

**COSTS AND BENEFITS
OF STRATEGIC ACQUISITION
OF LIMITED ACCESS
RIGHT-OF-WAY AT FREEWAY
INTERCHANGE AREAS**

**Costs and Benefits of Strategic Acquisition
of Limited Access Right-of-Way at
Freeway Interchange Areas**

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INTRODUCTION

Past research shows that access connections and signalized intersections within the functional area of an interchange can adversely impact safety and operations at the interchange and on the freeway. A variety of transportation problems occur when driveways and intersections are too close to interchange ramps. Signalized intersections too close to ramp termini can cause heavy volumes of weaving traffic, complex traffic signal operations, accidents, congestion, and traffic backing up the ramps on to the main line (1). Curb cuts and median openings near the ramp termini further compound these problems.

It follows, therefore, that avoiding access in the functional area of freeway interchanges through effective planning and access control will help to preserve traffic safety and operations and may eliminate or postpone the need for interchange improvements. Alternatively, access in the functional area of a freeway interchange could shorten the functional life of the interchange and lead to serious safety and operational problems on the mainline.

Although controlling access in the functional area of interchanges does have obvious safety and operational benefits, the cost-effectiveness of strategically acquiring additional limited access right of way for this purpose has not been examined. Is it cheaper, for example, to spend more of our limited transportation dollars on limited access right-of-way at the time an interchange is built, than to continue with current right of way acquisition practices? Would acquiring more access control in the vicinity of interchanges significantly postpone or avoid the need for interchange reconstruction? If so, will the up-front cost of acquiring more access control, be outweighed by the benefits of not having to reconstruct the interchange sooner than planned? And what are the safety implications if interchange area access is not effectively managed?

The Center for Urban Transportation Research (CUTR), under a grant from the Florida Department of Transportation (FDOT), is examining these important policy questions. The primary objective of the study is to assess the cost effectiveness of purchasing additional limited access right-of-way at the time of construction in lieu of retrofitting interchange areas after functional failure. The study is particularly important given the rapid growth and dramatic increase in right-of-way costs that has been observed in Florida over the past few decades.

BACKGROUND

The methods used to control access have historically fallen into two areas — police power and eminent domain. Governments may exercise police power for access control for the health, safety, and welfare of the traveling public. Examples of police power techniques for interchange access management include policies and regulations for the spacing, design and permitting of access connections, service road ordinances, and implementing ordinances for access management plans. Police power activities are generally not compensable to property owners, if the regulation addresses a legitimate public health, safety, or welfare issue and is applied within the limits of the U.S. Constitution.

Eminent domain is the right of government to take private property for a public use with compensation to the property owner, and is the process under which transportation right-of-way is acquired for interchanges and other transportation facilities. Compensation is typically determined based upon market value, as well as any business or severance damages that may

have been incurred by the impacted site. The acquisition of limited access right-of-way not only involves the purchase of land for right-of-way, but acquiring a property's right to access, as well. A key issue in purchasing limited access right-of-way is whether reasonable access exists for the remainder of the site. Otherwise, transportation agencies may be required to purchase the entire property.

Historical Context

The control of access around interchanges has been an issue for planners and engineers for decades. As early as the 1960's, Ross Netherton addressed this issue in *Control of Highway Access*, and concluded that interchange areas present special challenges concerning access management and land use control, due to the discrepancy in traffic volumes and speeds where the interchange connects with surface road systems (2). Managing this interface is critical to preserving the capital investments made in interchange areas (3).

Netherton noted that a properly planned and managed interchange area can become an economic asset for a community, while a poorly planned interchange can become a quagmire of reconstruction costs and property rights issues (2). He also noted that efforts to restrict access through police power had not been particularly effective in areas with high value property, because political pressure to allow access can be overwhelming (2). For these reasons, he advocated the purchase of access rights for control of interchange area access.

A 1968 study, which provided the basis for changes to Illinois access control policies for interchange areas, recommended expanding the acquisition of property access rights "in critical cross-route problem areas" (4). The study encouraged the development of a comprehensive plan for interchanges when the interchange is designed to discourage shallow frontages in the vicinity of interchanges and to redirect site frontage and access onto service drives or local streets. (Techniques for interchange area planning and access management are addressed in *Land Development and Access Management Strategies for Florida Interchange Areas*, CUTR 2000 (5).)

Current Practice

Most state transportation agencies address limited access right-of-way in their roadway design manuals, which reflect policies of the American Association of State Highway and Transportation Officials (AASHTO). The AASHTO publication, *A Policy on Design Standards – Interstate System*, recommends that access control lines for interchanges "should extend beyond the ramp terminal at least 100 feet in urban areas and 300 feet in rural areas...However, in areas where the potential exists which would create traffic problems, it may be appropriate to consider longer lengths of access control" (6). Therefore, state interchange access control policies are still primarily limited to the immediate area of the interchange.

However, recent research suggests a shift in state policy in response to contemporary guidance emerging from AASHTO and the Transportation Research Board. The 2001 edition of the AASHTO *Policy on Geometric Design of Highways and Streets* ("Greenbook") provides more extensive treatment of the subject of interchange area access control than previous editions. It addresses the importance of access control on interchange crossroads and mentions techniques to control access (7). It also identifies elements to consider in determining appropriate access separations and access control distances in the vicinity of free-flowing ramps (Figure 1).

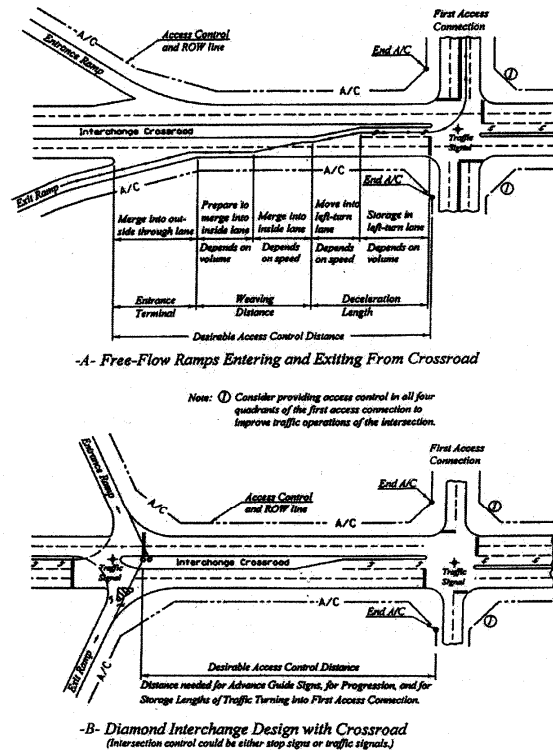


Figure 1: Factors influencing the lengths of access control along an interchange crossroad. (From A Policy on Geometric Design of Highways and Streets, Fourth Edition, © 2001 by the American Association of State Highway and Transportation Officials, Washington, DC. Used by permission. Documents may be purchased from the AASHTO bookstore at 1-800-231-3475 or online at <http://bookstore.transportation.org>.)

The most recent update to the state of the practice in interchange area access management is found in the *Access Management Manual* (TRB 2004), which builds upon work done in *NCHRP Report 420: Impacts of Access Management Techniques*, and research conducted for the Oregon Department of Transportation by Layton et al (8, 9). These sources recommend access spacing standards for access on the crossroads at freeway interchanges which are well beyond the minimum provisions of AASHTO policy (Table 1).

Table 1: Suggested Minimum Access Spacing Standards for 4-Lane Roads at Interchanges

Access Type	Area Type		
	Fully Developed Urban (35 mph)	Suburban (45 mph)	Rural (55 mph)
First Access from Off-Ramp	750	990	1,320
First Median Opening	990	1,320	1,320
First Access Before On-Ramp	990	1,320	1,320
First Major Signalized Intersection	2,640	2,640	2,640

Source: *NCHRP Report 420*, TRB 1999 (8).

Table 2 and Figure 2 illustrate the recommended access separation guidelines presented in *NCHRP 420*.

Table 2: Separation Distances from Interchange Exit Ramps

Weaving - moving across through lanes	800 feet on two lane arterials 1200 feet on four lane arterials 1600 feet on six lane arterials
Transition - moving into turn lane(s)	150 to 200 feet
Perception - reaction distance	100-150 feet
Storage	Adequate for volume without overflow into through lane (typically 200-300 ft. depending upon demand)
Distance to centerline of intersection	40-50 feet

Source: Guidelines adapted from *NCHRP 420* (8).

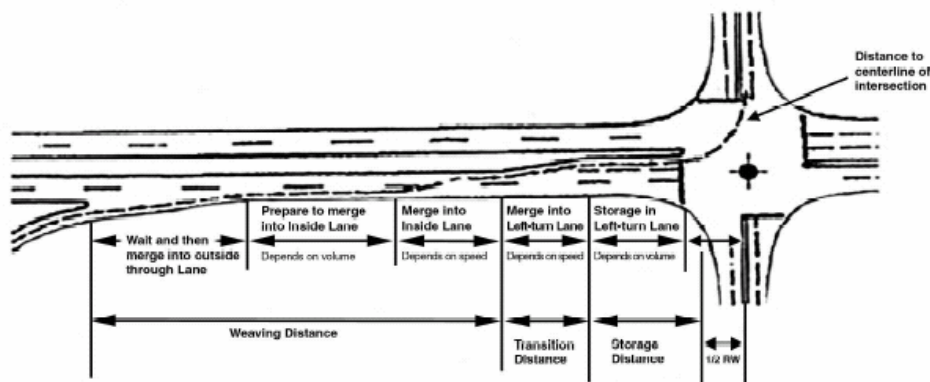


Figure 2: Access Separation Distances

These guidelines recommend limiting unsignalized access on the crossroad for a distance of at least 750 feet from the end of the interchange ramp and separating signalized intersections from ramps by at least $\frac{1}{2}$ mile. This is significantly more than the typical 100 to 300 feet of limited access right-of-way in use by most states. In response to these changing guidelines, several state transportation agencies have begun to revise their policies and practices to acquire more limited access right-of-way at interchanges. As noted in *NCHRP Report 420*: “Many states have established more stringent policies than AASHTO that reflect the importance of providing sufficient access control lengths and/or separation distances along crossroads (arterials) at interchanges” (8).

Agency Practices

A sample of state transportation agencies was contacted to obtain additional insight into current right-of-way acquisition practices at interchange areas. The majority of these agencies addressed the purchase of limited access right-of-way at interchanges in their Highway Design Manuals. The requirements varied from state to state, but most indicated that if additional limited access right-of-way is required, the reason is usually because of an identified safety issue. However, several states have programs specifically encouraging the acquisition of additional limited access right-of-way along critical roadways and interchanges. Summaries of these state practices are provided below.

Delaware

The State of Delaware has two practices that merit discussion. The first is the Corridor Capacity Preservation Program, which advocates coordination between land use and transportation in the planning process (10). The program involves the designation of specific corridors to convert to limited access facilities and addresses the location of access at interchanges in the corridor management planning process.

The second practice is the purchase of development rights for corridor preservation. The Delaware Department of Transportation purchases development rights at specific rural locations, including interchanges, which allows the owner to retain title and continue using the land for agricultural purposes. Staff indicate that this practice helps maintain the rural nature of the area and prevents access problems, such as encroachment problems at interchanges. The practice is restricted to agricultural areas due to property costs.

Kansas

The Kansas Department of Transportation's (KDOT) *Corridor Management Policy*, readopted in 2003, is dedicated to assisting local governments in limiting access to abutting properties on the State Highway System (11). Although the program does not specifically address interchanges, the policy does address corridors that include interchanges. The purpose of the policy is to create statewide consistency in transportation planning and to preserve access along important corridors. However, the policy is a guideline and therefore the access spacings are not mandated.

Each of the six districts in KDOT has a Corridor Management Plan that identifies transportation corridors experiencing development pressure and the need for increased management to preserve the functional integrity of the road. Cooperation with the local municipalities is of paramount concern to KDOT because the local jurisdictions control land use decisions and extensive communication is encouraged.

An example of KDOT's commitment to the control of access is in the District 6 Corridor Management Plan for the K-156 corridor near Garden City, Kansas. The K-156 corridor is a protected corridor because of its critical role as a commercial east-west corridor. KDOT and the local government believe that without access control the development pressure for direct access will jeopardize operations and safety along the road. Currently, there is no access control in place. KDOT is recommending the immediate purchase of access rights along K-156 for a minimum of two miles.

Staff note that access control is a priority of KDOT; the purchase of access rights or limited access right-of-way occurs whenever KDOT undertakes a road improvement project. There are no set distances for this purchase. If the improvement is one mile, staff indicate that they will try to purchase one mile of limited access right-of-way or as much limited access as they can acquire.

Ohio

The Ohio Department of Transportation manages access at interchanges through two documents – the Ohio Design Manual and the Ohio Access Management Manual (12, 13). The *Ohio Design Manual*, dated December 1992, provides geometric design criteria for the construction and modification of roadways. Access Control Policy 801.25 addresses access for interchange areas as follows (see Figures 3 and 4):

“No access shall normally be allowed in intersecting highways adjacent to highway interchanges for a minimum of 600 feet at diamond-type interchanges and 1,000 feet at other types of interchanges. This distance applies to each direction along the intersecting highway, measured from the outer-most ramp terminal intersections with the highway, see figures 801-1 and 801-2 for additional details” (12).

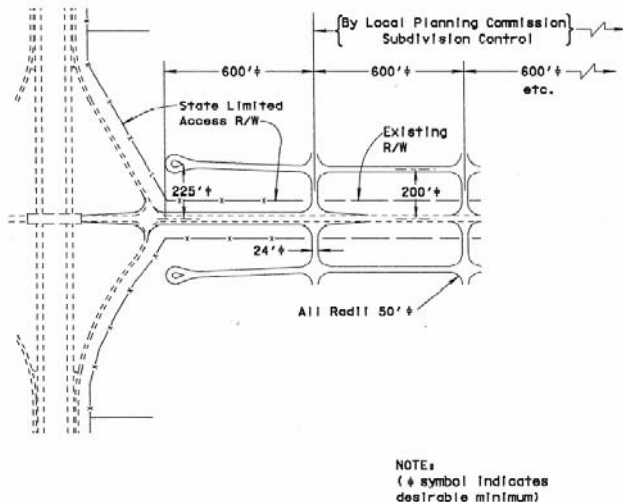


Figure 3: Limitations for Access at Diamond Interchanges (Figure 801-1, 12)

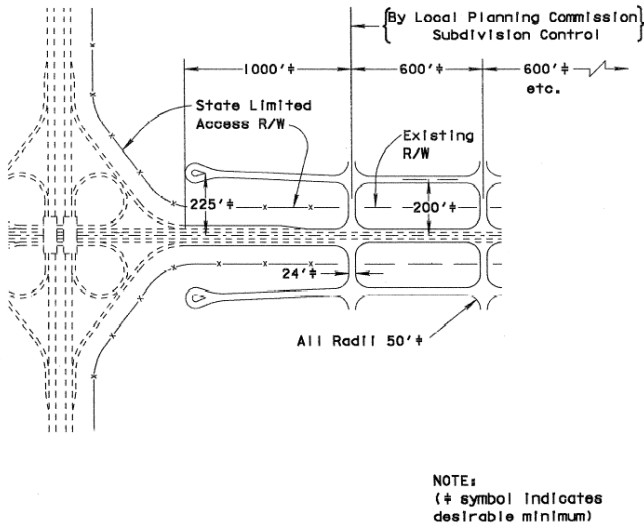


Figure 4: Limitations for Access at Cloverleaf Interchanges (Figure 801-2, 12)

Ohio DOT attempts to obtain 600 feet of right-of-way around diamond interchanges and 1,000 feet of right-of-way around cloverleaf interchanges when possible. Staff indicated that one of the challenges faced is when the acquisition causes parcels to be landlocked. In this case, Ohio DOT will provide an access road to the nearest eligible access point. However, if there is only one parcel Ohio DOT must purchase the property, because Ohio state law prohibits the condemnation

of one party's property to benefit another party. Ohio DOT is proactive in its approach to managing interchange area access, but staff note that there is no standardized plan to purchase limited access right-of-way around interchanges; it is project specific.

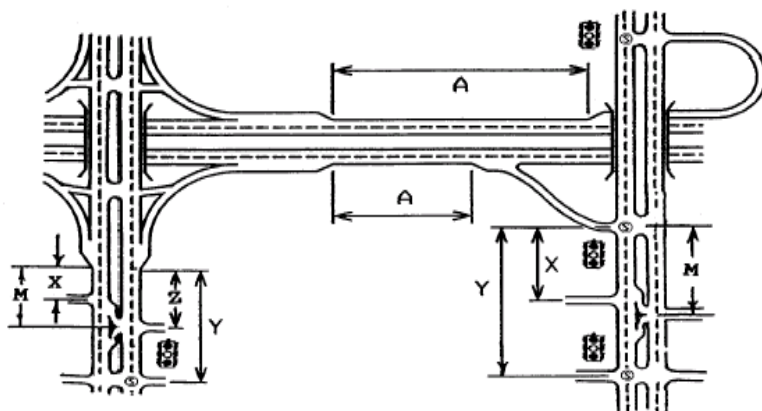
Oregon

The Oregon Department of Transportation uses *Access Management Administrative Rules, Chapter 734, Division 51* to govern interchange area access (14). Oregon DOT manages all grade-separated interchange areas. At the time of an improvement, an interchange will be required to meet spacing standards or at least move in the direction of meeting the spacing standards. Oregon uses interchange area management plans to address right-of-way, access control, and land use. Table 3 shows the recommended spacing standards for freeways.

Table 3: Minimum Spacing Standards Applicable to Freeway Interchanges with Multi-Lane Crossroads

Category of Mainline	Type of Area	Spacing Dimensions				
		A	X	Y	Z	M
Freeway	Fully Developed Urban*	1 mile	750 feet	1320 feet	990 feet	1320 feet
	Urban	1 mile	1320 feet	1320 feet	1320 feet	1320 feet
	Rural	2 mile	1320 feet	1320 feet	1320 feet	1320 feet

* Fully Developed Urban Interchange Management Area occurs 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.



Notes:

- 1) If the crossroad is a state highway, these distances may be superseded by the Access Management Spacing Standards, providing the distances are greater than the distances listed in the above table.
- 2) No four-legged intersections may be placed between ramp terminals and the first major intersection.
- 3) No application shall be accepted where an approach would be aligned opposite a freeway or expressway ramp terminal (OAR 734-051-0070(4)(a)).

- A= Distance between the start and end of tapers of adjacent interchanges
- X= Distance to the first approach on the right; right in/right out only
- Y= Distance to first major intersection; no left turns allowed in this roadway section to the first major intersection
- Z= Distance between the last right in/right out approach road and the start of the taper for the on ramp
- M= Distance to first directional median opening. No full median openings are allowed in non-traversable medians.

In regard to limited access right-of-way, Oregon DOT tries to acquire access on all crossroads around new and existing interchanges. Whenever possible, this acquisition is for a distance of 1,320 feet. In practice, Oregon DOT staff indicated that the purchase of access rights around interchanges in Oregon is a thorny issue. One reason for this is a ruling of the Oregon courts that the right to access is a property right and that Oregon DOT must allow breaks in the access control line for that access. In other words, if a break in the access control line is inevitable, there would be no advantage to acquiring to limited access right-of-way and it would be more advantageous to rely on police powers for proper access management.

Minnesota

The State of Minnesota has recently revised their access management policies. The current state policy, *Access Management Policy: Access Category System and Spacing Guidelines*, March 2002, recommends the nearest connection at an interchange to be at ½ mile. MnDOT staff believes that a statewide policy requiring a set amount of limited access right-of-way would not be practical in much of the state. Therefore, they prefer to advocate for the use of turn lanes and median control around interchanges, along with the MnDOT roadway design standard of 300 feet of full access control on either side of interchanges.

As an alternative to purchasing additional limited access right of way around interchanges, MnDOT staff are considering the use of Interchange Management Plans for each interchange. The Interchange Management Plans will combine modeling of future volumes and traffic operations simulations, with access management principles, to develop an appropriate plan for each interchange. Each access management plan would identify points of access, traffic signals, and roadway design elements, while addressing land use and the supporting road network. The emphasis will be on identifying existing non-conforming access points and bringing them into compliance.

Nebraska

The Nebraska Department of Roads (NDOR) adopted an *Access Control Policy* in November 2002. The policy explains the benefits of access control and provides guidance on criteria to use in determining the extent of access control. NDOR controls access through both police power and the acquisition of access rights. During the initial stages of project development, NDOR determines if they will acquire access rights for their recommended minimum distance, which is 660 feet at freeway interchanges. Limited access right-of-way is then purchased in the right-of-way acquisition phase of the road project.

Florida

The Florida Department of Transportation (FDOT) has several rules regulating access around interchange areas. The FDOT *Plans Preparation Manual* requires a minimum of 300 ft of limited access right-of-way beyond the end of the acceleration/deceleration lanes at rural interchanges and 100 ft. in urban areas. Additional rules that affect access and control the functional area of an interchange are in FDOT Rule 14-97. The standard set forth in FDOT Rule 14-97.003(1)(j) for interchange areas is as follows:

“Connections and median openings on a controlled access facility located up to ¼ mile from an interchange area or up to the first intersection with an arterial road,

whichever distance is less, shall be regulated to protect the safety and operational efficiency of the limited access facility and the interchange area...”

FDOT does acquire additional limited access right-of-way at freeway interchanges, but on a case-by-case basis and typically in response to identified safety issues. The Florida Turnpike Enterprise of FDOT routinely acquires additional LA ROW at new turnpike interchanges. For example, the Turnpike Enterprise acquired up to 1020 ft of limited access right-of-way east of the new SR54/Suncoast Parkway interchange (see Figure 5).

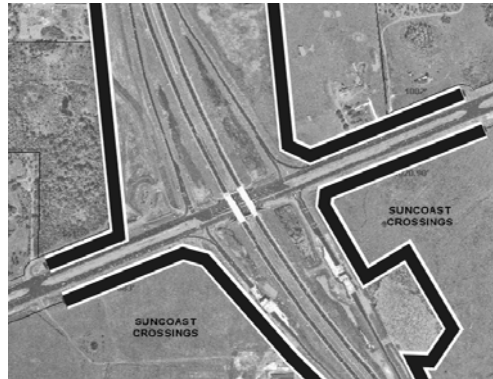


Figure 5: Limited access right-of-way for SR54/Suncoast Parkway Interchange. Source: Florida Turnpike Enterprise, 2000.

Other tools that FDOT uses to control access include:

- *Permitting of access where interchanges exit onto a state highway.* Rule 14-97, FAC, establishes spacing standards for connections and median openings, which vary by access classification and posted speed of the state highway. FDOT can attach conditions on the type and use of access through the permitting process, as well as conditions for future closure of access where alternative access is provided.
- *The review of applications for new interchanges or modifications to existing interchanges.* The *Interchange Request Development and Review Manual* contains criteria and procedures for the Interchange Justification Report (IJR) and Interchange Modification Report (IMR) process. However, the emphasis of the IJR's and IMR's is on capacity analysis of the interchange and crossroads, which does not adequately address interchange area access issues.
- *A specific handbook for interchanges.* The *Interchange Handbook* provides guidance on development requirements around interchanges. The Handbook provides that Access Management Agreements may be required by the FDOT District Interchange Review Committee between FDOT, local governments, and the applicant. The agreements will establish an access management plan for a property up to a minimum of 1,320 feet from the end of the interchange ramps. Failure to develop and have the agreement executed can result in the stopping of the proposal review process and/or denial. No examples of

such agreements were identified, as few new interchanges had been built following enactment of the agreement provision.

Issues in Current Practice

Interviews with various state transportation agency representatives and property appraisers revealed several issues or common problems related to the acquisition of limited access right-of-way at interchanges. These issues are discussed below.

Escalating Right-of-Way Costs

In Florida, the cost of right-of-way has continued to escalate and right-of-way costs now exceed construction costs in many areas. Staff of the Florida Department of Transportation indicated that under Florida law, they must take into consideration a variety of issues that affect the cost of right-of-way. In addition to the land itself, other costs of the right-of-way acquisition process include costs for title searches and reports, owner's appraisals, business damages, outdoor advertising, attorney fees, administrative settlements, court costs, relocation costs, property security, demolition, asbestos surveys and abatement, and clean up for contaminated sites. In addition, attorneys may contact property owners directly and assist them in obtaining the highest possible returns. The combination of high growth and encouragement to litigate has the Florida Turnpike Enterprise anticipating that almost 75 percent of right-of-way cases will file for litigation (15). The high cost of litigation combined with the 12 person jury for eminent domain cases, has contributed to high awards.

Unclear Documentation

The purchase of access rights is a technique used by every state transportation agency. Most state transportation agency design manuals also have requirements for limited access right-of-way at interchanges. However, little is written on the procedures for acquiring access rights. This is because most state right-of-way personnel interviewed for the study indicated they view access rights in the same way they view real property.

To determine how much was spent on limited access right-of-way or whether access rights were purchased at an interchange requires inspection of each parcel negotiation included in an improvement project. In addition, the improvements at interchanges are typically not listed by interchange, but as stand-alone projects. Institutional memory appears to be the most efficient method of obtaining information about specific locations. This creates problems when attempting to value access, inventory existing access rights, or to budget for future limited access purchases.

Valuation of Access Rights

Little literature is available on the valuation of access rights. One study that was identified was a 1995 thesis from the University of Texas which attempted to create a standard methodology for valuation of access rights using an econometric model (16). Researchers found little raw data on what agencies pay for access and encountered several other problems in creating a standard value for access rights, including the lack of standardized reporting of sales data, the site-specific nature of the value, and the lack of a standard definition of reasonable access (16). Courts award compensation based in part on the degree of reasonable access available to the site, which is determined on a case-by-case basis. This complicates the valuation of access rights and results in wide variation in monetary awards.

Individuality of Each Interchange Area

Another issue is that each interchange area is unique, making it difficult to apply a uniform policy for access control or to determine the potential costs of acquiring LA ROW. The design and controls needed at an interchange are dictated by the traffic patterns, topography, and land uses at that interchange. Most state transportation agency staff interviewed for the study agreed that acquiring additional limited access right-of-way would help safety and operations, but many felt it would probably be cost-prohibitive and difficult to budget. The reasons stated were that the value of property is too elastic from site to site and the procedures for purchasing right-of-way rely heavily on negotiations and the courts.

Given these issues, many felt that it would be difficult to determine if the acquisition would be cost effective, short of cost estimating every parcel. Establishing a standard value for the cost of limited access right of way is difficult in practice, given that any average cost would be too high for areas with large vacant tracts of land or too low for areas with numerous small or developed parcels. In addition, even if no land is actually needed for the improvement, the public agency may still have to purchase the entire property rather than simply imposing an access restriction in the deed, if the property does not have existing alternative access or a frontage road is not provided.

An example of the difficulty in determining a typical or average cost for limited access right-of-way can be found at the I-75 and Bruce B. Downs Boulevard interchange, which was the study interchange for the operations analysis component of this study. In 2004, FDOT was involved in improving the interchange and had acquired limited access right-of-way from two property owners at I-75 and Bruce B. Downs Boulevard. These two properties, a donut shop and a restaurant, had no direct access to Bruce B. Downs Boulevard and no property was taken. Both were located on and obtained access via a frontage road that exits onto Bruce B. Downs Boulevard at Donna Michelle Drive. They were compensated to ensure that no access could ever be obtained from Bruce B Downs Boulevard in the future and the property deeds were changed accordingly.

The FDOT's appraiser valued the access rights of the two properties at \$250,000—one for \$100,000 and the other for \$150,000. If the *only* available access to the properties had been on Bruce B. Downs Boulevard, then FDOT would have had to purchase both commercial properties at an estimated cost of about \$4,500,000 and would have also incurred costs to relocate the businesses. FDOT staff note that in a more urbanized location, which is developed with gas stations, auto dealers, and other businesses, right-of-way costs could have exceeded \$80 to \$100 million dollars. In rural settings, where land is still primarily agricultural or low density residential and parcel sizes are relatively large, limited access right-of-way can be acquired at a more reasonable cost.

Another variable is whether the additional limited access right-of-way is acquired before or after the interchange is built. Right-of-way valuation is based upon the highest and best use of the land. The highest and best use after an interchange is constructed is usually intense commercial, and thus the property owner receives a benefit in property use type which further increases the value of the land and the cost to the agency.

Holding the Limited Access Line

Access management administrators interviewed for the study noted problems with “holding the line” on access control. In other words, even when the state transportation agency owns limited access right-of-way, the agency may be pressured to provide breaks during access permitting or inadvertently do so as a result of poor tracking mechanisms. Such breaks in the access control line can rapidly undermine the ability of the agency to prevent further access and in turn result in inadequate access control.

Several respondents indicated that a good tracking mechanism is needed to identify limited access right-of-way that is owned by the agency. Review procedures would also help assure consistent administration and application of access management principles when evaluating requests for a break in the access control line. Efforts are currently underway at FDOT to establish a commitment compliance mechanism through a computer tracking system as part of the environmental streamlining (ETDM) process. For LA ROW, documentation could take the form of a check box on interchange access issues that is part of the project documentation passed on to other divisions involved in the project, along with a note that a limited access right-of-way purchase had occurred and any commitments made.

METHODOLOGY

The objective of the study was to determine whether it is cost effective for FDOT to strategically acquire additional limited access right-of-way at the time an interchange is built, and specifically what benefits could accrue to the State and the traveling public, in light of the potential costs. The methodology, which is discussed in more detail below, included the following basic steps:

1. Identify an interchange with the appropriate characteristics for use in the evaluation;
2. Conduct a traffic operations analysis of the interchange with varying access configurations, to determine the potential impact of access control on the operational life of the interchange;
3. Determine representative crash frequency for interchanges experiencing back-ups due to the proximity of signalized access to off-ramps;
4. Determine typical costs of limited access right-of-way in developed and undeveloped areas, and
5. Conduct a cost/benefit analysis of acquiring varying amounts of limited access right-of-way in light of the potential long term safety and operational benefits, and right-of-way costs.

Site Selection

With the assistance of FDOT, a list of potential sample interchanges was identified for possible use in this study. The team selected the interchange at I-75 and Bruce B. Downs Boulevard (CR 581) due to the availability of recent CORSIM data and the land development and access characteristics in the immediate area. The interchange is located in a high growth area north of Tampa, known as New Tampa, and has experienced considerable development in the immediate area. Figure 6 is an aerial of the interchange. Considerable development has occurred since the aerial photograph was taken.

The existing I-75/ Bruce B. Downs Boulevard (CR 581) interchange is a diamond configuration. The intersections of the I-75 ramp terminals with Bruce B. Downs Boulevard (CR 581) are

signalized. Single lane ramps are currently provided for the southbound off-ramp, the southbound on-ramp, and the northbound on-ramp. The northbound I-75 off-ramp was recently widened to provide a two-lane off-ramp. A 1,800-foot parallel deceleration lane was constructed on the I-75 mainline at the diverge area. Dual left-turn lanes are provided on this ramp for the northbound I-75 to southbound Bruce B. Downs Boulevard (CR 581) movement. Two right-turn lanes are provided on this ramp for the northbound I-75 to northbound Bruce B. Downs Boulevard (CR 581) movement. One of the two right-turn lanes joins the two northbound Bruce B. Downs Boulevard (CR 581) through lanes as a lane addition (i.e., a free-flow lane) resulting in three northbound lanes that continue north of the Donna Michelle Drive. The other right turn lane is located immediately adjacent to the dual left-turn lanes and is subject to signal control.

A signalized intersection at Bruce B Downs Boulevard and Donna Michelle Drive is approximately 1720 feet from the signalized intersection of northbound interchange off-ramp. The high traffic volumes on the Bruce B. Downs Boulevard (CR 581) and I-75 northbound off-ramp resulted in a significant queue on Bruce B. Downs Boulevard and periodic back-ups onto the mainline from the northbound off-ramp—a condition that resulted in the need for reconstruction of the northbound off-ramp. The existing right-of-way on I-75 is 324 feet with the limited access right-of-way extending along the ramps approximately 94 feet from the edge of the travel lane. The existing right-of-way on Bruce B. Downs Boulevard (CR 581) is 200 feet. These factors, coupled with the explosive growth of New Tampa, make the Bruce B Downs Boulevard/I-75 interchange an interesting site for further evaluation.



Figure 6: Aerial photograph of the I-75/Bruce B Downs Boulevard interchange.

Operational Analysis

The original CORSIM files for the interchange were obtained from FDOT for use in evaluating the operational effects of limiting access near the freeway interchange ramp. The models simulated operations at the interchange and its influence area, which includes several signalized intersections along the Bruce B. Downs Boulevard crossroad and a nearby interchange at I-75 and Fletcher Avenue.

After delving into the analysis using the original models, it became clear that the number of variables would make it nearly impossible to isolate the impacts of access control on the operational life of the interchange. For example, a change in access spacing resulting in an average delay reduction for the right turning vehicle of 15 seconds per vehicle, would likely be negligible if it were averaged into the total number of vehicles in the larger network. The presence of a sweeping free-flow right-turn lane also made the interchange configuration somewhat atypical for urban settings, where a wide radius is not typically needed because operating speeds are normally lower.

To more closely model an urbanized interchange, the free right turn lane was removed from the network and the CORSIM data was changed to reflect a standard diamond interchange configuration. Other than this, the number of lanes on the freeway, off-ramp, arterial, and intersection were the same as the actual interchange. Next, the links not affected by the length of limited access right-of-way were removed, as was the off-ramp interaction with an adjacent downstream traffic signal.

The final network includes one direction of the freeway, a small segment of the arterial cross-street, the off-ramp of interest, the corresponding on-ramp, and the downstream traffic signal — just enough links and nodes to properly simulate the interactions of interest. As the analysis proceeded, the spacing was changed between the ramp and the downstream signal, but the total lane-miles in the network remained unchanged. This allowed easy, direct comparisons of the results from the various simulation runs.

Two measures of effectiveness were used to evaluate the effects of the various degrees of access control on interchange operations. These were: 1) Queue Length on the interchange off-ramp; and 2) Vehicle Hours of Delay for the entire network. Obviously, a variety of other variables could also impact interchange operations. To focus the analysis on the impacts of access control, these other variables were considered to be constants and included the following:

- a) Distribution of traffic volumes on the freeway mainline and off ramp,
- b) Percentage of turning movement counts at the intersections,
- c) Proportion of “up” weaving vehicles (vehicles weaving from the freeway off-ramp into or across the arterial traffic),
- d) Proportion of “down” weaving vehicles (arterial traffic that weaves across the entering off-ramp traffic),
- e) Heavy vehicle percentage,
- f) Signal progression effects.

In sum, the final methodology for the operational analysis included the following three steps:

1. Modify the existing interchange configuration to an average urban diamond design, including the elimination of a free flow right-turn opportunity, and then increase the traffic flowing through the interchange area until the interchange fails operationally. To reduce the number of combinations of different traffic volumes on the off-ramp and arterial, the volume on the off-ramp was set the same as the directional volume on the arterial. (Note: A three percent annual growth rate in all traffic was assumed. "Fails operationally" indicates that the off-ramp traffic queue from the interchange traffic signal was observed backing up onto the interstate mainline based on CORSIM simulation.)
2. Model the modified interchange with 200 feet of separation between the freeway ramp intersection and the first signalized intersection on the crossroad (permitting no additional access between the ramp terminus and the intersection) and increase traffic flow until the interchange fails operationally.
3. Continue to model the interchange with the varied access spacing between the freeway ramp intersection and the first signalized intersection on the arterial at 200-foot increments (continuing to permit no additional access between the ramp terminus and the intersection) until the intersection is approximately one-quarter mile downstream, and increasing traffic flow at each increment until the interchange fails operationally.

Based on initial simulation studies, a highly significant correlation was observed between the queue length on the interchange off ramp and length of limited access frontage. The relationship between these two variables reveals how insufficient access spacing causes off-ramp traffic to back into the freeway mainline and create major delays on the interstate. The delay of the entire network could be used to quantify the operational benefits from reduced delay for the varied access spacings.

Safety Analysis

One of benefits for FDOT to acquire additional limited access right-of-way is the potential reduction of traffic crashes on the freeway due to traffic back-ups causing lane blockage. No past studies were found that examined the safety effects of length of limited access frontage on the freeway. To quantify the safety benefit, a safety analysis needs to be conducted to relate crash frequency to the length of access controlled frontage.

The study sites, selected in coordination with FDOT, were interchanges characterized by traffic back-ups onto the freeway mainline due to insufficient separation of signalized access on the crossroad. The objective of the safety analysis was to relate crash frequency to the length of access controlled frontage, and provide an approximate measure of potential crash reduction for the benefit and cost analysis.

Crash data for the study sites were obtained from FDOT for a five year period from year 1999 to 2003. For each site, crash data were obtained for a one-mile freeway section before the off-ramp. That is the freeway segment that would most likely experience safety problems due to short access controlled right-of-way. The study sites are as follows:

- I-295 N/Blanding Boulevard(Duval County)
- I-295 S/Blanding Boulevard(Duval County)

- I-95 S/J. Turner Butler Boulevard(Duval County)
- I-75 N/SR 54 (Pasco County)
- I-4 N/Lee Road (Orange County)
- I-95 N/Commercial Boulevard (Broward County)
- I-95 S/Commercial Boulevard (Broward County)
- I-275 N/Fowler Avenue (Hillsborough County)
- I-275 S/Fowler Avenue (Hillsborough County)
- I-275 N/Hillsborough Avenue (Hillsborough County)
- I-275 S/Hillsborough Avenue (Hillsborough County)

Linear regression models were developed to establish the relationship between the length of limited access frontage and the number of crashes to measure the safety effects of the length of limited access frontage. The models were developed for three different types of crashes including Fatalities, Injuries, and Property Damage Only (PDO).

FINDINGS

Operational Findings

The operational analysis included two parts: (1) effects of the length of access controlled frontage on the traffic back-ups on the interstate; (2) estimated delay savings between varied lengths of access controlled frontage. To test the effect of varied length of access controlled frontage on traffic back ups on the interstate, the length was set from 200 feet to 1320 feet at 200-foot increments. For each signalized access spacing, traffic volumes were gradually increased until the traffic on the off-ramp was observed to back into the freeway mainline.

To reduce the number of combinations of traffic volumes on the off-ramp and arterial, the volume on the off-ramp was set the same as the directional volume on the arterial. Figure 7 illustrates traffic volumes on the off-ramp and arterial that make the interchange fail operationally. For example, when the signalized access spacing was equal to 200 feet, the interchange failed operationally when the off-ramp volume or directional arterial volume reached 1,500 vph.

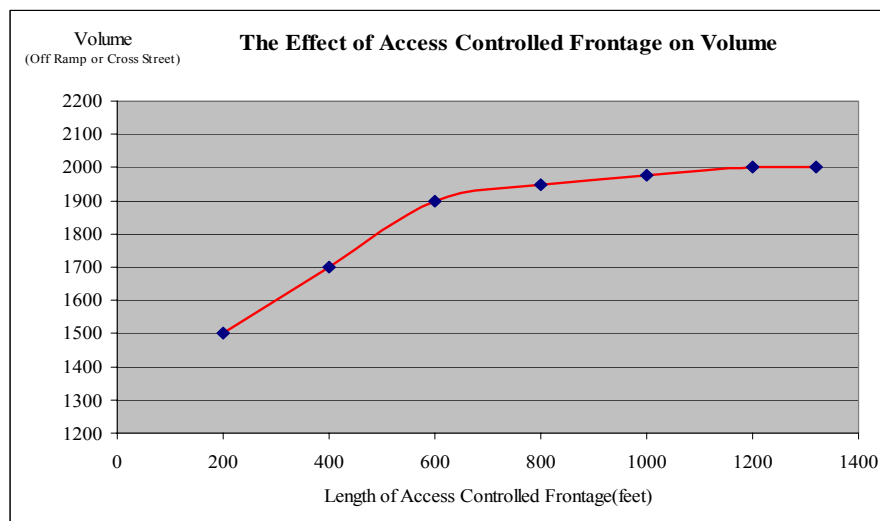


Figure 7: The Effect of Access Controlled Frontage on Volume

As seen in Figure 7, increasing access spacing from 200 feet to 600 feet resulted in the most significant capacity gains, and these capacity gains began to level off between 600 feet to 1320 feet. Volumes on the off-ramp and arterial were increased by approximately 400 vph when the access spacing was increased from 200 feet to 600 feet. Between 600 feet to 1320 feet, volume on the off-ramp increased by about 100 vph. At that point the off-ramp reached its capacity under the assumed geometrics.

Given the study assumptions, including a 3% growth rate in traffic volume, the increase of access spacing from 200 feet to 600 feet would postpone interchange failure for approximately 8 years. Acquiring one-quarter mile of limited access right-of-way could potentially extend the operational life of the interchange for approximately 10 years.

Based on the above analysis, three alternatives for acquiring different lengths of limited access frontage—200 feet, 600 feet, and 1320 feet—were recommended for evaluation in the cost benefit analysis. The difference of total network delay was used to quantify operational benefits of one alternative over the other. The assumptions included a 3% growth in traffic volume per year over a 20 year design life, with no changes to the geometry of the simulation network over the design life of the interchange. A total of 20 CORSIM simulation runs were conducted for each alternative. The results of simulation runs are listed in Table 4.

Table 4: Delay Reduction Between Different Alternatives

Year	Delay for Alternatives (Vehicle-hours)		
	200'	600'	1320'
BaseYear	285	120	105
Year 1	316	141	129
Year 2	352	151	139
Year 3	443	160	158
Year 4	476	173	168
Year 5	569	187	176
Year 6	566	229	183
Year 7	617	271	227
Year 8	620	312	272
Year 9	645	354	293
Year 10	679	399	333
Year 11	753	385	342
Year 12	752	435	367
Year 13	792	429	384
Year 14	809	440	348
Year 15	912	450	417
Year 16	911	466	441
Year 17	915	468	432
Year 18	943	499	459
Year 19	910	487	452
Year 20	921	516	447
Total	13,900	6952	6167
Reduction		6,948	7,733

Safety Analysis

To provide an approximate measure of potential crash reduction for the benefit and cost analysis, regression models were developed to establish the relationship between the number of crashes and the length of limited-access frontage. The total number of crashes on one mile of freeway segment before the off-ramp in the five-year period was used as the dependent variable. The length of limited-access frontage was used as the independent variable.

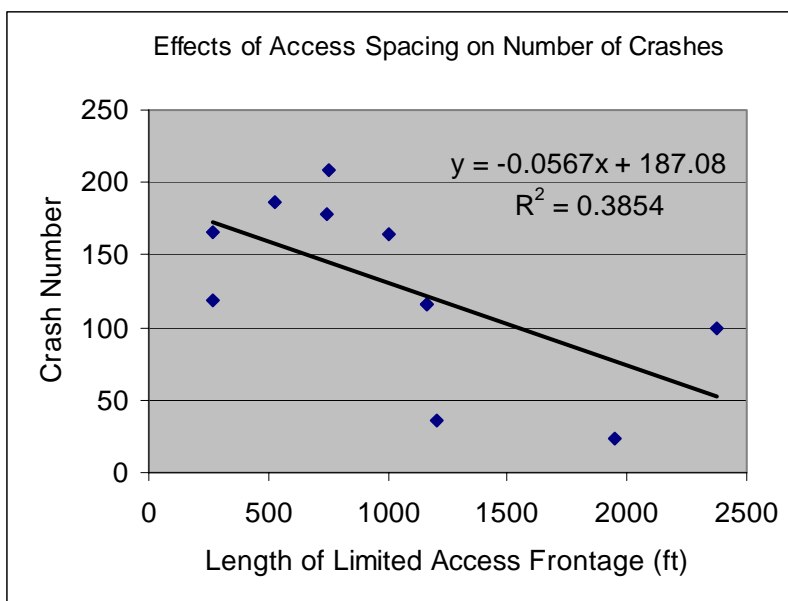


Figure 8: Effect of Length of Limited Access Frontage on the Number of Crashes

Crash data collected at 11 study sites were used to perform the regression analysis. Figure 8 illustrates the relationship between the actual number of crashes in five years and the length of limited-access frontage. It indicates the potential number of crashes that could be reduced when the length of limited-access frontage is increased.

In addition, regression models were developed for estimating the number of fatalities, number of injuries, and number of property damage only (PDO) crashes for different lengths of limited access frontage. Figures 9 to 11 illustrate the trend line for each type of crash.

The crash data collected from 11 study sites showed a consistent descending tendency for three types of crashes (fatality, injury, and PDO) with the increase of length of limited-access frontage. The R-squared values for the regression models are relatively low. The primary reason is that the length of limited access frontage only has an impact on the crashes caused by traffic back-ups onto the freeway mainline. However, it is very difficult to separate this type of crash from the others.

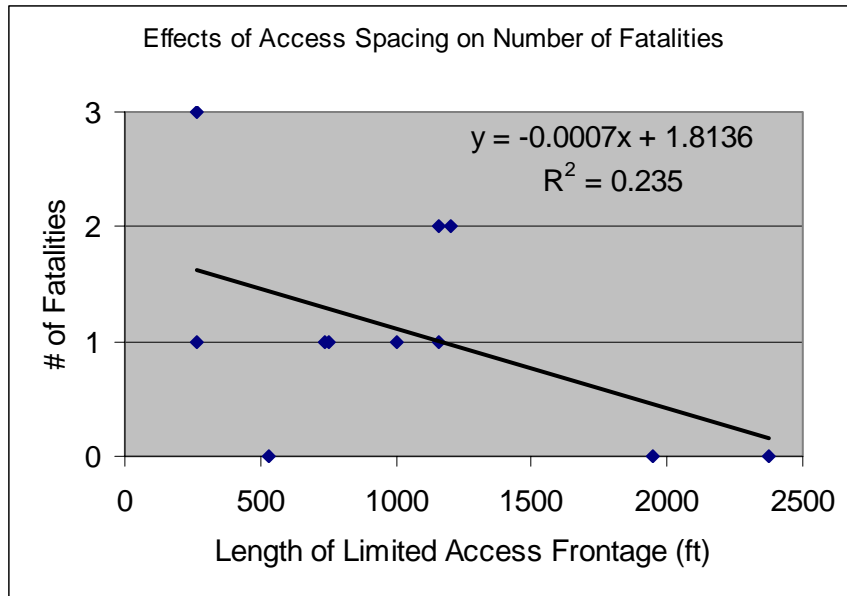


Figure 9: Effect of Length of Limited Access Frontage on the Number of Fatalities

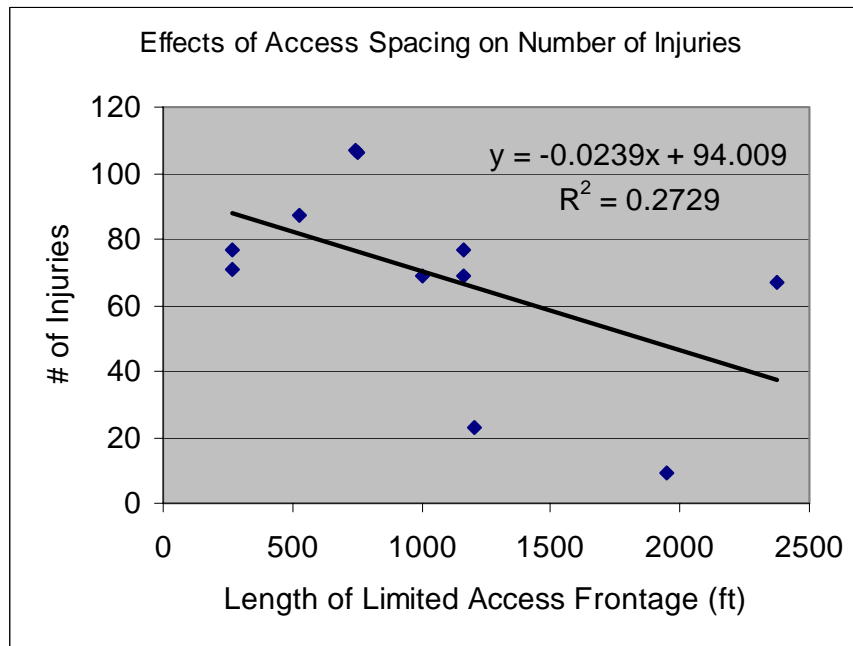


Figure 10: Effect of Length of Limited Access Frontage on the Number of Injury Crashes

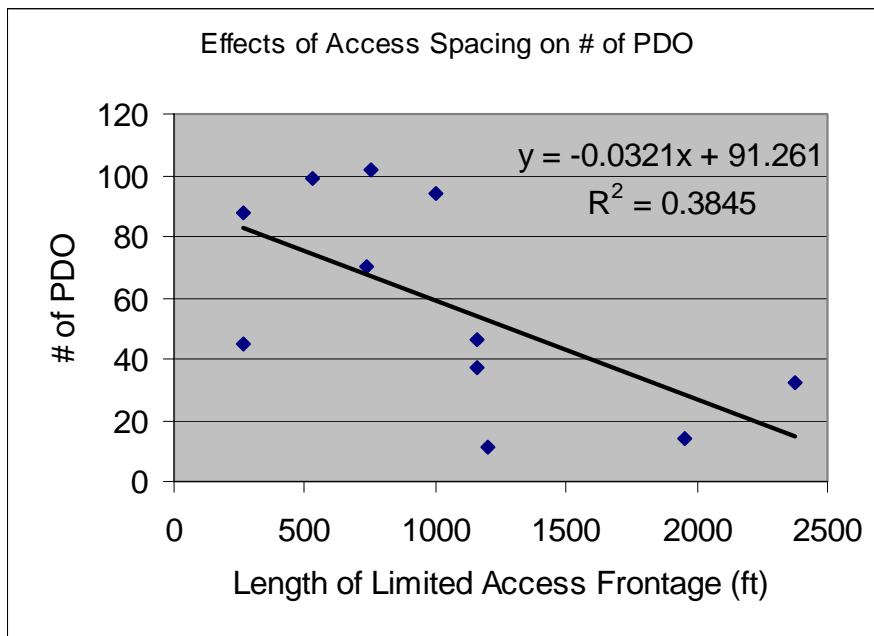


Figure 11: Effect of Length of Limited Access Frontage on the Number of Property-Damage-Only (PDO) Crashes

Cost/Benefit Analysis

The next step in the study was to determine the different costs and benefits associated with purchasing different lengths of limited access right of way at interchanges. The change (usually, an increase) in benefits and costs is used to calculate the benefit-cost ratio.

$$B/C = \Delta \text{ user benefits} / \Delta \text{ investment cost}$$

The cost/benefit analysis compared the following alternatives:

- Alternative A: Purchasing 200 ft of LA Right of Way (Current Practice)
- Alternative B: Purchasing 600 ft of LA Right of Way
- Alternative C: Purchasing 1320 ft of LA Right of Way

Below is an overview of benefits and costs factored into the analysis. The future benefits in each area were converted into present values using the federally recommended discount factor of 7% (17).

Benefits:

1. \$ savings for not purchasing LA ROW on developed land (B1)
 $B1 = \text{Average Cost of ROW Per Front Foot} * 400 / (1 + \text{DiscountFactor})^{20}$
 Where,

B1 = present value of ROW for 400 feet of developed land. 400 feet was believed to be the minimum length that needs to be purchased in order to reconstruct the freeway off ramp area.

2. decreased delay and travel time (B2)

$$B2 = \sum [(\Delta \text{Delay}_i * 1.25 * 2 * 250 * \text{average cost of time}) / (1 + \text{DiscountFactor})^i]$$

Where,

ΔDelay_i = the difference of delay between two alternatives in i years

i = the number of years from the base year up to twenty

Working Days: 250 days per year

Average Cost of Time (\$2002) \$13.25 per person hour

2 refers to 2 PM peak hours per day,

Vehicle Occupancy: 1.25 persons per vehicle

(Source: TTI Urban Mobility Report)

3. fewer accidents (B3)

$$B3 = \sum [(\Delta \text{Fatality}_i * \text{average cost per death} + \Delta \text{Injury}_i * \text{average cost per injury} + \Delta \text{PDO}_i * \text{average cost per PDO}) / (1 + \text{DiscountFactor})^i]$$

Where,

$\Delta \text{Fatality}_i$ = the difference of number of fatalities between two alternatives in i years

ΔInjury_i = the difference of number of injuries between two alternatives in i years

ΔPDO_i = the difference of number of Property Damage Only crashes between two alternatives in i years

i = the number of years from the base year up to twenty

Average cost for each type of crash:

Death: \$1,120,000

Nonfatal Disability Injury: \$45,500

PDO: \$8,200

(Source: National Safety Council 2003)

Costs:

1. Initial cost for purchasing additional LA Right of Way of undeveloped land (C1)

The average costs of ROW per front foot were obtained from the Florida Department of Transportation (FDOT) as follows:

- Average Rural Unimproved: \$500 per front foot
- Average Rural improved: \$1,000 per front foot
- Average Urban unimproved: \$1,625 per front foot
- Average Urban improved: \$15,000 per front foot

B/C Ratio

The benefit-and-cost ratio was calculated for two comparisons: Alternative A (200') vs. Alternative B (600') and Alternative A (200') vs. Alternative C (1320') using the following equation:

$$B/C = (B1+B2+B3)/C1$$

The results of benefit-and-cost analysis are listed in Tables 5-6. It is apparent from these findings that the combined benefits of acquiring additional limited access right-of-way near an interchange in advance of development far exceed the costs of cure after the fact.

Table 5: Benefit-and-Cost Ratio of Alternative A (200') vs. Alternative B (600')

	Urban		Rural	
	Benefit	Cost	Benefit	Cost
ROW (B1)	\$1,550,514	\$650,000	\$103,368	\$200,000
Delay (B2)	\$28,280,906	\	\$28,280,906	\
Crashes (B3)	\$1,809,178	\	\$1,809,178	\
Total	\$31,640,598	\$650,000	\$30,193,452	\$200,000
B/C Ratio	49		151	

Table 6: Benefit-and-Cost Ratio of Alternative A (200') vs. Alternative C (1320')

	Urban		Rural	
	Benefit	Cost	Benefit	Cost
ROW (B1)	\$1,550,514	\$1,820,000	\$103,368	\$560,000
Delay (B2)	\$31,256,063	\	\$31,256,063	\
Crashes (B3)	\$5,065,698	\	\$5,065,698	\
Total	\$37,872,276	\$1,820,000	\$36,425,129	\$560,000
B/C Ratio	21		65	

CONCLUSIONS AND RECOMMENDATIONS

Rapid population growth and escalating right-of-way costs in Florida have potentially dire implications for the ability of the Florida Department of Transportation to keep pace with transportation improvement needs. For interchange areas the problem is particularly acute, given the rapid development that occurs when an interchange is built. If this development is not carefully planned, the resulting access problems can lead to premature interchange failure and safety hazards on the freeway. At that point, reconstructing the interchange may prove cost prohibitive, given the cost of acquiring limited access right-of-way on commercial property.

Interchange areas are a highly valuable and visible community asset that should be carefully managed for the benefit of all users. Although the Florida Department of Transportation regulates access spacing in interchange areas, managing interchange area access through police power alone has certain limitations. Political pressures tend to be high for interchange area access, development is rapid but incremental, making coordinated planning difficult, and land ownership patterns and subdivision practices can limit the effectiveness of state policies. Access permits cannot be denied to individual properties when the result would be to deny all access, unless the property is acquired by the government agency or alternative access is provided.

Given these limitations, it is advisable for state transportation agencies to acquire additional limited access right-of-way (beyond the standard 100 or 300 feet) when the interchange is being planned and before the adjacent land is extensively subdivided and developed. This would help redirect access to more appropriate locations for safety and traffic operations. It would also help encourage the development of adequate internal street and circulation networks to accommodate interchange area development. Those who own businesses or have homes in the interchange area would benefit from improved access design and the lower likelihood that their land would be damaged or needed for interchange expansion. Supporting local government policies and regulations would help accomplish the desired outcomes.

The findings of this study indicate that the long term safety, operational, and fiscal benefits of purchasing additional limited access ROW at interchange areas, significantly exceed the initial up-front costs of acquiring additional limited access right-of-way. This is particularly true for new interchanges in areas where land has not yet been extensively subdivided and developed. The specific findings are preliminary, given the limited data set, the generalized nature of the study interchange, and the limitations of CORSIM. Additional research is suggested to further refine and expand upon the results. Nonetheless, the magnitude of these results suggests that state transportation agencies and the traveling public could benefit greatly by an increase in the amount of limited access right-of-way that is acquired at interchange areas to a minimum 600' and a desirable $\frac{1}{4}$ mile.

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