-flow ramps entering and exiting from a crossroad, the preferred access control distance includes the distance it takes a vehicle to merge from the ramp into the outside lane on the crossroad, the distance a vehicle needs to merge into the inside lane, the distance required for a vehicle to move into a left-turn lane, and the length of storage required for the left-turn lane. Figure 2 illustrates the components of the access control distance. This distance can be modified to incorporate the perception–reaction distance.

Many states rely on the guidance provided by AASHTO in an earlier publication, the 1991 *A Policy on Design Standards—Interstate System* (5). This publication recommends that access control be extended beyond the ramp terminal for a minimum of 100 ft in urban areas and 300 ft in rural areas. AASHTO recommends greater spacing for areas in which development has the potential to create traffic problems.

TABLE 1
SUMMARY OF ACCESS MANAGEMENT TECHNIQUES

Technique	Importance in Access Management	Previous Sources	Amenable to Analysis	Analysis in Phase II
Policy Techniques				
1. Establish comprehensive access code	High	—	No	No
2. Institutionalize advance purchase of right-of-way	High	—	No	No
3. Require internal circulation/site plan review	High	—	No	No
Design Techniques				
1a. Establish traffic signal spacing criteria	High	Some	Yes	Yes
1b. Establish spacing for unsignalized access	High	Few	Yes	Yes
1c. Establish corner clearance criteria	High	Few for upstream	Yes	Yes
1d. Establish access separation distances at interchanges	High	—	Yes	Yes
2a. Install physical (restrictive) continuous median on undivided highway	High	Many	Yes	Yes
2b. Replace two-way left-turn lane with restrictive median	High	Many	Yes	Yes
2c. Close existing median openings	High	Some	No	No
2d. Replace full median opening with median designed for left-turns from the major roadway	High	Few	Yes	No
3a. Install left-turn deceleration lanes where none exist	High	Some	Yes	No
3b. Install left-turn acceleration lane	Low	Few	Yes	No
3c. Install continuous two-way left turn lane	Medium	Many	Yes	Yes
3d. Install U-turns as an alternative to direct left turns	Medium-High	Few	Yes (Oper.)	Yes
3e. Install jug handle and eliminate left turns along highways	Medium	Few	Yes (Oper.)	Yes
4a. Install right-turn acceleration/deceleration lane	Medium	—	Yes (Oper.)	No
4b. Install continuous right-turn lane	Low	—	Yes	No
5a. Consolidate driveways	Medium	—	Yes	No
5b. Channelize driveways to discourage or prohibit left turns on undivided highways	High	—	Yes	No
5c. Install barrier to prevent uncontrolled access along property frontage	Medium	—	Yes	No
5d. Coordinate driveways on opposite sides of street	Low-Medium	—	Site-specific	No
6a. Install frontage road to provide access to individual parcels	Medium	—	Yes	Yes
6b. Locate/relocate the intersection of a parallel frontage road and a crossroad further from the arterial-crossroad intersection	Medium	—	Yes	Yes

Source: Gluck et al. (3).
Oper. = operational.

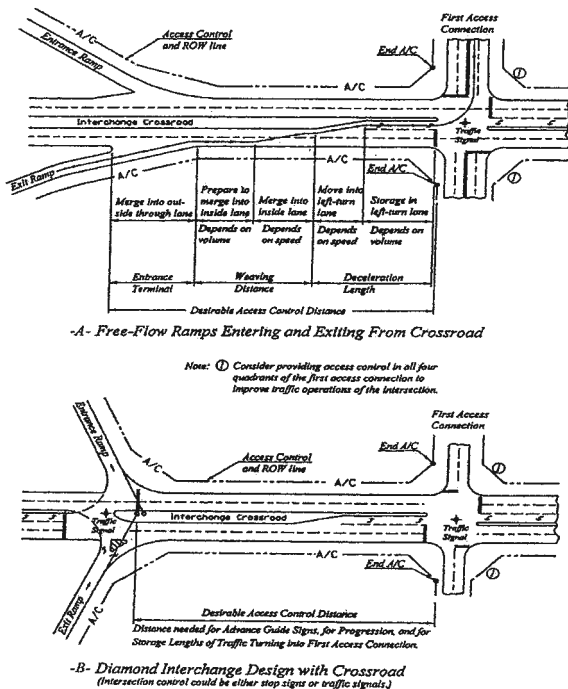


FIGURE 2 AASHTO access control distance.

For diamond interchanges or other interchange forms without free-flow ramps, the desirable access control distance on the crossroad includes the distance required for advance guide signs, progression, and storage lengths of traffic turning at the first access. The first access may either be controlled by a traffic signal or stop signs (4).

The distance for desirable access control is defined slightly differently in *NCHRP Report 420* (3). The distance to the first access is defined by the perception-reaction distance, weaving, transition, storage, and the right-of-way to the center of the intersection. Guidance on these distances is provided in that report. Summaries of the generally recommended distances are provided in Table 2 and are illustrated in the corresponding Figure 3.

Table 3 presents minimum spacing for freeway interchange areas for both multilane and two-lane crossroads. This table is provided in the *TRB Access Management Manual* (6) and is based on guidance provided in *NCHRP Report 420* (3). As shown in the table, access spacing guidance is provided for right-in/right-out-only access to the crossroad, for signalized intersections, and for openings

TABLE 2
SUMMARY OF TYPICAL RECOMMENDED ACCESS SPACING BASED ON 35 MPH

Component of Access Control Distance	Recommended Access Spacing
Perception–Reaction Distance	125 ft
Lane Transition	150–250 ft
Left-Turn Storage	Estimate using equation or use 50 ft per left turn per cycle
	$L = \frac{RV(25)}{N_c} = R125$
	V = left turns per hour; N_c = cycles per hour; l = left turns per cycle; R = randomness factor for less than 5% failure; R = 2.0 for random operations, 1.5 for operations where traffic platoons; and L = length of left-turn storage in feet.
Weaving Distance	700 to 800 ft, two-lane arterials 1,200 to 1,600 ft, multilane arterials
Distance to Centerline of Cross Street	50 ft

Source: Gluck et al. (3).

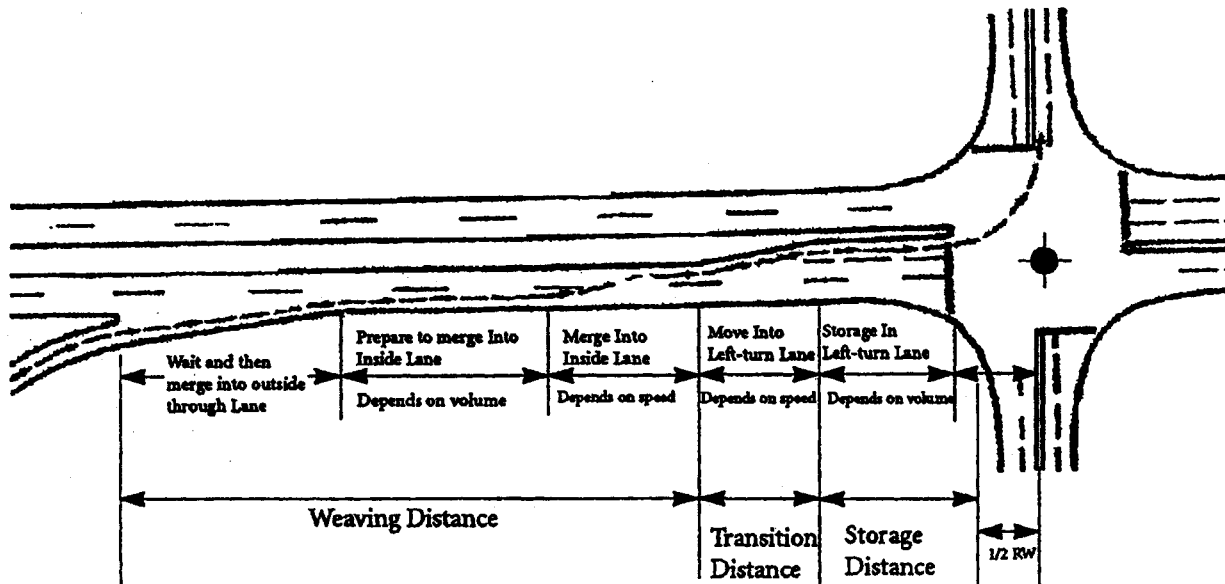


FIGURE 3 Recommended access spacing components (3).

in nontraversable medians based on whether the ramp is free flow or controlled by a traffic signal. The X , Y , Z , and M designations in the table indicate the distance between the access point on the crossroad and the interchange terminal. Guidance for minimum spacing standards is provided for fully developed urban areas, urban and suburban areas, and rural areas.

Several additional factors should also be evaluated in the determination of appropriate spacing between the interchange ramp and first access on the crossroad. Factors that

should be considered include the potential impact of the access on signal progression if the interchange ramp and adjacent intersections are included in a coordinated signal system, the number of other intersections and driveways in the vicinity of the interchange, the type and intensity of the land uses adjacent to the crossroad, and the impact of the access on anticipated traffic operations and safety (7).

Maximum egress capacity is yet another factor that can be considered in establishing access control spacing on the crossroad. Maximum egress capacity is the distance neces-

TABLE 3
MINIMUM ACCESS CONTROL SPACING FOR FREEWAY INTERCHANGES WITH
MULTILANE CROSSROADS

Type of Area	Spacing Dimension			
	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>M</i>
Fully Developed Urban ^a	750 ft (230 m)	2,640 ft (800 m)	990 ft (300 m)	990 ft (300 m)
Suburban/Urban	990 ft (300 m)	2,640 ft (800 m)	1,320 ft (400 m)	1,320 ft (400 m)
Rural	1,320 ft (400 m)	2,640 ft (800 m)	1,320 ft (400 m)	1,320 ft (400 m)

X = distance to first approach on the right; right-in/right-out only.

Y = distance to first major intersection. No four-legged intersections may be placed between ramp terminals and the first major intersection.

Z = distance between the last access connection and the start of the taper for the on-ramp.

M = distance to the first directional median opening. No full median openings are allowed in nontraversable medians up to the first major intersection.

^aFree-flow ramps are generally discouraged in fully developed urban areas and are questionable in suburban/urban areas because pedestrian and bicycle movements are difficult and potentially dangerous.

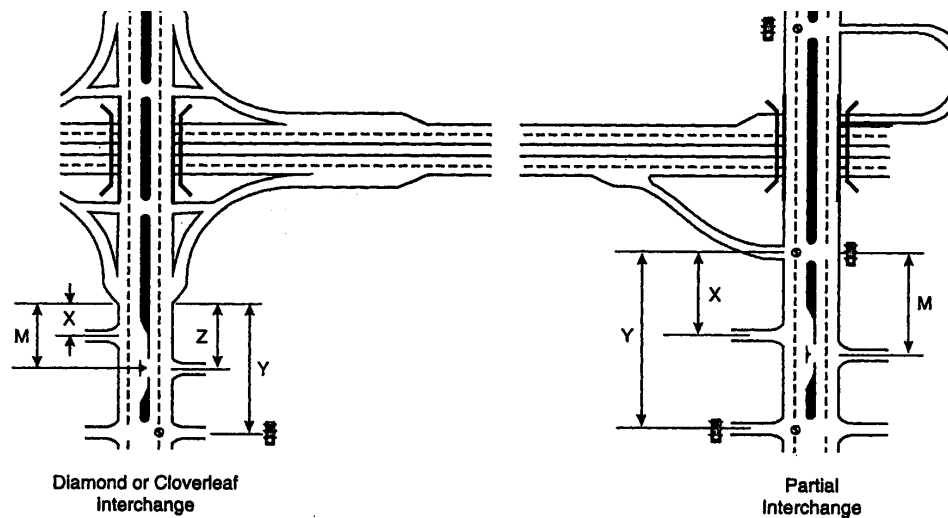


TABLE 4
MINIMUM ACCESS SPACING NEEDED TO PROVIDE
MAXIMUM EGRESS CAPACITY

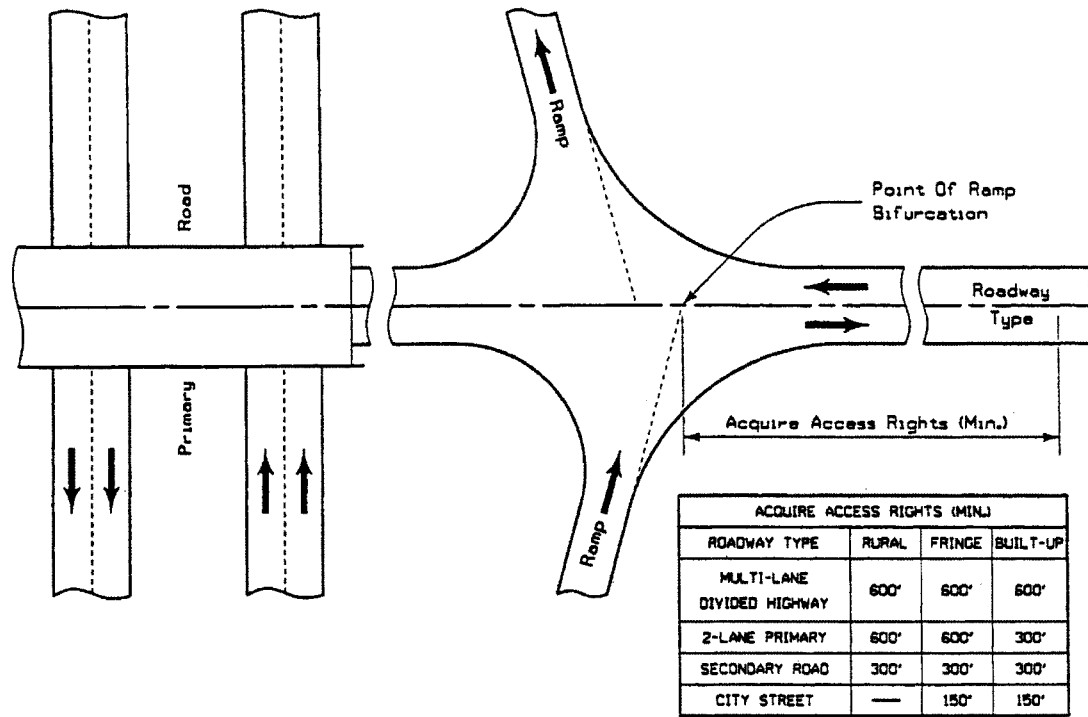
Area	Speed (mph)	1× Acceleration Distance (ft)	1.5× Acceleration Distance (ft)
Urban	35	300	450
Suburban	45	575	860
Rural	55	1,000	1,500

Source: Major and Buckley (8).

sary for vehicles to accelerate from zero miles per hour (mph) to the through traffic speed on the crossroad multiplied by 1.5. Research by Major and Buckley showed that when this distance is used between access points, delay to the through traffic will be reduced, and the rate in which vehicles can merge into the traffic stream will be improved (8). Table 4 shows the minimum access spacing needed to provide maximum egress capacity.

The maximum egress capacity can also be theorized as an appropriate measure to space downstream access points on crossroads in the vicinity of interchanges; however, no agency was found to use this calculation directly in determining its access spacing standards on crossroads. Layton's report, "Interchange Access Management," prepared for the Oregon DOT, presents in-depth discussion on these components and how they could and should relate to access spacing on crossroads (9).

Although many transportation officials tend to agree on the calculations used to determine the specific distances necessary to complete a given decision-making and maneuver process based on a given design speed, the additive implications associated with performing multiple functions and then relating them to the distance necessary between access points is still being debated. Furthermore, requiring the full mathematical distances associated with each deci-



ACCESS RIGHTS
112.11(5)&(6)

FIGURE 4 Access rights along crossroads (Iowa DOT).

sion-making process and vehicular maneuver between an interchange terminal and the downstream intersection is typically not practical on roadways with a design speed of more than 35 mph in urban environments. Thus, the majority of agencies are inclined to blend the scientific results of these calculations with the practicality of the surrounding land use environment (i.e., reasonable access of adjacent developments) when using design speed as a factor.

Several agencies have adopted access control standards and guidelines. Chapter three addresses these standards and guidelines, based on the survey administered as part of this research project. As part of the literature review for the project, the Iowa DOT's Access Management Policy was evaluated before the administration of the survey conducted as part of this synthesis report. In accordance with the policy, the Iowa DOT requires that when an interchange is constructed, access rights must be acquired along the crossroad to preclude access along a certain distance from the interchange ramp (10). Figure 4 depicts the minimum access control standards for the Iowa DOT.

In addition to establishing access control for a minimum distance from the interchange ramp terminal through policy, Iowa enforces control through the use of fences and inspections. A person must have written permission from the Iowa DOT before constructing a new access or modifying

an existing access. The access construction and modification is subject to inspection to ensure compliance with the department's specifications (10).

Corner Clearances

Several states have also developed specifications for corner clearances, which can be used to help determine access spacing on crossroads. As an example, Figure 5 depicts the various clearances for a crossroad intersection included in South Dakota's Highway Access Control Process. These distances are based on information contained in the Access Management, Location, and Design course offered by the National Highway Institute.

In Figure 5, clearance on the upstream crossroad (A) is equal to the upstream area of influence and includes storage necessary for left- and right-turning vehicles, perception-reaction time, and distance for deceleration. Clearance on the downstream crossroad (B) is a function of speed and should conform to the access spacing standards for unsignalized intersections. Upstream corner clearance on the minor road intersecting the crossroad (C) should be of sufficient length so as to minimize blockage to any driveways entering the minor road. Corner clearance on the downstream minor arterial (D) should be of sufficient dis-

tance such that speed changes do not become a safety issue (11).

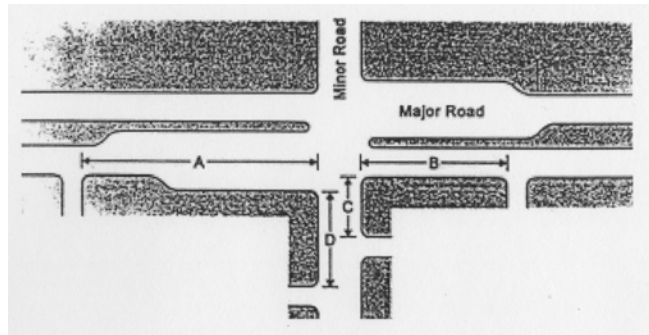


FIGURE 5 Corner clearance (South Dakota DOT).

Service Roads

The Center for Urban Transportation Research suggests that one way to achieve safe and efficient traffic operations in the vicinity of interchanges is through the application of service roads as an alternative to multiple driveways on the crossroad. By prohibiting access to developments from the crossroad, service roads separate through traffic from local traffic, thus reducing confusion, turning movement conflicts, and delays on the roadway (3,7). Frontage roads, backage roads, and local roads can all be considered as service roads. These facilities provide opportunities for additional property access, decrease direct access on arterial roads, and allow traffic from multiple developments to be channeled through a single access point on the crossroad (12). Their application is often the most effective on roads that are heavily traveled and that have higher speeds (13). Service roads may be provided on both sides of a crossroad, and may be either one-way or two-way. Figure 6 provides examples of frontage roads, as defined by *NCHRP Report 420* (3).

The design of a service road depends on its type of use. If the service road is to provide major access to a number of large developments and provides connections as a through route, it is characteristic of a collector street. If it is disconnected and provides access to few developments, its operations will be those of a local street (3).

Service roads can be designed as one-way or two-way facilities. One-way facilities have the potential to offer safer operations than two-way facilities, although one-way operations may not be feasible in a disconnected, irregular street system where additional travel time causes inconvenience for system users (3,14). Texas recommends one-way roads for retrofit projects on frontage roads. In Texas, all traffic must enter and exit the frontage road with merging or diverging movements with no signalized intersections along the arterial or frontage road (14). An example of that concept is illustrated in Figure 7.

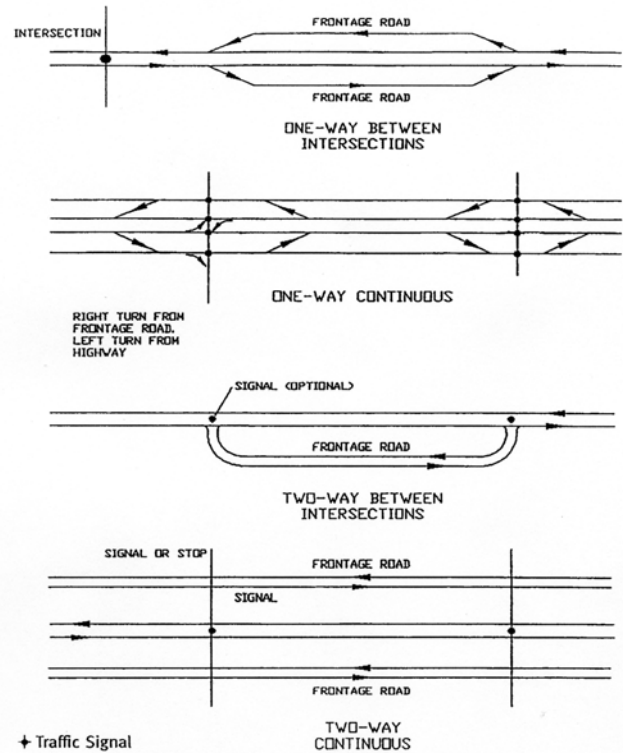


FIGURE 6 Frontage road concepts (3).

When designing a frontage or backage road, it is important to consider spacing standards. The frontage road needs to be designed carefully so as to not increase conflicts at intersections (16). According to the *Access Management Toolkit*, frontage and backage roads should be separated from arterials by a minimum of 300 ft along the crossroad. If adequate separation from arterials is not provided, additional conflict points are created with other vehicles when cars exit the frontage road and enter the functional area of the arterial (13).

NCHRP Report 420 stipulates a minimum spacing of 150 ft where two-way frontage roads are provided as alternate access from the crossroad, whereas a spacing of greater than 300 ft is preferable (3). That report also specifies that “reverse” frontage roads, or backage roads, are desirable in developing urban areas. Separation distances need to be larger for reverse frontage roads with 300 ft required as the minimum, and a distance of 600 ft preferred.

South Dakota defines the minimum spacing standards for frontage roads as 250 ft (11). South Dakota also requires a minimum outer separation between the frontage road and crossroad of 20 ft to be used as space for pedestrian refuge, for traffic control devices, and for landscaping. In addition, the state’s access management plan specifies that pedestrians and bicyclists should use the frontage roads, and frontage roads should be incorporated into a site’s internal circulation system if it is a major activity

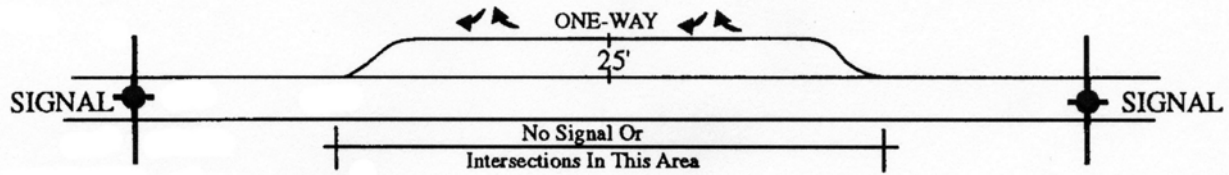


FIGURE 7 Frontage road design (15).

center along the arterial roadway. The use of frontage roads in South Dakota reduces the pedestrian, bicycle, and vehicular use of the crossroad for local trips.

Medians

Another common method of access management on crossroads in the vicinity of interchanges is through the use of medians. Examples of medians commonly used include continuous two-way left-turn lanes (TWLTL) and non-traversable (raised or depressed) medians with designated median openings.

The installation of a continuous TWLTL on an undivided highway can result in a lower crash rate and still allow full access to all public and private approaches along the crossroad. Thirteen studies that were documented in *NCHRP Report 420* showed that highway facilities with TWLTLs had a record of 38% fewer crashes compared with that reported for undivided highways (3). A two-lane crossroad with a continuous TWLTL is recommended for roadways that carry an average daily traffic of less than 17,000 vehicles. For roadways with average daily traffic in excess of 17,000 vehicles, the use of raised medians or added lanes should be considered.

The use of raised medians offers a number of operational and safety benefits. Examples of advantages include the prevention of crashes caused by crossover traffic, reduced distraction from headlight glare, and separation of left-turning traffic from the through lanes when combined with left-turn lanes. Additional advantages include the discouragement of strip development close to the interchange, encouragement of interconnection between parcels and fewer driveways, allowance of better control of land uses by local governments, provision of better pedestrian protection than available from undivided roadways, and provision of space for landscaping and other aesthetic treatments (13). A number of studies have documented improvements in safety and operations on roadways with raised medians. *NCHRP Report 420* reported that roadway facilities with raised medians had an overall crash rate of 5.2 crashes per million vehicle-miles traveled as compared with 7.3 crashes per million vehicle-miles traveled on facilities with continuous TWLTLs (3).

The primary disadvantage of raised medians is the need for some vehicles to travel out of direction to reach destinations. Doing so could result in concentrated left-turn and U-turn maneuvers at specific locations. Because of such disadvantages, businesses and landowners may oppose a median project if there is concern that it will limit direct left turns into their sites (13). For comparison purposes, the following list summarizes the advantages and disadvantages associated with each type of median as identified in the *Iowa Access Management Handbook* (17).

- Raised Median (advantages)
 - Discourages strip development;
 - Allows better control of land uses by local government;
 - Reduces number of conflicting maneuvers at driveways;
 - Provides pedestrian refuge;
 - If continuous, restricts access to right turns only;
 - Reduces crashes in midblock areas; and
 - Separates opposing traffic.
- Raised Median (disadvantages)
 - Reduces operational flexibility for emergency vehicles;
 - Increases left-turn volumes at median openings;
 - Increases travel time and circuitry for some motorists;
 - May increase crashes at openings;
 - Limits direct access to property; and
 - Operating speed is usually limited to 45 mph.
- Two-Way Left-Turn Lane (advantages)
 - Makes use of odd lanes;
 - Reduces left turns from through lanes;
 - Provides operational flexibility for emergency vehicles;
 - Is safer than road with no left-turn lanes or medians;
 - Facilitates detours; and
 - Separates opposing traffic.
- Two-Way Left-Turn Lane (disadvantages)
 - Encourages random access;
 - Is illegally used as a passing or acceleration lane;
 - Offers no refuge for pedestrians;
 - Has higher maintenance costs;
 - Operates poorly under high volumes of through traffic; and
 - Allows head-on crashes.

Examples of factors to evaluate when considering the installation of a continuous TWLTL or raised median on a crossroad in the vicinity of an interchange include

- Access management policy for and access class of the crossroad under consideration;
- Types and intensities of the adjacent land use;
- Supporting street system and the opportunities for rerouting left turns;
- Existing driveway spacing;
- Existing geometric design and traffic control features (e.g., proximity of traffic signals and provisions for left turns);
- Traffic volumes, speeds, and crashes; and
- Costs associated with roadway widening and reconstruction (17).

Successful alternate access techniques on crossroads will be further discussed in chapter four of this report.

IMPACTS OF ACCESS MANAGEMENT PRACTICES

Access management policies and practices on crossroads have an impact on operations and safety, and potentially on business operations located near the interchange. This section will discuss research on the operational impacts of access management, as well as the impacts of access management on the safety and economic vitality of a crossroad.

Operational Benefits

Several studies have indicated operational benefits from controlling access. The Colorado Access Control Demonstration project used TRANSYT 7F to compare the operations of a 5-mi segment of roadway with and without access control. The analysis looked at two scenarios, as summarized here.

- Access controlled scenario
 - One-half-mile signal spacing,
 - Nontraversable median, and
 - Right turns only at one-quarter-mile spacing.
- Uncontrolled scenario
 - One-quarter-mile signal spacing and
 - Full median openings at one-eighth-mile.

The study found that during congested conditions (volume equal to 95% of capacity), the total travel time was reduced by 42%, and the total delay was reduced by 59% under the access controlled scenario (18).

Safety Impacts

Studies indicate a strong correlation between access management and increased safety. These findings are consistent

for crossroads as well as for other higher-volume facilities. Increasing the spacing between intersections and access points improves traffic flow and safety by reducing the number of conflicts per mile and providing greater distance to anticipate and recover from turning maneuvers (19). Studies indicate that the greatest benefit of access management is usually experienced on urban arterials (20), although the benefits of crash reductions are experienced on both urban and rural streets.

A comprehensive safety analysis was conducted from crash information obtained from Delaware, Illinois, Michigan, New Jersey, Oregon, Texas, Virginia, and Wisconsin. The study evaluated approximately 240 roadway segments with more than 37,500 crashes. The study found that TWLTLs generally had lower crash rates than undivided roadways, and that nontraversable medians usually had lower crash rates than all other median treatments. Overall, the study found that urban roadway segments with more than 60 accesses per mile experienced approximately 2.2 times the number of crashes than roadways with less than 20 access points per mile. The study results led to the production of graphs that enable users to estimate crash rates for urban, suburban, and rural facilities, based on the type of median used and the access density (21). Figures 8–10 feature these graphs.

Figure 9 indicates that for rural areas, a TWLTL is estimated to have a crash rate slightly greater than a nontraversable median. As shown in Figure 10, the expected crash rates for access densities of more than 2.0 signals per mile are much greater than the expected crash rates for less than 2.0 signals per mile.

Economic Vitality

The application of access management techniques on crossroads in the vicinity of interchanges is often a concern to local businesses and landowners. Businesses and property owners may perceive that the modification of site access will negatively affect economics and property values. The economic impact of various access management treatments can depend on the extent to which access is controlled. In situations where left-turn ingress and egress to a business are eliminated, some motorists may change their driving habits and frequent a different business, whereas others will use well-designed U-turn facilities to access the same development (15).

To assess the level of impact of access management on local businesses, Iowa conducted a study using four analytic methods: community-level data, corridor business profiles, sales tax data, and business and customer surveys. The results of the study indicated the following:

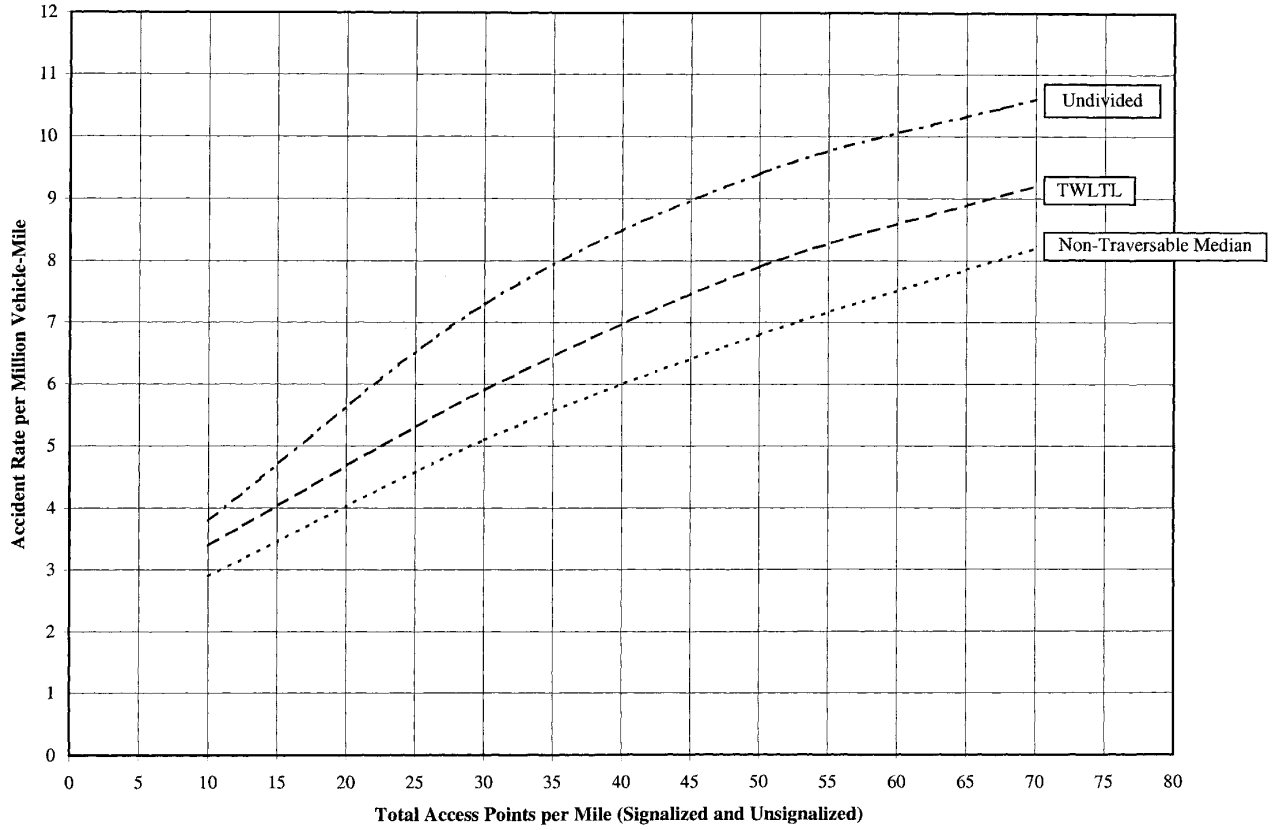


FIGURE 8 Estimated crash rates by types of median—urban and suburban facilities (3).

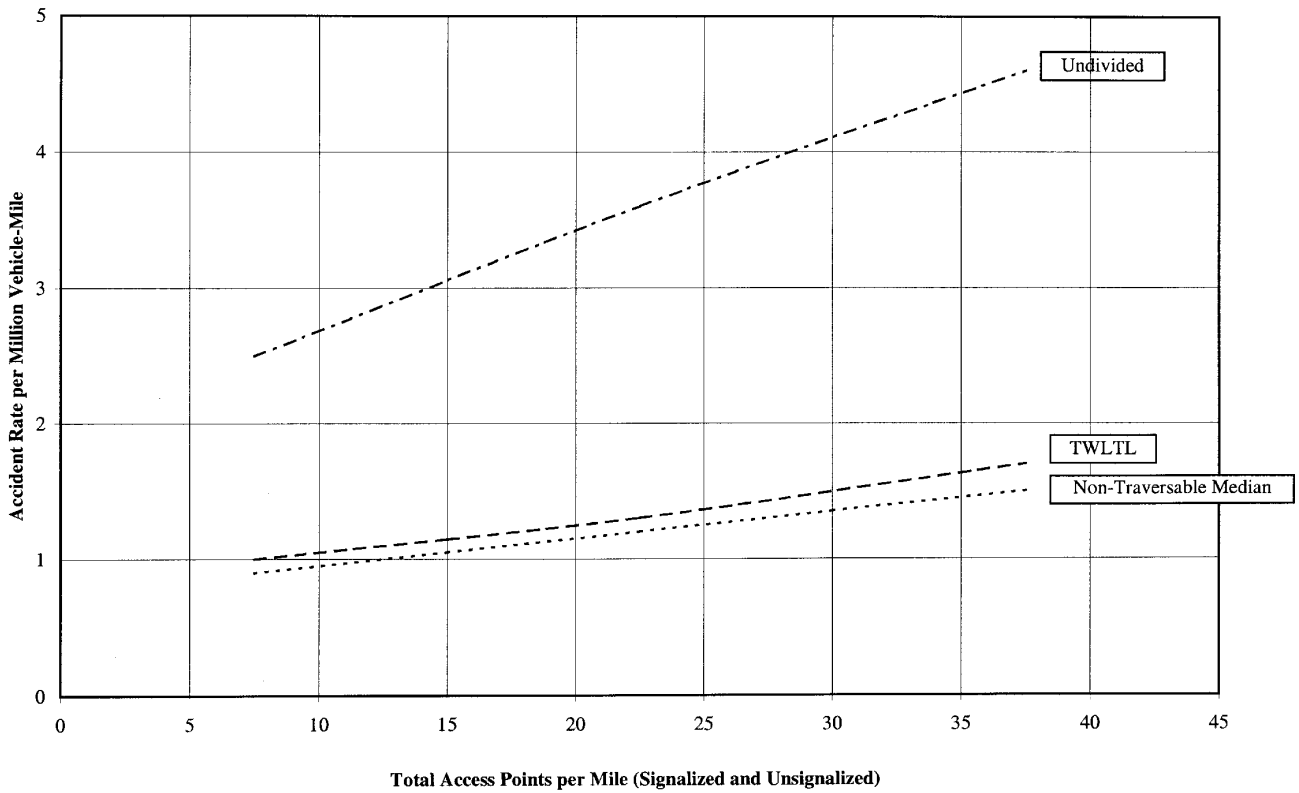


FIGURE 9 Estimated crash rates by type of median—rural facilities (3).

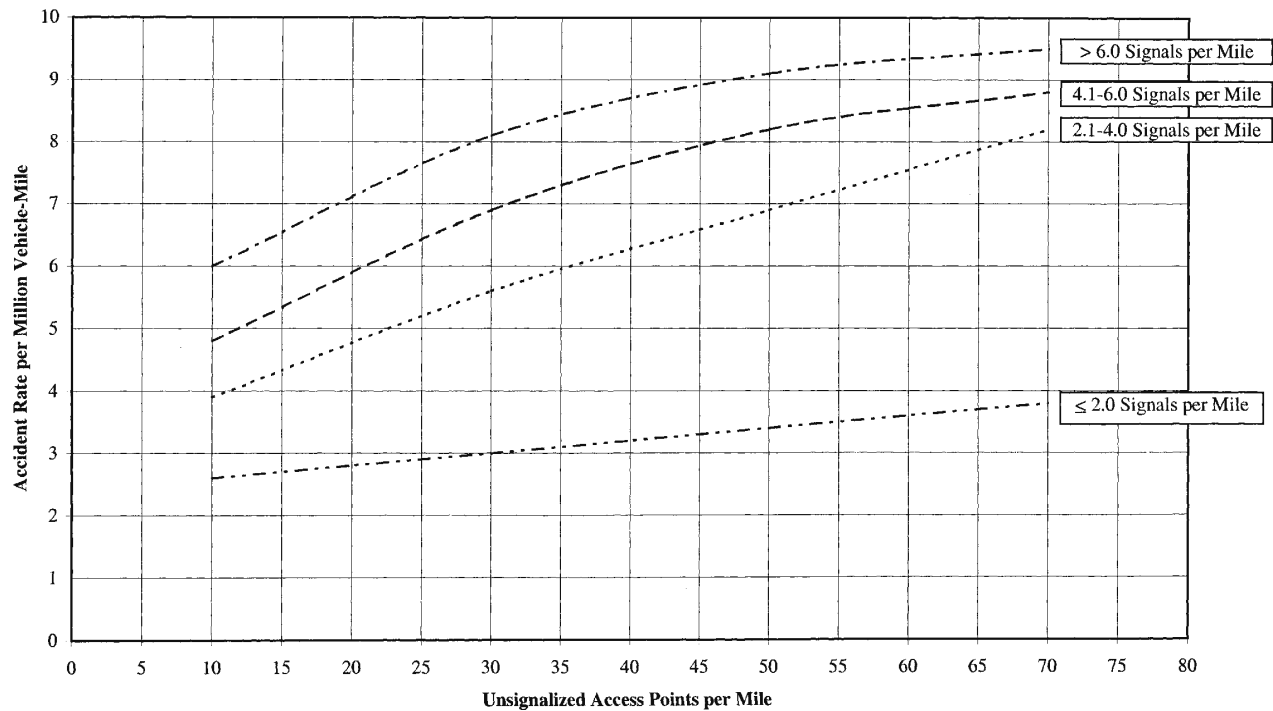


FIGURE 10 Estimated crash rates by access density—urban and suburban facilities (3).

- A review of the sales tax data for the study areas adjacent to the affected corridors revealed that sales in the study corridors outpaced those of the overall community by 10% to 20% once the access management projects were completed.
- The results of the business owner surveys indicated that more than 85% of the businesses reported that their sales after the access management technique was implemented either remained the same or increased. Only 5% indicated that sales declined after the access management project was completed, although this finding was not necessarily correlated to the implementation. The remaining business owners surveyed were uncertain of the impact following completion of the access management project.
- The results of the customer surveys revealed an overwhelming support for the access management project (22).

The Florida DOT (FDOT) conducted a similar analysis of the impact of access management on the economic vitality of Fort Lauderdale and Orlando. A study of the retrofit of Oakland Park Boulevard in Fort Lauderdale found that the majority (62.4%) of businesses surveyed reported no changes in business sales. A survey conducted after an access management project was completed in Orlando found that 80% of drivers believed that the road was safer and the traffic flowed better, and they favored the project. However, approximately 60% of the drivers surveyed found the U-turns inconvenient (23).

A study was also undertaken by the Minnesota DOT to assess the public's understanding of state highway access management issues. The study found that the participants recognized that uncontrolled access to a highway with high traffic volumes can result in congestion and safety problems. In addition, participants reported that they would be willing to drive farther to access a development if it meant less frustration, improved convenience, and greater safety (24).

Although customers may generally favor access management changes, business owners may be concerned with any such changes. Some possible solutions to opposition to access management projects include the following (25):

- Involve businesses as early as possible in access management project planning and development,
- Share genuine business experiences with them,
- Let businesses know that they may experience temporary sales disruptions,
- Be innovative in finding alternative access solutions, and
- Institute measures to help direct motorists to businesses where access is changed during and after the project.

IMPLEMENTING AN ACCESS MANAGEMENT PROGRAM

Recognizing that a comprehensive access management program can be used to balance mobility and accessibility

needs on crossroads, several agencies are reviewing their access management policies or implementing new access management programs. This section of the report discusses some of the key steps to creating an access management program to address access spacing on crossroads near interchanges and some tips on implementation as exemplified by state's experiences.

Creation of a Program

Several states have identified key steps and processes needed to establish a successful access management program. Information from from two states, Missouri and New York, is briefly discussed in the following paragraphs.

Missouri established a number of key steps in the development process. These steps included identifying stakeholders, educating participants on access management principles and impacts, developing specific statewide goals for access management, developing an access management roadway classification system based on the Missouri DOT's existing functional classification system, developing detailed sets of access management standards, developing administrative processes, identifying current and likely future access management problem corridors, identifying pilot project corridors where access management principles could be applied, and conducting access management awareness and training for stakeholder groups (26).

The New York State DOT used a different and unique approach to access management. It established an Arterial Access Management Team, Planning and Strategy Group to facilitate access management projects by using local jurisdictions with a bottom-up approach. The goal of the group is to work with local agencies to develop a strategy and plan to provide guidance on corridor preservation, land use, and financial elements for the planning and design of uncontrolled state arterials (27).

Intergovernmental Coordination

A number of states have also found that a successful access management program requires statewide support and intergovernmental coordination. State governments are typically in charge of controlling and permitting accesses on crossroads around interchanges, whereas local governments have jurisdiction over the permitted land uses in the vicinity of interchanges. Coordination between both such agencies ensures consistency when working with developers in approving or restricting accesses and consistent enforcement. To facilitate intergovernmental coordination, the *Access Management Manual* recommends that agencies work together to ensure that their access management policies are compatible, develop access management plans, es-

tablish a resolution or intergovernmental agreement, and coordinate review of developments and access permits (6).

As an example, Texas recently implemented an access management program even though several of the major metropolitan areas within the state had previously established local access management plans. The Texas DOT has found that the successful implementation of the state's access management plan requires careful coordination with the local jurisdictions (14).

Legal Authority for Implementation

To implement an access management plan to control access spacing on crossroads in the vicinity of interchanges it is necessary to review the policies of that state to assess the authority of the state DOT to regulate facilities. The Institute of Transportation Engineers publication on access management identifies four ways in which to regulate access (28).

1. Government Agency Regulation—State and local agencies have the basic statutory authority to control all aspects of highway design to protect public safety, health, and welfare. This type of control is typically enforced through the driveway and road-encroachment permitting process.
2. Acquisition of Access Rights—States and local agencies can acquire access rights. This form of controlling access can be more time consuming and expensive than other forms, but it is a stronger solution with lasting safety and operational benefits.
3. Land Development Codes—Local governments normally use land use controls to manage access. These types of controls include local zoning ordinances and subdivision regulations specific to parking, number and spacing of driveways, and other factors affecting the volume and circulation of traffic generated by the development.
4. Cooperative Agreements—Through the site plan approval process agencies can require that specific access management techniques be incorporated into development agreements negotiated between government agencies and private developers.

Education

Several states have also discovered that a key component of implementing a successful access management program is education and outreach to key stakeholders. Agencies in Minnesota, South Dakota, and Virginia stress the importance of education in the implementation process (29–31). In regard to South Dakota, for example, "Education and communication form an integral part of the project imple-

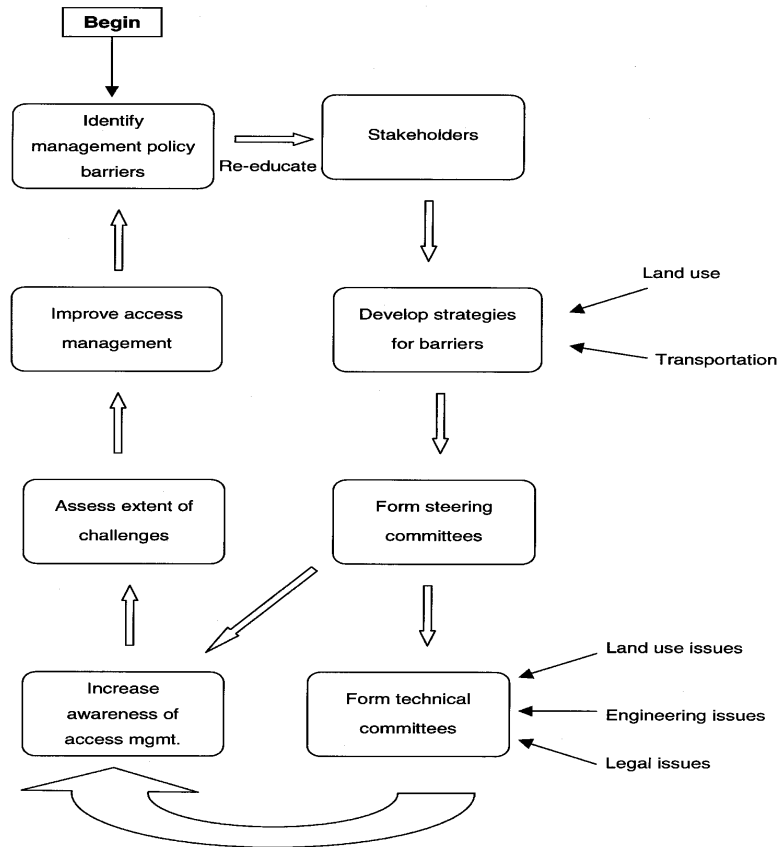


FIGURE 11 Interfacing between information and education in the access management plan implementation process (Texas DOT).

mentation plan, explaining the concepts, procedures, and actions required to address access management. This is particularly important given that many jurisdictions do not have staff with a background in or knowledge of access management” (30).

The Oregon DOT (ODOT) established an in-depth training course to educate its staff on key time lines, permitting criteria, appeal process, individual responsibilities, and understanding the relationship between their access management program and the 1999 Oregon Highway Plan (32). Similarly, the Virginia DOT has trained on access

management concepts, presented at state traffic conferences, interacted with local governments, and educated legislators as part of the education component of the implementation.

Education is a continual process involving stakeholders, jurisdictional staff, and/or oversight bodies charged with implementing access management. The staff and oversight bodies should educate the stakeholders about key elements in the plan; in turn, the stakeholders need to provide feedback about plan implementation. Figure 11 illustrates this continual process of information and education (33).

EXISTING AGENCY PROGRAMS

This chapter focuses on providing a summary of the strategies employed by various state DOTs, toll agencies, and other road authorities to manage access to and from crossroads in the vicinity of interchanges. The information presented in this chapter is primarily based on questionnaire responses received from the various agencies, a review of additional materials provided by the agencies, and follow-up telephone interviews with the respective agency contacts.

SURVEY QUESTIONNAIRE DESIGN AND DISTRIBUTION

To gain a better understanding of the current implementation of access management strategies used throughout North America to locate and manage access points on crossroads in the vicinity of interchanges, a comprehensive survey questionnaire was developed and distributed to various roadway agencies. The questionnaire was developed in concert with the research topic panel for this synthesis report to explore the current legislation, regulations, programs, practices, usage, and levels of success experienced by various agencies. Owing to the nature of the subject area, the questions were developed to balance the need for obtaining general comparative information with gaining a solid understanding of detailed implementation practices used in the field. Furthermore, the questions needed to be somewhat limited in number and length to encourage agencies to respond. According to these initial objectives and the information acquired, it is believed that the research team was provided with an adequate cross section of data and the necessary level of detail to distill successful access management strategies and provide the reader with information from case studies that demonstrate these practices as part of retrofit and new interchange projects (to be discussed in chapter four).

The 14 questions selected for the survey questionnaire covered a wide cross section of topics (see Appendix A). Questions 1 and 6 inquired as to the existence of a comprehensive access spacing program, spacing standards, and the access spacing requirements set forth by the individual agencies. Questions 2 through 5 explored the ways through which agencies implement access management strategies on crossroads. Question 7 sought to identify the specific methodology used to develop a given agency's access spacing standards. Questions 8 through 14 sought to uncover and analyze the process (planning, operation, and design) used by transportation agencies to improve and establish access locations on interchange crossroads. As part of several questions, in-

formation about the specific program and projects was requested to thoroughly examine and compare the various programs. That information is presented within this chapter and was used to develop the case studies in chapter four.

The survey questionnaire was distributed to all 52 U.S. state DOTs (including the District of Columbia and Puerto Rico), various toll authorities (two), and Canadian Provinces (four); a total of 58 separate agencies.

A total of 36 partially or fully completed survey questionnaires were received (a 62% response rate). The response rate was encouraging given the number of states that maintain relatively few grade-separated interchange facilities and active access management programs. Appendix B lists the responding agencies, and Appendix C provides a summary of the individual survey responses for each question.

ACCESS MANAGEMENT PROGRAM OVERVIEW

The management of access locations on crossroads in the vicinity of interchanges is defined and practiced in various ways throughout North America. Thirty-one of the 36 responding agencies (86%) actively manage access to and from crossroads in the vicinity of interchanges. However, the way in which these agencies manage access varies according to the adopted legislation, regulations, spacing standards, and control techniques they employ, as well as to how they plan, operate, and design these access locations for retrofit and new interchange projects. In addition, the level of sophistication that the agencies have developed is highly diverse. Those in Florida, Illinois, Oregon, Washington, and elsewhere (Arizona and Utah are in process) have adopted legislation and regulations, and have well-established planning, operation, and design criteria. Other states rely solely on district-level engineers to make do within the context of a given situation (e.g., level of development, traffic volumes, funding, and political environment). Some states have conducted internal research and developed specific legislation, whereas others tend to rely heavily on the 1991 AASHTO publication, *A Policy on Design Standards—Interstate System* (5).

SPACING STANDARDS ON INTERCHANGE CROSSROADS

Within nearly all the agencies surveyed [27 of 36 respondents (75%)], the spacing of access locations on inter-

TABLE 5
SUMMARY OF MINIMUM ACCESS SPACING STANDARDS OR GUIDELINES BY RESPONDING AGENCY

Agency	Minimum Spacing Requirement or Guideline: Stated Distance
Alberta Transportation	200 m (660 ft)
Arizona Transportation Research Center	90 m (300 ft)
Arkansas State Highway and Transportation Department	45 m (150 ft)
California DOT	125 m (415 ft)
Colorado DOT	105 m (350 ft)
Connecticut DOT	None
E-470 Authority (Colorado)	180 m (600 ft)
Florida DOT	135 m (440 ft)
Georgia DOT	30 m (100 ft)
Illinois DOT	45 m (150 ft)
Indiana DOT	30 m (100 ft)
Iowa DOT	30 m (100 ft)
Kansas DOT	None
Louisiana DOT and Development	30 m (100 ft)
Maine DOT	150 m (500 ft)
Maryland State Highway Administration	30 m (100 ft)
Michigan DOT	30 m (100 ft)
Ministère des Transports du Québec	None
Minnesota DOT	Developing guidelines
Mississippi DOT	30 m (100 ft)
Nebraska Department of Roads	200 m (660 ft)
Nevada DOT	90 m (300 ft)
New Brunswick DOT	65 m (215 ft)
New Jersey DOT	Varies
New York DOT	30 m (100 ft)
Nova Scotia DOT and Public Works	60 m (200 ft)
Ohio DOT	180 m (600 ft)
Oregon DOT	230 m (750 ft)
South Carolina DOT	30 m (100 ft)
South Dakota DOT	200 m (660 ft)
Texas DOT	140 m (460 ft)
Utah DOT	50 m (165 ft)
Virginia Transportation Research Council	30 m (100 ft)
Washington State DOT	40 m (130 ft)
West Virginia DOT	30 m (100 ft)
Wyoming DOT	45 m (150 ft)

change crossroads is documented through legislative rule making or adopted design standards, or it is documented in general agency guidelines and policies. However, it should be noted that only 13 of the 27 agencies (Colorado, Florida, Iowa, Maine, New Jersey, Oregon, South Carolina, South Dakota, Utah, Virginia, Washington, West Virginia, and New Brunswick, Canada) have their standards adopted by regulations. The access spacing standards are typically related to the type of downstream access location, including nearest access point (all types), right-in/right-out, left-in/right-in/right-out, full access, and signalized access points. However, the factors used to define the physical space between the interchange terminal and the downstream access locations vary dramatically. Table 5 outlines the range of minimum access spacing standards deployed by the responding agencies. (Summary responses for questions 1a, 1b, and 1c in Appendix C provide details on the minimum spacing requirements for right-in/right-out, full, and signalized access points downstream of the interchange terminal.)

Although many of the responding agencies had similar minimum access spacing standards, the measurement of the spacing varied from agency to agency. Agencies base their measurement on the centerline, the gore point, the end of radius, and the end of taper of the interchange ramp terminal. This topic is further discussed later in this chapter, in the section “Spacing Measurement on Interchange Crossroads.”

As shown in Table 5, 11 of the responding agencies (Georgia, Indiana, Iowa, Louisiana, Maryland, Michigan, Mississippi, New York, South Carolina, Virginia, and West Virginia) base their minimum access spacing standards at 100 ft. This standard comes directly from the recommendation made in AASHTO’s *A Policy on Design Standards—Interstate System* (5).

The low, high, and average minimum access spacing standards or guideline for downstream access points are 100 ft, 750 ft, and 210 ft, respectively. It should be noted

that a large majority of the agencies do not differentiate their access spacing standards based on the type of downstream access location. Furthermore, the access spacing distances presented in Table 3 represent minimums and could fluctuate based on a number of additional factors (crossroad design speed, cross section, etc.). Seventeen of the agencies stated that their spacing standards change according to these factors. (See summary responses for question 3 in Appendix C for a complete discussion, by agency.)

In general, most agencies use access spacing standards based on one or more of the following five types of access points downstream and upstream of the interchange terminal:

- *Nearest Access (all types)*—Several agencies do not differentiate between either the type of turning movements or traffic control associated with the access point on the crossroad. The access is merely defined as the first point of access to the crossroad downstream of the interchange terminal. Agencies such as those in Georgia, Louisiana, Michigan, Mississippi, New York, South Carolina, Virginia, and West Virginia rely strictly on the previously recommended guidelines from AASHTO that call for 100 ft of spacing in urban conditions and 300 ft of spacing in rural conditions.
- *Right-In/Right-Out Access*—Some agencies will allow private or public approaches that are controlled to right-in, right-out, or right-in/right-out movement downstream of the interchange terminal to be closer than those access points that allow left-turn or crossing maneuvers. These less stringent spacing standards are because right-turn movements generally do not require weaving maneuvers to occur downstream of the terminal, and they result in limited or no additional vehicular conflicts. Utah’s proposed State Highway Access Management Standards differentiate between right-in/right-out and full-access point spacing for crossroads with posted speeds of 50 mph or less.
- *Left-In/Right-In/Right-Out Access*—In addition to providing alternative, less restrictive spacing standards for right-in/right-out access point and more restrictive spacing standards for full-access points on crossroads, some agencies allow left-in maneuvers downstream of the interchange terminal before allowing full access. The reasoning for this alternative spacing standard typically is associated with providing increased accessibility without the introduction of significant vehicular conflicts associated with left-turn maneuvers from the side street. Oregon employs this approach by defining the first directional median opening (see Figure 3).
- *Unsignalized, Full Access*—Owing to the number of potential vehicular turning conflicts created by side street traffic and weaving movements on the cross-

road associated with downstream turning movements, the respondents generally recommended that full-access intersections be located far enough away from the interchange terminal to prevent congestion from causing operational impacts at the terminal itself. Furthermore, the increasing spacing allows the motorists to comprehend the necessary information and perform the correct vehicular maneuver before entering the influence area of the downstream intersection.

- *Signalized, Full Access*—As with unsignalized full-access intersections on crossroads, signalized full-access intersections are generally recommended to be located at the farthest point downstream of the interchange terminal, owing to similar operational concerns as well as potential vehicular queues created by the stopping of crossroad through and turning movements. The introduction of queues creates the need for motorists to complete their positioning maneuvers before approaching the back of queues at a signalized intersection. The required access spacing for signalized intersections from the responding agencies varied from 100 ft (Louisiana, Michigan, Mississippi, South Carolina, Virginia, and West Virginia) to one-half-mile (Nevada, New Jersey, and Washington). (See summary responses to question 1c in Appendix C for details.)

Although some states do not differentiate spacing standards based on the access to the crossroad being either downstream or upstream of the interchange terminal, some states, such as Oregon, and Utah, with its proposed standards, maintain different spacing requirements for right-in/right-out and full-access points. Figure 12 illustrates how Oregon differentiates between upstream and downstream approaches on interchanges located in fully developed urban areas by requiring 750 ft to the first right-in/right-out access point (X) and 1,320 ft to the first full-access point downstream of the interchange terminal (Y), and the state requires 990 ft from the first upstream access point (Z). In addition, this graphic illustrates how Oregon differentiates spacing requirements between right-in/right-out and signalized access points.

It was interesting to find that only 47% (15 of 32 agencies responding to question 7) based their access spacing standards on a specific scientific methodology. (See summary responses to question 7c in Appendix C for a detailed summary of methods and research used by these agencies.) However, all of the agencies that had developed their standards using a specific methodology also stated that their spacing standards had worked effectively and were viewed as being fair by the affected stakeholders.

The next section explores the various factors that agencies use in their access spacing regulations on crossroads in the vicinity of interchanges to determine the appropriate location for downstream and upstream access points.

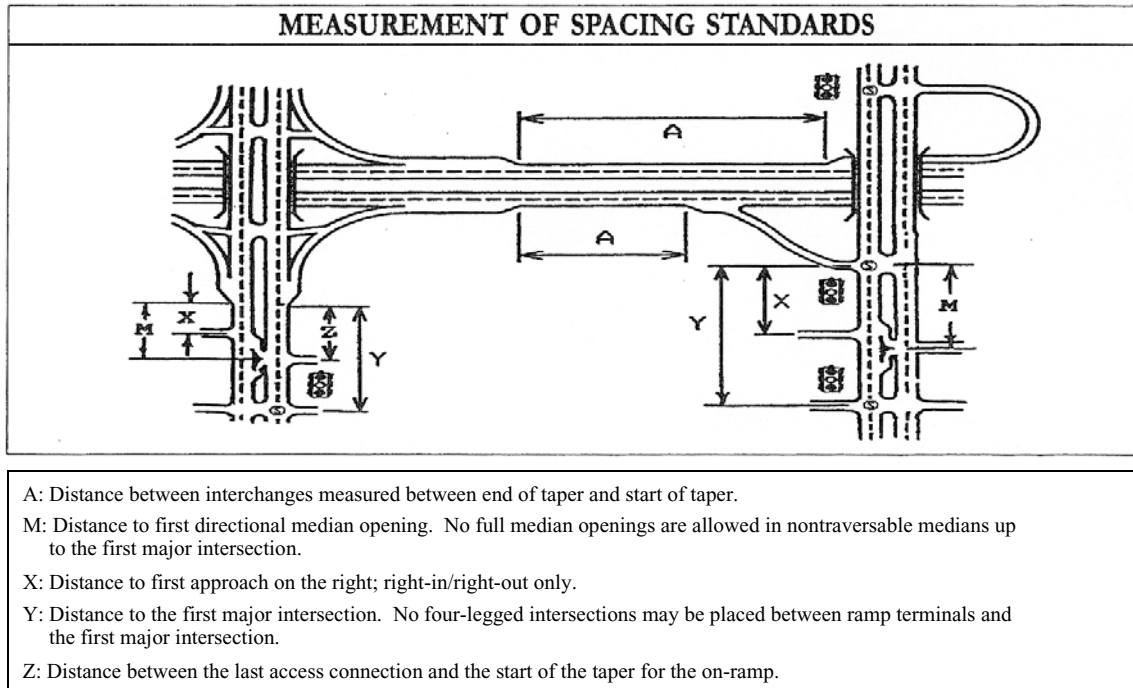


FIGURE 12 Upstream and downstream access spacing standards (Oregon DOT).

FACTORS INFLUENCING ACCESS LOCATION SPACING ON INTERCHANGE CROSSROADS

Many factors are evaluated by agencies in determining the required or recommended distance downstream of an interchange terminal at which an access location can be permitted. The survey questionnaire identified the following 13 factors that are used by the 36 responding agencies to determine their respective access management standards or guidelines:

- Surrounding land use and environment,
- Roadway classification,
- Interchange form,
- Public and private accesses,
- Type of downstream access point,
- Downstream storage requirements,
- Cross section,
- Design speed,
- Volume,
- Signal cycle length,
- Cost and economic impacts,
- Level of interchange importance, and
- Crossroad jurisdiction.

It should be noted that many of these factors may be specific to an agency's specific access management, administrative rules, or design standards, or they may be used to determine the access spacing on a case-by-case basis through a transportation planning study (e.g., access man-

agement plan) or operational analysis. Furthermore, many of the factors identified are at times combined into a single factor that accounts for multiple factors (e.g., roadway classification can incorporate several factors into a single factor). (Summary responses to questions 1a, 1b, 1c, and 3 in Appendix C provide a more detailed summary, by responding agency.)

Surrounding Land Use and Environment

The existing and planned surrounding land uses (comprehensive plan designations, zoning, parcel size, development, etc.) and environment (topography, wetlands, etc.) are used by some agencies to determine access spacing standards on crossroads. The majority of state agencies use urban and rural designations to determine access spacing standards. According to these land use designations, the responding agencies typically have more stringent (i.e., longer) spacing standards on rural interchanges than at other crossroads because the land use densities are much lower and the parcel sizes are generally much larger, allowing for alternative access points. In addition, crossroads located in rural areas typically have higher posted speeds, requiring longer distances to decelerate to either perform a turning maneuver or avoid a conflicting vehicular movement and there are fewer exclusive turning lanes to separate vehicles performing turning movements. Finally, the agencies are generally able to have more stringent standards in rural environments because the standards are eas-

ier to enforce from both a practical and political standpoint.

In contrast, an overwhelming majority of the agencies surveyed had less stringent standards in urban environments. These shorter spacing distance requirements are generally based on the concept that it is not practical to maintain significant distances between the interchange terminal and downstream intersections in an urban environment, because of the established block spacing within most cities, the smaller parcel sizes, and the land use intensity. Owing to these environmental constraints, the posted speeds on crossroads are typically lower under urban conditions; therefore, not as much deceleration length is required to perform various maneuvers. Consequently, under these conditions, the need for spacing between access points can be reduced.

Roadway Classification

The roadway classification of the crossroad is considered by many agencies in determining the locations of downstream and upstream access points from the interchange terminal. Because roadway classification is established primarily on the desired mobility and accessibility for a given facility, many of the access spacing factors (e.g., design speed, cross section, and volume) are encapsulated within this single factor. Traditionally, the higher-classified roadways (freeways, expressways, and arterials) call for more stringent spacing criteria, whereas the lower-classified roadways (frontage roads, collectors, local streets) call for more lenient spacing criteria. As a result, some agencies (e.g., Colorado, Kansas, Nebraska, and South Dakota) differentiate access spacing requirements on crossroads based on the facility’s classification. Table 6 il-

lustrates South Dakota’s access location criteria that use seven roadway classifications (34).

Interchange Form

The actual interchange form through which the subject crossroad passes can dictate the required access spacing standards in some states and provinces. In addition, the interchange terminal location and traffic control can further determine the necessary access spacing along the crossroad. The AASHTO *Green Book* identifies eight general interchange forms (4). Figure 13 illustrates the various interchange form categories.

The service interchange forms (diamond, one quadrant, and single point) generally do not, through their respective designs, create significant downstream or upstream weaving areas, because all initial vehicular movements occur through a traditional signalized or unsignalized intersection at the interchange terminal. This type of traffic control condition typically allows motorists entering the crossroad at the interchange terminal to transition into their desired lanes during their initial turning movement onto the crossroad. Thus, service interchanges typically do not require as much downstream access spacing as free-flowing interchanges with ramps. The Illinois DOT uses interchange form as one factor in determining its access spacing requirements.

Although agencies may require all service interchanges to maintain the same access spacing standards on the crossroad, the distance from the interchange ramp terminal to the downstream access point can be minimized through the interchange selected. Some DOTs, such as those in Washington State and Minnesota, have started to use single-

TABLE 6
SOUTH DAKOTA’S ACCESS LOCATION CRITERIA

Access Class	Signal Spacing Distance (mile)	Median Opening Spacing (mile)	Minimum Unsignalized Access Spacing (feet)	Access Density	Denial of Direct Access When Other Available?
Interstate	N/A	N/A	N/A	N/A	Yes
Expressway	1/2	1/2	2,640	at half-mile increments	Yes
Free-Flow Urban	1/2	1/2 F, 1/4 D	1,320	at quarter-mile increments	Yes
Intermediate Urban	1/2	1/2 F, 1/4 D	660	at eighth-mile increments	Yes
Urban Developed	1/4	1/4	100	2 accesses/block face	Yes
Urban Fringe	1/4	1/2 F, 1/4 D	1,000	5 accesses/side/mile	Yes
Rural	N/A	N/A	1,000	5 accesses/side/mile	Yes

Notes:

1. Access to the Interstate system is governed by SDDOT interchange policy. No new access shall be provided on non-Interstate routes within one-eighth mile of Interstate ramp terminals.
2. N/A = not applicable, F = full movement—all turns and through movements provided, D = directional only—certain turning and through movements not provided.
3. SDDOT may defer to stricter local standards.
4. SDDOT will seek opportunities to reduce access density whenever possible.
5. Rural class minimum unsignalized access spacing may be reduced to 660 ft by the area engineer, based on results of an engineering study as described in Administrative Rules, Chapter 70:09-01:02.

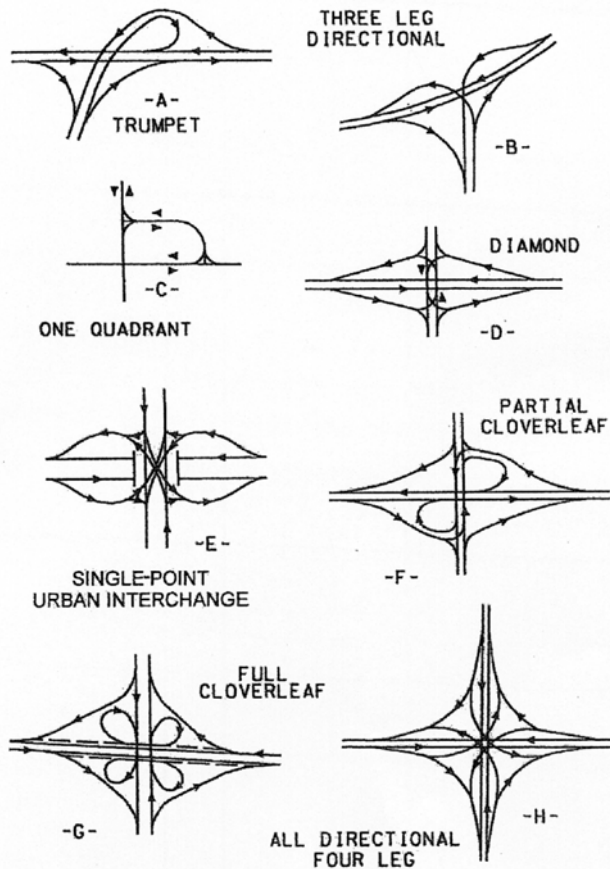


FIGURE 13 Interchange forms (4).

point interchanges in urban environments as a way to reduce the overall distance required between the main line and the downstream access point on the crossroad. This strategy, although sometimes more expensive to implement initially, can achieve many of the desired access management benefits on the crossroad without disrupting the previously established street network, and still maintain the required access spacing distances. Furthermore, the single-point interchange form reduces the number of traffic signals on the crossroad from two to one, and thereby provides additional traffic control strategies that may allow the agency to reduce spacing and increase capacity.

In contrast to service interchanges, cloverleaves and partially directional and fully directional interchange forms require some agencies to develop much more stringent spacing standards as a result of the uncontrolled weaving maneuvers that are introduced because of the merge point of the interchange off-ramp and the crossroad. Under these conditions, the speed on the crossroad, the volume on the crossroad and off-ramp, and the cross section of the crossroad can significantly increase the distance needed for the motorist to traverse before introducing the first access point. The Illinois DOT goes to great lengths in its access control/access management regulations to differentiate among interchange forms, including diamond, two-quadrant

parclo, four-quadrant parclo (Type A), four-quadrant parclo (Type B), and trumpet interchanges. Figure 14 shows an example of the Illinois requirements for a four-quadrant parclo (Type B) interchange (35).

It is important to note that although some agencies have well-established design standards and regulations for access spacing on crossroads, the overall effectiveness of these access management strategies is significantly affected by the prior planning and design used to implement a new or retrofit interchange project in the first place. The decision made to select an interchange form should recognize the needs of the surrounding transportation system and land uses to minimize the number of weaving movements and vehicular conflicts necessary to access that system and the local properties. Conversely, an inappropriately selected interchange form can lead to unnecessary operational and safety issues, as well as undesired political issues associated with enforcing the prescribed spacing standards on the crossroad. Therefore, it is important not only to have well-designed spacing standards, but also rigorous planning, operation, and design processes when selecting the interchange form. Doing so would avoid unnecessary access management issues associated with interchange crossroads.

Public and Private Accesses

For some agencies, the issue of a public versus private access approach to the crossroad may affect the overall access spacing requirements from the interchange terminal, or in some cases it may completely restrict nonpublic approaches, depending on the classification of the crossroad. Public versus private access designations in many ways serve as a surrogate for the level of traffic generated by a given access and the practicality of restricting private access to smaller parcels of land where no alternative means of access is available. Theoretically, private access approaches typically generate less traffic compared with traffic at public approaches, owing to the number of land uses served. Therefore, the amount of traffic and the number of turning movement conflicts are correspondingly less. Generally, the issue of public or private access is not of significant importance, and as a result, it is not incorporated into many state policies. However, some agencies (e.g., Nevada, Oregon, and Washington) maintain spacing criteria for private access approaches that are less restrictive than those for public access approaches.

In some instances, agencies are also faced with the dilemma of either providing access to a small landlocked parcel at locations below their adopted spacing standards or purchasing the subject parcel to prevent the access from occurring. Thus, by default, some agencies have reduced spacing standards or exceptions for allowing access to private approaches to crossroads. To address the close access spacing posed by these parcels, some agencies construct or

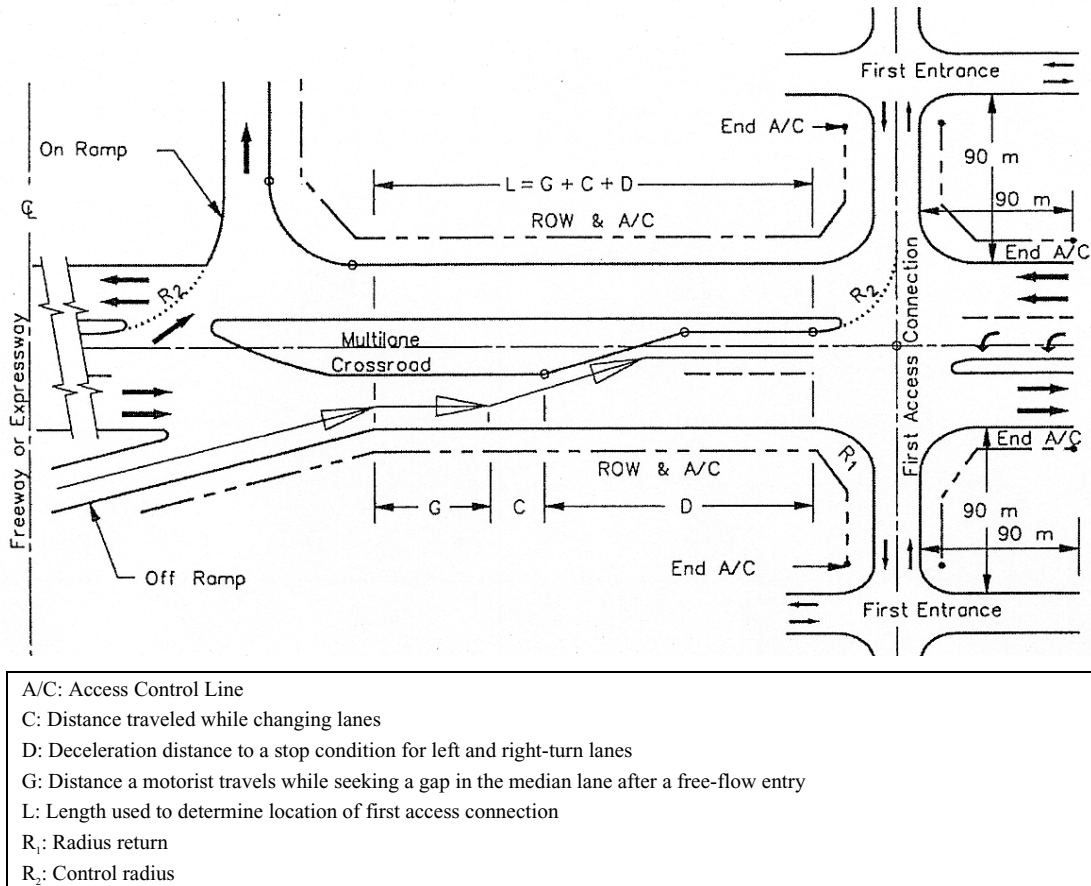


FIGURE 14 Access control along crossroad at four-quadrant parclo (Type B) interchange [Illinois DOT (35)].

require the private property owner to construct raised medians on the crossroads to prevent left-turn ingress and egress movements from occurring at these locations.

Although some agencies allow shorter spacing distances for private access approaches, others, as well as those that do maintain these standards, may completely restrict private approaches from being permitted, given the classification of the crossroad facility. For a higher-level crossroad facility (e.g., an expressway), some agencies restrict private accesses completely within the influence of the interchange and approach the management of the facility from a standpoint that if an access is to be allowed, it should serve as many properties as possible—thereby reducing the need for additional access points to the facility. Some states, including Florida and Oregon, employ this practice on expressway facilities and new approaches within the interchange influence area.

Type of Downstream Access Point

As mentioned previously in this chapter, some agencies have developed access spacing standards based on the type

and control of the downstream access point. In general, the agencies surveyed required additional access spacing distance between the interchange terminal and the downstream access point based on the turning movements allowed and the type of traffic control provided on the crossroad itself. Therefore, the spacing is usually increased in the following order of downstream access points:

- Right-in-only access,
- Right-out-only access,
- Right-in/right-out-only access,
- Left-in/right-in/right-out-only access,
- Unsignalized full access,
- Signalized full access, and
- Grade-separated interchange.

The primary reasons cited for the increase in spacing along the crossroad for various types of downstream accesses pertain to the time necessary for the motorist to complete decisions and the physical distance needed to complete the vehicular movement. A right-in-only access downstream of the interchange terminal requires only that the motorist stay in the outside lane on the crossroad; it does not create any vehicular conflicts outside of the decel-

eration necessary to enter the access. Conversely, turning left downstream on a crossroad at a signalized intersection requires the motorist to find gaps in traffic (time) to weave across (distance) the roadway and enter the left-turn pocket. In addition, the motorist must complete these decision-making and vehicular maneuvering processes before approaching the back of the vehicular queues on the crossroad created by the traffic signal itself. As a result, the more complicated the downstream access point makes the motorist's decision-making process and the vehicular maneuvers to complete a movement, the further the access point should be spaced from the interchange terminal.

Downstream Storage Requirements

A few agencies, such as Maryland, require that the downstream vehicular queue storage requirements be examined to determine the appropriate access spacing on the crossroad. Because the queue storage requirements are based on the vehicular demand, cycle length, and intersection geometry at the downstream intersection, the spacing requirements need to be based on specific land uses and the street network in the vicinity of the interchange under both near- and long-term conditions. Thus, the more sophisticated agencies employ 20-year access management plans, interchange access management plans, or interchange area management plans to determine the appropriate distances based on the surrounding land uses and future transportation system improvements. Oregon uses a somewhat unique intergovernmental agreement process (Interchange Area Management Plans), whereby it actually reviews and sometimes changes or limits the allowed land uses within the proximity of the interchange, to protect the integrity of the interchange terminals.

Once the downstream storage requirements are determined through an operational analysis, the few agencies that employ this technique typically determine the remainder of the access spacing requirements from the distance needed to traverse from the interchange terminal to the appropriate lane before confronting the back of queues created by the downstream signalized intersection. Because this process is highly dependent on the knowledge of future traffic demands and land use development, relatively few agencies use downstream storage requirements as an overall determining factor in establishing crossroad spacing requirements.

Cross Section

Several agencies consider the cross section (width and lane geometry) of the crossroad when determining proper access spacing to the downstream access location. This factor typically is associated with interchange form, traffic con-

trol at the interchange terminal, and downstream left-turn movements. Illinois, Texas, and several other states examine the interchange form to determine if weaving movements will occur based on the interchange form and traffic control at the interchange terminal. In situations where the ramp movement is uncontrolled (e.g., cloverleaf, parclo, and directional interchanges or free-flow right-turn movements at service interchanges), the spacing distance to the downstream access location is dictated by the number of lanes that need to be crossed, the advancing volume on the crossroad, and left-turn storage at the downstream intersection. The Illinois methodology uses a factor of 3 s per lane change to determine the longitudinal distance necessary for each lane traversed on the crossroad.

Design Speed

Several agencies link access spacing standards to the design speed of the crossroad. Illinois goes to a high level of detail to incorporate the interchange form, cross section, length of taper, type of access, and deceleration distance as functions of design speed into the overall access spacing requirements. Other states, such as Oregon, use stopping sight distance and decision sight distance to justify the location of the first access location downstream of the interchange terminal. Generally, the design speed of the crossroad is used to determine the physical requirements (distance) necessary to perform various decision-making processes or vehicular performance parameters (acceleration, deceleration, transitioning, etc.). Many of the key calculations based on design speed and used to justify or develop access spacing distances by the surveyed agencies are defined here.

Stopping Sight Distance—The distance necessary to come to a complete stop to avoid another vehicle's decelerating or stopping to turn at an access point. This distance is made up of two components: braking reaction time and braking distance. According to the 2001 AASHTO *Green Book (4)* definition, stopping sight distance is based on the following equation:

$$D = 1.47vt + 1.075 \left(\frac{v^2}{a} \right)$$

where

- D = stopping sight distance (ft),
- v = design speed (mph),
- t = braking reaction time (2.5 s), and
- a = deceleration rate (ft/s²).

If a vehicle is traveling at 35 mph, it will need approximately 250 ft of stopping sight distance. This estimate is based on an assumed deceleration rate of 11.2 ft/s².

Some agencies contend that stopping sight distance should be maintained as a minimum distance between the interchange terminal and crossroad access locations, to ensure that motorists are not placed in situations where they would not have time to avoid a vehicle decelerating or stopping to turn from the crossroad or a vehicle entering the crossroad from the access point.

Decision Sight Distance—The distance necessary to perceive and react to unexpected, unusual, or complex conditions. The distance is made up of three components: perception, reaction, and control action (braking, weaving, etc.). From the 2001 AASHTO *Green Book (4)*, definition decision sight distance is based on the following equation for avoidance maneuvers (speed/path/direction change):

$$D = 1.47vt$$

where

- D = decision sight distance (ft),
- v = design speed (mph), and
- t = total premaneuver and maneuver time (10.2 to 14.5 s).

For example, a vehicle traveling at 35 mph will require a decision sight distance from 525 to 750 ft depending on the premaneuver and maneuver time assumed in the calculation.

Some agencies contend that decision sight distance is necessary between the interchange terminal and the downstream access point on the crossroad. Stopping sight distance is adequate for drivers to come to a quick stop under ordinary circumstances. However, in areas where there are unexpected maneuvers or where information is difficult to understand, such as an interchange area, drivers may need more distance to react appropriately. In an interchange area, motorists entering the crossroad at the interchange terminal need time to perceive what is going to occur downstream (e.g., the location of their desired access point, the lane they need to be in to enter that access, and the interaction of other vehicles), complete the necessary maneuvers, and decelerate to enter the access point. Decision sight distance provides the additional distance in which drivers can understand the complexity and react accordingly.

Volume

A few agencies, including the Colorado DOT, employ crossroad volumes to determine appropriate spacing distances on crossroads. Although not specifically mentioned by some agencies, volume is typically considered by nearly

all agencies indirectly through either crossroad roadway classification or other surrogate factors identified in this section of the report. The guiding principle behind this is that higher-volume roadways have a potential for more operational deficiencies and turning movement conflicts. As a result, agencies will allow crossroads with lower volumes to have closer access spacing, whereas they will require crossroads with higher volumes to have more restrictive access spacing. Colorado employs volume as one factor in determining access spacing on crossroads.

Signal Cycle Length

Signal cycle length is used by relatively few agencies to determine access spacing on a crossroad. New Jersey is one state that incorporates cycle length, in combination with speed, into its access spacing standards. In New Jersey, the lower the cycle length, the shorter the spacing standard is for signalized intersections on a crossroad. A cycle length of 60 s translates to a 1,100-ft spacing standard, and a 150-s cycle length requires a spacing distance of 2,640 ft. This technique is designed to ensure adequate progression of vehicles and maintain queues between the downstream traffic signal and the interchange ramp terminal.

Cost and Economic Impacts

Cost and economic impacts of access management on crossroads are typically considered either directly or indirectly by most agencies. Although regulations and policies as adopted by several agencies either omit or state that these factors are not considered in regulating access to crossroads in the vicinity of interchanges, the economic reality of constructing new or retrofit facilities or maintaining the economic vitality of a community definitely comes into play. For some agencies, this economic factor is so significant that access management policies are either non-existent or very limited, owing to the actual or political cost of implementing such policies. In other agencies, the access management standards weigh the importance of the subject facility to the impact associated with a given access point. South Carolina indicated that it makes many of its access spacing decisions based on the cost of right-of-way and the impacts to adjacent development. This decision-making and approval process is typically dealt with through a deviation or exception procedure, or a separate planning alternative such as a specific access management plan for a given crossroad facility.

Level of Interchange Importance

As with the roadway classification factor, the level of importance of the interchange is considered by some agen-

cies. Louisiana uses interchange importance as a factor in its access spacing policies. The higher the importance of the main line and crossroad facilities, the more aggressive the access spacing requirements become. For example, an interchange between two Interstate freeways would likely require a directional interchange form and completely restrict access downstream of the interchange, with the exception of properly spaced grade-separated interchanges.

Crossroad Jurisdiction

The jurisdiction on the crossroad may dictate the downstream access location in certain situations. Assuming that the local agency (e.g., city or county) has permitting authority on a crossroad facility, the access location in some states is dictated by the local jurisdiction's development guidelines and design standards. In some instances, the first access location occurs immediately outside of the original right-of-way or access control purchased at the time the interchange was constructed. In other situations, the local agencies may have intergovernmental agreements with the state DOT or toll authority to manage access on the crossroads in the vicinity of interchanges.

As demonstrated previously, agencies use a variety of factors to determine the access spacing requirements on crossroad facilities in the vicinity of interchanges. Some of the agencies surveyed use a combination of these factors to develop their standards, whereas others rely simply on industry standards such as AASHTO's 1991 *A Policy on Design Standards—Interstate System* recommendation of 100 ft of spacing for urban conditions and 300 ft of spacing for rural conditions (5).

SPACING MEASUREMENT ON INTERCHANGE CROSSROADS

In comparing various agency spacing standards, it is important to realize that any two agencies with identical access spacing distances for a given situation (e.g., 100 ft for urban and 300 ft for rural conditions) may actually measure the distances differently by using various reference points: (1) centerline of the ramp at the interchange terminal to centerline of the access point location on the crossroad, (2) end of radius at the interchange terminal to the beginning of the radius at the access point location, (3) gore point of the off-ramp with the crossroad to the downstream radius or centerline, and (4) end of the off-ramp taper with the crossroad to the downstream radius or centerline. Each of these reference points is defined as follows:

- *Centerline-to-Centerline*—longitudinal distance between the geometric intersections of the off-ramp or on-ramp centerline with the centerline of the cross-

road, and the downstream access point centerline with the centerline of the crossroad.

- *Gore Point*—point at which the off-ramp's inside edge of pavement and the crossroad's outside edge of pavement merge.
- *End of Radius (tangent section)*—point at which the radial edge of pavement or curb transition between the off-ramp and crossroad terminates or becomes parallel to the crossroad centerline.
- *End of Taper*—point at which the off-ramp transition lane and the crossroad's outside lane become one.

Figure 15 illustrates the various reference points agencies use to measure their established spacing standards. (Summary responses to question 1d in Appendix C provide details of what each responding agency uses to measure access spacing distances on crossroads.)

As illustrated in Figure 15, if two agencies use different references to establish their access spacing distances, the resulting distance between successive access points can be quite different. Thus, it is important to correctly understand how the reference point of measurement corresponds with the access spacing factors that a given agency may be trying to implement.

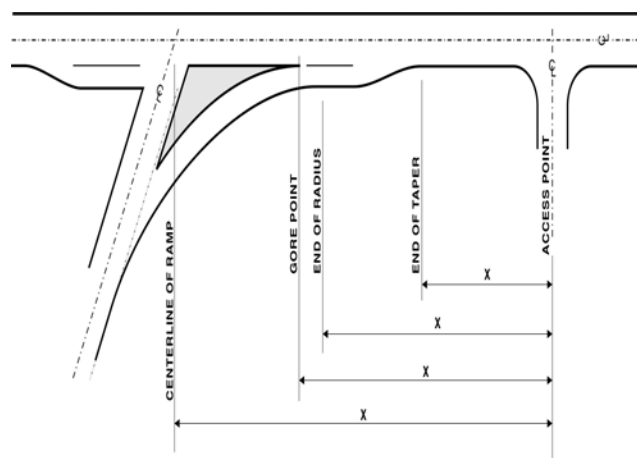


FIGURE 15 Different access spacing point references.

ACCESS MANAGEMENT TECHNIQUES USED ON CROSSROADS

The methods by which agencies manage crossroad facilities differ dramatically from state to state; however, the primary techniques typically fall into nine categories: positive control, acquisition, legislation and regulation, intergovernmental coordination, planning, operational, design, land use, and local agency regulations. In addition, the ability to successfully implement these techniques is highly dependent on the legal and nonlegal relationship between the agency that maintains and operates the interchange and

the agency that maintains and operates the crossroad. The remainder of this section describes the methods used by various agencies

Positive Control Techniques

Some states employ positive control techniques within the interchange and crossroad right-of-way to control and restrict access downstream of the interchange terminals. These techniques include traversable and nontraversable median islands, various types of fences installed along the right-of-way, guardrails, and curbs along the edge of the crossroad. Although these positive access control techniques are used extensively throughout North America, it was interesting to find that the states that do not maintain or effectively implement access management legislation or regulations list these techniques as their only effective tools to manage access points to the crossroad.

Although raised medians can be effective in controlling left-turn ingress and egress movements as well as crossing movements, some of the agencies that do not have well-developed access management programs or planning processes basically are forced to install the medians to prevent the operational and safety problems associated with multiple access points on the crossroad. Thus, all of these desired traffic movements (left turns in and left turns out) are relocated to the first downstream intersection. This situation can result in multiple U-turns at the downstream intersection, as vehicles reroute to access driveways across from the raised median. As a result, the operations of that downstream intersection may deteriorate. These difficulties are typically related to the lack of (1) defined local parallel street systems, (2) cross access easements between parcels, and (3) shared access driveways that could be developed with a more effective access management regulation or planning process.

Acquisition Techniques

More than three-quarters of the responding agencies indicated that they use some form of acquisition (right-of-way or access control) to manage the access to crossroads in the vicinity of interchanges. Several agencies purchased access control along the crossroad as part of the original interchange project or through subsequent purchases. However, the most common acquisition technique employed by the responding agencies was to obtain access rights to the crossroad. This technique is referred to variously throughout North America, including (1) purchase of access rights, (2) nonaccess lines, and (3) access control lines. However, it is important to note that nearly all the agencies that use acquisition techniques (20 of 32) acquire access rights to the crossroad by property deed. (See summary responses to

question 5 in Appendix C for details.) The range of access rights acquisition among the responding agencies varied from 100 ft in urban conditions (Connecticut, Florida, Georgia, Louisiana, Michigan, Mississippi, South Carolina, Virginia, and West Virginia) to 1,320 ft in Oregon. Some of these agencies, including the Washington State DOT, have specific access control lines for new interchanges. Washington's access rights acquisition technique for a typical interchange is illustrated in Figure 16.

As shown in Figure 16, the Washington State DOT looks to acquire 300 ft of access control (measured from the centerline at the interchange terminal) downstream of the interchange terminal and 130 ft on each leg of a downstream intersection that is located within 350 ft of the interchange terminal (36).

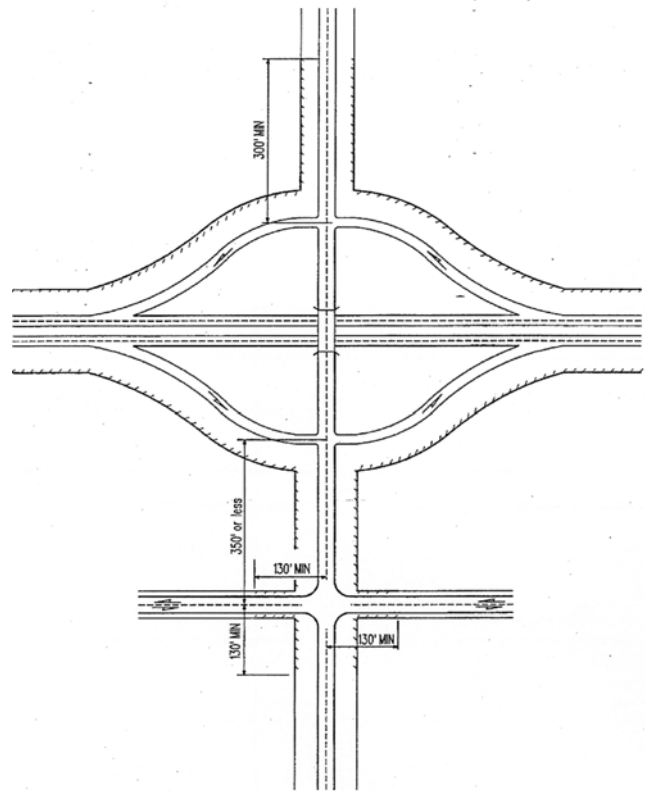


FIGURE 16 Access control for typical interchanges (36).

Legislation and Regulation Techniques

The agencies that have the most success in controlling access to the crossroad in the vicinity of interchanges are those that have adopted legislation that gives an agency a clear and specific mandate to manage access. According to survey responses, nine agencies (Colorado, Florida, Iowa, Maine, Oregon, Virginia, Washington, New Brunswick, and Nova Scotia) currently have some form of adopted legislation and regulation that allows them to manage access

on crossroads in the vicinity of interchanges. In addition to these agencies, New Jersey, South Carolina, South Dakota, Utah, West Virginia, and Wyoming have their access spacing standards on crossroads adopted as regulations.

From a review of the various legislative and regulatory materials received through this synthesis research, it can be seen that using legislation and regulation provides the best technique for agencies to effectively manage access on crossroads in the vicinity of interchanges. Such effectiveness is the result of the rules being usually clear and prescriptive, and providing certainty not only for the agency, but for the property owners and business owners that abut the crossroad, and for the local agencies that own and maintain the crossroad. This certainty results in a significant decrease in the number of applications and proposed land use plans that would otherwise propose undesired access points on the subject crossroad.

Intergovernmental Coordination

One of the more successful practices for agencies has been the partnering with local governments on land development reviews. Local governments traditionally have much more control over the land use process that leads to access requests, whereas state agencies typically have control only over access permitting on state highways. When a state agency works effectively with a local agency to provide education and to become involved in development proposals, both agencies can combine their respective authorities to prevent undesirable and unnecessary access points in proximity to the interchange.

Planning Techniques

Most agencies use a 20-year traffic forecast and design year to plan and evaluate new or retrofit interchange projects. In addition, several agencies follow the FHWA or AASHTO guidelines to manage access downstream of the interchange terminal. In planning new interchange facilities, nearly all the agencies reported that they rely on a planning process based on an upfront forecasting analysis that evaluated several of the 13 factors: surrounding land use and environment, roadway classification, interchange form, public and private accesses, type of downstream access point, downstream storage requirements, cross section, design speed, volume, cycle length, cost and economic impacts, level of interchange importance, and crossroad jurisdiction. However, only 60% of the agencies believed that they use an integrated planning process that maintains the safety and efficiency of the interchange through access management.

The success of an individual agency's planning technique to manage access on the crossroads came down to

two key factors: the public involvement process and the strength of the agency's access management legislation and regulations. These two factors were shown as either the agency's strongest or weakest part of its planning process. As a result, the majority of successes in planning new or retrofit interchange projects and the access to the crossroad are experienced by those agencies that have adopted legislation and regulations and that effectively manage the public involvement process. Conversely, the agencies without the adopted legislation and regulations experience difficulties that can be further complicated by poorly developed public involvement processes. As a result, the final interchange plans in these circumstances are dictated more by local desires and implementation costs than by sound transportation planning and traffic engineering practices.

Most of the agencies that employ successful planning processes use one of the following tools to complete their processes:

- Access management plans,
- Circulation plans,
- Interchange access management plans, and
- Interchange area management plans.

Florida and Oregon have some of the most detailed planning practices when it comes to managing access to crossroads in the vicinity of an interchange. Florida's *Interchange Handbook* (37) and Oregon's *1999 Oregon Highway Plan* (38) prescribe specific procedures through which new and retrofit interchanges are planned. Oregon's Interchange Access Management Plan process, described here, was used as part of the Highway 18/99W interchange case study that is presented in chapter four of this report.

ODOT uses interchange area management plans, which describe the roadway network, right-of-way, access control, and land parcels in the analysis area of an existing or planned interchange. The planning provision was first introduced in 1999 and actually implemented on a series of projects in 2002. ODOT requires an interchange area management plan for any new interchange or significant retrofit to an existing interchange. The interchange area management plans are developed with the goal of protecting the functional integrity of an interchange by maximizing the capacity of the interchange and allowing the safe transition of vehicles between the higher-level facility and the crossroad. In addition, the plan provides for safe and efficient operations on the crossroads to minimize the need for major improvements at existing interchanges.

Interchange area management plans include current and projected future 20-year traffic volumes and flows, roadway geometry, traffic control devices, current and planned

TABLE 7
OPERATIONAL TECHNIQUES USED BY VARIOUS AGENCIES IN EVALUATING INTERCHANGE TERMINALS AND CROSSROAD FACILITIES

Agency	LOS	V/C	Travel Time	Queues	Weaving	Progression
California	X					
Florida	X	X		X		X
Kansas	X			X	X	X
Louisiana	X			X		X
Nevada	X					X
New York	X	X				
Oregon		X		X	X	X
South Carolina	X			X		X
South Dakota	X		X	X		X
Texas						X
Washington	X			X		X

Notes: LOS = level of service; V/C = volume-to-capacity.

land uses and zoning, and location of all current and planned approaches. The study areas are sufficient enough (one-quarter mile from the interchange terminals at a minimum) to ensure the safe operation of the facility through the design traffic forecast period. In addition, interchange area management plans contain short-, medium-, and long-range actions to improve operations and attain desired spacing along the crossroad facilities. These actions address necessary roadway improvements, including local street network improvements and construction, as well as access consolidations, crossover easements, and shared approaches.

Operational Techniques

To properly assess existing and future operations at the interchange terminals and along the crossroad, some agencies measure and/or design to a specific operational performance measure, including level of service, volume-to-capacity, corridor travel time, 95th-percentile queue storage, weaving analysis, and progression. These operational techniques are sometimes used separately or in combination. Table 7 shows a sample of the various operational techniques that some responding agencies use.

To assess the operations of the interchange ramp terminals and crossroad facilities, some agencies use simulation. Simulation has the advantage of looking at the interchange and crossroad system as a whole. Simulation can handle queue interaction between signals, can handle unserved queue traffic from one period to the next, can vary demand over time and space, and can model unusual arrival patterns (39). Based on some of these features, simulation provides a better approximation compared with a deterministic model of the effect of access and closely spaced driveways or intersections to the interchange ramp terminals. Colorado, Florida, and Oregon use simulation to model the effects of various access management techniques for specific projects.

Design Techniques

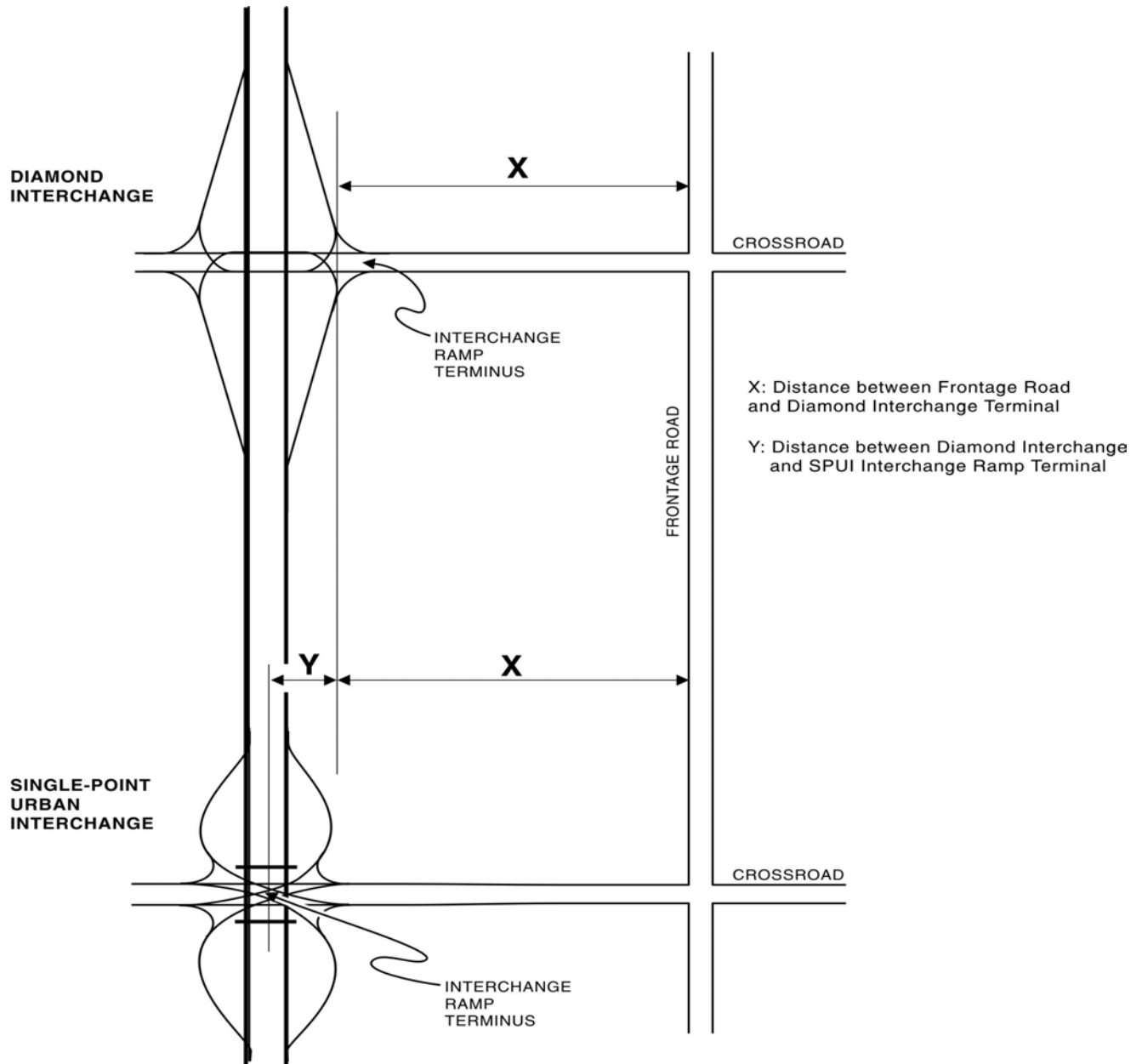
From a design perspective, nearly all the responding agencies prefer to deploy nontraversable medians on crossroads in the vicinity of interchanges to improve and maintain safe and efficient operations within the interchange area. The propensity toward medians is somewhat driven by the ability of agencies to better control what is within their right-of-way versus what accesses their right-of-way. The Georgia DOT, for example, has a volume threshold policy for medians on crossroads in the vicinity of interchanges. Table 8 shows the volume thresholds and corresponding median strategies.

TABLE 8
GEORGIA DOT MEDIAN TREATMENTS FOR ALL MULTILANE FACILITIES

Crossroad Volume (ADT)	Median Treatment
<18,000	Traversable TWLTL
18,000 to 24,000	Traversable TWLTL maintaining ROW for a future 20-ft raised nontraversable median
>24,000	Nontraversable, raised median

Notes: ADT = average daily traffic; ROW = right-of-way; TWLTL = two-way left-turn lanes.

Many agencies continue to rely on FHWA and AASHTO design guidelines to drive their design processes. However, several agencies have taken advantage of the various available interchange forms that lend themselves to improved operations downstream of the interchange terminal. Interchange forms such as the single-point urban interchanges have been introduced in highly developed urban areas to maximize the distance between the interchange terminal and the downstream access locations on the crossroads. Minnesota uses both single-point and folded diamond interchange forms to reduce the amount of downstream weaving and to improve both the overall mobility and accessibility within the interchange area. Figure 17 shows the potential additional separation provided by a single-point urban interchange versus that provided by a traditional diamond interchange.



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FIGURE 17 Comparison of access spacing by interchange form (diamond interchange versus single-point interchange).

Land Use Techniques

Although many transportation and land use professionals understand the relationship between adjacent land use densities and the ability of transportation systems to support such densities, few agencies attempt to use zoning or other

land use mechanisms to influence access locations on crossroads in the vicinity of interchanges. Oregon, through the recent introduction of its Interchange Area Management Plans, has begun to address adjacent land uses on interchanges located outside urban growth boundaries. A number of agencies, including cities, counties, and states have recently undertaken

a joint effort to examine future urban zonings and land partitions to ensure that a new or retrofitted interchange can be properly designed and preserved by controlling the allowable land uses within the vicinity of the interchange and the densities to which those uses can develop.

Local Agency Regulations

In many states, local agency regulations play a significant role in the ability to define and regulate the location of accesses on crossroads downstream of the interchange terminal. In several instances (e.g., Kansas, Nebraska, and Texas), the agency responsible for a subject interchange is highly reliant on the local agency and its adopted regulations. Access points sometimes are limited only by the original right-of-way purchase as part of the interchange project (typically not more than 100 to 300 ft downstream of the terminal) and the fence that delineates the corresponding access control line. Therefore, crossroads not owned or regulated by the interchange agency may not have any formal access management standards or land use regulations (zoning, comprehensive plan designations, etc.) that limit the amount of traffic demand placed on the facility. Generally, the states experiencing the most success in managing interchange crossroads have some level of coordination with the local agencies through intergovernmental agreements or statewide administrative rules.

PLANNING, OPERATION, AND DESIGN PRACTICES FOR NEW INTERCHANGES

In reviewing the various agencies’ experiences of implementing specific planning, operation, and design techniques to manage access on the crossroad as part of new interchange projects, it was found that a high percentage of the survey respondents indicated that their programs implemented various access management techniques more than 60% of the time. Figure 18 provides a summary of the agencies responses, with the corresponding percentage of techniques deployed in the field.

As shown in Figure 18, 26 of the 33 agencies responding to question 11 reported that 60% or more (i.e., judged to be very successful or fairly successful) of their access management techniques in the vicinity of interchanges are deployed on new interchange projects. Chapter four includes three case studies documenting these new interchange projects.

Definition of Success

Although responding agencies had varying ways of defining a successful new interchange project that deployed access management techniques, most found their projects to

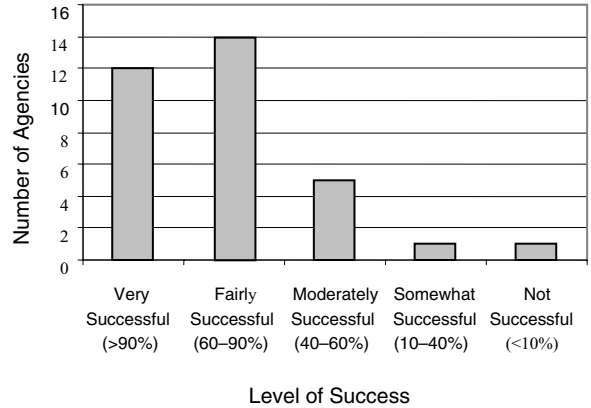


FIGURE 18 Agencies’ level of success with managing crossroads as part of a new interchange project.

be successful based on the interchange operations and increased safety in the interchange area. By establishing access control and reducing the number of conflict points, many agencies met their operations and safety standards. During the projects, agencies sometimes faced opposition to driveway closures, yet were able to successfully close the accesses based on defensible access management standards and providing alternate access. In addition, several agencies found their projects to be successful based on providing adequate spacing between the interchange terminals and the nearest intersection. (See summary responses to question 12c in Appendix C for details.)

Techniques Deployed

The majority of responding agencies indicated that they relocated, consolidated, or closed existing access driveways, median openings, frontage roads, or public street connections as part of their new interchange projects. Some of the agencies (Minnesota, Nebraska, New Jersey, South Carolina, and New Brunswick) combined and relocated access driveways to service roads. The provision of service roads allowed businesses to continue operation and reduced their impact to the interchange crossroad operations. As part of this process, New Jersey officials notified property owners and responded to concerns to aid in the closure of driveways. (Summary responses to question 12e in Appendix C outline the various techniques deployed by the agencies that had completed a new interchange project within the past 5 years.)

Funding Issues

Some responding agencies found funding critical to the success of new interchange projects. Funding affected the ability to purchase right-of-way and conservation easements. Without the funds to make these purchases, it was difficult to preserve the future operations and safety of a

crossroad facility through the use of access control. To meet its goal, Minnesota spent much of its funds on the access management component of the project to achieve the desired access spacing on the crossroad. As a result, the agency focused on suburban and rural roadways. Similarly, New Jersey found funding to be a factor in establishing access control, yet used funding restraint to promote creativity in design and construction. Other agencies, such as Nevada, were not limited in access control by funding, but they were required to meet federal standards because they received federal funding for the project. Likewise, several other agencies found that funding did not influence the techniques used for their interchange project. (See summary responses to question 12f in Appendix C for details.)

Lessons Learned

As a result of the agencies' experiences with new interchanges, several lessons were learned in access management for the new interchanges. Access management techniques should be considered in the earliest planning stages of the interchange project. Considering access management early in the project allows for better planning and education of the public on access management issues. When planning the interchange project, the design team should verify that the level of access control corresponds with the interchange design. Although the standards and guidelines for design should be followed, the design should also incorporate some level of flexibility.

Oregon found planning for the future functionality of the crossroad to be extremely beneficial through the use of intergovernmental coordination. In Oregon's sample project, the city, county, and state worked together to review and mitigate public and private development actions that might otherwise have affected the crossroad. Working together allowed the agencies to establish common goals, and it facilitated the understanding of the project and its implementation in a briefer time.

Alberta Transportation found that access management policies should be defensible. In Alberta's sample project, the agency was strongly opposed by the local community and the local elected representative. Defensible standards allowed the closure of access points and ultimately provided for a safer and more efficient transportation system.

Several agencies cited the importance of funding. Minnesota noted that with sufficient funding interchange access management techniques can be applied. Proper funding also allows for the future preservation of the interchange crossroad and vicinity. Similarly, the E-470 Authority, a toll authority in Colorado, noted the importance of funding, specifically with regard to the need for controls to force developers to keep their financial com-

mitments to the project. Inadequate funding can limit the extent of access control, and it could compromise the future operations and safety of the interchange area. (See summary responses to question 12g in Appendix C for details.)

PLANNING, OPERATION, AND DESIGN PRACTICES FOR RETROFIT INTERCHANGES

In reviewing the various agency experiences in implementing specific planning, operation, and design techniques to manage access on the crossroad as part of retrofit interchange projects, it was found that less than half of those surveyed indicated that their programs implemented those techniques more than 60% of the time. Figure 19 provides a summary of the agencies' responses, along with the corresponding percentage of access management techniques used in the field.

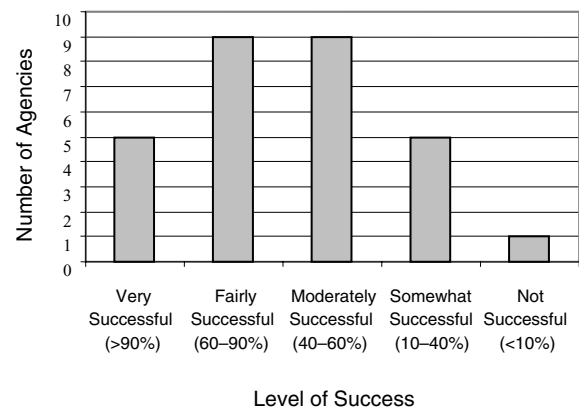


FIGURE 19 Agencies' level of success with managing crossroads as part of a retrofit interchange project.

As shown in Figure 19, 14 of the 29 agencies responding to question 13 reported that 60% or more (i.e., judged to be very successful or fairly successful) of their access management techniques in the vicinity of interchanges are deployed on retrofit interchange projects. Chapter four includes five case studies documenting these retrofit interchange projects.

Definition of Success

Similar to the definition of success for new interchange projects, the agencies defined success for retrofit interchanges as improved operations and safety at the retrofit interchange and on the crossroad. In the experience of Nebraska's retrofit interchange case study, the elimination of county roads close to the interchange ramp terminals improved operations and safety, thus meeting state guidelines for success. In addition, some agencies compare before-

and-after crash data to determine their levels of success on a retrofit interchange project.

Minnesota found its access management project at the retrofit interchange to be successful based on the support of the local community for the raised median concept on the crossroad. Public support can make a significant difference in whether a project is implemented. Therefore, in this example, public support for the project made it a success. (See summary responses to question 14c in Appendix C for details.)

Techniques Deployed

All responding agencies involved in successful retrofit interchange projects relocated, consolidated, or closed existing access driveways, median openings, frontage roads, or public street connections. Some of the responding agencies installed medians on the crossroad. Nevada installed a median to eliminate a weaving problem caused by right-turning traffic exiting off the southbound ramp attempting to make left turns at the next signal. In addition to using a raised median, Minnesota constructed a frontage road to remove the number of turning movements off the crossroad and onto the service road.

Washington State used a public process for access management projects. This process communicated the access changes to owners of abutting property. As part of this process, an access report was completed. The report communicated to the local jurisdiction the extent of the proposed access modifications. The report was followed by a hearing in which property owners were able to express their concerns with the proposal. Similarly, Nebraska purchased the right-of-way, and it held public hearings and informational meetings with the landowners and community to complete their access modifications. The public process was found to be a necessary step in educating and informing the public about the project. In contrast, South Carolina closed accesses by condemning property and taking part in negotiations. (Summary responses to question 14e in Appendix C provide details about techniques deployed by various agencies on retrofit projects.)

Funding Issues

Some of the responding agencies found no funding issues related to access management techniques, whereas Minnesota found funding imperative to the success of its retrofit interchange project. Minnesota needed funding for the reconstruction of the crossroad, for the construction of addi-

tional frontage roads, and for redirecting driveways. Similarly, the E-470 Authority in Colorado found funding important, but it recommended that retrofit projects wait until complete funding is available, as opposed to retrofitting the interchange in a piecemeal process.

Other agencies did not find funding imperative to the success of the access management component of the retrofit interchange project. Nevada's retrofit interchange project received federal funding for the retrofit interchange process, and thus it was required to meet federal standards on all access management techniques. (See summary responses to question 14f in Appendix C for details.)

Lessons Learned

The surveyed states had a variety of lessons learned from retrofit interchange projects. It was found that involving the public early on in the retrofit interchange planning process was very beneficial. Early public involvement allowed for the education process and provided opportunity for feedback from the community. When using such public involvement, Ohio found that it was important to have access management standards that are easy to explain to the community, to gain local support for the project.

In addition, several states found that establishing access management guidelines before beginning the project would have been beneficial. Minnesota had no formal guidance for access management around an interchange before the start of a retrofit interchange project. As a result, additional time was spent working for municipal consent on access spacing. (See summary responses to question 14g in Appendix C for details.)

According to the survey responses about the planning, operation, and design of new and retrofit interchanges, the responding agencies generally had the same experiences for both new and retrofit projects. The major difference between new and retrofit interchanges, as noted among respondents, was the importance of community and stakeholder support for the retrofit interchange project. It was found that retrofit interchange projects involving the public early on in the planning stages were successful in achieving desired access control. Typically, a retrofit interchange project involves an interchange in a developed area with operational and/or safety issues. Because there may be adjacent developments, acquiring access can be a challenge; therefore, community support is important. In contrast, new interchanges are typically built in less constrained areas, where acquiring access may raise fewer objections and therefore may be more feasible.

CASE STUDIES

This chapter provides several case studies illustrating how various transportation agencies have dealt with access locations on crossroads in the vicinity of interchanges, through either new or retrofit interchange projects. The responses from the survey questionnaires sent to various agencies throughout North America, and follow-up interviews, form the basis of the following case studies in this report.

The three new interchange projects studied were Suncoast Parkway (New Port Richey, Florida), the County Line Road/Interstate 65 interchange (Indianapolis, Indiana), and the Tamarack Road/Interstate 494 interchange (Woodbury, Minnesota). The retrofit interchange projects studied were State Route 202 and State Route 201 interchanges (Huber Heights, Ohio), the Highway 18/Highway 99W interchange (McMinnville, Oregon), the Fern Valley interchange (Phoenix, Oregon), the SC-60/Interstate 26 interchange (Columbia, South Carolina), and the Piney Grove Road/Interstate 26 interchange (Columbia, South Carolina). Background, objective, process, outcome, techniques employed, and supplemental resources are presented for each case study.

NEW INTERCHANGE—SUNCOAST PARKWAY, FLORIDA'S TURNPIKE ENTERPRISE

Project Background

To develop an alternate north–south route along Florida's west coast, Florida's Turnpike Enterprise (FTE) constructed a new 42-mi limited-access toll highway, the Suncoast Parkway. The Suncoast Parkway connects Hillsborough with Pasco and Hernando counties, and includes seven new interchanges and two additional proposed interchanges. One of the new interchanges constructed for this project was the State Route 54 (SR-54)/Suncoast Parkway interchange in New Port Richey, Florida. The SR-54/Suncoast Parkway interchange was surrounded by large parcels of designated rural land that were ready to be developed into residential and commercial areas. Considering the potential for development in the interchange vicinity, the FTE acquired access control along the interchange crossroad to ensure that development would not interfere with the future operations of the interchange ramps. Figure 20 shows the existing area for the proposed SR-54/Suncoast Parkway interchange.

For a project such as the Suncoast Parkway, the Turnpike considered both the spacing standards in the FDOT



FIGURE 20 SR-54/Suncoast Parkway interchange before the project (Courtesy: Florida DOT).

Plans Preparation Manual and the access management standards in Department Rules, Chapter 14-97. The Plans Preparation Manual requires 300 ft of access control on crossroads in rural areas for the terminus of an interchange project. The access management spacing in Chapter 14-97 requires the minimum spacing between the interchange ramp terminal and nearest intersection to be a one-quarter mile for the designated access classification of SR-54. To ensure that one-quarter mile minimum access spacing standards were protected from future development patterns, the FTE decided to purchase additional access control where it was possible along SR-54, as well as on other interchange crossroads.

Objective

The primary objective was to provide a connection to the new limited access toll facility while preserving the functional integrity and safety of the facility by purchasing additional access control at the interchange.

Process

During the design process, diamond interchanges were selected for all of the interchanges on the Suncoast Parkway. Typical configurations on the Turnpike main line used trumpet interchanges so that all traffic converged at a single point, the toll plaza. The diamond interchange design allowed for more queue length at the toll, more capacity, and less weaving than did the trumpet interchange. In addition, the Suncoast Parkway included a plan for a bike trail along the entire length of the western side. The diamond interchange allowed for stop conditions on the crossroad at signalized intersections, thus allowing the bike trail users to cross the road.

As part of the project, access control was purchased at each interchange. The SR-54/Suncoast Parkway interchange was a significant success because access control was purchased for more than 800 ft to the west and more than 1,000 ft to the east of the interchange ramp terminals. In addition, the design included a continuous median approximately one-quarter mile from each ramp terminal along the crossroad. Having purchased access control, the FTE also constructed an access road on the north side of SR-54 to provide access to those developments that lost frontage on the crossroad and to provide access to the bike trail. Figures 21 and 22 depict the completed SR-54/Suncoast Parkway interchange and access control spacing.



FIGURE 21 SR-54/Suncoast Parkway interchange after the project (Courtesy: Florida DOT).

The FTE worked with the public on the Suncoast Parkway through the Project Development and Environment Study. Public hearings and workshops were held and newsletters were posted.

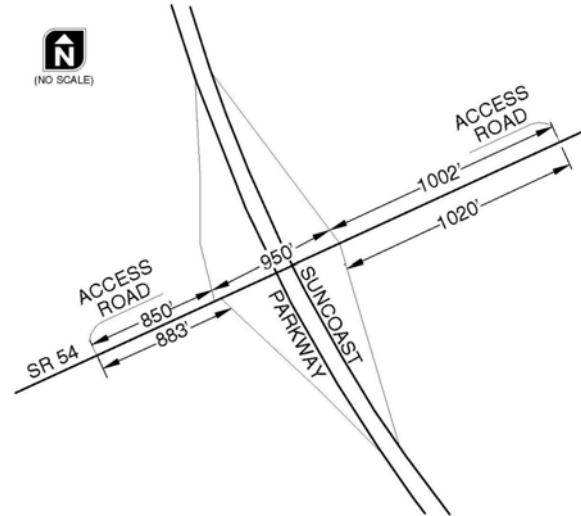


FIGURE 22 SR-54/Suncoast Parkway interchange access control spacing.

Outcome

The outcome of the Turnpike's effort to purchase additional access control was the prevention of driveway and cross-street access in close proximity to the interchange ramps. With the eventual development of the area, the purchase of the additional access control has supported access management on the crossroads around the Turnpike interchanges. That access control has been critical to the safe operational performance of these facilities as high-speed, high-volume traffic movers.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Purchased access control rights along the crossroad for more than 800 ft west and 1,000 ft east of the interchange ramp terminals;
- Constructed access roads to properties on the crossroad allowing access driveways on SR-54 to be closed; and
- Allowed for public involvement through hearings, workshops, and newsletters.

Supplemental Resources

In addition to the information as presented, the following documents and websites can be referenced for further information about this project:

- *The Interchange Handbook*—<http://www11.myflorida.com/planning/systems/sm/intjus/interchangehandbook/PDFs/Preface.pdf>.

- State Highway System Access Management Classification System and Standards—<http://www11.myflorida.com/planning/systems/sm/accman/pdfs/1497.pdf>.

NEW INTERCHANGE—COUNTY LINE ROAD/INTERSTATE 65 INTERCHANGE

Project Background

The County Line Road/Interstate 65 (I-65) interchange south of Indianapolis, Indiana, is located in an area undergoing transition from agricultural to suburban land use. I-65 provides connections from Indianapolis to Louisville to the south and Chicago to the north. As suggested by the name, County Line Road (crossroad) runs along the border between Marion and Johnson counties. The interchange site is located 2.4 mi south and 1.5 mi north of the existing interchanges at Southport Road and Greenwood Road, respectively, on I-65. The Greenwood Municipal Airport is located just southwest of the interchange. Before the interchange was constructed, County Line Road crossed over I-65 by means of an overcrossing bridge, but it provided no access to the Interstate.

The proposed interchange was studied as a part of the Indiana DOT (INDOT) Interstate Interchange Evaluation System. Owing to increased traffic in the area, an interchange was investigated to serve expected future demand. Commercial and residential subdivisions had started to develop in the northwest and southwest quadrants of the grade-separated crossing and required access to the Interstate system. Figure 23 depicts the old I-65 and County Line Road alignment along with the previous rural land uses. A sketch of the proposed interchange design is also indicated in this figure. As shown, existing accesses to County Line Road were located approximately 1,100 ft to the west and 675 ft to the east of the overcrossing.

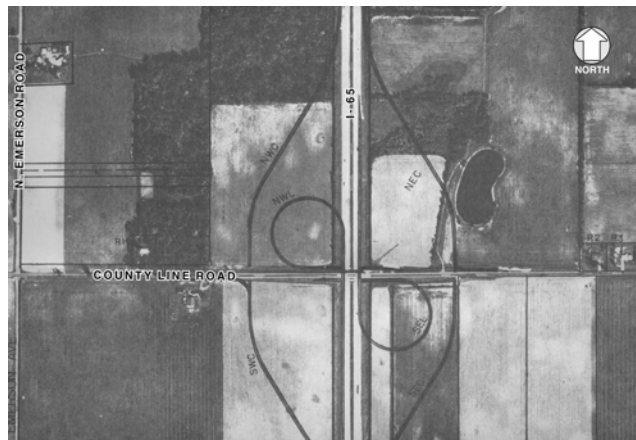


FIGURE 23 County Line Road/I-65 interchange before the project (Courtesy: Indiana DOT).

As part of an interchange design, INDOT's *Design Manual* (Chapters 46 and 48) specifies minimum and desirable distances from the interchange ramp terminal taper extremity to the first access. According to the manual, the full-access control line along the crossroad should extend for a minimum of 300 ft, although 500 ft is desirable in rural areas [per AASHTO's *A Policy on Design Standards—Interstate System* (5)]. INDOT's *Design Manual* also suggests the use of a 600-ft minimum and an 800-ft desirable distance for access control extension beyond the ramp terminal taper extremity point, where the upstream or downstream first access point is expected to warrant active traffic signal control in the future.

Objective

The primary purpose of constructing the County Line Road/I-65 interchange was to provide a long-term solution to increased traffic in the area as commercial and residential subdivisions continue to develop.

Process

INDOT developed several alternatives for the proposed interchange. The alternatives included a partial cloverleaf interchange and a diamond interchange design. Based on the projected operations of the interchange and the impacts to the surrounding area, a partial cloverleaf full-access interchange was determined to be the most appropriate design. The design included full-access control between Emerson Avenue and Arlington Avenue. Figures 24 and 25 show the completed interchange and access control spacing on County Line Road. The interchange off-ramp terminals were designed to be stop controlled, with the provision for traffic signals when signal warrants were met.



FIGURE 24 County Line Road/I-65 interchange after the project (Courtesy: Indiana DOT).

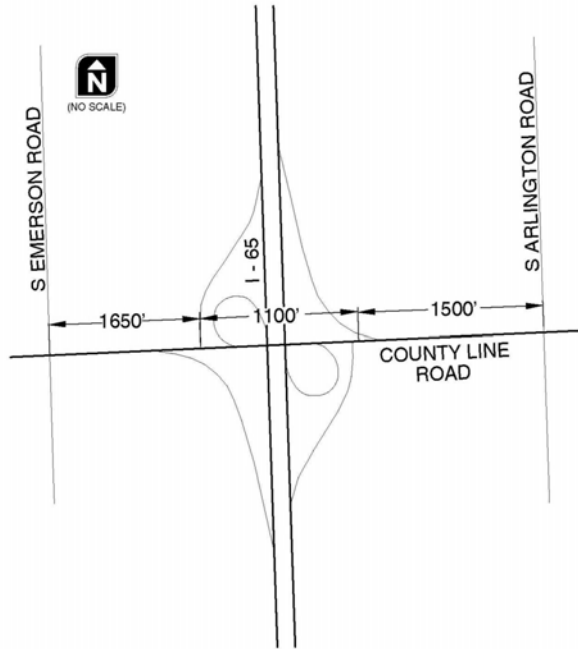


FIGURE 25 County Line Road/I-65 interchange access control spacing.

As part of the design, access roads were constructed from both Emerson Road and Arlington Road. The access roads provided entry to landlocked parcels that would otherwise have required access to County Line Road in close proximity to the interchange ramp terminals.

Outcome

As a result of the new interchange, congestion at the interchanges on I-65 directly to the north and south of County Line Road has been relieved. The southbound ramp terminal was signalized, whereas the northbound ramp remains unsignalized. Very little development has occurred to the east of the interchange, and therefore signalization of the northbound ramp is not anticipated in the near future.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Established full-access control lines to maintain operational integrity of County Line Road in the vicinity of the interchange.
- Provided access roads to landlocked parcels to avoid access to County Line Road in close proximity to the interchange terminal ramps.
- Allowed for public education and involvement during the planning and design process.

Supplemental Resources

In addition to the information as presented, the *Indiana DOT Design Manual* can be referenced for further information about this project.

NEW INTERCHANGE—TAMARACK ROAD/INTERSTATE 494 INTERCHANGE

Project Background

In 2002, the city of Woodbury completed the Tamarack Road/Interstate 494 (I-494) interchange located directly east of St. Paul in Washington County, Minnesota. The interchange is located in a partially developed suburban area within the city of Woodbury. I-494 provides a connection to the city of Woodbury from Interstate 694 and Interstate 35E. As shown in Figure 26, existing interchanges are located to the north at Interstate 94 (I-94) and to the south at Valley Creek Road.



FIGURE 26 Tamarack Road/I-494 interchange vicinity map (Courtesy: City of Woodbury, Minnesota).

In the early 1990s, traffic congestion continued to be a problem within the study area. The congestion was attributed to the major residential and commercial development near the arterials. The Valley Creek Road interchange oper-

ated at near or over capacity during the peak hour, and Century Avenue and Radio Drive also experienced significant congestion. A study report on traffic was prepared for the I-494 area within the city of Woodbury. The study reviewed the existing and future conditions, and it recommended proposed improvements to the system. In addition, the study recommended the construction of two new interchanges on I-494 to relieve the Valley Creek Road interchange. The Lake Road interchange (1 mi south of Valley Creek Road) was opened in 1995, and a new interchange was recommended at Tamarack Road (crossroad).

The current access spacing on Tamarack Road was not an issue for this project, because the area was primarily undeveloped. Minnesota is currently developing guidelines for the management of access spacing on crossroads in the vicinity of interchanges. Woodbury has a minimum access spacing standard of 660 ft for roadways within the city. Figure 27 depicts the I-494 corridor in the vicinity of Tamarack Road before construction of the interchange.

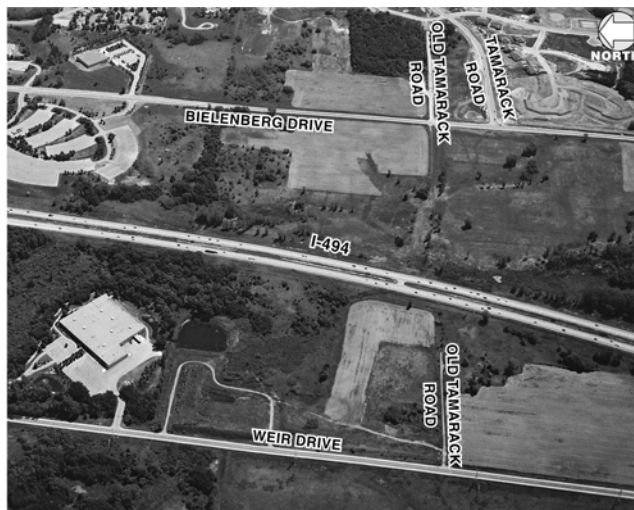


FIGURE 27 Tamarack Road/I-494 interchange before the project.

Objective

The primary purpose of this project was to relieve traffic congestion at other interchanges providing access to the city of Woodbury, and to provide access to and stimulate development along other portions of the I-494 corridor, while preserving the functional integrity of the facility.

Process

The city of Woodbury developed alternatives for the Tamarack Road/I-494 interchange based on existing land constraints. The interchange was constrained to the south by wetlands and could not be moved further north, owing to minimum interchange spacing standards on I-494. As a re-

sult, the city selected a folded diamond design for the Tamarack Road/I-494 interchange. Figures 28 and 29 depict the completed Tamarack Road/I-494 interchange and access control spacing.



FIGURE 28 Tamarack Road/I-494 interchange after the project.

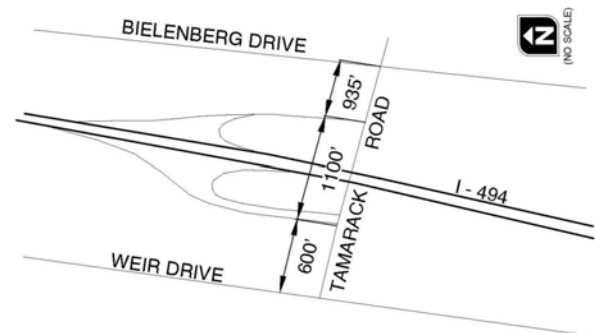


FIGURE 29 Tamarack Road/I-494 interchange access control spacing.

As part of the preferred alternative, Tamarack Road was extended to Weir Drive. Weir Drive in the northwest quadrant of the interchange was relocated and now functions as a frontage road from Tamarack Road. Limited access was obtained along Tamarack Road between Weir Drive and Bielenberg Drive to preserve the future operations on the crossroad. In addition, the city of Woodbury plans to connect the east interchange ramp terminal to Bielenberg Drive opposite Nature Path. The Minnesota DOT did not allow a south connection from the west interchange ramp terminal, owing to minimum spacing standards.

The city of Woodbury educated the public on the project through the use of neighborhood meetings, workshops, and committee meetings among the regulatory agencies. The meetings focused on the relationship between land uses

and the transportation facilities in the northwest area of the city.

Outcome

The Tamarack Road/I-494 interchange was completed in November 2002. The finished interchange met the city's expectations of improved operations in the study area. As a result, the city has observed less congestion on I-94 and Radio Drive, as well as on I-494 and Valley Creek Road. In addition, the city continues to monitor the performance of the interchange and crashes.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Provided frontage roads to access adjacent property and removed turning movement conflicts from Tamarack Road,
- Limited access was obtained between Weir Drive and Bielenberg Drive to preserve the functionality of Tamarack Road in the vicinity of I-94,
- Provided medians on Tamarack Road to reduce turning movement conflicts, and
- Allowed for public education and involvement during the planning process.

Supplemental Resources

In addition to the information as presented, the following documents and websites can be referenced for further information about this project:

- Study Report Supplement for SP 192-102-06 I-494 Interchange Access.
- Access Management Policy: Access Category System and Spacing Guidelines—<http://www.oim.dot.state.mn.us/access/index.html>
http://www.oim.dot.state.mn.us/access/MnDOT_Access_Guidelines.pdf.
- City of Woodbury Access Management Standards.

RETROFIT INTERCHANGE—STATE ROUTE 202 AND STATE ROUTE 201 INTERCHANGES

Project Background

In September 2001, the city of Huber Heights, Ohio, completed its Interchange Modification Study for Interstate 70 (I-70) at the State Route 202 (SR-202) and State Route 201

(SR-201) interchanges. The interchanges are located within Montgomery County, approximately 7 mi north of the city of Dayton. I-70 provides access for residents commuting to and from work, and it connects Huber Heights to downtown Dayton. The study interchanges are spaced approximately 1.97 mi apart on I-70 and have become the focal points for residential, industrial, and commercial activity. Figures 30 and 31 show the existing interchange layout for the SR-202/I-70 and SR-201/I-70 interchanges, respectively.



FIGURE 30 SR-202/I-70 interchange before the interchange modification study (Courtesy: Ohio DOT).



FIGURE 31 SR-201/I-70 interchange after the interchange modification study (Courtesy: Ohio DOT).

SR-202 is surrounded by commercial and industrial development directly north of the I-70 interchange. The increase in development has contributed to the current congestion and overcapacity at the ramp terminals of the interchange. During the peak hours, queues from the ramp

terminals back up onto I-70, causing severe congestion on the Interstate system.

The existing diamond interchange at the SR-201 interchange also exhibits operational deficiencies. The interchange ramp terminals are spaced 380 ft apart, limiting the left-turn storage available between the ramp terminals. In addition, closely spaced bridge piers limit sight distance for the stop-controlled traffic on the ramp. These problems are expected to be further exacerbated by the expected continued growth in the area.

The I-70 corridor has already been identified for improvements, which include a third lane in each direction. This study identified further needs to be addressed at these interchanges for the forecasted 2027 volumes. Ohio's current access management standards on crossroads in the vicinity of interchanges require a minimum distance of 600 ft from the ramp terminal to the closest access point for diamond interchanges and 1,000 ft for directional interchanges, including cloverleaves. The current spacing on SR-202 between the west terminal and the nearest driveway is less than 150 ft. Between the east terminal and the nearest driveway, a spacing of approximately 100 ft is available for storage. Similarly, the current spacings on SR-201 between the west terminal to the nearest driveway and the east terminal to the nearest driveway are 200 ft and 100 ft, respectively. In addition to having close spacing between the ramp terminals and the nearest driveways, both crossroads have numerous driveways accessing the roadway without any standard spacing separating the driveways.

Objective

The primary objective of this interchange retrofit project was to provide a long-term (20 years from project completion) improvement plan based on traffic analysis to support the safety and capacity improvements to the I-70 corridor in Huber Heights, Ohio. These improvements include not only adding a third lane to I-70 in each direction, but also modifications to the SR-202 and SR-201 interchanges.

Process

Several alternatives were identified for each interchange. The designs were constrained by existing developments to the north and south of I-70. The city of Huber Heights based the selection of alternatives on the expected traffic operations, right-of-way requirements, ability to maintain or increase the access control area from the ramp termini, potential environmental impacts, and expected cost. As a result of applying the selection factors to the alternatives, a diamond interchange and single-point urban interchange were considered for each study interchange on I-70. Al-

though both alternatives provided similar operations, diamond interchanges were selected for both the SR-202 and SR-201 interchanges, based on the projected cost and the ability to construct raised medians to limit crossing traffic near the interchange terminals. Figures 32 through 35 show the proposed plan for the SR-202 and SR-201 interchanges and the corresponding access control spacing.

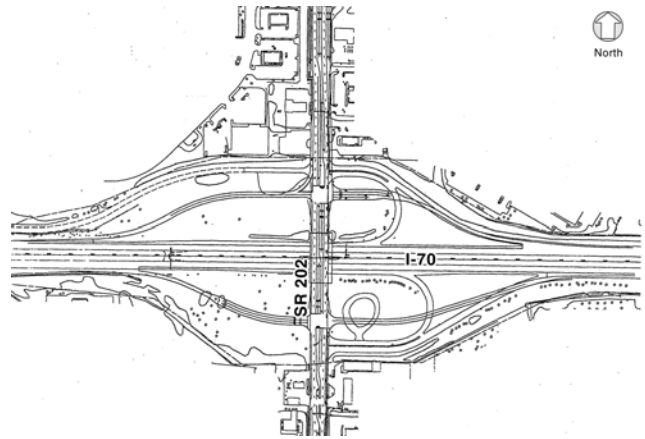


FIGURE 32 SR-202/I-70 interchange improvement plan (Courtesy: Ohio DOT).

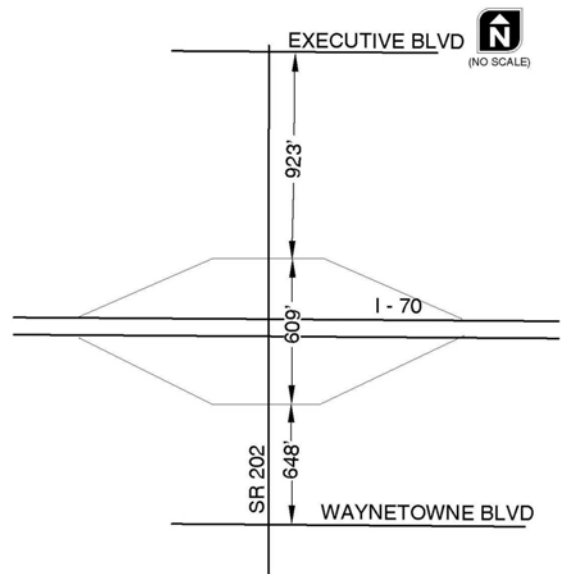


FIGURE 33 SR-202/I-70 access control spacing.

Outcome

As part of the recommendations for the SR-202 interchange, nontraversable medians were recommended north and south of the interchange to limit crossing traffic at and near the interchange. In addition, the interchange ramp

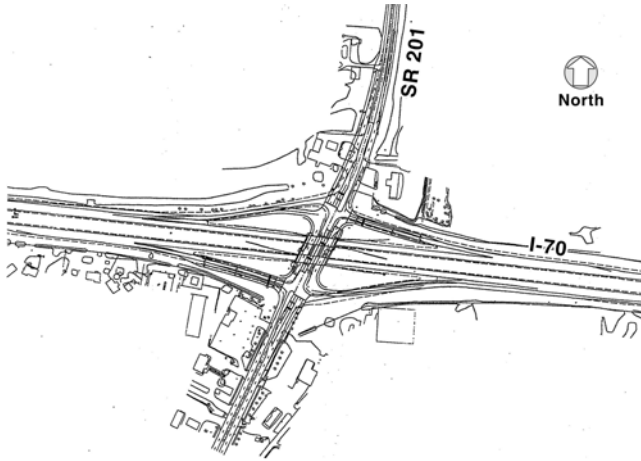


FIGURE 34 SR-201/I-70 interchange improvement plan (Courtesy: Ohio DOT).

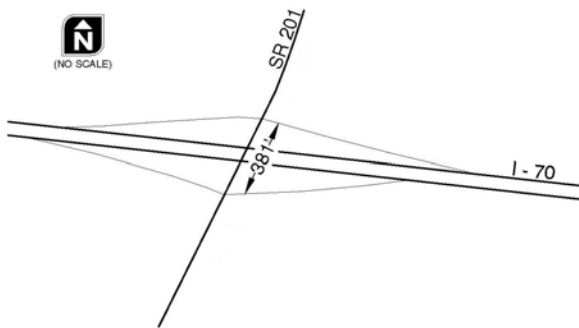


FIGURE 35 SR-201/I-70 access control spacing.

terminals were positioned to maximize the distance from the limited access right-of-way boundary to the ramp terminal.

The recommended design for the SR-201 interchange was limited by the close proximity of numerous businesses. As a result, a nontraversable median was selected to limit the existing accesses to right-in/right-out maneuvers.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Eliminated vehicular turning movement conflicts in the vicinity of the interchange terminals through the use of medians and
- Reduced conflict points on crossroads by consolidating driveways and converting full-access driveways to right-in/right-out accesses.

Supplemental Resources

In addition to the information as presented, the following documents and website can be referenced for further information about this project:

- Interchange Modification Study MOT-70-19.00/20.97 SR-202 and SR-201 Interchanges.
- *State Highway Access Management Manual*—http://www.dot.state.oh.us/planning/AccessMgmt/Manual_Default.htm.

RETROFIT INTERCHANGE—HIGHWAY 18/HIGHWAY 99W INTERCHANGE

Project Background

In 2002, ODOT, the city of McMinnville, Oregon, and local property owners and developers initiated a study for an interchange access management plan to address near- and long-term development within the Highway 18/Highway 99W interchange area (defined as the properties and roadways located within at least one-quarter mile of the interchange), as well as the operational and safety integrity of the interchange. The current interchange is located on the south end of the city and provides in essence a triangle-shaped terminal between the primary business route (Highway 99W) through the city and the bypass (Highway 18) around the city. Figure 36 shows the layout of the existing interchange before the interchange access management plan study and subsequent development.



FIGURE 36 Highway 18/Highway 99W interchange before the interchange access management plan and near-term transportation improvements.

Highway 99W provides access from McMinnville to Portland, Oregon, to the north and Eugene, Oregon, to the south. Highway 18 connects McMinnville west to the coast and Highway 101. The interchange area is surrounded by a

mix of commercial uses and vacant land. Linfield College owns the vacant land to the north of Booth Bend Road, and is expected to expand into a portion of this area.

This project was relatively unique because the interchange access management plan was driven and funded by local property owners and developers, and it was not formally on ODOT's or the city of McMinnville's near-term transportation planning agenda. In this case, the unique geometrics of the interchange area, combined with the existing land use and parcel configurations, made it extremely difficult to develop and access the large undeveloped parcels located within the interchange area. Furthermore, the standard access management administrative rules for permitting access on the crossroads in the vicinity of various interchange terminals (Highway 99W and the Highway 18 Connector) did not provide an acceptable long-term solution to either the involved agencies or the developers.

Oregon's administrative rules allow only one access point to a parcel on the crossroad within 1,320 ft of an interchange, and no access to the crossroad if alternative reasonable access is available (38). This type of administrative rule is highly effective, reflecting a responsible hierarchical access management approach. However, the uniqueness of this interchange, combined with the access management rules, created an unintended operational issue by forcing additional traffic through the signalized Highway 99W/Sheridan Road/Highway 18 Connector intersection to access the various on-ramps and off-ramps of the interchange. That is, motorists traveling westbound on Highway 18 and desiring to access the subject parcel off a potential Highway 18 Connector access point would be forced to travel out of direction through the critical Highway 99W/Sheridan Road/Highway 18 Connector intersection. Thus, the long-term viability of the overall local transportation system and interchange terminals would be compromised, resulting in an operational degradation to the interchange area owing to the increased pressure placed on this critical noninterchange terminal.

Objective

The primary objectives of this interchange retrofit project were to develop a long-term (20-year) access management and roadway improvement plan within the vicinity of the interchange that would meet ODOT's and the city of McMinnville's mobility standards and provide acceptable access to all parcels located within the interchange management area. These objectives were evaluated against four primary criteria: maintaining acceptable interchange terminal and local intersection operations, providing safe and efficient access to all developed and undeveloped properties, minimizing impacts to business and property owners, and creating an economically viable set of solutions that would

allow near-term development without sacrificing the long-term operational integrity of the interchange.

Process

The interchange access management plan was developed through a relatively simple opportunity and constraints exercise that included ODOT and city staff as well as local property and business owners. The exercise was focused on developing long-term local circulation plans, as well as possible alternative interchange forms to accommodate both local development and regional growth over a 20-year period. From this process, four circulation alternatives were found to meet the overall project objectives and the long-term transportation system needs. Based on these alternatives, specific access plans for each parcel were developed that accounted for forecasted 20-year traffic volumes and vehicular queues. As a result, ODOT, the city of McMinnville, and the local property and business owners could select a preferred alternative that they believed best suited the long-term development and business interests of the community. Figures 37 and 38 show the interchange access management plan and the specific transportation improvements, respectively. Figure 39 indicates the resulting access control spacing.



FIGURE 37 Highway 18/Highway 99W interchange access management plan.



FIGURE 38 Highway 18/Highway 99W interchange specific transportation improvement plan.

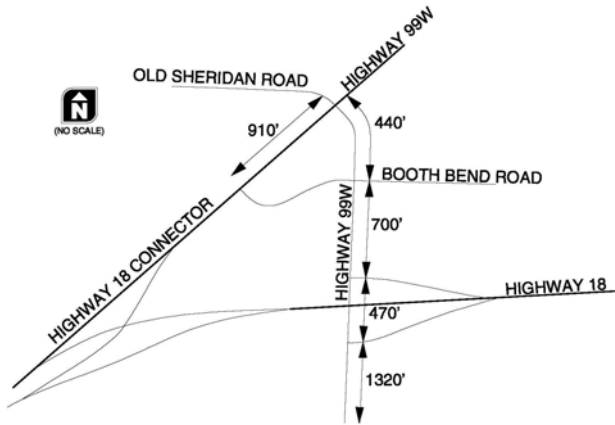


FIGURE 39 Highway 18/Highway 99 interchange access control spacing.

The preferred alternative establishes a raised curb median on the Highway 18 Connector and Highway 99W to restrict turning movement conflicts. Additional turn lanes were added at intersections to reduce the delay to the mainstream traffic caused by turning vehicles. In addition, a future connection was established with the extension of Booth Bend Road to the Highway 18 Connector. The extension of Booth Bend Road provides access to the parcels of land located within the triangle formed by Highway 99W, Highway 18, and the Highway 18 Connector, and it eliminates the need for access directly onto these facilities.

Outcome

Based on the study process conducted for the Highway 18/Highway 99W interchange, an interchange access management plan was developed and adopted jointly by ODOT and the city of McMinnville, which clearly identifies a long-term access plan as well as an implementation plan for the necessary transportation improvements within the interchange area. This plan provides a high level of certainty to the roadway agencies and the local property and business owners. As a result, several elements of the plan have recently been deployed in the field through two development-related projects.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Provided a flexible process (interchange access management plans) that allowed the agency to consider the unique aspects of the established transportation system and adjacent land uses;
- Consolidated access approaches through the implementation of crossover easements, local circulation roadways, and parallel roadway facilities;

- Eliminated vehicular turning movement conflicts in the vicinity of the interchange terminals through aligning and consolidating access approaches to the crossroads, and in some instances installing nontraversable medians; and
- Allowed for public education and involvement during the planning process.

Supplemental Resources

In addition to the information as presented, the following documents and websites can be referenced for further information about this project and the specific rules associated with Oregon's interchange access management plans:

- Highway 18/99W Interchange Access Management Plan.
- 1999 Oregon Highway Plan—<http://www.odot.state.or.us/tdb/planning/highway/>.
- Oregon Administrative Rule 734-051—http://www.odot.state.or.us/tdb/planning/access_mgt/PDF%20Folder/Adopted_Rules/OAR%20734-51%202-14-00.pdf.

RETROFIT INTERCHANGE—FERN VALLEY INTERCHANGE

Project Background

In June 2001, ODOT completed Phase 1 of the Fern Valley interchange study in Phoenix, Oregon. The study interchange was at the junction of Interstate 5 (I-5) (main line) and Fern Valley Road (crossroad), approximately 3 mi south of Medford, Oregon. I-5 is the primary north-south truck route in western Oregon connecting to California and Washington. Figure 40 shows the existing interchange layout for the Fern Valley interchange.



FIGURE 40 Fern Valley interchange before interchange project (Courtesy: Oregon DOT).

As shown in this figure, the existing Fern Valley interchange is located in a mixed residential and commercial area. Commercial developments are located in the north-west and southeast quadrants of the interchange, and residential communities are located to the west.

Recent development in Phoenix and the continued expansion of southeast Medford has contributed to capacity-related problems at the interchange terminals. The truck stop in the southeast quadrant of the interchange and the commercial development to the west of the interchange contribute to this congestion, which at times results in backups onto the off-ramps from I-5. As vehicles exit the ramp, motorists have limited sight distance on the overcrossing structure, making it difficult to ascertain safe gaps in traffic. In addition to the capacity deficiencies at the interchange terminals, the close spacing between the frontage roads and interchange ramp terminals creates conflicts and safety concerns in the interchange area. The existing frontage road and nearby private approaches on Fern Valley Road do not meet ODOT's minimum access spacing standards for crossroads.

For a crossroad such as Fern Valley Road, ODOT requires a minimum access spacing of 1,320 ft between the interchange ramp terminals and the nearest downstream access point.

Objective

The primary objective of this interchange retrofit project was to provide a long-term (20-year) improvement plan based on a traffic operational analysis to support the safety and capacity improvements to the Fern Valley interchange in Phoenix, Oregon.

Process

ODOT identified more than 30 long-term and short-term alternatives for the Fern Valley interchange project. Each alternative was assessed to compare the relative benefits and costs based on the expected traffic operations and right-of-way requirements. As a result of the alternatives evaluation, ODOT identified a partial cloverleaf interchange design as the most promising future design. The selected alternative moves the frontage roads away from the interchange ramp terminals, thus providing more storage capacity for queuing. In addition, the plan includes signalizing the interchange ramp terminals and moving two existing public roads (Luman Road and N. Phoenix Road) farther away from the existing interchange ramps. Access control techniques also included closing or combining driveways, constructing a median on Fern Valley Road to permit right-in/right-out movements only, and placing an

access control line along the road frontage within the newly acquired right-of-way boundaries. Figures 41 and 42 depict the proposed plan for the Fern Valley interchange and access control spacing.

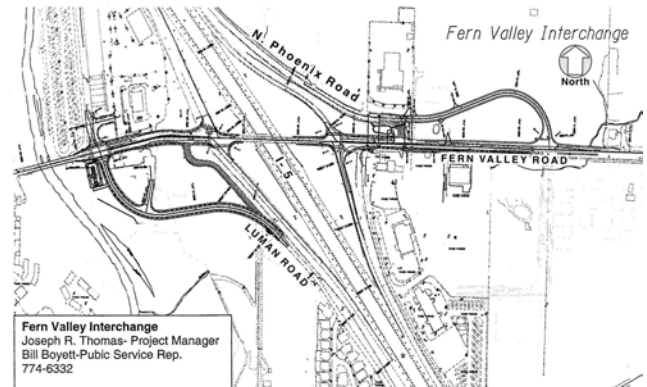


FIGURE 41 Fern Valley interchange transportation improvement plan (Courtesy: Oregon DOT).

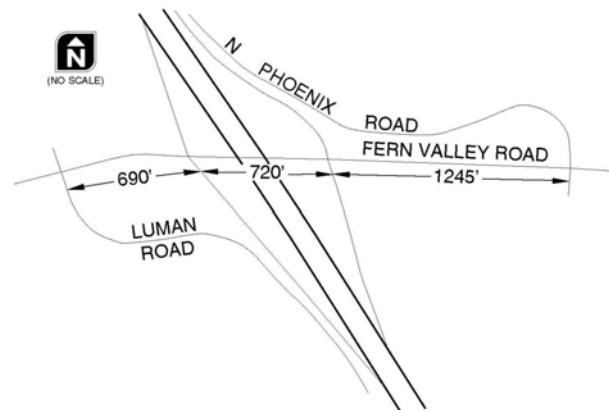


FIGURE 42 Fern Valley interchange transportation improvement access control spacing.

During the design process, the involvement of the city of Phoenix in the access management decisions was crucial. The Interchange Growth Agreement with the city required them to agree on the placement of the access control line on streets now owned and maintained by the city. No driveway accesses were permitted along this line. The access issues were dealt with individually with each property owner through the design process and completed through the right-of-way acquisition process.

As part of the project development process, ODOT held several open houses in the city of Phoenix. In addition, the solutions team for the project was made up of city and state staff, along with a citizen's advisory committee. This public involvement process was found to be relatively successful in developing an acceptable short-term improvement plan.

Outcome

Phase 1 of the Fern Valley interchange is under construction and was scheduled for completion in the summer of 2003. At this time, the second phase of the project, from Luman Road to Highway 99, will begin. The second phase will include an Environmental Assessment and Interchange Area Management Plan to address the entire project area for the long-term growth, including the reconstruction of the interchange structure and the implementation of new loop ramps. The Phase 1 portion of the project was limited to a short-term design life of 10 years.

As a result of this project, a legal challenge was brought by a property owner contesting the closing of a public road on the east side of the interchange. Because of the particular use of the property (truck stop), the implications of rerouting truck traffic farther from the ramps has resulted in numerous complaints by the residents living within a newly developed residential area. This situation has advanced the need to build a traffic signal to handle the volumes of vehicles now being rerouted farther from the existing ramps. ODOT found that the impacts of the rerouted trucks should have been addressed in the development process.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Moved frontage road farther from ramp terminals to provide queue storage between intersections,
- Eliminated vehicular turning movement conflicts in the vicinity of the interchange terminals through the use of a nontraversable median on Fern Valley Road,
- Consolidated accesses on Fern Valley Road to reduce the number of conflict points on the crossroad, and
- Used an open and interactive public involvement program.

Supplemental Resources

In addition to the information as presented, the following documents and websites can be referenced for further information about this project:

- Fern Valley Interchange Phase I, Oregon DOT, June 2001.
- 1999 Oregon Highway Plan—<http://www.odot.state.or.us/tdb/planning/highway/>.
- Oregon Administrative Rule 734-051—http://www.odot.state.or.us/tdb/planning/access_mgt/PDF%20Folder/Adopted_Rules/OAR%20734-51%202-14-00.pdf.

RETROFIT INTERCHANGE—SC-60/INTERSTATE 26 INTERCHANGE

Project Background

In the early 1990s, the South Carolina DOT (SCDOT) identified the SC-60/Interstate 26 (I-26) interchange for retrofit improvements. The interchange is located east of the town of Irmo in a developing rural area. I-26 (main line) provides a connection east through Columbia to Charleston, while SC-60 (crossroad) provides one of the gateways to the town of Irmo, located just northwest of Columbia. Figure 43 illustrates the layout for the SC-60/I-26 interchange before it was retrofitted. As shown in this figure, a shopping center in the northwest quadrant of the interchange accessed the crossroad approximately 300 ft west from the western-most ramp terminal. The east ramp terminal aligned with Kinley Road across SC-60, providing access to a mixture of commercial and residential developments northeast of the interchange. As shown in the figure, the existing partial interchange did not provide access to westbound I-26.



FIGURE 43 SC-60/I-26 interchange before the project (Courtesy: South Carolina DOT).

South Carolina has established minimum access spacing standards between the interchange ramp terminal and the nearest access to the crossroad. They require that a full-access control line extend along both sides of the crossroad beyond the interchange ramp terminal for 100 ft in urban areas and 300 ft in rural areas [per AASHTO's publication, *A Policy on Design Standards—Interstate System* (5)].

Objective

The purpose of the SC-60/I-26 interchange retrofit was to convert the partial interchange into a full interchange to provide full access to and from I-26. The full interchange is planned to accommodate the anticipated 20-year growth in the region and meet federal requirements.

Process

To meet federal guidelines, the SCDOT developed several alternatives for the SC-60/I-26 interchange. The selection of a design was based on the heavy demand of commuters traveling from the south to the west. The SCDOT selected a partial cloverleaf design to meet the requirements for a symmetrical design with no weaving sections. The design increased the access spacing between the interchange ramp terminals and the nearest intersections to meet state standards. In addition, the plan called for the interchange ramp terminals to be stop controlled with the provisions for signals in the future. The nearest signalized intersections to the interchange ramp terminals provided access to frontage roads near the interchange. As part of the selection process, the SCDOT held open forum public information meetings, as well as public hearings, to inform and engage the community and local stakeholders.

Outcome

This project was unique in that the owner of the shopping center in the northwest quadrant of the interchange constructed a frontage road (Columbiana Drive) off the crossroad to provide access to his development. Once the interchange project was completed, the SCDOT purchased the frontage road and extended it north along I-26. Figures 44 and 45 show the configuration of the completed partial cloverleaf interchange and the corresponding access control spacing.



FIGURE 44 SC-60/I-26 interchange after the project (Courtesy: South Carolina DOT).

As a result of the completed project, more development has moved into the interchange area. Owing to the increased growth, the town of Irmo annexed the interchange area. This interchange continues to operate well. South Carolina is tracking the crashes at the interchange to monitor the performance.

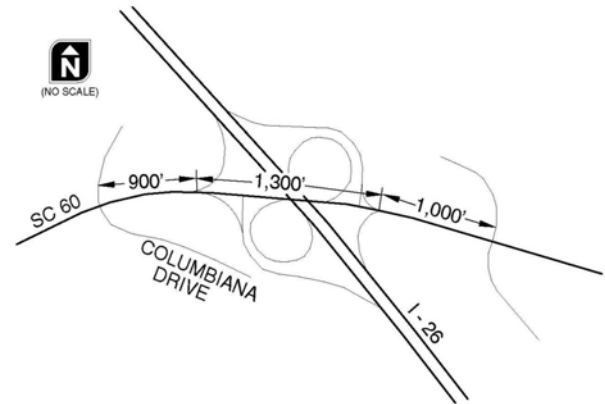


FIGURE 45 SC-60/I-26 interchange control spacing.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Used frontage roads to access developments on crossroad and reduce number of driveways on SC-60;
- Established an access control line between the interchange ramp terminals and nearest signals to the east and west, thus meeting SCDOT access spacing standards; and
- Allowed for public education and involvement during the planning process.

Supplemental Resources

In addition to the information as presented, the SCDOT Access and Roadside Management Standards can be referenced for further information regarding this project.

RETROFIT INTERCHANGE—PINEY GROVE ROAD/ INTERSTATE 26 INTERCHANGE

Project Background

The Old Pine Grove Road/I-26 interchange in South Carolina was constructed in the 1960s. The old interchange, located in the town of Irmo, provided access to the neighboring developments on Piney Grove Road (crossroad) and the residential housing in the surrounding area. I-26 (main line) provided a connection from the town of Irmo to Columbia and Charleston. Figure 46 indicates the old layout of the Piney Grove Road/I-26 interchange. As shown in this figure, the original interchange used two-way frontage roads to separate conflicting movements at the interchange, which are sometimes called scissor ramps. The two-way ramps from Piney Grove Road provided access to the frontage roads and multiple developments. Developments



FIGURE 46 Piney Grove Road/I-26 interchange before the project (Courtesy: South Carolina DOT).

within all four quadrants of the interchange were allowed full access to the ramp frontage roads. With the provided access, the access spacing on the ramps and frontage roads did not meet access spacing standards. As a result, the frontage roads experienced operational deficiencies and had the potential for safety problems.

South Carolina has established minimum access spacing standards between the interchange ramp terminal and the nearest access to the crossroad. They require that a full-access control line extend along both sides of the crossroad beyond the interchange ramp terminal to 100 ft in urban areas and 300 ft in rural areas.

Objective

The purpose of the Piney Grove Road/I-26 interchange retrofit was to improve the safety and operations of the interchange through the elimination of the two-way ramps. The retrofitted interchange was planned to accommodate the anticipated 20-year growth in the region and will provide improved access to I-26.

Process

To mitigate the existing operational deficiencies, the SCDOT developed a diamond interchange. The design was constrained by existing developments in all four quadrants of the interchange. The frontage roads were offset from the interchange ramp terminals to meet minimum state access spacing standards. In addition, the design included a concrete median on Piney Grove Road with left-turn pockets

to control access and turning movement conflicts on the crossroad. As part of the selection process, the SCDOT held public information meetings to inform and engage the community and local stakeholders. This project was an expensive endeavor owing to the necessary closing of access driveways on the interchange ramps and old frontage road. Figures 47 and 48 depict the retrofitted Piney Grove Road/I-26 interchange and corresponding access control spacing.

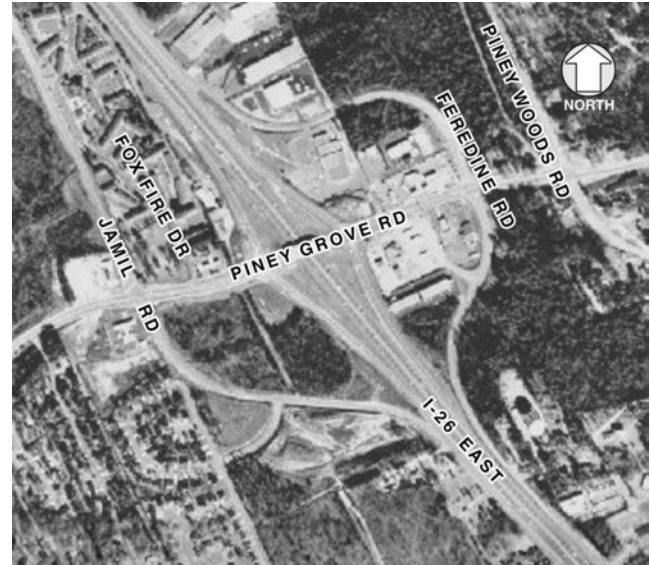


FIGURE 47 Piney Grove Road/I-26 interchange after the project (Courtesy: South Carolina DOT).

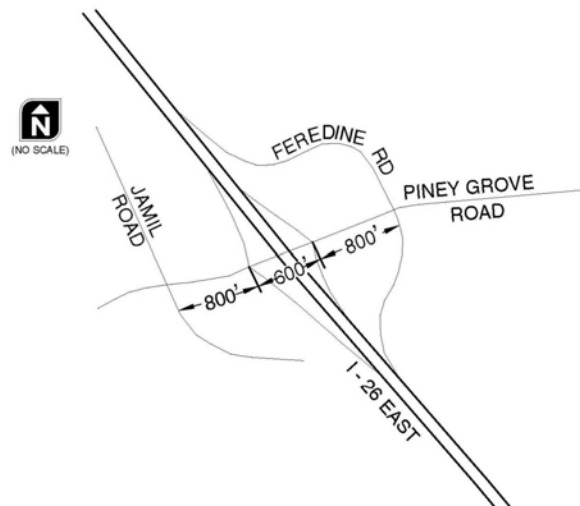


FIGURE 48 Piney Grove Road/I-26 interchange access control spacing.

Outcome

As a result of the project, the new interchange has operated well with no significant operational or safety problems on

Piney Grove Road. The early public involvement helped to manage access and aided in the understanding of local issues early on in the project.

Techniques Employed

This project used the following techniques for locating accesses on crossroads in the vicinity of interchanges:

- Eliminated the two-way frontage roads and scissor ramp interchange design,
- Separated the frontage road from the interchange ramps to reduce turning movement conflicts in vicinity of interchange ramps,
- Established a raised median with left-turn bays to reduce the number of conflicting movements on Piney Grove Road through the restriction of right-turn and left-turn movements, and
- Allowed for public education and involvement during the planning process.

Supplemental Resources

In addition to the information as presented, the SCDOT Access and Roadside Management Standards can be referenced for further information about this project.

SUMMARY OF CASE STUDIES

Three case studies of new interchanges were provided to illustrate examples of various agencies' experiences with controlling access in the vicinity of the interchange. The new interchanges varied in design from a partial cloverleaf interchange to a traditional diamond interchange. The interchange form selected depended on existing land uses, topography, and projected traffic patterns. All projects maintained access control on the crossroad for preservation of the safety and operations of the interchange area.

In addition to the new interchange projects, five case studies of retrofit interchanges were provided to illustrate examples of controlling access in the vicinity of interchanges. Most of the retrofit interchange case studies illustrated examples of changing the interchange form or moving interchange ramps, in addition to applying other means

of access control. The two case studies from Oregon maintained the existing interchange and instead moved access roads or provided other means of access control in the interchange vicinity. All of the projects required retrofit based on operational and/or safety concerns.

As a part of the new and retrofit interchange projects, there were five primary access control techniques used. These techniques are summarized here.

- **Purchase Access Control**—Many of the agencies illustrated in the case study purchased access control in the vicinity of the interchange. The purchase of access control provides for the future preservation of the crossroad and interchange vicinity by not allowing any new accesses to the crossroad.
- **Provide Access Roads**—As the case studies illustrated, many of the agencies provided access roads in conjunction with the purchase of access control. To purchase access control, it was sometimes necessary to provide access to landlocked parcels by means of a service road to preserve the integrity of the crossroad. The provision of access roads removed turning movements from the crossroad and rerouted them to the access road.
- **Consolidate and Close Accesses**—Most of the responding agencies indicated that they relocated, consolidated, or closed existing access driveways, median openings, frontage roads, or public street connections as part of the new or retrofit interchange project. The consolidation and closing of accesses reduces the number of potential conflict points on the crossroad in the vicinity of the interchange.
- **Provide Public Education and Involvement**—Each of the case studies included some form of public education involvement process. The agencies found the process necessary to gain support for the project.

Although these case studies illustrated successful access management projects, much of the success was based on the fundamental strength of the transportation agencies' legislative rules or regulations and the ability of the agencies to conduct successful and meaningful public involvement programs as part of the projects. The legislative rules and regulations allowed the agencies to have defensible standards and justifications for the access management projects, while the public involvement process educated the individuals affected and garnered support for the projects.

CONCLUSIONS

Several important findings were revealed through this synthesis research effort in regard to the current state of the practice in locating access points on crossroads in the vicinity of interchanges. This section summarizes the key findings associated with research conducted to date within this subject area, and current practices and experiences of transportation agencies throughout North America. In addition, several topics are recommended for further research.

- General Practices
 - Nearly 90% of the surveyed state and provincial transportation agencies and toll authorities currently manage, to varying degrees, access to crossroad facilities upstream and downstream of the interchange terminals.
 - Only 9 of the 36 transportation agencies responding to the survey (Colorado, Florida, Iowa, Maine, Oregon, Virginia, Washington, Nova Scotia, and New Brunswick) have their access spacing standards supported directly by legislation and adopted through regulation. In addition to those agencies, New Jersey, South Carolina, South Dakota, Utah, West Virginia, and Wyoming have had their access spacing standards on crossroads adopted as regulations.
 - Only 60% of the surveyed agencies indicated that they operate an integrated process that maintains the safety and efficiency of an interchange through access management (an integrated process is based on and includes planning, and it continues through design and into operations and maintenance).
- Access Spacing Standards
 - Agencies use a wide range of factors to determine the appropriate spacing to the first access location downstream and upstream of the interchange terminal including the surrounding land use and environment, crossroad classification, interchange form, public and private access, type of downstream access point, downstream storage requirements, cross section, design speed, volume, cycle length, cost and economic impacts, level of interchange importance, and crossroad jurisdiction.
 - The majority of state departments of transportation rely on the 100-ft urban and 300-ft rural spacing guidelines provided in the 1991 AASHTO publication, *A Policy on Geometric Design of Highways and Streets*, when acquiring access rights, managing public and private access to the crossroad, and constructing new interchanges or retrofitting existing ones. However, no underlying rationale for these spacing distances is presented within that document.
- Access spacing standards for crossroad facilities vary in distance, from basically zero to 1,320 ft; however, only 50% of the transportation agencies with such standards had a specific methodology that was used to determine the actual distances.
- A variety of reference points are used by state agencies to determine the access spacing distance to the nearest downstream intersection on the crossroad. These reference points are (1) centerline of the ramp at the interchange terminal to centerline of the access point location on the crossroad, (2) end of radius at the interchange terminal to the beginning or radius at the access point location, (3) gore point of the off-ramp with the crossroad to the downstream radius or centerline, and (4) end of the off-ramp taper with the crossroad to the downstream radius or centerline.
- Access Control Techniques
 - Nine primary access control techniques—positive control, acquisition, legislation and regulation, intergovernmental coordination, planning, operational, design, land use, and local agency regulations—were found to be commonly deployed by transportation agencies on crossroad facilities.
 - The most successful access control techniques found were those based on adopted legislation and/or regulations and implemented through proper and thorough land use and transportation planning, and fundamentally strong public involvement processes.
 - Some transportation agencies are using single-point urban interchanges as a strategy to maximize downstream access spacing on crossroad facilities within developed urban areas. This interchange form by its nature increases spacing distances compared with other service and system interchange forms. The interchange form further reduces the number of signalized intersections on a crossroad facility by maintaining a single interchange terminal.
- Access Spacing Relationships
 - Service interchanges (i.e., diamond and single point) typically require less downstream access spacing on

crossroads compared with that of cloverleaf and higher-level system interchanges, owing to the fewer required weaving movements and vehicular deceleration needs.

- As turning movement complexity increases and traffic controls are introduced at a downstream intersection the more access spacing distance is required on the crossroad facility. The type of downstream intersection also coincides with the downstream storage length requirements, cycle length, and volume factors used to select appropriate access locations.
 - Design speed plays an important role in selecting the appropriate spacing distance on a crossroad facility; that is, the higher the speed, the longer the access spacing distance should be. The general physical relationships between design speed and the braking distance needed to bring a vehicle to a stop are understood. However, the additive implications associated with performing multiple functions and then relating them to the distance necessary between access points is still being debated.
 - The surrounding land use and environment, crossroad classification, and level of interchange importance are important factors in determining appropriate crossroad locations. However, the categories used to quantify these factors are relatively subjective and not used consistently throughout North America.
- Deployment Results on New and Retrofit Interchange Projects
 - It was found that more than three-quarters of the surveyed transportation agencies acquire access rights on crossroads in the vicinity of interchanges.
 - Twenty-six of the 33 responding agencies reported that 60% or more of their access management techniques in the vicinity of interchanges are deployed on new interchange projects, whereas only 14 of 29 stated that those techniques were deployed during retrofit interchange projects.
 - The majority of responding agencies indicated that they relocated, consolidated, or closed existing access driveways, median openings, frontage roads, or public street connections as part of their new or retrofit interchange project.
 - Some responding states found funding to be critical to the success of the new and retrofit interchange projects. Funding primarily affected the ability to purchase right-of-way.
 - The level of success for nearly all projects was based on the fundamental strength of the transportation agencies' legislative rules or regulations, along with the ability of the agencies to conduct successful and meaningful public involvement programs as part of the projects.

In conclusion, the location and control of access points on crossroads upstream and downstream of interchange terminals have been researched and considered ever since the first interchange in North America was constructed in Woodbridge, New Jersey in 1928. The management of these access locations, although sometimes difficult to implement from a land use and political perspective, and expensive to achieve, has shown time and again significant benefits in maintaining the integrity and functionality of interchange facilities.

Although significant research has been conducted and much information has been collected on the benefits of managing and locating access points outside of interchange terminals, the following three primary issues continue to limit the ability of transportation professionals to successfully implement these practices:

1. A lack of established access management legislation and regulations at the state, provincial, and local agency levels;
2. Transportation planning practices that do not adequately consider both the transportation system and the land uses that the system serves; and
3. Public involvement programs that fail to properly educate stakeholders and community members on access management issues and the importance of controlling access on crossroads near interchanges. Instead, the public process should build consensus and trust among all affected stakeholders, to gain support for the project.

These impediments can be and have been overcome by agencies that have solid access management legislation and/or regulations, and that employ integrated processes to plan, design, operate, and maintain interchange facilities and the downstream access location points on crossroads. It is hoped that the information presented in this report will aid transportation agencies in developing the necessary legislation and/or regulations to properly manage access locations on crossroads in the vicinity of interchanges.

From the research documents reviewed as part of the literature review and the information gathered from the surveyed transportation agencies across North America, several topics are recommended for further research.

- The 13 access spacing factors presented in this report (see chapter three) and others should be analyzed to determine an appropriate methodology in which the combined effects of these factors could be quantified into an appropriate spacing distance based on the current and future desired geometric, operational, and traffic control characteristics of the crossroad facility.
- To provide consistency within a given transportation agency and throughout North America, the manner in which spacing distances are measured (e.g., center-

line and end of taper) could be reviewed to determine if a universal measurement might be determined and successfully used in locating access points.

- Further research could be conducted to review agency access control distances and the effectiveness of the distances on maintaining the safety, capacity, and longevity of an interchange and the interchange crossroad.
 - To provide consistency within a given transportation agency and throughout North America, the access spacing factors of surrounding land use and environment (e.g., rural, urban, and urban fringe), crossroad classification, and level of interchange importance should be reviewed to determine if an appropriate categorical definition could be developed and used successfully in properly locating access points on crossroad facilities.
- The use of design speed to develop access spacing standards on crossroad facilities is a relatively common and documented practice. However, other alternative speed-based factors should be examined to determine if an all-encompassing measure could be developed; for example
 - Do motorists driving along a crossroad perform all functions related to stopping sight distance or decision sight distance associated with a downstream access location between the interchange terminal and that given access location?
 - Do motorists entering the crossroad from an off-ramp at a service interchange perform avoidance and braking maneuvers at the design speed between the interchange terminal and the downstream intersection?

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GLOSSARY

Access management is the practice of controlling access to public roads, streets, and highways. With development and traffic pressures increasing, it has become more important for public agencies to control access to maintain safe and acceptable traffic operations. Previously, agencies sought solutions primarily to enlarge the capacity of key corridors by adding lanes. Now, agencies are relying on the management of access as well to maintain safe and acceptable operations on the roadway facilities. Managing access has the effect of reducing the number of locations at which vehicles can turn onto and off the system, thereby reducing the number of vehicle conflict points.

Access management is of particular importance on crossroads in the vicinity of interchanges, where poor access control on the crossroad has the potential to create traffic queues onto the higher-level, grade-separated facility. To aid in the discussion of current access management practices on interchange crossroads, a list of definitions has been provided. These definitions were developed from the *Access Management Manual*, produced by TRB, and various state access management plans.

Acceleration lane—Speed change lane, including tapered areas, that enables a vehicle entering the traffic stream to accelerate to a speed at which it can more easily merge with through traffic.

Access—Public or private roadway used by a vehicle to enter or leave a public highway or roadway from an adjacent land parcel. The design of an access depends on the type of the adjacent land use and volume of traffic generated by that use.

Access classification—Functional designation system that is used to assign spacing, operation, and design standards for accesses located along specific roadways or roadway segments.

Access management—Systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a designated roadway. This also includes roadway design applications that affect access, such as median treatments, auxiliary lanes, and the separation of traffic signals.

Access management plan—Identification of the location, and in some cases the design, of the ingress and egress to every parcel on a roadway segment or within an interchange area. This plan is often jointly developed and adopted by each of the jurisdictions that maintain and control the subject roadway and that have jurisdiction over land development in the affected area.

Access management program—Sum of all actions taken by a governing council, board, or agency to maintain the safety and traffic carrying capacity of its roadways through the control and design of access along those roadways. These actions may include enacting ordinances that control driveway location and design. The adoption and implementation of a comprehensive planning and zoning ordinance to guide the overall pattern of growth also can be an effective component of an access management program if it is aimed at avoiding or limiting strip development with an excessive number of access points.

Access permit—Documentation issued by a governing agency for the construction, maintenance, and use of a driveway or street that connects to a subject highway or roadway.

Access point—Location where a private or public roadway or driveway used for ingress and egress to adjacent land uses intersects with a roadway.

Arterial—Major roadway intended primarily to serve through traffic on these facilities. Access to adjacent lands is of secondary importance and is often carefully controlled. Generally, these roadways are of regional importance and are intended to carry moderate to high volumes of traffic traveling relatively long distances at higher speeds.

Average daily traffic (ADT)—Number of vehicles passing over a designated location on an average day.

Auxiliary lane—Lane striped for use, but not for through traffic.

Backage road (reverse frontage road)—Local street or roadway that parallels an arterial or highway. A backage road is used to provide access to the land uses abutting the arterial as a means of controlling access to the arterial. Access to the backage road is provided at the rear lot line of the property.

Capacity—Maximum flow rate at which vehicles reasonably can be expected to traverse a point on a lane or roadway during a specified period under prevailing traffic, roadway, and traffic control conditions. Capacity is typically expressed as vehicles per hour and is often considered the maximum amount of traffic that can be accommodated by a roadway during peak hours of demand.

Collector—Roadway that combines the need for direct access to the adjacent land use with the need to serve

- through traffic demands. Collectors connect local roadways with the arterial street system.
- Conflict**—Traffic event that causes a driver to take evasive action to avoid a collision with another vehicle. It usually results in a braking application or a lane change.
- Conflict point**—Any point where a vehicle path crosses, merges, or diverges with the path of a vehicle, pedestrian, or bicycle.
- Cross access**—Service drive between two or more continuous land uses that allows motorized vehicles, pedestrians, and cyclists to traverse between the uses without the need to access the adjacent street system.
- Crossroad**—Lower functional classification facility of the two facilities that intersect at an interchange.
- Deceleration lane**—Speed-change lane, including tapered areas, that enables a turning vehicle to exit a through lane and slow to a safe speed to complete its turn.
- Divided highway**—Roadway with opposing traffic movements that are physically separated by medians, concrete barrier rails, raised traffic islands, or pavement markings. The use of a two-way left-turn lane on a facility indicates a nondivided highway.
- Driveway**—Ingress and egress used by vehicular traffic to access property abutting a highway or other roadway. As used in this synthesis, the term includes residential driveways as well as commercial and other nonresidential driveways.
- Easement**—Grant of one or more access rights by a property owner to or for use by the public or another person or entity.
- Egress**—Act of leaving a place or exiting; the exit of vehicular traffic from abutting properties to a roadway.
- Expressway**—Major roadway that is designed for relatively uninterrupted high volumes of traffic. Access to these facilities is limited and may be provided through a mixture of at-grade intersections and grade-separated interchanges.
- Frontage road**—Roadway that generally parallels a public street between the right-of-way of the street and the front building setback line. A frontage road provides access to land uses abutting a higher-level roadway facility and can be used as an effective access management tool.
- Functional classification**—System used to group public roadways into designated classes based on access and mobility needs. The classification system includes design and operational standards criteria.
- Ingress**—Entry into a place; the entrance of vehicular traffic into abutting properties from a roadway.
- Interchange**—Facility that provides grade separation between intersecting roadways. Directional ramps are used for movements between the intersecting roadways. The grade separation structure and ramps are considered to be part of the interchange.
- Intersection**—Location where two or more roadways or accesses meet. For the purpose of this synthesis, all intersections are assumed to be at-grade.
- Land use**—Purpose for which land or the structure on that land is being used.
- Limited access highway**—Roadway facility in which access management is used to restrict ingress and egress to adjacent lands. The type and frequency of accesses to these facilities are based on facility congestion levels or operational condition, such as the presence of crashes or maintenance activities.
- Median**—Portion of a roadway that separates opposing traffic flows.
- Nontraversable median**—Physical barrier in a roadway that separates opposing traffic flows. Examples of nontraversable medians include concrete barriers or landscaped islands.
- Perception–reaction distance**—Distance traveled during the time between the occurrence of an event and the ensuing decision that a driver makes as a result of the information he or she has obtained from his or her combined senses.
- Ramp terminal**—Intersection between an interchange ramp and the crossroad.
- Return radius**—Geometric radius of curb or edge of pavement between a major street and the intersecting street or access.
- Right-of-way**—Land reserved, used, or designated by use for a highway, street, alley, walkway, drainage facility, utility, or other public purpose.
- Service interchange**—Interchange between a freeway and a surface street (i.e., arterial or collector street).
- Service road (frontage road, backage road)**—Public or private street or road, auxiliary to and normally located parallel to a controlled access facility. It is used to main-

tain local road continuity and provide access to land uses adjacent to the controlled access facility.

Signal progression—Movement of traffic, at a planned rate of speed, through adjacent signalized locations within a traffic control system.

Signal spacing—Distance between traffic signals along a roadway.

Stopping sight distance—Distance required by a driver of a vehicle, traveling at a given speed, to bring the vehicle to a stop after an object on the roadway becomes visible, including the distance traveled during the driver's perception and reaction times and the vehicle braking distances.

Storage lane lengths—Amount of lane storage that is provided to accommodate the maximum number of stopped vehicles anticipated during a peak period.

Taper—Triangular pavement area that is used to provide a transition between a through lane and a ramp or an auxiliary lane; a taper is also used to add or drop through lanes.

Traffic impact report—Written documentation of the anticipated effect that the traffic generated by a proposed

development will have on the public roadway system. A traffic impact report may be referred to as a transportation impact analysis or a traffic impact study.

Traffic signal—Electrically operated device that controls and directs the flow of traffic at an intersection.

Traversable median—Median that vehicles can enter or cross. Examples include painted medians and continuous two-way left-turn lanes.

Two-way left-turn lane (TWLTL)—Lane shared by opposing directions of traffic for left-turn ingress and egress into unsignalized intersections and accesses.

Undivided roadway—Roadway with no physical separation of traffic in opposing directions.

Weaving—Crossing of two or more traffic streams traveling in the same general direction along a significant length of highway, without the aid of traffic control devices. Weaving areas can be created when a merge area is closely followed by a diverge area, or when an entrance ramp is closely followed by an exit ramp and the two ramps are joined by an auxiliary lane.

APPENDIX A

Survey Questionnaire

NCHRP PROJECT 20-5

Topic 34-12

ACCESS LOCATION ON CROSSROADS IN THE VICINITY OF INTERCHANGES

QUESTIONNAIRE

PURPOSE OF THE SYNTHESIS

The purpose of this synthesis is to document the current state of the practice in locating and controlling accesses on crossroads in the vicinity of interchanges. This survey is a part of an NCHRP Synthesis project, funded by various state transportation agencies. In addition to the survey, the final report will include a literature review and case studies submitted by respondents. As a result of this effort, information regarding this topic should become more readily available to individuals and agencies interested in pursuing access management in the vicinity of interchanges.

RESPONDING AGENCY/ORGANIZATION INFORMATION

Please provide the following information to help us identify the specific agency or organization you are affiliated with and to contact you in the future regarding the outcome of this project.

Agency/organization: _____

Questionnaire completed by: _____

Position/title: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ E-mail: _____

Fax: _____

**PLEASE RETURN THE COMPLETE QUESTIONNAIRE
EITHER BY MAIL, FACSIMILE, OR E-MAIL
NO LATER THAN APRIL 14, 2003**

To: Marc A. Butorac, P.E., P.T.O.E.

Via mail: Kittelson & Associates, Inc.
610 SW Alder, Suite 700
Portland, OR 97205

Via fax: (503) 273-8169

Via E-mail: mbutorac@kittelson.com

If you have any questions regarding the questionnaire, please contact Marc Butorac at (503) 228-5230.

INSTRUCTIONS

Please answer all of the following questions to the best of your abilities and feel free to attach relevant materials (hard copies, electronic copies, website addresses, etc.) that you believe will provide additional information and/or clarification. If you believe another individual or department within your agency or organization is better suited to complete a portion or the complete questionnaire, please forward a copy of this questionnaire to that individual or department to complete. If you have any additional questions regarding this survey, please feel free to contact Marc Butorac at (503) 228-5230 or via e-mail at mbutorac@kittelson.com.

1. Does your agency currently control access (intersections with driveway, streets, frontage roads, etc.) to and from a roadway in the vicinity of interchange ramps? Yes No
 - a. What spacing distance do you require between the interchange ramp terminal and the first downstream right-in/right-out access point? (If the spacing distances are different for different ramp types or configurations, please list the different requirements.)
 - b. What access spacing distance do you require between the interchange ramp terminal and the first downstream access point (both right in/out and left in/out)?
 - c. What access spacing distance do you require between the interchange ramp terminal and the first downstream signalized intersection?
 - d. How is the spacing distance measured (e.g., end of ramp radius to beginning of access point radius)?
2. What methods are you using to control access on crossroads in the vicinity of interchanges?
3. Do your methods to control access change due to the speed, cross section, and/or jurisdiction of the crossroad at the interchange? Yes No
(If yes, please describe what factors result in these changes.)
4. Do you acquire access rights on crossroads in the vicinity of interchanges? Yes No
 - a. If yes, how far do you typically acquire access rights downstream of the interchange ramp terminal?
 - b. How is the distance measured (e.g., centerline to centerline)?

5. Does your state or local agency control access rights on crossroads by deed?
Yes No
6. Does your organization have any formal (or informal) standards or other criteria for access spacing at interchanges?
Yes No
- a. If yes, are the standards adopted legislatively? Yes No
- b. If yes, are the standards adopted in regulations? Yes No
- c. Please describe or provide a copy of your access spacing standards in the vicinity of interchanges. If possible, please either e-mail this information as an electronic attachment with your complete questionnaire to **mbutorac@kittelerson.com** or mail a hard copy.
7. Did your organization use a specific methodology (scientific) to develop the access spacing standards (the distance from the interchange ramp terminal to the nearest access point downstream) crossroads in the vicinity of interchanges? Yes No
- a. If yes, does the methodology work effectively for your organization? Yes No
- b. If yes, has the methodology been received as being fair and effective by other stakeholders? Yes No
(If no, what issues do the stakeholders have with the methodology?)
- c. If yes, please describe or provide a copy of the methodology. If possible, please either e-mail this information as an electronic attachment with your complete questionnaire to **mbutorac@kittelerson.com** or mail a hard copy.
8. What processes does your agency or organization use to plan, operate, and design access points on crossroads in the vicinity of interchanges?
- a. Planning elements (e.g., planning year horizons, land use regulation through zoning or other means, development of local streets systems, etc.).
- b. Operational elements (e.g., mobility or level of service standards, queuing, progression, or other measures of effectiveness).
- c. Design elements (e.g., access restrictions through median design, interchange forms, etc).
9. How does your agency or organization engage stakeholders (other governmental agencies, impacted business or property owners, facility users, etc.) on interchange retrofit and new interchange projects?
10. Does your agency/organization have an integrated process to maintain the safety and efficiency of an interchange through access management (i.e., an integrated process that depends on good policy, begins in planning, and continues through design, into operations and maintenance)? Yes No
- a. What part of your agency's process is strongest?
- b. What part of your agency's process is weakest?

11. How successful is your organization in implementing specific planning, operation, and design techniques to control access on crossroads as part of *new* interchange projects?

- Very successful (90% or more of the techniques are deployed in the field).
 Fairly successful (60% to 90% of the techniques are deployed in the field).
 Moderately successful (40% to 60% of the techniques are deployed in the field).
 Somewhat successful (10% to 40% of the techniques are deployed in the field).
 Not successful (10% or less of the techniques are deployed in the field).

12. Have you had a *new* interchange project(s) in the past 5 years that you or your organization believes was implemented from an access management perspective either very or fairly successfully? Yes No

- a. If yes, please identify one project and state the reasons you believe it was successful.

Project name: _____
 Interchange name: _____
 Nearest city: _____

- b. Why was the project completed?

- c. Why do you believe this project was successful? (Are you tracking performance measures, such as crash rates? Do you have goals or expectations regarding safety and efficiency?)

- d. Did you have to relocate, consolidate, or close existing access driveways, median openings, frontage roads, or public street connection? Yes No

- e. If yes, what techniques did your organization use to complete these access relocations, consolidations, or closures during the project?

- f. How did funding availability influence the techniques that were selected for this interchange project?

- g. What lessons did your organization learn from this project that could be applied to future projects?

- h. Do you have a report that you could provide that documents the project and/or process? Yes No
 (If yes, please provide a copy of the report.)

13. How successful is your organization in implementing specific planning, operation, and design techniques to control access on crossroads as part of interchange *retrofit* projects?

- Very successful (90% or more of the techniques are deployed in the field).
 Fairly successful (60% to 90% of the techniques are deployed in the field).
 Moderately successful (40% to 60% of the techniques are deployed in the field).
 Somewhat successful (10% to 40% of the techniques are deployed in the field).
 Not successful (10% or less of the techniques are deployed in the field).

14. Have you had a *retrofit* interchange project(s) in the past 5 years that you or your organization believes was implemented, from an access management perspective, either very or fairly successful? Yes No

- a. If yes, please identify one project and state the reasons you believe it was successful.

Project name: _____
 Interchange name: _____
 Nearest city: _____

- b. Why was the project completed?

- c. Why do you believe this project was successful? (Are you tracking performance measures, such as crash rates? Do you have goals or expectations regarding safety and efficiency?)
- d. Did you have to relocate, consolidate, or close existing access driveways, median openings, frontage roads, or public street connection? Yes No
- e. If yes, what techniques did your organization use to complete these access relocations, consolidations, or closures during the project?
- f. How did funding availability influence the techniques that were selected for this interchange project?
- g. What lessons did your organization learn from this project that could be applied to future projects?
- h. Do you have a report that you could provide that documents the project and/or process?
Yes No (If yes, please provide a copy of the report.)
- i. Do you have before and after photos that you could provide? Yes No (If yes, please provide a copy of the photos.)

**THANK YOU AGAIN FOR YOUR TIME AND
PARTICIPATION IN THIS SYNTHESIS STUDY!**

APPENDIX B

List of Responding Agencies

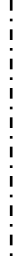
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Colorado Department of Transportation <i>Phil Demosthenes</i>	Mississippi Department of Transportation <i>John B. Pickering</i>
Connecticut Department of Transportation <i>Dan Gladowski</i>	Nebraska Department of Roads <i>Phil TenHulzen</i>
The E470 Authority (Colorado) <i>Ken Mauro</i>	Nevada Department of Transportation <i>Jeff Lerud</i>
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Illinois Department of Transportation <i>Scott Stitt</i>	New York Department of Transportation <i>P. Gupta</i>
Indiana Department of Transportation <i>Brad Steckler</i>	Nova Scotia Department of Transportation and Public Works <i>Michael Croft</i>
Iowa Department of Transportation <i>Dave Widick</i>	Ohio Department of Transportation <i>Larry Sutherland</i>
Kansas Department of Transportation <i>Chris Huffman</i>	Oregon Department of Transportation <i>Douglas Norval</i>
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Texas Department of Transportation
Mark Marek

Utah Department of Transportation
Tim Boschert

Virginia Transportation Research Council
Steve Van Cleef



Washington State Department of Transportation
Darlene Sharar

West Virginia Department of Transportation
Randy Epperly

Wyoming Department of Transportation
Paul Jones

APPENDIX C

Summary of Survey Questionnaire Responses

NCHRP PROJECT 20-5

Synthesis Topic 34-12

ACCESS LOCATION ON CROSSROADS IN THE VICINITY OF INTERCHANGES

QUESTIONNAIRE

1. Does your agency currently control access (intersections with driveway, streets, frontage roads, etc.) to and from a roadway in the vicinity of interchange ramps?

Yes	31
No	2
Sometimes	2

- a. What spacing distance do you require between the interchange ramp terminal and the first downstream right-in/right-out access point? (If the spacing distances are different for different ramp types or configurations, please list the different requirements.)
- 400 m rural areas, 200 m urban areas (Alberta)
 - 300 ft minimum (Arizona)
 - 300 ft minimum rural areas, 150 ft minimum urban areas (Arkansas, Wyoming)
 - 125 m minimum, 160 m preferred (California)
 - 350 ft minimum, 550 ft desirable (Colorado)
 - 600 ft (E-470)
 - 660 ft where the posted speed limit is greater than 45 mph and 440 ft where the posted speed limit is 45 mph or less (Florida)
 - 100 ft urban, 300 ft rural (Georgia, Louisiana, Michigan, Mississippi, New York, South Carolina, Virginia, West Virginia)
 - Distance varies by crossroad design speed, interchange type, and ramp type (Illinois)
 - 100–200 ft urban, 300–500 ft rural (Indiana)
 - (1) 600 ft from the point of ramp bifurcation in a built-up area. (2) 300 ft desired, 150 ft minimum, from the point of ramp bifurcation in a built-up area. (3) 150 ft from the beginning of a deceleration lane or taper. (4) 100 ft from the beginning or end of a median. When an interchange is constructed as a half-diamond or partial cloverleaf, the department may permit an access directly opposite a ramp connection to the primary road (Iowa)
 - 500 ft minimum between driveways and off-ramps (Maine)
 - 100–150 ft minimum (Maryland)
 - 660 ft minimum (Nebraska, South Dakota)
 - 300 ft minimum, 500 ft preferred (Nevada)
 - 65 m minimum (New Brunswick)
 - No spacing is required. No access is permitted within a full width acceleration lane or deceleration lane (New Jersey)
 - 60 m minimum (Nova Scotia)
 - 600 ft minimum for diamond interchanges, 1,000 ft minimum for directional interchanges (Ohio)
 - 750 ft for fully developed urban areas,¹ 1,320 ft for other urban areas and rural areas (Oregon)
 - 100 m minimum rural, 50 m minimum urban (Utah)
 - 130 ft minimum, 300 ft preferred (Washington)

¹Occurs when 85% or more of the parcels along the developable frontage area are developed at urban densities and many have driveways connecting to the crossroad.

b. What access spacing distance do you require between the interchange ramp terminal and the first downstream access point (both right in/out and left in/out)?

- 400 m rural areas, 200 m urban areas (Alberta)
- 300 ft minimum (Arizona, Kansas)
- 150 ft minimum urban, 300 ft minimum rural (Arkansas, Wyoming)
- 125 m minimum, 160 m preferred (California)
- 350 ft minimum, 550 ft desirable (Colorado)
- 660 ft where the posted speed limit is greater than 45 mph or 440 ft where the posted speed limit is 45 mph or less (Florida)
- 660 ft for urban reconstruction, 1,000 ft desirable for urban, 1,320 ft preferred for rural (Georgia)
- Distance varies by crossroad design speed, interchange type, and ramp type (Illinois)
- 100–200 ft urban, 300–500 ft rural (Indiana)
- (1) 600 ft from the point of ramp bifurcation in a rural or fringe area. (2) 300 ft desired, 150 ft minimum, from the point of ramp bifurcation in a built-up area. (3) 150 ft from the beginning of a deceleration lane or taper. (4) 100 ft from the beginning or end of a median. When an interchange is constructed as a half-diamond or partial cloverleaf, the department may permit an access directly opposite a ramp connection to the primary road (Iowa)
- 500 ft for off-ramps (Maine)
- Once beyond 100–150 ft distance becomes a function of operations (Maryland)
- 100 ft urban, 300 ft rural (Michigan, Mississippi, New York, South Carolina, Virginia, West Virginia)
- 500–800 ft in fully developed and developing areas (Minnesota)
- 660 ft minimum (Nebraska, South Dakota)
- 300 ft minimum, 500 ft preferred (Nevada)
- 65 m minimum (New Brunswick)
- No spacing is required. Desired minimum access control 100 ft urban, 300 ft rural (New Jersey)
- 60 m minimum (Nova Scotia)
- 600 ft minimum for diamond interchanges, 1,000 ft minimum for directional interchanges (Ohio)
- 1,320 ft minimum unless crossroad is a state highway (Oregon)
- 100 m minimum rural, 50 m minimum urban (Utah)
- 130 ft minimum, 300 ft preferred (Washington)

c. What access spacing distance do you require between the interchange ramp terminal and the first downstream signalized intersection?

- 400 m rural areas, urban areas 200 m, 400 m for arterials (Alberta)
- 300 ft minimum (Arkansas)
- 125 m minimum, 160 m preferred (California)
- One-quarter mile most likely, one-half mile desirable (Colorado)
- 1,320 ft is recommended, warranted signals are allowed closer (Florida)
- 660 ft minimum urban reconstruction, 1,320 ft minimum preferred rural (Georgia)
- Distance varies by crossroad design speed, interchange type, and ramp type (Illinois)
- 100–200 ft urban, 300–500 ft rural (Indiana)
- Work with local jurisdiction to maintain as much spacing as possible (Iowa)
- 1,320 ft (Kansas, South Dakota)
- 100 ft urban, 300 ft rural (Louisiana, Michigan, Mississippi, South Carolina, Virginia, West Virginia)
- Dependent on speed limit (Maine)
- 500 ft (Maryland)
- 500–800 ft in fully developed and developing areas (Minnesota)
- One-half mile spacing between signalized intersections, one-quarter mile spacing for interchanges (Nevada)
- 65 m minimum (New Brunswick)
- One-half mile depending on speed and cycle length (New Jersey)
- Dependent on conditions (New York)
- 60 m minimum (Nova Scotia)
- 600 ft minimum for diamond interchanges, 1,000 ft minimum for directional interchanges (Ohio)

- 1,320 ft minimum, signalized intersections on statewide and regional highways require one-half mile (Oregon)
- 100 m minimum rural, 50 m minimum urban (Utah)
- One-half mile spacing, if possible (Washington)
- 50 ft minimum urban, 300 ft minimum rural (Wyoming)

d. How is the spacing distance measured (e.g., end of ramp radius to beginning of access point radius)?

- Centerline to centerline (Alberta, Arkansas, Georgia, Kansas, Michigan, New Brunswick, New Jersey, Oregon,² South Dakota, Washington, Wyoming)
- End of radius return on crossroad (Arizona)
- Edge of travel way to edge of travel way (California, Minnesota)
- Not defined (Colorado)
- Outside shoulder line to centerline of access (E-470)
- End of the taper of the on-ramps and off-ramps (Florida)
- Near edge of ramp pavement to radius point of access connection (Illinois)
- Point of bifurcation to the center of the access point (Iowa)
- End of ramp radius to edge of access point (Louisiana)
- Radius return to radius return (Maine, Ohio, South Carolina, West Virginia)
- End of ramp to next intersection (Maryland)
- End of taper to first access point (Mississippi)
- Radius point of any ramp touchdown curve (Nevada)
- End of ramp taper to beginning of taper of curb return (Nova Scotia, Virginia)
- Theoretical gore to access radius point (Texas, Utah)

2. What methods are you using to control access on crossroads in the vicinity of interchanges?

- Access permit (1)
- Access spacing standards (4)
- Acquire access control (8)
- Acquire access rights (4)
- Acquire right-of-way (4)
- Construct fencing (4)
- Coordinate with local governments (2)
- Legislation (4)
- Median islands (3)
- Nonaccess lines (1)
- Purchase of limited access control (3)
- Police Powers (1)
- Traffic studies and permits (2)

3. Do your methods to control access change due to the speed, cross section, and/or jurisdiction of the crossroad at the interchange?

Yes 18

The responding agencies reported that their methods to control access on the crossroad at the interchange depended on the items listed below.

- Cost of right-of-way (1)
- Cross section (6)
- Functional classification (2)
- Future land use potential (2)

²Measurement of the approach road spacing is from center to center on the same side of the roadway, except for ramp taper configurations as shown in OAR 734-051 Figures 1–4, in which case the measurement is from the beginning/end of taper to center of the approach road.

- Impact to developers (2)
- Interchange importance (1)
- Jurisdiction (2)
- Length of left-turn lane at downstream intersection (1)
- Sight distance (1)
- Speed (8)
- Urban vs. rural (2)
- Volume (2)

No 15

- Only signal spacing changes—ramps themselves can be signalized (Maine)

Both 1

- The L/A program does not take speed into consideration, while the M/A program route classification does include speed (Washington)

4. Do you acquire access rights on crossroads in the vicinity of interchanges?

Yes 23
No 8
Varies 3

a. If yes, how far do you typically acquire access rights downstream of the interchange ramp terminal?

- 400 m (Alberta)
- 300 ft (Arizona, Minnesota, South Dakota)
- 150 ft minimum for urban, 300 ft minimum for rural (Arkansas)
- 15 m minimum, 30 m preferred for urban, and 100 m preferred for rural (California)
- 350 ft minimum, 550 ft desirable (Colorado)
- 30 to 90 m (Connecticut)
- 600 ft (E-470)
- 100 ft minimum for urban, 300 ft minimum for rural (Georgia, Florida, Louisiana, Michigan, Mississippi, South Carolina, Virginia, West Virginia)
- Dependent on project and budget (Kansas)
- 500 ft of off-ramp (Maine)
- 660 ft (Nebraska)
- Obtained for a distance of 500 ft, but no less than 300 ft along the intersecting street (Nevada)
- 600 ft minimum for diamond interchanges, 1,000 ft minimum for directional interchanges (Ohio)
- 1,320 ft (Oregon)
- Dependent on road environment, minimum of 130 ft or 300 ft (Washington)
- 150 ft urban, 300 ft rural, 100 ft to the right-of-way limits of a frontage road (Wyoming)

b. How is the distance measured (e.g., centerline to centerline)?

- Centerline to centerline (Alberta, Arkansas, Kansas, Michigan, Oregon,³ South Dakota, Wyoming)
- At right-of-way (Arizona)
- End of curb return (California)
- Ramp shoulder line to access centerline (E-470)
- End of ramp taper (Florida)
- Radius return to radius return (Georgia, Ohio, South Carolina, West Virginia)

³Measurement of the approach road spacing is from center to center on the same side of the roadway, except for ramp taper configurations as shown in OAR 734-051 Figures 1–4, in which case the measurement is from the beginning/end of taper to center of the approach road.

- End of ramp radius to edge of access point (Louisiana)
- Edge to edge (Maine, Nebraska)
- Centerline of the ramp to the nearside right-of-way line cross street (Minnesota)
- Radius point of any ramp touchdown curve (Nevada)
- Theoretical gore to access radius point (Texas)
- Centerline of ramp (Washington)

5. Does your state or local agency control access rights on crossroads by deed?

Yes	20
No	9
Varies	3

6. Does your organization have any formal (or informal) standards or other criteria for access spacing at interchanges?

Yes	27
No	6
Varies	1

a. If yes, are the standards adopted legislatively?

Yes	8
No	18

b. If yes, are the standards adopted in regulations?

Yes	13
No	9

c. Please describe or provide a copy of your access spacing standards in the vicinity of interchanges.

7. Did your organization use a specific methodology (scientific) to develop the access spacing standards (the distance from the interchange ramp terminal to the nearest access point downstream) crossroads in the vicinity of interchanges?

Yes	15
No	17

a. If yes, does the methodology work effectively for your organization?

Yes	14
No	0

b. If yes, has the methodology been received as being fair and effective by other stakeholders?

Yes	14
No	0

Washington: “Y & N, both depending on the audience. If WSDOT has to condemn, understandably, the property owner does not view this as fair. When access/connection locations are denied or relocated, this also at times is difficult to explain. The public process does help with the fairness and understanding.”

c. If yes, please describe or provide a copy of the methodology.

- No issues with stakeholders (Arkansas)
- Access is beyond our 600 ft limit then state or local agencies grant access and coordinate with the E-470 PHA (E-470)

- Use a method developed by Joel and Jack Leisch in Procedures for Analysis and Design of Weaving Sections (Florida)
- Many of the standards were implemented from the NHI course Access Management, Location and Design. Also see the website: http://www.nevadadot.com/business/forms/pdfs/TrafEng_AccessMgtSysStandards.pdf (Nevada)
- The methodology used to develop a distance of 65 m is based on the minimum recommended stopping sight distance while traveling at 50 km/h. Also, it is the distance where we could attempt to synchronize traffic lights if required at various points (New Brunswick)
- New Jersey DOT Design Manual—Roadway, Section 7—Interchanges 7-11. <http://www.state.nj.us/transportation/cpm>, look under manuals (New Jersey)
- Background Paper #2 “Interchange Access Management” contains ODOT’s methodology used to develop the interchange access spacing standards. The background papers are found on ODOT’s website at: http://www.odot.state.or.us/tdb/planning/access_mgt/papers/papers.html (Oregon)
- The spacing standards were developed through a research study. See the research at: http://www.state.sd.us/Applications/HR19ResearchProjects/Projects/SD1999_01_Final_Report.pdf (South Dakota)
- Based on access management study, February 2001 (Utah)
- AASHTO’s “A Policy on Design Standards—Interstate System” (Virginia)
- Limited Access Hearings: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=chapterdigest&chapter=468-54>. Managed Access Hearings: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=468-51-150> (Washington)

8. What processes does your agency or organization use to plan, operate, and design access points on crossroads in the vicinity of interchanges?

Correspondence with governments:

- Work with the local governments (Arizona)
- Planning is controlled by the cities and counties, which comprise our governing board (E-470)
- Consult with local government, road authority, and property owners. In many cases, municipal consent is necessary for project approval (Minnesota)
- Work cooperatively with local governments to plan access points on the crossroad ahead of development (South Dakota)

No process/dependent on situation:

- It is a site-specific analysis (California)
- Identification of need based on major traffic generators and 20-year projections of traffic volumes (Connecticut)
- All such situations are treated as unique and are reviewed on their own merits (Kansas)
- Engineering experience, TRB’s impact calculator, and computer models (Louisiana)
- No processes in place specific to accesses near interchanges (Nova Scotia)
- This is considered in the planning process in preliminary engineering, and in the final design/right-of-way phase of project development (West Virginia)

Dependent on manuals/guidelines/standards:

- An interchange handbook specifies the study needed to approve a new interchange (Florida)
- Design manual provides guidance. Engineering judgment is used (Indiana)
- Driveway and entrance standards (Maine)
- The most effective way is to obviously purchase right-of-way of through highway controls. Levels of service calculations, queue analysis, road segment analysis, and signal system analysis all contribute to the analytical process to aid in determining proper and acceptable access scenarios (Maryland)

Guided by policy:

- <http://www.nebraskatransportation.org/roway/pdfs/accesscontrol.pdf> (Nebraska)
- We follow FHWA guidelines and our Access Management Standards (AMS) (Nevada)
- Per AASHTO/NYS DOT Design Manual (New York)

- We use AASHTO standards and corridor agreements to plan, operate, and design access points (Utah)

Other processes:

- A study is prepared to determine the configuration of the interchange, and the standards and specifications are laid out before the start of the study. A technical review team, including members of the local government, attempts to get support for the study findings. Public meetings are held to solicit input from the landowners, stakeholders, and the public. If the interchange is not scheduled for construction for a number of years, we then control the access through legislation, in that our agency reviews all development applications that are located within 800 m of the highway (Alberta)
 - Access points are developed outside Control of Access limits in accordance with our Driveway Policy, in conjunction with policies of local metropolitan planning organizations (Arkansas)
 - We obtain what we can based on the land use, existing access points, costs to relocate and close access points, volume, current and future of the cross street (Colorado)
 - We work with local jurisdictions as well as property owners and developers. Public hearings are held to share concepts and receive input (Iowa)
 - The permit process, which allows for a review by District Traffic Engineers and other appropriate people. Once our AM program is in place, if minimal spacing standards cannot be met, the permit will require approval by the Headquarters Permit Engineer (Louisiana)
 - Crossroads in the vicinity of interchanges are not within the jurisdiction of NJDOT. Local jurisdictions will plan, operate, and design access on crossroads beyond the acceleration/deceleration lanes (New Jersey)
 - We specify no access points within the distances noted in question 1a (Ohio)
 - The study area shall be sufficient to provide adequate assurance of the safe operation of the facility through the design traffic forecast period, typically 20 years (Oregon)
 - Design, regulations, zoning, land use, site development, driveway permits, and road networks (South Carolina)
 - Stopping sight distance is typical (Texas)
 - Other than either utilizing the 130 or 300 ft distance for acquiring limited access, WSDOT does not have jurisdictional abilities for access management down non-state crossroads and streets (Washington)
- a. Planning elements (e.g., planning year horizons, land use regulation through zoning or other means, development of local streets systems, etc.):
- Use planning year horizons (Alberta, Colorado, Florida, Georgia, Louisiana, Michigan, Minnesota, Nebraska, Nevada, Ohio, South Carolina, Washington)
 - Access points are developed outside Control of Access limits in accordance with our Driveway Policy, in conjunction with policies of local metropolitan planning organizations (Arkansas)
 - Usually the cross street is in the local's jurisdiction and they control the local street system and land use (California)
 - We use our above standard distance as minimums; however, we typically acquire a greater distance with new projects for No Access, depending on rural versus urban (Mississippi)
 - Land use zoning through the local agencies (Nevada, South Carolina, Texas)
 - Traffic volumes projections (New York, Virginia)
 - No formal process in place. Any driveway or intersection proposed in the vicinity of an interchange would require a detailed traffic impact study that included planning, operational, and design elements (Nova Scotia)
 - Mobility standards are provided in the Oregon Highway Plan, Highway Design Manual, and FHWA requirements. The Department plans for and operates traffic controls within the Interchange Access Management Area with a priority of moving traffic off the main highway, freeway, or expressway and away from the interchange area. Within the Interchange Access Management Area, priority is given to operating signals for the safe and efficient operation of the interchange (Oregon)
 - Corridor agreements are used in the planning phase; we attempt to work with the local governments, developers, and individuals to best serve their needs and still meet our requirements (Utah)
- b. Operational elements (e.g., mobility or level of service standards, queuing, progression, or other measures of effectiveness):
- Level of service standards (California, Florida, Kansas, Louisiana, Nevada, New York, South Carolina, South Dakota, Washington)

- Cost-effectiveness (Colorado)
- Weaving analysis (Kansas)
- Vehicle queues (Kansas, Louisiana, Minnesota, Nevada, New York, South Carolina, South Dakota, Texas, Washington)
- Progression (Kansas, Louisiana, Minnesota, South Carolina, South Dakota, Washington)
- Travel time/speeds (Nevada, South Dakota)
- Capacity (New York)

c. Design elements (e.g., access restrictions through median design, interchange forms, etc.):

No process/dependent on situation:

- It is site-specific (California)

Interchange forms:

- All of the listed elements are used (Colorado)

Dependent on manuals/guidelines/standards:

- Our local agencies usually subscribe to CDOT and AASHTO standards as modified for local use (E-470)
- AASHTO Design Standards are used when applicable, yet sometimes other considerations need to be taken into effect to accommodate our customers (Utah)
- Control of crossover locations utilizing FHWA guidelines, AASHTO (*Green Book*), etc. (Virginia)
- Design is done in accordance with the guidelines in the AASHTO *Green Book* (West Virginia)

Median design:

- All multilane roads receive a median. Driveways are controlled by permit and are consolidated where possible during reconstruction projects (Georgia)
- Divided medians are often used in urban, lower speed environments where there is a need to control left turns (Kansas)
- We implement access restrictions through the use of medians on major reconstruction projects (South Dakota)

Interchange forms:

- We increasingly use single-point interchanges and folded diamonds to reduce the need for weaving and to improve both mobility and access. Many times, the design elements of an interchange are determined based on the operational analysis and modeling (Minnesota)

Median design and interchange forms:

- We encourage the use of restrictive use of medians (not flush or two-way left-turn lanes) in the immediate interchange area. We also have a policy of not allowing partial interchanges (Florida)
- Some median designs have been used to restrict left turns. Also, interchange forms are considered in the overall analysis to provide sufficient (or maximum) spacing between intersections when developing the preferred alternative (Nevada)

9. How does your agency or organization engage stakeholders (other governmental agencies, impacted business or property owners, facility users, etc.) on interchange retrofit and new interchange projects?

Public meetings/involvement:

- Public meetings are held to solicit comments from stakeholders, landowners, and the general public (Alberta)
- Early coordination with local metropolitan planning organizations, public involvement meetings, and public hearings (Arkansas)
- Public information meetings, public hearings, websites, and publications (Connecticut)
- The Department has worked extensively with local governments, as well as property owners regarding the design of new interchanges (Florida)
- Public involvement now begins at concept stage and lasts throughout plan development process. Controversial projects get citizen advisory teams, and all major projects will typically have at least two public information meetings (Georgia)
- We involve stakeholders via the public hearing process (Iowa)

- Each project has its own public involvement element, which is designed to the unique needs of the situation at hand (Kansas)
- Public is generally involved on retrofit projects, but existing control of access is usually not changed; all others mentioned are involved in new projects (Louisiana)
- Public meetings (Michigan)
- All of our interchange projects have a large amount of public involvement in the planning and preliminary design phases. In most cases, municipal consent is necessary, so the predesign phase involves several public meetings, landowner meetings, and open houses (Minnesota)
- The environmental process involves all (Mississippi)
- Special project meetings, public information meetings, and public hearings (Nebraska)
- Kickoff meetings are held with all of the stakeholders to address the project specific needs and interests. Public information meetings are held to inform the public of proposed project alternatives and the potential impacts of the projects. Location/design hearings are held near completion of the NEPA process to explain and request input on the preferred alternative (Nevada)
- They are involved in the planning process during public meetings and/or interdepartmental consultation (New Brunswick)
- Stakeholders are engaged through public meetings. Business and property owners are notified if there is a modification or relocation of their access. Hearings, both formal and informal, follow if there is a challenge to the modification or revocation (New Jersey)
- Typically, new interchanges and retrofits would involve public consultation through “Open Houses” and “Public Information Sessions.” Then we would engage in direct consultation with local businesses and municipal governments. This process is not documented, legislated, or formalized in any manner. New interchanges and major retrofits are not very common in Nova Scotia (Nova Scotia)
- During the project design alternative selection phase, ODOT provides affected citizens with the opportunity to comment on design alternatives and discuss project impacts. During the final phase of design, ODOT works with property owners in the project’s right-of-way (Oregon)
- Predesign meetings, public design hearings, individual landowner meetings (South Dakota)
- Solicit input from citizens through citizen information meetings, public hearings, etc. (Virginia)
- WVDOT uses public meetings, hearings, and coordination with local, state, and national agencies and organizations (West Virginia)
- Public meetings, notification of project, and requests for input from stakeholders (Wyoming)

Other processes:

- Project scoping includes full public involvement process. (2) When private owners approach us on new interchanges we work with them to promote the informal policy (Arizona)
 - This generally occurs through (1) regional planning; both the state and locals agree to general concepts, (2) the environmental process, and (3) an outreach process of Context Sensitive Design (Caltrans has defined it a little differently and calls it Context Sensitive Solutions) (California)
 - Meetings, NEPA processes, and the right-of-way acquisition process (Colorado)
 - Letters/meetings/permit process/public hearings, etc. (New York)
 - Through meetings both public and private, and we generally pay to provide new access (Ohio)
 - Through early involvement in the project development phase (South Carolina)
 - We do work with municipalities as part of their zoning/platting (Texas)
 - As part of our Environmental Process, we engage stakeholders with correspondence and multiple open houses to get their input on the proposed changes and reasons for the changes. Once a project is set into motion, the applicable individuals are notified and discussion and arrangements are made, in order to allow the project to flow as smoothly as possible (Utah)
 - WSDOT has a design team for modified and new interchange projects. It is noted in our Design Manual Chapter 1425 (Washington)
10. Does your agency/organization have an integrated process to maintain the safety and efficiency of an interchange through access management (i.e., an integrated process that depends on good policy, begins in planning, and continues through design, into operations and maintenance)?

Yes 21
No 14

If the Interstate System is affected, we are required to follow NEPA requirements as administered by CDOT and comply with their Procedure Directive 1601. If it is a State Highway Interchange, we are required to meet CDOT interchange study procedures as per CDOT Procedure Directive 1601. If it is a local interchange we enter into an intergovernmental agreement (IGA) with the local jurisdiction and include any involved developer via a contractual agreement (E-470)

a. What part of your agency's process is strongest?

Policy/guidelines:

- Informal access policy for minimum distance to access (Arizona)
- We have a clear policy that is part of the Administrative Rules. This provides the basis for the management of the access through the other phases (Iowa)
- Since we have a policy, this is our strongest part of the process (Mississippi)
- Our access management policies are really guidelines, not standards; for this reason, our distances from the interchange that allow access are the strongest (Ohio)
- Department Design Process Manual (Utah)
- Providing Design Manual guidance for our regions and partners (Washington)

Planning:

- Planning (Alberta)
- Planning and design (Louisiana)
- Planning and traffic (Michigan)

Public involvement:

- Design/public involvement (New York)
- The planning process, public consultation, and the creation of legislation to control the access points (New Brunswick)
- Involve all of the stakeholders (Maryland)
- Citizen and local input (Virginia)

Others:

- We attempt to analyze all of these features during the environmental process. Detailed design supports the environmental process. We do not have access management (California)
- It's a continuum (Colorado)
- Our IGA for the design and construction is not weak; however, it is flexible, and the terms are negotiated with the local jurisdictions and their developers (E-470)
- We have an integrated process to protect access management in interchange areas. This process begins in the planning and design phases as specified in our Interchange Handbook, continues with coordination with local governments on new developments in the area, and is further strengthened by the fact that we manage the permitting process in the area (Florida)
- New designs and driveway permitting (Georgia)
- This is a new process and we seem to be sharing the roles equally (Maine)
- (1) Good traffic engineering and analyses. (2) Beginning to get the local governments to do planning for land use and circulation around the interchange area (Minnesota)
- Corridor protection:
- <http://www.nebraskatransportation.org/roway/pdfs/accessshwy.pdf>
- Design Traffic flows are reviewed. Access control:
- <http://www.nebraskatransportation.org/roway/pdfs/accessshwy.pdf> (Nebraska)
- Access Design (New Jersey)
- OAR 734-051 integrates ODOT's access management process into a set of rules which were developed through a collaborative process with ODOT and the Access Management Advisory Committee and were intended to clarify the management of access on state highway facilities while considering the interests of property owners and the safety of the traveling public. AMAC was a 17 member group of citizens representing business, developers, cities, counties, and agricultural and environmental interests. The consolidation of access management procedures into a single set of indexed rules increased the level of

consistency within the ODOT permitting process, while providing an increased level of predictability for the applicants (Oregon)

- Access permit process (South Carolina)
- All equally strong (South Dakota)

b. What part of your agency's process is weakest?

Political/public involvement:

- Dependency on cooperation with local governments and property owners (Arizona)
- We do not control local planning (California)
- Coordination with local governments in their development plans and education for the roadway design engineers on the benefits of access management (Florida)
- Political process (Maine, Mississippi, Nebraska, Utah, Virginia)
- Local governments' differences in interest with regard to access management (Maryland)
- The requirements for municipal consent sometimes water down the safety and operational needs of an interchange by making the project go "political" (Minnesota)
- As with most programs, it is subject to political influences (Washington)

Access management regulations:

- Access Management Guidelines (Ohio)
- The access management rules are complex and do not allow a great deal of staff flexibility (Oregon)

Planning:

- Planning—No method of controlling land use or real way of integrating with transportation plan (Georgia)
- Planning and project development process (South Carolina)

Others:

- Design and implementation (Alberta)
- Early investment to prevent long-term impacts; that is, under design (Colorado)
- Operations, but that is currently changing (Louisiana)
- Maintenance—This is where political/economic pressures seem to create the greatest problems in access management (Iowa)
- Enforcement (New Brunswick)

11. How successful is your organization in implementing specific planning, operation, and design techniques to control access on crossroads as part of *new* interchange projects?

- Very successful (90% or more of the techniques are deployed in the field)—12
- Fairly successful (60% to 90% of the techniques are deployed in the field)—14
- Moderately successful (40% to 60% of the techniques are deployed in the field)—5
- Somewhat successful (10% to 40% of the techniques are deployed in the field)—1
- Not successful (10% or more of the techniques are deployed in the field)—1

12. Have you had a *new* interchange project(s) in the past 5 years that you or your organization believes was implemented from an access management perspective, either very or fairly successfully?

Yes 15

No 18

a. If yes, please identify one project and state the reasons you believe it was successful.

Colorado: Interchange name: Highway 216/Whitemud Drive Interchange
Nearest city: Edmonton

Colorado:	Project name:	North 40
	Interchange name:	Several interchanges were completely rebuilt
	Nearest city:	North of Denver
E-470:	Project name:	Gartrell Road Interchange
	Interchange name:	Gartrell Road Interchange
	Nearest city:	Aurora
Florida:	Project name:	Suncoast Parkway
	Interchange name:	SR-54
	Nearest city:	Pasco County near Tampa
Indiana:	Interchange name:	I-65 at County Line Road
	Nearest city:	South side of Indianapolis
Minnesota:	Project name:	TH-371 Bypass Junction with old TH-371
	Interchange name:	South Bypass I/C
	Nearest city:	Baxter
Nebraska:	Interchange name:	South Locust Street/I-80
	Nearest city:	Grand Island
Nevada:	Project name:	Contract 3044
	Interchange name:	US-95/Durango Interchange
	Nearest city:	Las Vegas
		I believe it was successful because the project was on the outskirts of Las Vegas, so the access control was relatively easy compared to that of a project performed closer to the city. Detours were easy to set up as well. The project converted a hazardous at-grade intersection into a modern and well-functioning, full-movement interchange.
New Brunswick:	Project name:	Fredericton–Moncton Highway Project
	Interchange name:	Oromocto Interchange
	Nearest city:	Town of Oromocto
New Jersey:	Project name:	Route 1/Meadow Road Interchange
	Interchange name:	Route 1/Meadow Road Interchange
	Nearest city:	Princeton
Ohio:	Project name:	Polaris Interchange
	Interchange name:	Polaris
	Nearest city:	Columbus
		Met all the standards and guidelines.
Oregon:	Project name:	Bend Parkway
	Interchange name:	US-97 at multiple crossroads
	Nearest city:	Bend
		The Bend Parkway was constructed in sections from 1996 to 2002. The Parkway is on new alignment for US-97 through Bend. US-97 is a Statewide Highway on the National Highway System that goes from Biggs Junction to the California state line. The Bend Parkway is a 6.9-mi-long, four-lane limited access facility, with a raised median, bike lanes on the shoulders, sidewalks in some areas, and left-turn lanes at selected intersections. It includes signalized intersections and interchanges. It begins just north of the US-20/US-97 junction north of Bend and extends south to about Romaine Village Way. The design speed is 45 mph.

South Carolina:	Project name:	SC-60 Widening
	Nearest city:	Columbia
	When the project was planned the area was rural. Within a year after completion of the project the interchange was annexed into the town of Irmo owing to the development that had sprung up. The frontage roads met our design regulations and interchange operations very well.	
South Dakota:	Project name:	Russell Street Interchange
	Interchange name:	Russell Street Interchange
	Nearest city:	Sioux Falls
	Under construction.	

b. Why was the project completed?

- Constructed to replace a set of signals and to convert a highway to a freeway (Alberta)
- Capacity and operational problems (Colorado)
- The interchange was located in a rural area south of a major recreational area. A new bypass rerouted the highway TH-371 around the old urban core (Minnesota)
- Increased economic development for a section of the city (Nebraska)
- The project was completed to provide grade separated access between US-95 and Durango Drive in a suburban area that is developing very quickly. Numerous subdivisions have been built in the area and access was becoming a safety issue (Nevada)
- New 4-lane highway is part of the national highway network (New Brunswick)
- To promote and enhance safety and mobility on the transportation system (New Jersey)
- Expanded growth area (Ohio)
- The connection and spacing of local roads was carefully designed and will be managed to maintain the long-term function of the Parkway. An intergovernmental agreement was signed that recognizes that ODOT will close or restrict public road connections if they begin to affect the safety and function of the Parkway. Access rights to abutting properties were purchased for the entire length of the Parkway. To add capacity to US-97 to allow Bend's transportation system to safely and efficiently accommodate existing and future traffic volumes. To meet the goal and objective of the Access Oregon Highway program by improving capacity, safety, and travel time. To improve the operation of the local street network (Oregon)
- The project was completed because of anticipated growth and partial interchange that existed with access to Eastbound I-26 only (South Carolina)
- Design features prevent access too close to interchange (South Dakota)
- Working through WSDOT's Access Point Decision Report process, it was determined that the project was needed. As part of the need, the process determined that the need could not be met by implementing local system improvements (Washington)

c. Why do you believe this project was successful? (Are you tracking performance measures, such as crash rates? Do you have goals or expectations regarding safety and efficiency?)

- All access points were closed in spite of strong vocal opposition (Alberta)
- The project looks good and has the best access management feasible (Colorado)
- The project limited access to the crossroad as per our 600 ft requirement with only minor adjustment to our right-of-way and multi-use easements to accommodate access to the toll road for new development (E-470)
- I believe the project was successful because access management was considered in the early planning phases and we were fortunate to have nothing but large land owners in the vicinity where over 1,000 ft of limited access right-of-way did not impact their development plans (Florida)
- It affected higher-than-minimum protection of access (extension of limited access right-of-way) along the crossroad, near one-half mile on each side (Indiana)
- The interchange provided adequate spacing to the nearest intersections. Part of the reason it was successful was that it was along new alignment through a rural area so the impact on adjacent property owners was minimized (Minnesota)
- Access will be increased and should serve the city for a long time into the future (Nebraska)

- It is really too early to provide hard statistics as the interchange just opened about 6 months ago, but we are quite certain that the accident rate will diminish drastically (Nevada)
- The department is tracking accidents, etc., along the section of highway and monitoring the results (New Brunswick)
- The interchange project involved removal of an at-grade signalized intersection and construction of a grade-separated interchange. Safety and efficiency are implied improvements. No specific goals were established. (New Jersey)
- No safety goals per se, but want to maintain LOS “D” until design year (Ohio)
- The number of accidents on US-97 in the Parkway project area was higher than the statewide average for primary, non-freeway highways. The Parkway has not been open long enough to obtain comparable crash data.
- The connection and spacing of local roads were carefully designed and will be managed to maintain the long-term function of the Parkway. An intergovernmental agreement was signed, which recognizes that ODOT will close or restrict public road connections if they begin to affect the safety and function of the Parkway (Oregon)
- We’re not monitoring performance yet (South Dakota)

d. Did you have to relocate, consolidate, or close existing access driveways, median openings, frontage roads, or public street connection?

Yes 10
No 3

e. If yes, what techniques did your organization use to complete these access relocations, consolidations, or closures during the project?

- After achieving political approval, we eliminated access points by either providing an alternative access (converting a full at-grade intersection to high-speed right-in/right-out ramps or extending a local road into the area) or closing the access points entirely because the parcels of land already had other accesses (Alberta)
- Condemnation and police powers (Colorado)
- Private and public accesses south of the interchange were combined and redirected to frontage roads (Minnesota)
- Public hearings, meetings, buyouts, and frontage roads (Nebraska)
- The project eliminated an at-grade intersection on what was a partially controlled access facility. We provided a detour and alternate access to the freeway for the crossroad during construction. The facility is now fully access controlled from this point on, into and through downtown Las Vegas (Nevada)
- Alternate access is normally provided via property access roads. These are public roads that are typically located at or near the limits of access control at interchanges (New Brunswick)
- Notification of property owners and Department response to stated concerns (New Jersey)
- Construction of the first phase of the Parkway began in 1994. The 3-mi facility included six bridges, three interchanges, and two lanes of traffic in each direction. Construction costs for the first phase were nearly \$31 million. The entire 7-mi, \$101 million project was completed in 2001. The termini of the Bend Parkway were funded by the Access Management Bonding Fund (Oregon)
- There was one developer on one quadrant that was aware of the project and coordinated the location of the frontage road and his drives with us. He went in before we had broken ground for the interchange and built a portion of the frontage road on his property. We bought that portion of the frontage road from the developer later on (South Carolina)
- Relocation (South Dakota)

f. How did funding availability influence the techniques that were selected for this interchange project?

- Funding was provided entirely by our agency (Alberta)
- Funding did not dictate the engineering development of the interchange, but it did dictate the financial arrangements between the parties (E-470)
- The fact that the landowners in the interchange area were large land owners where over 1,000 ft of limited access right-of-way did not seriously impact their development plans had a positive impact on the cost of good access management in this interchange area (Florida)

- Funding availability did not influence the techniques selected for the interchange project (Indiana, Ohio, South Carolina)
- Available funding was critical to this project. MnDOT spent a lot of money to get the desired spacing. The District (primarily rural and recreational land use) was able to use more of their budget to get the desired result, having fewer critical issues and less congestion than more urbanized Districts could (Minnesota)
- Funding availability affected this project in the purchase of right-of-way and conservation easements (Nebraska)
- There was federal funding involved, so federal standards were met (Nevada)
- Funding and timing considerations were factors that positively influenced creativity in design and construction of the project (New Jersey)
- In retrospect, it is easy to identify a number of land use and growth management techniques that theoretically could have maintained (for some undefined longer period) the function and capacity of the US-97 on Third Street. However, it is important to recognize that these techniques are to a large extent the result of these earlier “failures.” Without them, it is questionable whether ODOT would have had the cultural, political, and technical advances that currently allow incorporation of the Parkway techniques mentioned above. Whether it would have been possible to implement these types of measures 25 years ago is doubtful. It is increasingly apparent that they should be considered and incorporated in current project development and implementation activities. (Oregon)

g. What lessons did your organization learn from this project that could be applied to future projects?

- One needs to have defensible standards, be able to convince the powers that be that what you are doing is a good thing, and coordinate controversial closures by a head office (Alberta)
- Roundabout alternatives need stronger investigation (Colorado)
- We need tighter means and controls to make sure developers keep their financial commitment to the project (E-470)
- It is to do good access management planning at interchange areas where access management has been considered at the earliest planning stages (Florida)
- With sufficient funding, interchange access management techniques can be obtained (Minnesota)
- That the type or level of access control may have to vary depending on the design of the interchange (New Brunswick)
- Design flexibility (New Jersey)
- Mandate the standards and guidelines to be followed (Ohio)
- The city, county, and ODOT have a close working relationship in reviewing and appropriately mitigating all private or public development actions (partitions, zone changes, site plan review, etc.) which might potentially affect the Parkway.
- The city, county, and ODOT are working closely together on a long-range transportation plan that will include a number of measures that will maintain the function of the Parkway (development of a good local grid system, mixed use development, provision of alternative transportation modes, etc.) (Oregon)
- Design, coordination, cooperation of developers (South Carolina)

h. Do you have a report that you could provide that documents the project and/or process?

Yes	3
No	9

13. How successful is your organization in implementing specific planning, operation, and design techniques to control access on crossroads as part of interchange *retrofit* projects?

- Very successful (90% or more of the techniques are deployed in the field)—5
- Fairly successful (60% to 90% of the techniques are deployed in the field)—9
- Moderately successful (40% to 60% of the techniques are deployed in the field)—9
- Somewhat successful (10% to 40% of the techniques are deployed in the field)—5
- Not successful (10% or less of the techniques are deployed in the field)—1

14. Have you had a *retrofit* interchange project(s) in the past 5 years that you or your organization believes was implemented, from an access management perspective, either very or fairly successfully?

Yes 10

No 22

- a. If yes, please identify one project and state the reasons you believe it was successful.

- E-470: Project name: Chambers Road
Interchange name: Chambers Road
Nearest city: Parker
The project is being done in stages as local financing of the interchange makes construction feasible. The first stage in 1991 was overpass construction with the initial construction of E-470. The second stage in 2002 was the construction of the west ramps of the diamond interchange. The third stage, expected in 2003, will be the widening of the overpass structure from two to four lanes plus median turn lanes. The fourth stage will be the construction of the west ramps possibly in 2005 as funding becomes available.
- Minnesota: Project name: Belle Plaine I/C
Interchange name: Belle Plaine TH-169
Nearest city: Belle Plaine
- Nebraska: Interchange name: N-63/I-80
Nearest city: Greenwood
- Nevada: Project name: Contract 3003
Interchange name: I-15/Sahara Interchange
Nearest city: Las Vegas
- New Brunswick: Project name: Route 1
Interchange name: Route 1 and Route 121 Interchange
Nearest city: Sussex
- Ohio: Project name: MOT-I-70
Interchange name: SR-202
Nearest city: Huber Heights
- Oregon: Project name: Fern Valley Interchange
Interchange name: Fern Valley Interchange
Nearest city: Phoenix
The project addresses safety issues at the Fern Valley Interchange, which carries North Phoenix Road over Interstate 5. The initial work will occur off the main roadway with the realignment of Luman Road west of the interchange. The work is not expected to impact traffic. Luman Road and North Phoenix Road will be relocated further away from the ramps. In the final phase, traffic signals will be installed on the ramps. Pear Tree Lane will be converted into a cul-de-sac after the city of Phoenix finishes a new street for access into the commercial businesses. Several driveways will also be closed near the interchange. Access into the Pear Tree Factory stores and McDonalds will be limited to one entrance and exit. A new entrance to Luman Road will be located on the southern side of Fern Valley Road.
- South Carolina: Project name: Pine Grove Interchange at I-26
Nearest city: Columbia

b. Why was the project completed?

- TH-169 is being transitioned into a grade-separated facility. The city of Belle Plaine straddles the existing four-lane expressway. The new interchange will be located near the primary highway–commercial center of the city (Minnesota)
- Increase capacity of the main line Interstate (Nebraska)
- It was completed to add capacity to I-15 and to the arterial street, Sahara Avenue, and improve operational characteristics by providing a direct access ramp, thereby eliminating a signalized intersection, and improving the acceleration lane for one of the on-ramps (Nevada)
- Upgrading to Route 1 and divided highway network (New Brunswick)
- Growth in area (Ohio)
- When the interchange was designed, the immediate area was rural in nature. Forty years later, Phoenix and the interchange area are growing. Increased traffic volume, caused by increased commercial and residential growth, has made the interchange hazardous at various times of the day. At times, traffic is backed up from the on-ramps onto I-5. Motorists who are en route to east Medford are also using the interchange to connect with North Phoenix Road, thus adding congestion. Both the northbound and southbound freeway traffic off-ramps at the I-5 Fern Valley Interchange are failing and becoming unsafe for motorists (Oregon)
- The project was completed to eliminate two-way ramps and provide better access to I-26 (South Carolina)

c. Why do you believe this project was successful? (Are you tracking performance measures, such as crash rates? Do you have goals or expectations regarding safety and efficiency?)

- Though not yet completed, the folded diamond interchange was approved by the local community (although MnDOT did have to go through the process of overriding Municipal Consent). The community wanted to maintain the existing private entrances that would be located between the two ramp termini and have a two-way center left-turn lane through the whole interchange area. MnDOT's proposal was a raised median and redirecting the private entrances to the frontage roads. In the end, MnDOT's proposal was accepted (Minnesota)
- Elimination of county roads close to the ramp terminals and elimination of access drives (Nebraska)
- We were able to improve the traffic operations and capacity of both the freeway and the cross street. The project is too new to have hard data to back up this statement, but everyone who drives the facilities will vouch for its accuracy (Nevada)
- Goals for efficiency (Ohio)
- The Fern Valley Interchange project will move Luman and North Phoenix Roads farther away from the I-5 ramps. Luman and Fern Valley Road will get a traffic signal, which will also access the nearby outlet mall.
 - Once completed, the new street will take traffic from Fern Valley Road south into the commercial businesses—Petro Truck Stop, Pear Tree Motel and RV Park, and Palm Harbor Homes. On the northern side of Fern Valley Road will be the new beginning of North Phoenix Road, which has become a route for access into the growing Medford neighborhoods.
 - The project will also widen the northbound off ramp, which will allow for a right-turn lane. That should help traffic traveling to services on the eastern side of I-5, as well as North Phoenix Road (Oregon)
- The interchange operates very well, and we have not seen any operational problems with the design implemented (South Carolina)
- The department is tracking accidents, etc., along the section of highway and monitoring the results (New Brunswick)

d. Did you have to relocate, consolidate, or close existing access driveways, median openings, frontage roads, or public street connections?

Yes	10
No	0

e. If yes, what techniques did your organization use to complete these access relocations, consolidations, or closures during the project?

- Constructed a frontage road system and installed a raised median (Minnesota)

- Purchased right-of-way, public hearings, and information meetings with the landowners and public. Reconstruction in new location while maintaining access (Nebraska)
- There was a weave problem where the right-turn traffic from the southbound off-ramp was having weaving problems between the ramp and the next intersection where they wanted to turn left. Thus, a raised island was installed and carried back beyond the ramp terminal to avert that movement. Also, driveway access was consolidated for a gas station adjacent to the southbound off-ramp from two driveways to one driveway located on a side street (Nevada)
- Installation of medians, combining driveways and right-in/right-out driveways versus full movements (Ohio)
- The short-term solution to the project calls for traffic signals at the end of the off-ramps. This will allow for safer left turns. Because of the curve of the overpass, left-turning vehicles are at risk. Plus, an exclusive right-turn lane on the northbound ramp will help separate right- and left-turning traffic. The project will also relocate Luman and North Phoenix Roads farther from the current ramps (Oregon)
- Condemnation, negotiation, total takes, etc. (South Carolina)
- WSDOT utilizes a public process for limited access projects. This process communicates the access changes to abutting property owners (Washington)
 - An “Access Report” is completed. The Access Report is provided to the local agency. The report shows the local agency the proposed project modifications. An Access Hearing is conducted to display the project access changes. The hearing allows affected property owners or their representatives an opportunity to present their concerns with the proposal.
 - The document that is developed from the Access Hearing is called the “Findings and Order.” The Findings and Order addresses concerns brought forward at the Access Hearing and establishes “Limited Access” for a project.
- They would be supplied alternate or temporary access during the different phases of construction (New Brunswick)

f. How did funding availability influence the techniques that were selected for this interchange project?

- MnDOT invested a great deal of money, including reconstructing the cross street (a country road) adding frontage roads and redirecting driveways (Minnesota)
- Funding did not influence the techniques used on this project (Nebraska, Ohio)
- Federal funds were involved in this project, so federal standards were met (Nevada)
- Perhaps wait until funds are available to complete the interchange in fewer projects rather than piecemeal the process. Availability of funding from the developers through the county dictate schedule but not design engineering practice (E-470)

g. What lessons did your organization learn from this project that could be applied to future projects?

- Since MnDOT had no formal guidance for access around interchanges, working for municipal consent was difficult. Following this interchange, we began to develop guidance (Minnesota)
- Standards that can be easily explained to the community and that show how the operation of the roadway will be enhanced are readily accepted (Ohio)
- ODOT, in concert with local government, will develop an interchange area management plan following the provisions of OAR 734-051-0200 for the project consistent with the Oregon Highway Plan. The city of Phoenix will adopt the interchange area management plan as part of a legally binding, enforceable intergovernmental agreement between Phoenix and ODOT as provided in Oregon law. The intergovernmental agreement will include the following elements:
 - The interchange management plan will be presented to the OTC for review and approval before funds for construction are released.
 - Protection of resource lands will be addressed in the interchange management plan.
 - If the agreement is to be terminated, that the city of Phoenix give notice to ODOT in advance of a public hearing on the matter and that the public hearing be held prior to the expiration of the agreement.
 - Changes or termination of the agreement in advance of expiration shall require formal affirmative action by the Oregon Transportation Commission and city of Phoenix.
 - The agreement can expire if Phoenix includes the interchange area management plan in its Transportation System Plan.

- The interchange area management plan will provide for the protection of safe and efficient operation of the interchange between connecting roadways and will minimize the need for major improvements to existing interchanges.
- The intergovernmental agreement will call for any amendments needed to the local plan and Oregon Highway Plan needed for this to be accomplished (Oregon)
- Early public involvement (South Carolina)
- Limits and/or levels of access control may vary due to the type of interchange being constructed (New Brunswick)

h. Do you have a report that you could provide that documents the project and/or process?

Yes 2
No 7

i. Do you have before-and-after photos that you could provide?

Yes 1
No 7

Abbreviations used without definition in TRB Publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation