

**THE USE OF ACCESS MANAGEMENT TO  
PROMOTE ARTERIAL MOBILITY**

by

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## SUMMARY

Traffic congestion on arterial streets has grown to the point where the construction of additional lanes on existing arterials cannot fully alleviate current or future congestion. In conjunction with the continued reconstruction of arterial streets, transportation officials have searched for additional methods with which to improve traffic flow along major thoroughfares. One successful method is access management. Trying to replicate the efficiency and safety of the interstate system, transportation officials have superimposed many of the interstates' access management principles onto the nation's arterial network. Since full access control is neither feasible nor entirely desirable along arterial roadways, effective access management is required to promote mobility while still allowing limited access to abutting property owners.

Access control is an effective method for reducing congestion and is a necessary part of a congestion management system (CMS). Access management techniques include signal coordination, signal spacing, the use of non-traversable medians, the spacing of median openings, the design of unsignalized medial access to prohibit crossings and left-turns, turning lanes, and interparcel circulation. All of these are effective in improving traffic flow and reducing congestion on arterial streets.

Increasing the signalized intersection spacing to uniform intervals of one-half mile and the use of a non-traversable median to restrict left-turns will increase the capacity of a four-lane urban arterial by about 50% as compared to quarter-mile signal spacing and unrestricted left-turns. This is the same increase in capacity that can be obtained by widening a four-lane divided arterial to six lanes. Also, safety will be increased and congestion reduced to a greater extent than by the roadway widening.

Fewer, but better designed, driveways reduce the conflict between turning and through traffic which translates to reduced congestion. It also increases the capacity for traffic to enter the arterial street from adjacent properties. And, interparcel circulation reduces congestion by removing trips from the public street system.

Existing arterials experiencing congestion can be improved through access control measures. However, retrofit programs are often opposed by developments abutting the arterial. Fearing a loss of business due to the installation of a raised median or driveway closure, business owners voice their complaints to the local government officials. The government officials often withhold funding for the projects unless it can be proved that the access control measures will increase the arterial's capacity without diminishing the traffic generated by the business. A two block section of Texas Avenue in College Station, Texas was investigated to determine the impacts of retrofitting the arterial. The study found that a raised median and fewer median breaks would increase the capacity and reduce the number of potential accidents along Texas Avenue without greatly impeding access to adjacent developments.

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# INTRODUCTION

## Objectives

To thoroughly define access management, discuss the methodologies currently being used, and to address the access control techniques needed to relieve congestion on arterial streets, the following objectives will be met:

- Present an overview of the extent of congestion on major arterial streets in the United States.
- Discuss how effective access management can alleviate congestion on arterials.
- Explain and discuss the following selected access control techniques in terms of implementation and benefits: signalized intersection spacing, medial access, and marginal access.
- Provide examples of access management policies on the local and state levels.
- Discuss the obstacles encountered when trying to retrofit access control measures on existing arterials with adjacent development.
- Make recommendations on which access control measure can be used under varying circumstances.

## Scope

The scope of this paper will be limited to researching three access control techniques (signalized intersection spacing, medial access, and marginal access) for major arterials in the United States. A hypothetical case study will be used to emphasize the opposition to retrofit programs and to explain how to overcome this opposition

## Background

Congestion can be defined as the condition where traffic on streets or highways ceases to operate at an acceptable level of service -- speeds diminish and drivers experience delays. Congestion increases vehicle-hours of delay, wastes fuel, and increases vehicular emissions. Roadways operating at or above capacity are the primary cause of congestion. Capacities can be increased to accommodate the traffic demand by the construction of additional lanes and/or by imposing congestion management measures which enhance the flow of traffic along the arterial.

Under the Intermodal Surface Transportation Efficiency Act (ISTEA), all states are required by law to develop a system for identifying, addressing and monitoring congestion. This system is referred to as a congestion management system. Congestion management systems (CMS) are used to: 1) manage or reduce the existing congestion; and 2) prevent

future congestion problems from occurring. CMSs consist of a wide assortment of congestion management measures aimed at reducing congestion.

In the past, the primary measures used to reduce or prevent congestion have been the construction of new street systems or the reconstruction of existing street systems. However, on highly congested roadway sections, reconstruction alone cannot fully alleviate congestion. In response to the growth in congestion and mounting environmental regulations -- most notably the Clean Air Act Amendment of 1990 -- transportation agencies are looking at alternatives that utilize existing arterial streets. Access management techniques are often used in conjunction with roadway reconstruction projects to reduce and manage congestion.

### **Access Control**

For over thirty years the interstate system has been a testament to the benefits of access control. No other system of roadways uses the high level of access control found on the interstates; and consequently, no other roadway system operates as efficiently. Improved capacity can also be achieved on major arterial streets with the implementation of access controls. In the construction or reconstruction of arterial roadways, some degree of access control needs to be designed for -- particularly new facilities where the potential for commercial or office development exists.

Access management relies on the following non-inclusive list of access control techniques to promote efficient vehicular movements:(4,24)

- 1) Limit Number of Conflict Points.
- 2) Separate Conflict Points.
- 3) Limit Deceleration.
- 4) Remove Turning Vehicles from Through Lanes.
- 5) Space major intersections to facilitate progressive travel speeds along arterials.
- 6) Provide adequate on-site storage to accommodate both ingress and egress traffic.

Several access management techniques implement all six of the listed categories in one measure. Of these techniques, signal spacing, medial access treatment, and marginal access treatment (driveway spacing) will be discussed due to their significance and proven proficiency in congestion management.

## Street System Hierarchy

The 1984 edition of **A Policy on the Design of Geometric Highways and Streets** uses functional design rather than the previously followed volume-based design. "The failure to recognize and accommodate by suitable design each of the different trip stages of the movement hierarchy is a prominent cause of highway obsolescence." (1 p.2; 2 p.2) The functional design of streets utilizes the fact that individual elements of a street system do not serve travel independently. A hierarchy exists in the provision of transitions between facilities that is meant to accommodate different degrees of access vs. movement. Each element of a functional hierarchy serves as a collecting/distributing facility for the next higher element of the system. This hierarchal street system provides for the graduation in function from access to movement. Congestion and conflicts occur along major arterials when the transitions are either misplaced or functionally inadequate. Congestion impedes on the function of arterials: to provide movement of traffic. Access to an arterial is controlled to reduce interferences, promote movement, and subsequently reduce congestion.

### Access Control Benefits

An additional benefit of effective access management along major arterials is the improvement in fuel efficiency. The fuel consumption rate per mile is reduced by improving the quality of vehicular traffic flow.(28) Decreasing the number of stops, starts, and their respective accelerations and decelerations improves a vehicle's fuel efficiency. Studies conducted by the Texas Transportation Institute (29) documented the fuel savings as a result of access control measures. The study compared an arterial with half-mile signal spacings and right turns only to an arterial with quarter-mile signal spacings and allowing left and right turns. The arterials considered had the following conditions and results:

#### Conditions:

- Ten-mile section of urban arterial
- 700 vehicles per hour per lane in peak direction
- 55-45 directional split
- Two-hour morning and two-hour evening peak periods
- Speed of 13 mph without access control, 22 mph with access control

#### Fuel Savings:

- Improvements in speed      240,000 gal/yr
- Reduction in delay      335,000 gal/yr
- 575,000 gal/yr

Employing functional design guidelines, access management maximizes steady, uncongested, and safe traffic flows while still allowing access to abutting property. Implementing access management, as a part of a congestion management system for new

major streets, ensures that mobility retains the highest priority. Effective access management also improves traffic safety. The number of conflict points, and therefore accidents, are reduced by careful management of the access points granted along an arterial. Therefore, the ranking of all potential access points according to their functional hierarchy is imperative. The following three access management concerns will be addressed in detail:

- 1) Signalized Intersection Spacing
- 2) Medial Access Treatment (i.e. Unsignalized Intersection Spacing and Mid-block Median Access)
- 3) Marginal Access Treatment (i.e. Driveway Spacing)

The access control techniques will be addressed in the sequence listed previously. The sequence was chosen with regards to the hierarchal classification of intersection associated with each conflict. Traffic signals along major arterials are placed at the intersections of other major arterials. In the hierarchal order of functional classification, unsignalized intersections are a step below signalized intersections of major arterials. Of the three types of intersections discussed, the lowest classification of intersections is the intersection of a major arterial and a driveway. Functional design dictates that intersections be designed in accordance with their hierarchy. In compliance, this report will address the three intersections and their respective access control techniques in a sequence which follows the hierarchal order of design: 1) signal spacing; 2) medial access control, and 3) marginal access control.



## SPACING OF SIGNALIZED INTERSECTIONS

### Introduction

During the planning, design, and operation stages of a signalized arterial street system four variables need to be considered (3):

- 1) Speed of the Progression Platoon
- 2) Signal Cycle Length
- 3) Signal Spacing
- 4) Efficiency of Progression

The capacity of an arterial street depends on the speed of the traffic stream. Maximum flow rates occur at a uniform speed of approximately 35 mph (55 -km/h) to 40 mph (65 -km/h). To accommodate peak hour traffic volumes, the arterial needs to operate within this range of speeds. In addition to capacity considerations, vehicle emissions and fuel consumption are also minimized when speeds range between 35 (55-km/h) and 40 mph (65-km/h). However, during off peak operation, drivers travel at a higher range of progression speeds. On major arterials, traffic operates at 45 mph (70-km/h) to 55 mph (90-km/h) during off peak periods. Therefore, to accommodate both peak and off-peak traffic demands, it is necessary that the signal timing plan maximize efficient traffic flow for a range of speeds.(4)

Stover, Demosthenes and Weesner's "Signalized Intersection Spacing: An Element of Access" states that major arterial streets must be able to operate efficiently under a range of combinations of speeds vs. cycle lengths in order to accommodate traffic volumes as they change over time.(3) A cycle length of about 60 seconds is commonly used during off peak hours. The larger volumes present during the peak hours require a longer cycle length of up to 120 seconds to minimize lost time per phase and therefore reduce the overall delay at the intersection. This lost time results from perception-reaction time at the beginning of the green indication, as well as lost times due to excessive headways between queued cars prior to achieving the minimum headway.

The final variable involved in the planning, design, and operation of signalized arterial street systems is the efficiency of traffic progression (progression band width divided by cycle length). As a consequence of increasing the efficiency, capacities increase and delays decrease. A reduction in stopped and delayed vehicles has a direct impact on lowering speed variance, reducing vehicle emissions, and lowering fuel consumption.(3) The effects of these reductions are obviously beneficial to both the environment and congestion management.

## Optimal Signal Spacing

The effects exhibited by cycle length, signal spacing, and efficiency of progression were analyzed by Stover, Demosthenes, and Weesner (3) using PASSER II-87. The optimum combinations of speed and cycle length for 1/2-mile (0.804-km), 1/3-mile (0.536-km) and 1/4-mile (0.402-km) spacings were determined by varying speeds from 15 mph (24-km/h) to 60 mph (97-km/h) in 5 mph (8-km/h) increments. PASSER II provided the optimum cycle length and phasing through the optimization of the progression band width.(3,4,5,13) The results of these trials are given in Table 1 and Figure 1.

As seen in Figure 1, one quarter mile (0.402-km) spacings can achieve acceptable progression speeds of 30 mph (50-km/h) when using cycle lengths equal to or shorter than 60 seconds. A 1/3-mile (0.536-km) spacing allows for a progression speed of 30 mph (50-km/h) for cycle lengths shorter than 80 seconds. However, these spacings result in low progression speeds, and therefore poor levels of operation, when longer cycle lengths are implemented.(3) The longer cycle lengths are often needed to accommodate left-turn phasings and pedestrian clearance times.

Table 1. Optimal<sup>1</sup> Cycle Lengths  
for Various Speeds and Signal Spacings (3).

Speed mph(km/h)	Signal Spacings		
	1/4-mile (0.402-km)	1/3-mile (0.536-km)	1/2-mile (0.804-km)
15(24)	120 sec		
20(32)	90 sec	120 sec	
25(40)	72 sec	96 sec	
30(48)	60 sec	80 sec	120 sec
35(56)	51 sec	69 sec	103 sec
40(64)	45 sec	60 sec	89 sec
45(72)		53 sec	80 sec
50(80)		48 sec	72 sec
55(88)			65 sec
60(97)			60 sec

<sup>1</sup> Maximum progression efficiency

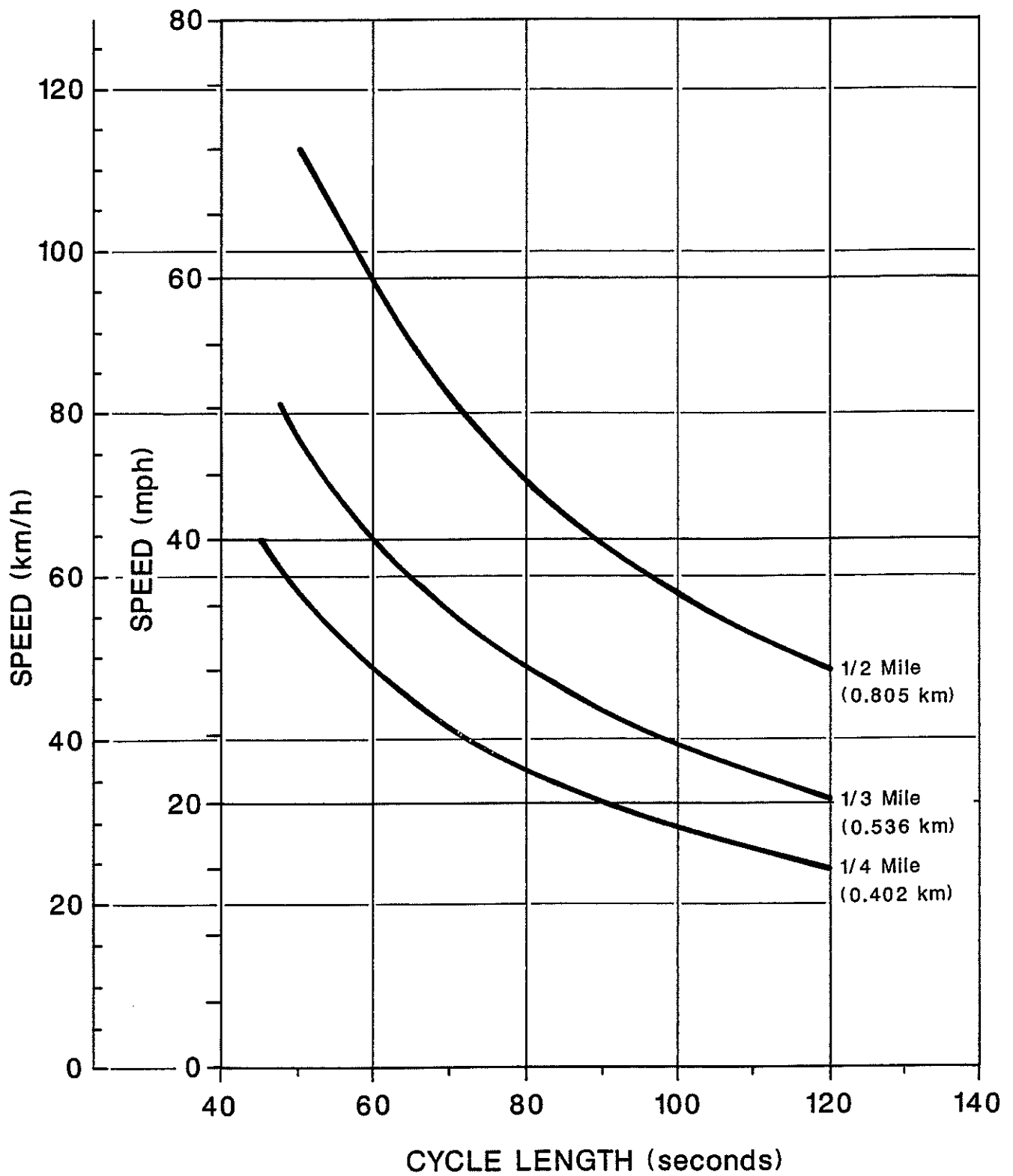


Figure 1. Optimal Signal Spacing as a Function of Speed and Cycle Length (3).

During the peak hour operation of an arterial street system, traffic volumes increase, and a greater demand is placed on the arterial's capacity. Minimizing lost times with longer cycle lengths is an effective means of increasing the capacity of an arterial. Therefore, Figure 1 shows that during peak hour operation with 1/2-mile (0.804-km) signal spacing, the use of a 120 second cycle length provides traffic progression at speeds of 35 to 40 mph (55 to 65-km/h).(4)

The 1/2-mile (0.804-km) spacing also can be used during the off peak hours by utilizing shorter cycle lengths. Cycle lengths less than 120 seconds limit the progression of vehicles to reasonable speeds. Shorter cycle lengths of 65 and 80 seconds result in off-peak progression speeds of 55 mph (90-km/h) and 45 mph (70-km/h) respectively. For 1/2-mile (0.804-km) spacings, cycle lengths shorter than 65 seconds result in speeds which are too fast. Cycle lengths longer than 80 seconds result in speeds which are too slow for off peak operation.(4)

Stover, Demosthenes, and Weesner (3) used PASSER II-87 to generate progression efficiencies for various speeds at 60, 90 and 120 second cycle lengths. These efficiencies were found to decrease rapidly as the spacing departs from the optimum signalized intersection interval. Table 2 shows the decrease in efficiencies with slight variations from the optimal signal spacing (200 feet and 400 feet variances for cycle lengths of 60 and 120 seconds respectively). It was also discovered that as the cycle length increases, the progression efficiency increases. The maximum efficiency obtained using a 60 second cycle was just over 0.30, while for a 120 second cycle, the maximum efficiency rose to approximately 0.34. This increase in efficiency can be attributed to the reduction in lost time due to fewer phase changes.

Table 2. Progression Efficiency (3).

Cycle Length (Seconds)	Signal Spacing (Feet)	Approximate Progression Efficiency
60	1540	0.31
	1340	0.05
120	3040	0.34
	2640	0.08

The Colorado Access Control Demonstration Project compared a 4-lane divided access controlled arterial having 1/2-mile (0.804-km) signal spacing and right-turns only at the 1/4-mile (0.402-km) locations with an uncontrolled access roadway having 1/4-mile (0.402-km) signal spacing and full movement access every 1/8-mile (0.201-km). As shown in Table 3, the controlled access condition displays substantially better traffic flow than the uncontrolled situation. The Florida Department of Transportation has concluded that an

access controlled 4-lane arterial has the same capacity as a 6-lane roadway without access control. (21)

### **Evaluation of 1/2-Mile (0.804-km) Uniform Signal Spacing**

The improvements in both peak and off-peak traffic progression due to the adoption of 1/2-mile (0.804-km) signal spacing has been documented in theory (PASSER II-87) and in practice (Colorado Access Control Demonstration Project). As progression speeds improve, a reduction in delay will follow. It is the opinion of the author that, implementing 1/2-mile (0.804-km) signal spacings with the proper cycle lengths to suit the respective time periods, is the single most effective design tool used to manage congestion on major arterials.

### **Safety Issues**

The safety benefits of long (1/2-mile) uniform signal spacings has yet to be researched in-depth. Many of the newer reconstructed arterials with 1/2-mile (0.804-km) signal spacing are also fitted with other access control measures. This makes it difficult to determine what percentage of the benefits (accident reduction) can be attributed to each measure.

Figures 2 and 3 show the relationship between the number of signals per mile and the number of accidents per million vehicle-miles on four and six lane arterials with either raised medians or continuous 2-way left-turn lanes (C2WLTLs). For each case, the total accidents increased linearly with an increase in signals per mile.(6)

### **Spacing of Signalized Intersections Conclusions**

The 1/2-mile (0.804-km) spacing measure has gained acceptance as an effective way to combat congestion. This is due in part to the success of the Colorado Access Control Demonstration Project. Although other access management controls were also implemented, the spacing of traffic signals was determined to be the most important design element available to increase the throughput of an arterial.(5)

The Colorado Access Control Demonstration Project reported that a 4-lane access controlled divided arterial (1/2-mile (0.804-km) signal spacing and right turns only at the 1/4-mile (0.401-km) locations) would have the same capacity as a 6-lane divided arterial with frequent access (1/4-mile (0.401-km) signal spacing and full movement access every 1/8 mile (0.201-km)). Not including the additional right-of-way costs needed for the six-lane arterial, the estimated cost of the six-lane arterial was 34% higher than the access controlled four-lane arterial.(5) The Florida Department of Transportation conducted a study showing that a typical access controlled 4-lane arterial can accommodate nearly 150% of the capacity found on the same 4-lane arterial without access control.(21)

One issue not yet determined is whether or not the implementation of 1/2-mile (0.804-km) signal spacing onto an unrestricted (limited or no access control) arterial can consistently provide the same benefits highlighted by the Colorado Access Control Demonstration Project. The upgrade in the quality of service obtained through uniform signal spacing is primarily dependent on the rigidity of its placement and on the extent to which other access control measures are implemented.

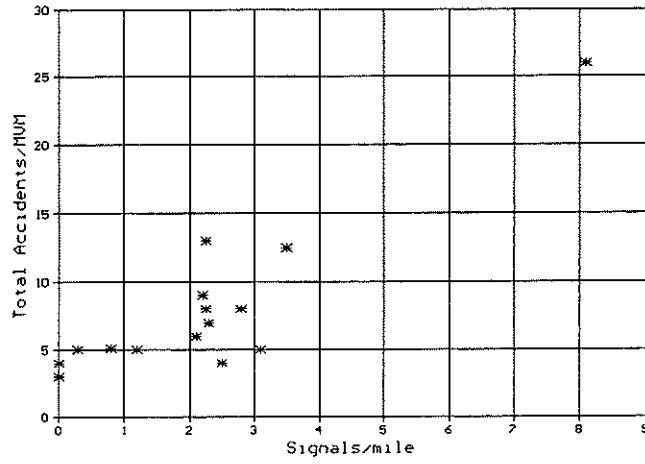


Figure 2a. Raised Median four-lane section (6).

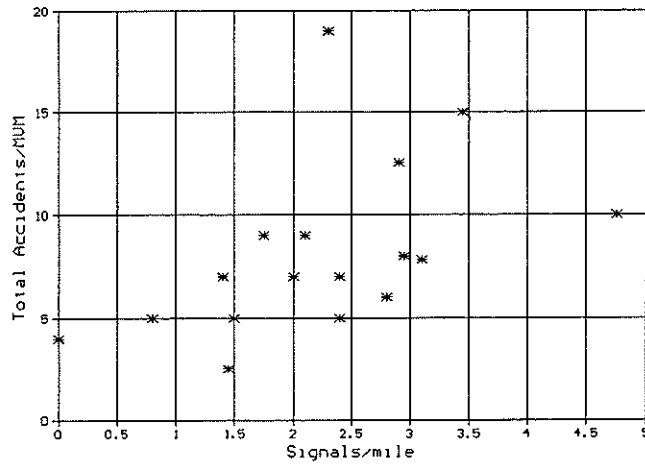


Figure 2b. Raised median six-lane section (6).

Figure 2. Total Accidents vs. Signals/Mile (6).

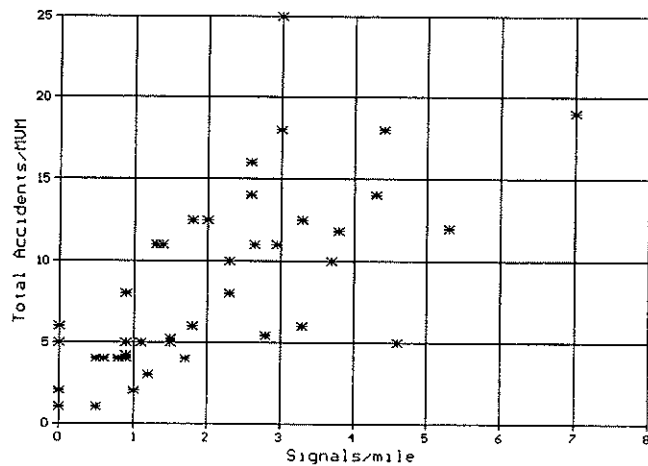


Figure 3a. TWLTL four-lane section (6).

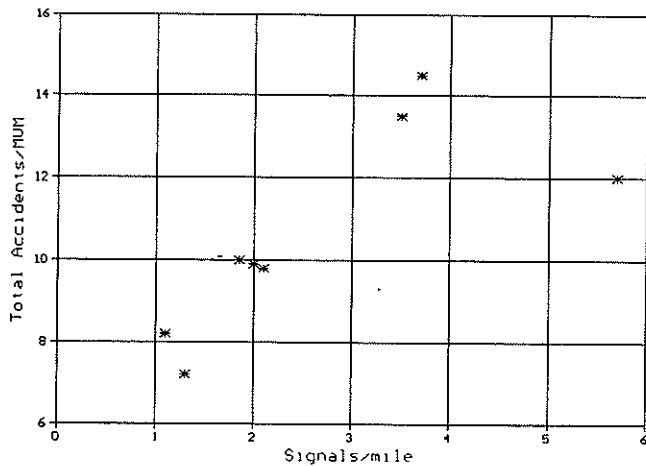


Figure 3b. TWLTL six-lane section (6).

Figure 3. Total Accidents vs. Signals/Mile (6).



## MEDIAL ACCESS

### Introduction

Medians are segments of roadways that separate traffic travelling in opposite directions. Since the median is defined as part of the "travelled way," restrictions in medial access are easier to mandate with the exercise of police power than restrictions on marginal access.(4) The design of medians as an access control measure involves the following elements: median type, median width, the geometrics of median openings, and spacings of median openings.

### Median Types

Median designs fall into the following three classifications; non-traversable, traversable, and continuous 2-way left turn lane. The non-traversable design actively discourages medial crossings using either a raised or depressed median. The traversable design is a flush or slightly raised median which vehicles may easily cross. The continuous 2-way left turn lane is a flush traversable center lane which provides storage for, and allow for deceleration of, left turning vehicles.(4)

#### *Non-traversable*

Although non-traversable medians have numerous design options, the most common urban median is 12 to 20 feet (3.7 to 6.1 metres) wide, with barrier curbs.(7) To provide for dual left turn bays, the width of urban medians needs to be expanded to 28 to 30 feet (8.534 to 9.144 metres). A 28 foot (8.534 metres) median provides two 12 foot (3.658 metres) lanes and a 4 foot (1.219 metres) median. A median width of 28 to 30 feet (8.534 to 9.144 metres) also aids in restricting medial movements by providing adequate width to accommodate medial channelization.(23)

Non-traversable medians are the only positive access control measure to control/restrict left-turns. With the implementation of non-traversable medians, cross traffic and left turning movements on and off the major arterial can be eliminated or restricted to certain locations, and full movement access points are limited to major intersections. This results in three consequences; 1) increasing the throughput capacity of an arterial, 2) discouraging new strip development, and 3) greatly improving traffic safety.(6)

When adding non-traversable medians to an existing arterial, additional delay time occurs for left turning vehicles at the intersections due to the rerouting of mid-block traffic. However, through speeds increase approximately 5 mph ( $\approx$ 10-km/h) with the implementation of a raised or depressed median.(9)

Major arterials with high through volumes are generally the recipients of non-traversable medians. For raised medians, unsafe conditions occur if speeds exceed 45 mph (70-km/h). Rather than guiding the vehicle back onto the roadway, the raised median may cause the vehicle to overturn or go out of control at speeds above 45 mph (70-km/h).(6)

## *Traversable*

As the name implies, traversable medians permit cross traffic and left turns along their entire length using a slightly raised or flush median design. Compared to non-traversable medians, mountable or flush medians pose less of a safety hazard at higher speeds, but are less effective as an access control measure.(7) In areas with traversable medians, drivers often make maneuvers such as crossing or executing left turns despite pavement markings and signing which prohibit these movements. (4) Therefore, since access control is desirable along all segments of major arterials, traversable medians should not be used.

### *Continuous 2-Way Left Turn Lane (C2WLTL)*

Continuous 2-way left turn lane treatments are flush traversable medians that allow maximum left turn access without impeding the arterial's through volume. In doing this, C2WLTLs reduce the delay of left turning vehicles at intersections.(6) Although C2WLTLs improve operational flexibility, they defeat the concept of principal arterials by permitting access along the entire left side of the roadway. C2WLTLs make no attempt to reduce points of conflict along the arterial.(9) C2WLTLs become a real problem when the v/c ratio exceeds 0.8. There are too few gaps to allow unsignalized left turns and yet the turns are not focused at one point.

### **Safety Issues**

When converting from a traversable median to a non-traversable median on an arterial roadway, a shift in accident trends occurs. The new traffic patterns resulting from the non-traversable median dictate a rerouting of all mid-block crossings to the nearest intersection. This results in transposing potential mid-block accidents onto the nearest intersection.(6) By reducing the potential conflict area down to just the functional area of each intersection -- as opposed to the entire length of an unrestricted arterial -- the designer can eliminate a large proportion of potential accidents by concentrating his safety measures at the intersection.

The severity of accidents is diminished when a C2WLTL is replaced with a raised median.(2) A reduction in the number of right angle conflict points due to the raised median is the primary cause in lowering the occurrence of severe collisions. With the installation of a non-traversable median, mid-block rear end collisions -- caused by vehicles turning off the main arterial -- should also decrease.(9)

Table 3 summarizes the accident data analyzed in a Georgia Tech sponsored research project for Gwinnett County Georgia.(8) The study identified 32 raised median sections totaling nearly 48-miles and 50 C2WLTL sections with a total length of almost 75-miles. The objective of the study was to compare accident data on C2WLTL versus raised median treatments to determine whether there is a significant difference in the accident rates. The study concluded that with a confidence interval of 78 percent, four-lane raised-median designs experience fewer total accidents; and with a 95 percent confidence interval, six-lane raised-median arterials are safer.

Table 3. Summary of Accident Data (6).

	Total Accidents			Midblock Accidents		
	C2WLTL	Raised Medians	Percent Change	C2WLTL	Raised Medians	Percent Change
Accidents/MVM						
4 Lane Sections	8.99	7.67	-14.7	3.50	1.34	-61.7
6 Lane Sections	10.82	8.15	-24.7	4.19	1.92	-54.2
Accidents/Mi/Yr						
4 Lane Sections	99.45	70.91	-28.7	38.78	12.39	-68.1
6 Lane Sections	130.26	94.07	-27.8	50.46	22.13	-56.1

Another project investigated the safety effectiveness of replacing a C2WLTL with a raised median on Memorial Drive, a high-volume, six-lane arterial in Atlanta, Georgia. The study showed that, in the year after the median replacement, 300 accidents and 150 injuries were prevented. This resulted in a 37 percent reduction in the total accident rate and reduction of 48 percent in the injury rate.(25)

Previous studies (6,8,25,14,9) have recommended that, due to safety considerations, all future major arterials' geometric designs should include raised medians. The studies also recommended that if existing arterials with C2WLTL have projected ADT's in excess of 24,000 to 28,000, they should be considered for reconstruction with raised medians. The upper ADT limits were selected because there was a dramatic increase in the delay per left-turning vehicle due to the limited number of gaps in the opposing traffic stream at ADT's above 28,000.(8)

When comparing the effectiveness of a C2WLTL treated arterial with that of an undivided arterial, safety studies conducted in Michigan and Arizona both favor the implementation of C2WLTLs(7). These studies indicated that the addition of a C2WLTL to an undivided arterial can reduce the number of accidents by 33 to 36 percent. However, the studies did not give comparable accident rates for C2WLTL vs raised medians.

In addition to improving the traffic flow and vehicular safety along arterials, raised medians also serve as a pedestrian safety measure. Raised medians separate conflicting traffic movements and provide a refuge for pedestrians.(6) Sheltering of pedestrians is especially important on wide arterials with high pedestrian volumes.

As raised medians are constructed, left-turns become concentrated at median breaks. This often brings about opposition from adjacent property owners requesting median breaks for left-turn ingress and egress movements. Interparcel access is often used to accommodate

consolidating left-turn movements of several business at selected median breaks.(8) The individual cities or counties have the responsibility of promoting and/or providing this interparcel access through; joint parking lots, back alleys, driveways, or any combination of these.

### Median width

There are three primary reasons for requiring minimum median widths: 1) separate opposing traffic streams; 2) provide auxiliary lane(s) to decelerate vehicles and store left turning vehicles and U-turners; and 3) protect cross traffic at medial breaks.(7) Table 4 shows the recommended minimum and desired median widths for arterials. Raised medians should be landscaped with a contrasting surface to provide perceptible delineation to drivers. The minimum medial width required for landscaping is 8 to 10 feet.

Table 4. Recommended Minimum and Desired Median Widths For Urban Arterials (14).

Median Function	Minimum Width ft(m)	Desired Width ft(m)
Separation of Opposing Traffic Streams	4(1.2)	10(3.0)
Pedestrian Refuge and Room for Signs and Appurtenances	6(1.8)	14(4.3)
Storage of Left Turning Vehicles		
Single Left Turn Bay	14(4.3)	18(5.5)
Dual Left Turn Bay	25(7.6)	30(9.1)
Protection for Vehicles Crossing or Turning Left	25(7.6)	30(9.1)
Design for Selected Ingress or Egress Movements Only	18(5.5)	30(9.1)
Provide for U-Turns:inside (left) lane to outside (right) lane, passenger cars, 4-lane facility	45(13.7)	45(13.7)
Provide for U-Turns:inside lane (left) to outside (right) lane, passenger cars, 6-lane facility	33(10.1)	33(10.1)
Provide for U-Turns:inside (left) lane to inside (left) lane, passenger cars, 4-lane facility	56(17.1)	60(18.3)

## Spacing of Median Openings

Medial access spacing guidelines are designed to maintain the functional integrity of major arterials. This entails preserving the balance between providing steady and safe traffic flow and still allowing abutting property a degree of access suitable for a major arterial.(24) Median opening spacings are directly related to the existing spacing of signalized intersections, unsignalized intersections, and private driveways. The regulations concerning median opening spacings along a developed arterial where direct driveway access is already present differs greatly from the regulations needed along undeveloped arterials where direct access restrictions can be rigorously enforced to avoid driveway and side street connections.(24)

Examining the variables attributed to a particular arterial determines the spacing of median openings. These variables include; functional classification of arterial and intersecting roadway, progression speed of arterial, design year ADT, and location (suburban or urban area).(14) Using the variables of the existing environment, minimum spacings, based on the distances needed to decelerate and provide storage for left turning vehicles, are calculated and shown in Table 5.(14)

Table 5. Minimum Distance Between Median Openings (14)

Arterial Speed mph(km/h)	Absolute Minimum <sup>a</sup> ft(m)	Desired Minimum <sup>b</sup> ft(m)
	Plus 25 ft (7.6m) per car to be "stored"	
25(40)	140(43)	390(119)
30(50)	190(58)	370(113)
35(55)	240(73)	460(140)
40(65)	300(91)	530(162)
45(70)	360(110)	670(204)
50(80)	430(131)	780(238)
55(90)	510(155)	910(277)

### Notes:

- <sup>a</sup> 8.0 ft/s<sup>2</sup> (2.44 m/s<sup>2</sup>) deceleration rate with 10 mph (16.09-km/h) deceleration in through lane  
<sup>b</sup> 6.5 ft/s<sup>2</sup> (1.98 m/s<sup>2</sup>) deceleration rate with no deceleration in through lane

A study (14) of accident data from 388-miles (620-km) of divided urban and rural highways in North Carolina reported that unrestricted median openings under conditions of low arterial volume, a wide median, and light roadside development are generally not a safety problem.(14) However, with an increase in volume and adjacent land development, the frequency of median openings has a significant impact on increasing accident potential. However, an analysis of the relationship between median openings and accident rates yielded no conclusive results on the optimal medial spacings on 4-lane divided arterials.(14)

Spacings of median openings along arterials should be designed to eliminate or substantially reduce speed differentials found within the traffic. Figures 4a and 4b show the probability of being involved in an accident is minimal when a vehicle is traveling at or slightly under the average speed of traffic and increases as speeds vary from the average. Figure 4a shows the relationship between speed differential and two car, rear-end accidents. Figure 4b highlights that the accident involvement rate increases substantially when a vehicle travels much faster or slower than the average speed of traffic. Research by Solomon (10,11) documented this relationship between speed differential and accidents. 10 mph is used as the upper limit in allowable speed differentials on streets with a functional classification of arterials or higher.

### **Turn Bays**

Turn bays lower the possibility of speed differentials greater than 10 mph. To remove turning vehicles from the traffic stream, turn bays should be provided at all median openings along major arterial roadways.(7) AASHTO specifically states that "Driveways should not be situated within the functional boundary of at-grade intersections. This boundary would include the longitudinal limits of auxiliary lanes."(1) The distance required to eliminate conflicting intersections is the functional length. Four components make up the length of the functional area of an intersection; 1) the length required to store queued vehicles, 2) the length needed to decelerate turning vehicles, 3) the length of the entering taper, and 4) the distance traveled during the perception-reaction (PIEV) time.(2) Figure 5 illustrates the functional area of an intersection. Minimum median spacings are calculated to eliminate any overlap in the functional areas of adjacent intersections (public intersections or private driveways).

### **Medial Access Conclusions**

In terms of safety and capacity, non-traversable medians should be constructed along all major arterials. Constructing arterials 28 to 30 feet (8.5 to 9.0 meters) wide in design provides flexibility. The wider median can accommodate dual left-turn lanes at major intersections and it also facilitates channelization at minor intersections where full movement is not desired. A key element in median design is to limit the number of median breaks allowed per stretch of arterial. Providing turn-bays at these limited median breaks improves the flow of traffic along the arterial by eliminating or reducing the speed differential between through traffic and turning vehicles.

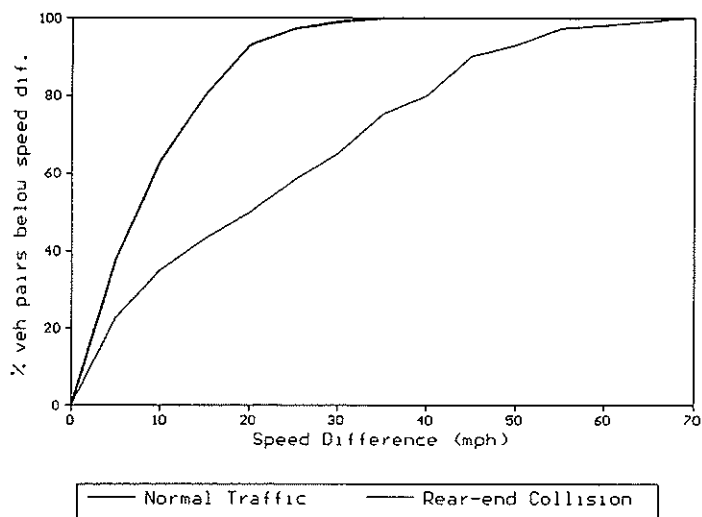


Figure 4a. Incidence of rear-end accidents as a function of speed differential [10].

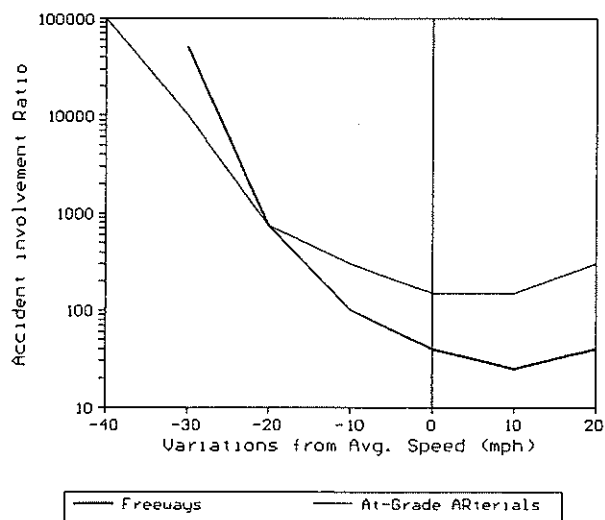
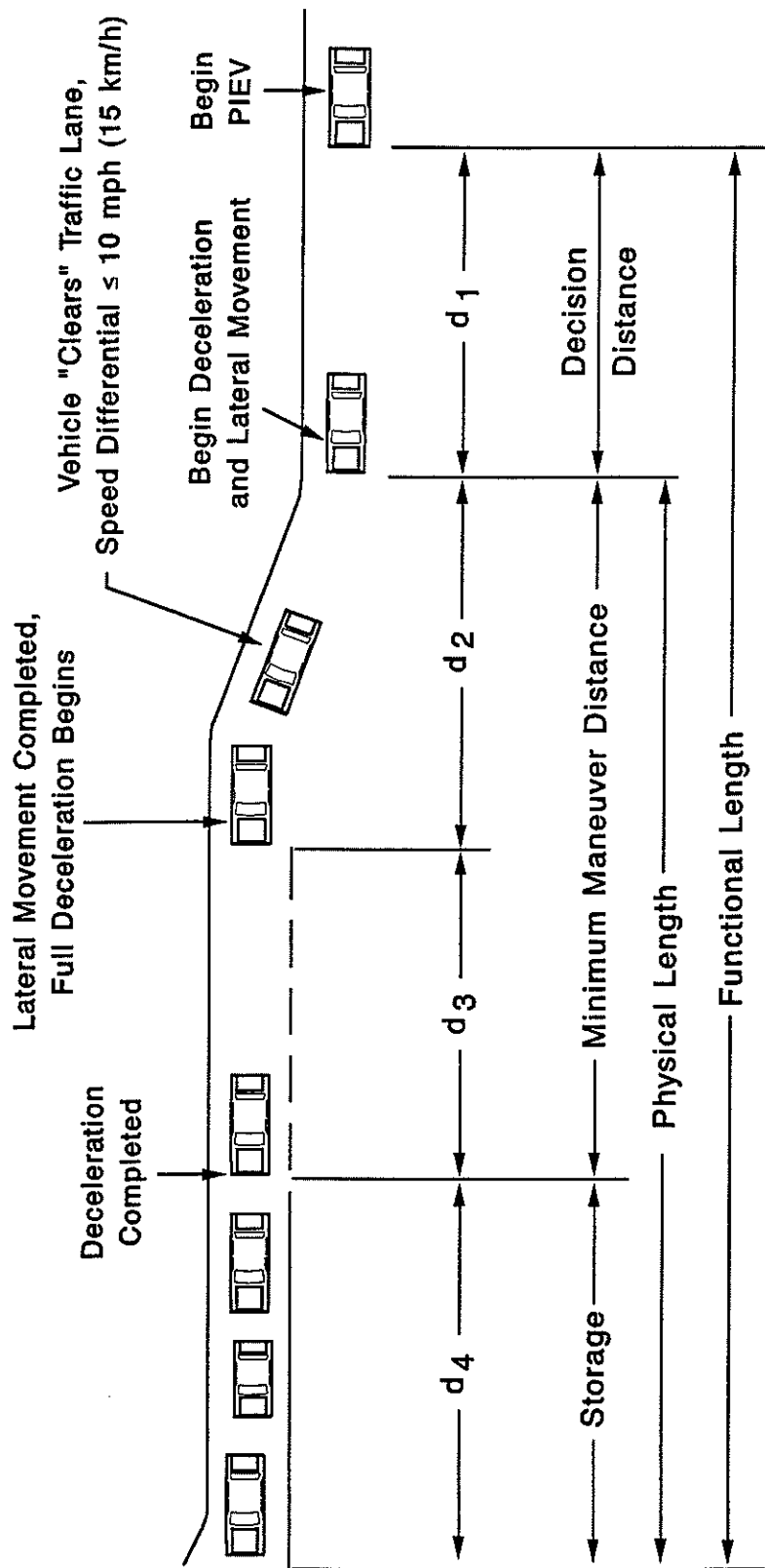


Figure 4b. Accident rate per 100 million vehicle-miles as a function of speed differential [10].

Figure 4. Relationship between Speed Differential and Accidents (10).



- $d_1$  = distance traveled during perception-reaction time
- $d_2$  = distance traveled while driver decelerates and maneuvers laterally
- $d_3$  = distance traveled during full deceleration and coming to a stop or to a speed at which the turn can be comfortably executed
- $d_4$  = storage length

Figure 5. Determinants of the Intersection Maneuver Distance (20).



## MARGINAL ACCESS

### Introduction

Marginal access includes both public and private intersections with the major arterial. Although commercial driveways often carry traffic volumes comparable to public intersections, they have not been designed as such in the past. All intersections, public as well as private, must be designed to enhance traffic flow along the arterial. As with medial access guidelines, marginal access guidelines are established to eliminate or reduce speed differentials greater than 10 mph found between through traffic and right turn ingress and egress movements.

### Capacity and Delay

Uncontrolled marginal access results in reduced roadway capacity. Marginal access describes the access provided to unsignalized intersections caused by either private driveways or public roadways. One source estimates that, "... under average conditions, the capacity of a four-lane arterial street with a 45 mph speed limit will be reduced by one percent for every two percent of the traffic that turns between the right lane and the driveways at unsignalized intersections." (12) Consider the author's following example.

A four lane major arterial has an initial capacity of 1600 vph in one direction without marginal access. Currently the roadway is carrying 1500 vph, which is under capacity. If driveway access were permitted, what would be the effect on the arterial?

Capacity will be reduced by 1% for every two percent of the turns. Assuming 20% turns per mile (10% into driveways and 10% out of driveways), roadway capacity will be reduced by 10%. The capacity with driveway access can be estimated as:

$$\text{Reduction} = 0.10 * 1500 \text{ vph} = 150 \text{ vph}$$

$$\text{Capacity w/Driveways} = 1600 \text{ vph} - 150 \text{ vph} = 1450 \text{ vph}$$

The capacity for the major arterial has been reduced to 1450 vph. Demand now exceeds capacity and congestion will occur along the arterial. Therefore, by allowing marginal access along the major arterial, capacity has been sufficiently reduced to create undesirable levels of congestion.

Another study indicated that multiple driveways at close spacings do not decrease vehicular delay for vehicles turning onto an arterial (14). In addition, contrary to popular opinion, the closely spaced driveways do not increase the capacity of the arterial through lanes to absorb traffic(13). Major and Buckley reported as early as 1962 that for high-volume traffic generators, in order to reduce delay to vehicles entering the traffic stream, driveways must be spaced at distances greater than 1.5 times the required acceleration distance of a normal vehicle (27). The absorption characteristics of the arterial traffic

stream are increased with a wider spacing of driveways. The resulting driveway spacings for various acceleration rates are shown in Table 6.

Table 6. Minimum Spacing between Driveway Access Points to Maximize Egress Capacity (34).

Speed mph (km/h)	Spacing feet (metres)
30 (50)	340 (105)
35 (55)	450 (140)
40 (65)	625 (190)
45 (70)	850 (260)
50 (80)	1150 (350)
55 (90)	1500 (455)

"Under high volume conditions, even a few turning movements will cause serious problems in the through traffic stream." (14, p.44) It is evident from observation that the problem is the number and spacing of the access points more than the number of vehicles. Frequent unsignalized access points of short spacings " . . . result in lower egress capacity from the abutting properties and increased delay to the vehicles waiting to enter the arterial." (14, p. 45) Therefore, by providing adequate spacing between unsignalized access points, capacity and traffic flow will be improved on both the arterial and at the access points. (14)

Marginal access can also impact the capacity and safety of smaller two-lane collector roadways. The East Central Wisconsin Regional Planning Commission (ECWRPC) prepared an access control plan for Waushara County which documented the benefits incurred through the implementation of access control along all classifications of roadways. (26) ECWRPC reported a sharp increase in accidents per mile when the access density (driveways per mile) fell below 300 feet. The accidents per mile along roadway segments with an access density less than 300 feet was nearly three times greater than that of the entire of the roadway system. (26)

### Turn Bays

When marginal access is allowed along major arterials, right turn bays (or continuous right turn lanes) are recommended. As with left turn bays, right turn bays/lanes provide length for vehicles to decelerate without impeding on the mainline through traffic. For safety and capacity reasons, a maximum speed differential of 10 mph is desired. Figure 6 shows the relationship between speed differential and accidents.

In determining the spacing required between marginal access points, the functional area of the intersection must be calculated. The functional area shown for left turn bays in Figure 5 can be repeated for right turn bays -- with one exception for private driveway access. The length provided for storage in the functional area should not be used. Right turn storage should be provided on-site for private access driveways -- provide no on-street storage.(20) However, provide storage when designing for the intersection of two public roadways.

### Safety Issues

Driveways and unsignalized intersections introduce conflicting movements into the traffic stream which affect roadway safety. A study of Chicago suburbs indicated that over 11% of all accidents on major arterials involved turns in and out of a driveway.(12) Other studies have shown similar percentages, such as 14.4% of two-vehicle accidents on county roads in Indiana involved driveways and 6.5% of accidents in Los Angeles county involved uncontrolled driveway access.(15) Another study reported that each accessible driveway along an arterial street adds between 0.1 and 0.5 accidents per year, and driveway accident rates decrease as the number of accessible driveways is decreased.(16)

In a recent article from an FHWA report on access management, safety research indicated that there was a direct correlation between the accident rate and the number of uncontrolled access points, as shown in Figure 6.(17) As the number of businesses and driveways increase per mile, the accident rate increases accordingly. Therefore, to reduce the accident rate on major arterial roadways, driveway access must be limited and controlled. Another study (21) reinforced the correlation between accident rates and driveway spacing. This data is shown in Table 7.

Table 7. Effects of Driveway Spacing on Accidents (21).

	Accidents per Million Kilometres Traveled
0-12 Access Points per Kilometer	1.2
Over 12 Access Points per Kilometer	2.5

Uncontrolled driveway access along high volume arterial streets results in an increased accident rate, lower roadway capacity and increased vehicular delay for turning vehicles. All of these problems result in some form of arterial congestion. Therefore, controlled driveway access should be included as a necessary part of a congestion management program.

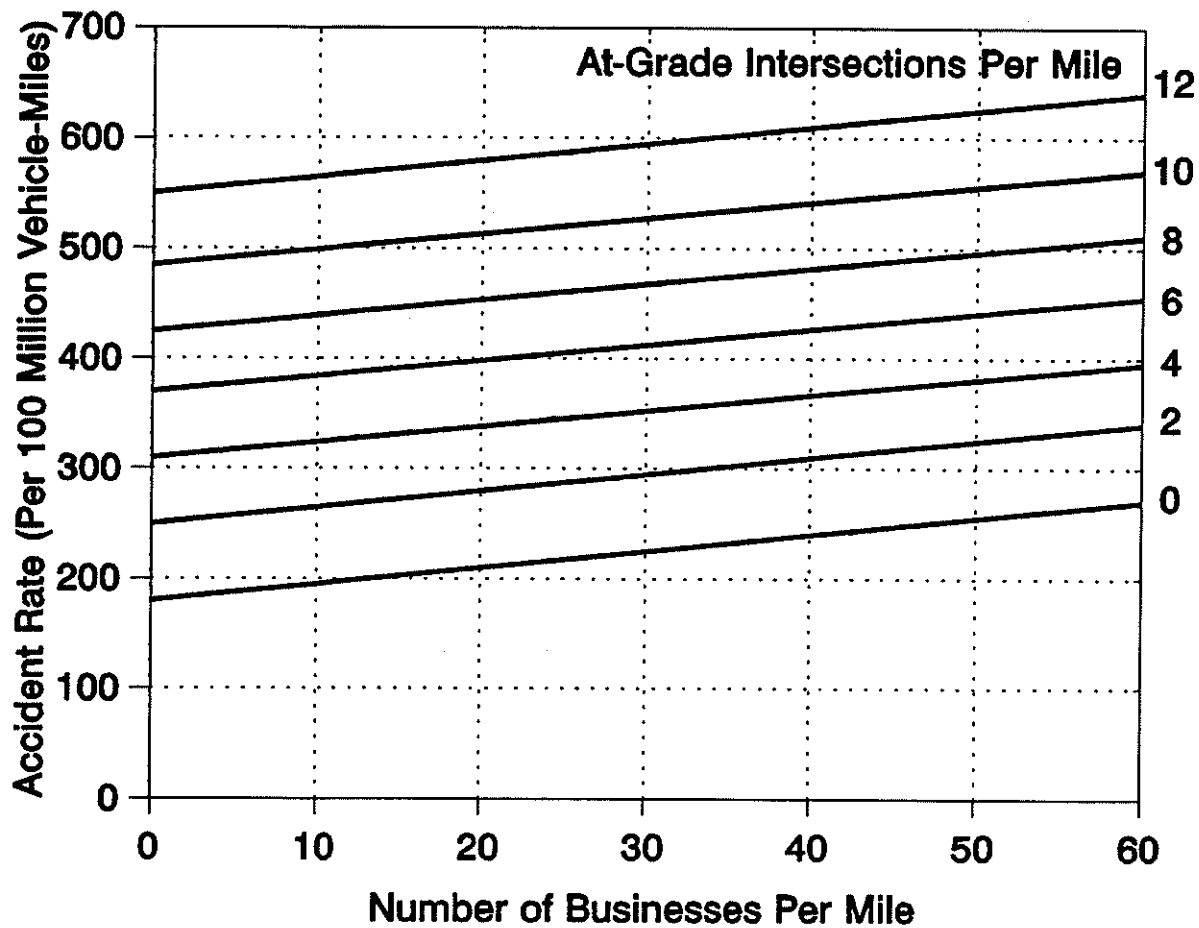


Figure 6. Accident Rate on 4-lane Divided Arterials Due to Uncontrolled Access (7).

## **Marginal Access Conclusions**

Efficient marginal access management generates the same overall benefits obtained from medial access controls. Higher traffic volumes are able to operate safely by reducing the speed differential between through volumes and turning vehicles. The two primary access control measures used are:

- Based on the speed of the arterial, mandate minimum spacings to be allowed between intersections.
- Provide turn bays at all intersections.

Numerous safety studies cited within the report have documented the benefits of implementing marginal access control measures.

## ACCESS MANAGEMENT PRACTICES

### Introduction

Access management guidelines as congestion management measures have been implemented at both the states and local levels. A discussion of state practices has been covered in a previous Access Management session, and therefore only a few of the states with active programs will be mentioned in this paper.

### State Practices

Colorado, New Jersey, and Florida are the nation's leaders in obtaining legislative support for their access management programs. Each state's access management program uses various combinations of criteria to determine marginal and medial access -- there is no one criteria used by all agencies. Either the posted speed limit, ADT, the functional class of the arterial, or a combination of the three is the dominant criteria used in developing spacing requirements. In April of 1992, New Jersey published the *New Jersey State Highway Access Management Code* in compliance with the "State Highway Access Management Act" of 1989. (19) The State of Florida DOT uses trip generation to determine: impact fees; "significant change" in land usage; and access features needed. (22) Impact fees are used to increase private sector participation in the financing of public infrastructure -- primarily street-related improvements. Several years ago, high growth areas such as California and Florida first began to implement the usage of impact fees. When private interests and public policy desires increased growth, public financing is often not able to keep abreast of the infrastructure needs generated by desired growth. Impact fees help to bridge the financial gap.

### Local Practices

Many local communities and counties have taken the initiative in developing access control plans or ordinances independently of any state mandates.

In Wisconsin, the Waushara County Access Planning Committee, in conjunction with the East Central Wisconsin Regional Planning Commission and the Wisconsin Department of Transportation, developed the *Waushara County Access Control Plan*. (30) Waushara County is rurally situated and contains two major roadways -- one is divided. Based on accident studies, the report recommends the incorporation of driveway access spacing into the county's zoning and subdivision ordinances. Also recommended is the need to consider specific corridor-related access management strategies for sections of the county with high development potential.

In Illinois, Lake County may regulate the access to county highways by abiding by the Lake County Board regulations and using the authority granted by the laws of the State of Illinois. (31) Lake County may restrict access or require the use of an indirect access to serve a property through the use of its police power. The standards and specifications found within the *Lake County Highway Access Regulation Ordinance* were written to provide for

the efficient flow of traffic, reduce congestion on public roadways, and serve as a safety measure. In an effort to maintain and promote economic growth within the county and also finance the necessary roadway improvements, Lake County approved the *Fair Share Road Improvement Impact Fee Ordinance*.

The Northwest Municipal Conference (NWMC), a corporate organization representative of municipalities and townships chartered within the State of Illinois and Cook County, developed a Model Traffic Mitigation Ordinance to ensure reasonable and safe levels of service within and between the individual communities.<sup>(32)</sup> As the name implies, the document is intended to serve as a model ordinance which each community can modify to attend to their individual transportation needs. Any proposed developments requesting land use or zoning changes are required to submit a Traffic Impact Study to determine whether adjacent major arterials and the local roadway network can uphold safe and reasonable levels of service. To ensure efficient traffic flow between communities, the model ordinance stressed the importance of individual municipalities maintaining the continuity of major arterials.

### **Access Management Practices Conclusions**

The benefits of access management cannot be argued. However, in cases of retrofitting arterials, state and local agencies are often faced with opposition from adjacent property owners and the affected businesses who do not wish for any restrictions to be placed on their access. The ideal situation entails passing ordinances restricting access to arterials. This methodology is most effective when done prior to the development along an arterial, but it is also effective when used in a retrofit program.

Local governments often make land use and transportation decisions which affect access control along state highways. Mutual goals between local and state agencies often expedites the process of receiving support for access control measures at the political level. Cooperating agencies need to work together to develop long-range access control plans in areas with potential for extensive development.<sup>(33)</sup>

## LEGAL ISSUES

### Introduction

Many of the access management techniques mentioned must be retrofitted for use on existing arterials. Actions such as street closures, restricting midblock crossings, or eliminating driveways often angers abutting property owners. Businesses argue that any reduction in access will result in decreased patronage, and residents complain about being rerouted to and from their homes. Local jurisdictions need legal precedence when faced with possible lawsuits from adjacent businesses and residents.

### Restricting Side Street Access

Increasing the efficiency of arterials by restricting or prohibiting conflicting vehicle movements at selected side streets causes the side street traffic to be rerouted to the nearest major arterial. The intersection of major arterials can then be designed to accommodate the traffic in an efficient manner. If a cross street is interfering with the traffic flow of a arterial while benefiting only the low volumes on the side street, the net effect of that street remaining open is burdensome and dangerous. Stanhagen and Mullins (18) reported that in these situations, it is generally the law throughout the country that roads and streets be vacated or closed if they are burdensome, useless, inconvenient, or unsafe.

### Restricting Midblock Left Turns

Left turning movements into and out of the arterial's traffic stream is a major cause of interference and congestion. Preventing left turns between major intersections requires either construction of a raised median or else making left turns illegal without changing the physical structure of the arterial. Two legal issues are raised under these circumstances: Does the local government have the authority to restrict access? What rights do the abutting property owners have when access restrictions are imposed? (18) Stanhagen and Mullins (18) reported that if the prohibition of left turn ingress and egress movements promotes public safety and convenience, is valid exercise of the police power and does not require the compensation of affected landowners.

### Restricting Access to Driveways

Although the courts agree that an abutting property owner has a right to construct a driveway to the public street, they often disagree as to its application. Some courts have allowed the denial of a driveway to one street so long as reasonable access was provided to another street. However, other courts have ruled that there is an absolute right of access to every abutting street. The latter alternative draws a sharp line and leaves no room for interpretation. The first scenario is dependent on what criteria are used to determine the reasonableness of the alternative driveway. Factors that conjecture the loss to the abutting owner versus the gain to the highway users are weighed.(18)



## RETROFIT PROGRAMS

### Introduction

Transportation officials agree unanimously that effective access management increases the throughput of arterials. In the construction of new arterials along undeveloped corridors, there is relatively little opposition to access control measures as compared to retrofitting an existing arterial with the same access control measures. Implementing access control techniques on existing roadways is usually very difficult. Right-of-way limitations are frequently encountered. Political acceptance is difficult to obtain with opposition from adjacent property owners. The problems of applying access control to a developed arterial is more of a political challenge than an engineering challenge.

### Signalized Intersection Spacing Retrofit Programs

The only retrofit program available for signalized intersection spacing is the removal of unwarranted traffic signals. The removal of unwarranted signals will improve safety, reduce maintenance costs, and generally improve the flow of traffic along arterial roadways.(4) Removing signals to improve the uniform spacing of signalized intersections has the same benefits associated with the 1/2-mile spacing previously discussed (i.e. reduced stopped delay, increased fuel efficiency, lower vehicular emissions, and increased capacity along the arterial).

Opposition to the removal of traffic signals is extreme due to the anticipated decrease in safety perceived by the public. Drivers are accustomed to the signalized intersection; and often expect an increase in accidents, despite traffic studies on the intersection which indicate otherwise.

Retrofitting 1/2-mile signal spacing onto an existing street network is possibly the least achievable retrofit measure. Intersections along arterials are often spaced at irregular intervals; and in urban areas, the intersections are generally spaced less than 1/4-mile apart. Removal of the signals is highly unlikely at these locations where arterials intersect. This makes it nearly impossible to achieve progression on any of the arterials.

### Medial Access Retrofit Programs

Constructing a raised median on an existing arterial along a developed corridor is a politically charged decision. Left-turns entering and exiting driveways account for 70% of all driveway accidents and substantial amount of delay.(34) Although accidents and delays will be reduced with the median installation, business owners, without a median break opposite their entrance, often anticipate a financial setback due to a loss of customers. Before and after studies in three Texas cities found that after non-traversable medians were installed on arterials, some businesses experienced a decline in sales while others had increases in sales.(35,36,37) It is the opinion of the author that, if provisions for U-turns are made in the redesign of the intersections, the accessibility to the developments abutting the arterial should only decrease slightly, if at all. In addition, the overall impact on the

businesses will remain the same. An increase in traffic on the arterial due to the raised median will provide developments with greater exposure to pass-by shoppers.

### **Marginal Access Retrofit Programs**

The first step in controlling driveway access along arterials is to develop an effective driveway permit program. This ensures that all developments wishing to create or alter a driveway must obtain a permit from the appropriate jurisdiction which has the authority approve, disapprove, and assure compliance with the permit program's specifications. Implementing a permit program can only regulate new driveways or changes to existing driveways.

Marginal access controls installed as retrofit programs are difficult to accomplish. Adjacent business owners vehemently oppose any changes in their access to the arterial. They often fear that any driveway closures or consolidations will result in substantial financial losses due to the loss in traffic imagined with the access modification. Obstacles such as this nearly impossible to overcome unless it can be shown that the driveway modifications will not only improve safety and increase capacity along the arterial, but also that the changes will not adversely affect the adjacent developments.

### **Case Study: Texas Avenue, College Station, Texas**

To highlight potential retrofit programs, their benefits, and the constraints which limit them, a two block section of Texas Avenue in College Station, Texas will be used as a hypothetical case study for the implementation of access control measures. The section of Texas Avenue to be investigated lies between two arterials -- George Bush Drive and Harvey Road.

Currently, this section of roadway has a C2WLTL with "spaghetti" medians (raised, one foot wide medians) at the intersections of George Bush, Harvey and Dominik Drive. There are numerous curb cuts for driveways along the east and west sides of Texas Avenue. The greatest problems observed during heavy volume operations are the conflicts resulting from left-turns at Dominik and along the C2WLTL. Dominik Drive lies within the functional area of the George Bush Drive intersection. Neither Dominik nor George Bush have adequate room to provide sufficiently long left-turn bays. Consequently, both intersections experience poor levels of service.

To improve the flow of traffic along Texas Avenue without investing in additional acquisitions of right-of-way, a raised median should be constructed. One median break needs to be provided midway between Harvey and George Bush, but no median break should be provided at Dominik Drive. To compensate for the elimination of left-turns along the Texas, the median breaks at Harvey, George Bush, and midblock need to be designed to accommodate U-turns. Signal removal is inappropriate for this situation, and the current driveway spacing does not warrant any closings or consolidations.

The retrofitted two block section of Texas Avenue will show an improvement in safety resulting from a decrease in potential left-turn conflicts. The flow of traffic will

increase, but the increase will be limited by the non-access controlled sections of Texas Avenue abutting either side of the two block study section. Greater improvements would be recognized with the construction of a raised median along the entire length of Texas Avenue.

### **Retrofit Programs Conclusions**

During any retrofit process, it is imperative to keep the public informed. Negative reactions from businesses are generally found where a signal is removed, a median is installed, or excess driveways are closed; and it is necessary for all involved parties to have a full understanding of the realistic projected impacts and benefits associated with the proposed retrofit programs prior to the implementation. The information provided must be documented by an engineering study containing an economic evaluation of the impacts on the adjacent businesses.

As stated previously, any financial losses suffered due to a loss of direct access, can be compensated for with greater exposure due to an increase in throughput along the access controlled arterial. However, this trade-off is difficult to convey to the affected businesses and their political representatives.

## CONCLUSIONS

One of the greatest problems encountered along undeveloped roadways is the belief that low volume arterials will tolerate more direct land access because they provide less through movement. However, as traffic volumes increase, the direct access will prove to be a hinderance. It is easier to start without access than to try to retrofit an arterial and take accesses away from businesses and residents at a later date.(9)

Achieving a long range access management plan requires cooperation between local and state agencies and developers. Although developers often want unlimited access for their clients, the experienced developers also realize the long term benefits and marketability of efficient access control -- high volumes on adjacent arterials entices business owners with the prospect of drawing customers off of the roadway.

Access control measures work best when transportation agencies are supported by legal precedence. Ordinances preventing future access and police power eliminating existing access give local and state agencies the authority to restrict access efficiently.

## RECOMMENDATIONS

Maximum flow rates along arterial streets occur when traffic is operating at a uniform speed of roughly 35 mph (55-km/h) to 40 mph (65-km/h). Fuel consumption and emissions are also minimized under these conditions. To accommodate peak hour volumes, traffic speeds need to fall within this range. In achieving these speeds, a long uniform signal spacing of 1/2-mile (0.804-km) is essential to develop signal timing plans which will provide for efficient traffic progression. A 120 second cycle length allows traffic progression speeds of 35 to 40 mph (55 to 65-km/h) with 1/2-mile (0.804-km) signal spacing. The 1/2-mile (0.804-km) signal spacing is the single most effective design tool used to manage congestion on major arterials.

All new or reconstructed major arterials should be designed with non-traversable medians. A non-traversable median is the only medial design which provides positive access control measure. Non-traversable medians can be designed to only allow openings at selected locations. Full medial breaks should be placed at all 1/2-mile (0,804-km) signal locations, and partial breaks may be allowed every 1/4-mile (0.402-km). Partial breaks utilize channelization to restrict allowable turning movements. To accommodate channelization and dual left-turn bays at signalized intersections, a minimum median width of 28 to 30 feet (8.534 to 9.144 metres) is recommended.

Marginal access restrictions are often harder to implement due to the property owner's right to access. Interparcel access can alleviate this problem by condensing several access locations into one intersection. The spacing of marginal access locations varies according to the speed of the arterial. Marginal access points require either right-turn bays or continuous turn lanes to eliminate speed differentials greater than 10 mph (16-km/h).

Access management retrofit programs are politically charged and generally difficult to implement. Successful retrofit programs require cooperation among the jurisdictional agencies and the public. Retrofit programs improve the safety and increase the capacity along arterials without decreasing the business of the adjacent developments.

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