Incorporating Access Management into the Texas Transportation Institute's Urban Mobility Report

by

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ABSTRACT

The Texas Transportation Institute's Urban Mobility Report has provided an easy-to-understand view of urban transportation congestion issues for nearly 20 years. In recent years, operational treatments, high-occupancy-vehicle lanes, and public transportation facilities have been incorporated into the study to include the effects of these treatments on reducing delay and improving mobility. Delay reduction factors have been used for the operational treatments to reduce the incident and/or recurring delay for each of these treatments by an appropriate percentage. Access management is the latest mobility tool to be incorporated in the study.

This paper describes the importance of access management and how the use of access management is being incorporated into the study. Specifically, the presence of a raised median is being incorporated. Raised medians are a common access management treatment that reduce vehicular conflict points along arterial roadways. Highway Performance Monitoring System (HPMS) is the primary data source for the Urban Mobility Report, and the HPMS database includes the presence of a raised median for the 85 urban areas in the study. Using National Cooperative Highway Research Program (NCHRP) Report 395 as a basis, recurring and incident delay factors were computed by signal density and congestion level for the condition with a raised median in comparison to when a two-way left-turn lane (TWLTL) is present. Incorporating a raised median resulted in a net delay reduction.

It must be noted that the Urban Mobility Report results (and methodology) are most appropriate at the areawide level. For specific corridors, the delay reduction factors for any of the operational treatments may not be appropriate. Researchers at the Texas Transportation Institute continue to evaluate the delay reduction factors for all of the operational treatments as new literature becomes available.

OVERVIEW OF THE URBAN MOBILITY STUDY

For nearly 20 years, the Urban Mobility Report has provided an easy-to-understand view of urban transportation congestion issues. The study, and associated reports, identify several significant trends on urban mobility and provides information to the discussion of problems and solutions at the local, state, and national levels.
The study uses data from federal, state, and local agencies to develop estimates of congestion and mobility within an urban area. The methodology developed by several previous research studies (*1-5*) yields a quantitative estimate of urbanized area mobility levels, utilizing generally available data, while maximizing the use of existing databases.

The Urban Mobility Report methodology primarily uses the Federal Highway Administration's Highway Performance Monitoring System (HPMS) database, with supporting information from various state and local agencies (*6*). The HPMS database is used because of its relative consistency and comprehensive nature. State departments of transportation collect, review and report the data annually. Since each state classifies roadways in a slightly different manner, TTI reviews and adjusts the data to make it comparable and then state and local agencies familiar with each urban area review the data.

The Urban Mobility Report procedures have been modified to take advantage of special issue studies that provide more detailed information, but the assumptions used in the methodology do not fully account for the effect of all operational improvements. Comparisons between cities are always difficult and the local and state studies are typically more detailed and relevant for specific areas. The procedures used in the report are more applicable for comparisons of trends for individual cities, rather than any value for a particular year.

The continuing goal of the research study that produces the Urban Mobility Report is to develop a set of mobility performance measures, the tools to use them in a broad set of applications and guidance on how to utilize several sources of data to create a complete picture of urban transportation conditions. To satisfy this goal, on-going research tasks include a variety of transportation, land use, economy and other concerns as a way to encompass the decision-making factors of individuals, businesses and agencies. Objectives of these tasks include:

1. Refining the methods, data and measures used to estimate mobility concerns at the urban area and corridor level of detail.

2. Developing performance measures that can be used to inform several different technical and non-technical audiences about attributes of a variety of urban transportation solutions. Testing the measures and producing guidance documents for including the effect of the solutions into mobility performance measures.

3. Identifying relationships between transportation system operations and other important decisions made by urban residents such as home or office location and economic activity indicators.

To further analyze urban mobility, operational improvements and the effects of public transportation and high-occupancy vehicle facilities have also been incorporated into the study in recent years. This paper describes the incorporation of the latest treatment into the Urban Mobility Report methodology—access management.

INCORPORATING OPERATIONAL IMPROVEMENTS AND TREATMENTS TO REDUCE TRAVEL DELAY

The Urban Mobility Report procedures provide estimates of mobility at the areawide level. The approach that is used describes congestion in consistent ways using generally available data allowing for comparisons across urban areas or groups of urban areas. Past procedures only looked at projects that added lanes or reduced demand and overlooked many other types of projects that affected the demand characteristics. Volume 2 of the 2003 Urban Mobility Report (*7*) extends the procedures to several other treatments and even to public transportation. The goal is to include all improvements, but good data are necessary to accomplish this.

The Volume 2 report describes a framework for incorporating treatments and shows effects of those treatments. It is important to note that these two pieces should be viewed separately. The Volume 2 report was a "first attempt" at showing the benefits of such projects and programs at an areawide level. The methodology for analyzing the treatments is developing just as transportation systems are also in a constant growth and development cycle. The results from the analysis could easily change as the research proceeds in this area.

The operational improvements and treatments to reduce delay in the Urban Mobility Report include (*7*):

1. Ramp Metering—improves the ability of the freeway to maintain relatively high speeds under conditions of high demand and postpones the onset of congestion.
2. Traffic Signal Coordination—Traffic signal coordination programs reduce delay by allowing more vehicles to maintain a smooth flow—particularly in the peak direction.
3. Incident Management Programs—Quickly detecting and removing crashes and vehicle breakdowns reduces delay by returning traffic capacity to normal levels.
4. High-occupancy Vehicle (HOV) Lanes—Providing reliable high-speed travel improves mobility levels in the corridors where HOV service is available. The HOV travel volume and speed statistics have been added to the current roadway system database for each area to produce an areawide reduction effect.
5. Public Transportation Service—Including public transportation service in the mobility measures is accomplished with two methods. One method is to include the percentage of on-time transit riders in the uncongested roadway travel categories. The other is to transfer transit riders into private automobiles and recalculate the mobility measures to estimate the increased congestion levels.

Three factors are key to estimating the mobility effects of operational treatments:
1. Area covered by the treatment—how much of the system has the treatment?
2. Density of the treatment within the covered area (particularly as it applies to patrol programs)—how often is the area patrolled, updated or viewed?
3. Delay reduction effect—how much effect does the treatment have?

The procedures used to estimate travel delay can be modified by these factors to estimate new values that more accurately reflect the mobility contributions of the treatments. Further, the delay reduction factors are applied to either (or both) the recurring or incident delay, depending upon what is appropriate for the operational treatment (i.e., freeway service patrols and surveillance cameras are applied only to the freeway incident delay and traffic signal coordination is applied to principal arterial recurring and incident delay). The area and density factors can be estimated from HPMS, and the ITS Deployment Tracking Survey (IDTS) database will be used when specific project effect information is not available or may be used to supplement specific project information. The ITS Deployment Analysis System (IDAS) contains the tracking information and methods used by the U.S. Department of Transportation to evaluate ITS systems nationally.

Access management is the next delay-reducing roadway treatment being incorporated into the Urban Mobility Report. Research has documented the benefit of access management techniques. Further, many states are benefiting from access management practices. Therefore, there was an interest in including access management into the Urban Mobility Report methodology.

WHY INCORPORATE ACCESS MANAGEMENT?

Access management is the balancing of access to land with the traffic mobility needs of the roadway. It includes a set of tools that help protect public investments in roadways and improve safety. Primary access management tools and techniques include the location, spacing and design of unsignalized intersections (cross streets and driveways), raised medians and median openings, signalized intersections, and acceleration/deceleration lanes. Access management is primarily discussed in the context of the non-freeway environment although freeways (limited-access facilities) can also benefit from appropriately spaced exit and entrance ramps.

Figure 1 demonstrates the balance between traffic movement and land access. It indicates that facilities on the "upper end" of the functional class spectrum are oriented primarily for traffic movement (e.g., freeways). These facilities primarily exist to get motorists from Point A to Point B without interruptions and limited access locations. The "middle" of the spectrum (arterials and major collectors) includes a combination of both traffic movement and access. This is where typical access management treatments (e.g., raised medians, driveway consolidation) can provide the most improvement to roadway performance when applied. At the "bottom" of the spectrum are local streets and cul-de-sacs which primarily serve to provide access to residential land.

Conflict points are locations where two vehicle paths may intersect or influence one another. Access management techniques reduce conflict points and also manage the location of potential conflict points to enhance roadway capacity and mobility. Reducing conflict points reduces crash potential. Therefore, reducing the number of driveways and controlling the location of driveways can provide for improved mobility and reduced incidents along a corridor. Recent research has documented the relationship between access points per mile and crash rates (*9*). This relationship, shown in Figure 2, indicates that doubling the number of access points per mile from 10 to 20 results in a 30 percent increase in the crash rate. The same research summarized representative crash rates by median type and the total number of access points to the roadway. This is shown in Table 1. The table is based upon work previously completed and documented in National Cooperative Highway Research Program (NCHRP) Report 395 entitled, "Capacity and Operational Effects of Midblock Left-turn Lanes" (*10*). The table shows that the non-traversable (raised) median has a lower crash rate potential than the two-way left-turn lane (TWLTL) and undivided roadways.

The benefits of access management techniques have been realized in many states for decades. Many states have implemented comprehensive access management programs and related design standards to support access management techniques by design and/or through municipal development regulations. Colorado, Florida, New Jersey, and Oregon are recognized throughout the nation as leaders in the implementation of access management. Numerous other states have recently reviewed, or are reviewing, statewide policies and practices related to access management and related rules and regulations. A few of these states include Michigan, Minnesota, Montana, Ohio, Texas, and Wisconsin, among others.

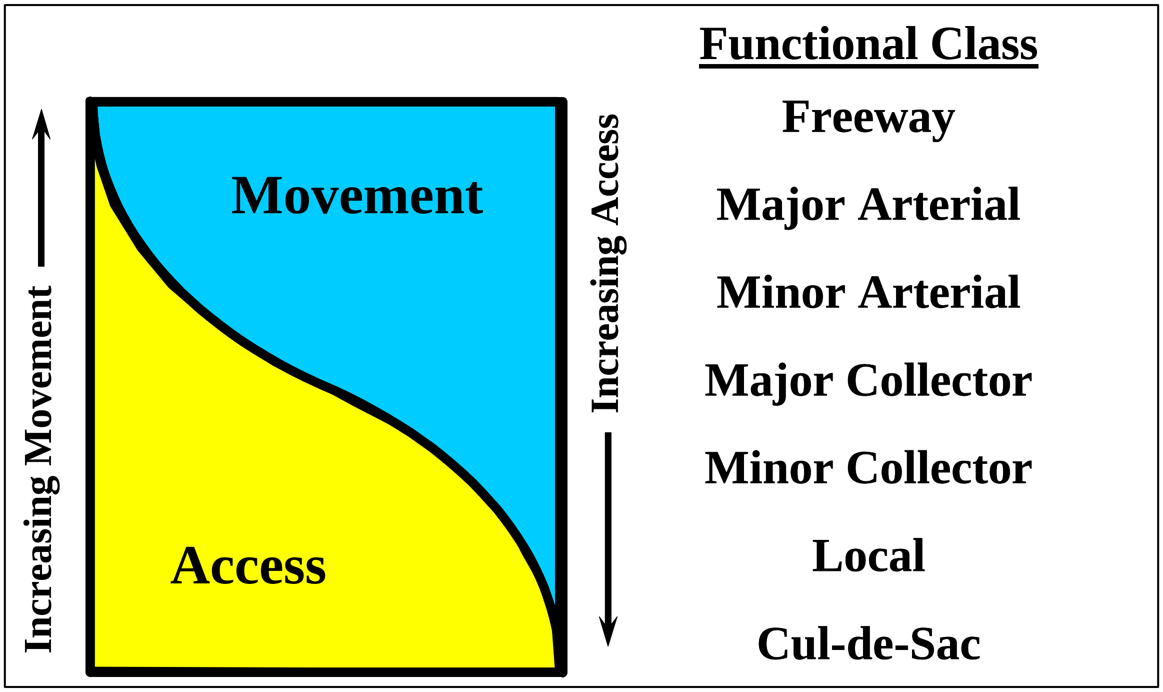

FIGURE 1 Hierarchy of roadways in a functionally designed system (adapted from Reference *8*).

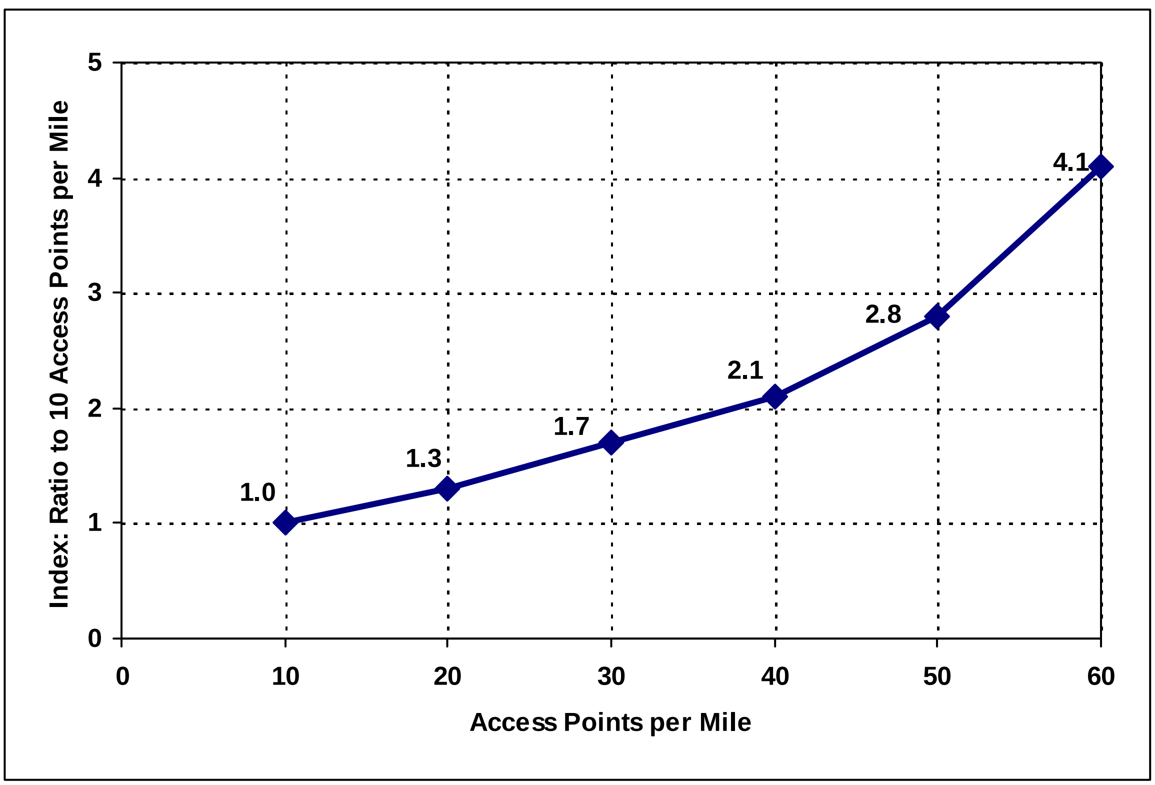

FIGURE 2 Relationship between access points per mile and indexed crash rates (Reference *9*).

TABLE 1 Representative Crash Rates (Crashes per Million VMT) by Median Type (Reference *9*)

Total Access Points per Mile[1]	Median Type		
	Undivided	Two-way Left-turn Lane	Non Traversable Median
≤ 20	3.8	3.4	2.9
20.01-40	7.3	5.9	5.1
40.01-60	9.4	7.9	6.8
> 60	10.6	9.2	8.2
All	9.0	6.9	5.6

[1]Includes both signalized and unsignalized access points.

PROCEDURE FOR INCORPORATING ACCESS MANAGEMENT INTO THE URBAN MOBILITY STUDY

Necessary HPMS Data Items

The inclusion of access management into the Urban Mobility Report methodology incorporates the effect of raised medians being present and whether the signal density is relatively high or low. Consideration was also initially given to providing benefit to driveway consolidation into the methodology as well. However, it was found that the HPMS data related to access control (for raised median inclusion) were more complete than for access point density (for driveway consolidation inclusion). It is intuitive that for the purposes of HPMS reporting, roadway characteristics within the roadway (HPMS item "Median Type") may be more complete than those adjacent to the roadway (HPMS item "Number of At-grade Intersections"). Further, the number of at-grade intersections is separated into, 1) signalized intersections (HPMS item #92), 2) stop-controlled intersections (HPMS item #93), and 3) intersections with no control (HPMS item #94), and it is not clear whether, and to what extent, driveways would be included in HPMS item #93 or #94 to get an access point estimate.

HPMS item "Median Type" (HPMS item #56) includes coding as 1) curbed, 2) positive barrier, 3) unprotected, and 4) none (*11*). For purposes of the methodology, those data coded as either "curbed" and "positive barrier" were combined and considered the "raised median" locations, and those data coded as either "unprotected" or "none" were combined and considered as the "TWLTL" locations.

Data from NCHRP 395

NCHRP Report 395 (*10*) was the primary reference used for estimating the delay reduction benefits for access management (i.e., raised median inclusion). NCHRP Report 395 provides a recent and comprehensive evaluation of the operational and safety impacts of mid-block left-turn lanes, and, subsequently, median treatment (i.e., raised median or TWLTL). The research is panel-reviewed and also included geographic representation that is typical of national research performed through NCHRP. For these reasons, the research team was comfortable with using this reference for estimating the delay reduction factors.

NCHRP Report 395 published useful tables that summarize the results of the operations model developed as part of the study. The operations model output annual delay (hours/year) to major-street left-turn and through vehicles for each median condition (raised, TWLTL, and undivided). The table includes the delay for a given percent of left-turning traffic, access point density, ADT and number of lanes. These tables are shown for the raised median in Table 2 and the TWLTL in Table 3. Report 395 also published similar tables with the annual crash frequency for each median condition in crashes/year. The table provides the crash frequency for a given property-damage-only crash percentage, access point density, ADT and land use. These tables are shown for the raised median condition in Table 4 and the TWLTL condition in Table 5.

The analyses are performed for a 1,320-foot (0.25-mile) segment, and NCHRP Report 395 indicated that these results can be extrapolated to larger segments. The analysis only includes delay to major-street left-turn and through vehicles. Cross-street traffic is not handled in the analysis. This is acceptable because the HPMS data are for traffic on the major roadway only, and traffic information on the cross-street is not included. Subsequently, the origin-destination patterns of vehicles are not known. This information would be necessary to include cross-street traffic impacts in locations where they interact with the major roadway.

TABLE 2 Annual Delay to Major-street Left-turn and Through Vehicles for the Raised Median Treatment (hours/year) (Reference *10*)

Through Lanes	ADT	Access Pt. Density[1] (ap/mi)	Left-Turn Percent per 1,320-ft Segment Length[2]					
			0	5	10	15	20	30
4	17,500	30	300	400	800	1,000	1,200	1,600
		60	300	400	800	1,000	1,300	1,700
		90	300	400	800	1,000	1,300	1,700
	22,500	30	500	800	1,300	1,700	2,000	2,700
		60	500	800	1,400	1,800	2,200	2,900
		90	500	900	1,400	1,800	2,200	2,900
	27,500	30	800	1,300	2,100	2,700	3,200	4,400
		60	800	1,300	2,300	3,000	3,600	5,000
		90	800	1,500	2,300	3,000	3,600	5,000
	32,500	30	1,200	2,000	3,100	4,000	4,900	6,900
		60	1,200	2,100	3,500	4,800	5,900	8,500
		90	1,200	2,200	3,400	4,700	5,900	8,400
	37,500	30	1,600	2,900	4,400	5,900	7,300	10,600
		60	1,700	3,100	5,300	7,300	9,300	13,800
		90	1,800	3,200	5,100	7,200	9,300	13,500
	42,500	30	2,200	4,100	6,100	8,400	10,700	16,100
		60	2,400	4,600	7,600	10,900	14,200	21,800
		90	2,500	4,500	7,300	10,600	14,100	21,200
6	26,250	30	300	800	1,300	1,800	2,100	3,200
		60	400	900	1,400	2,000	2,400	3,200
		90	400	900	1,400	2,100	2,500	3,500
	33,750	30	500	1,400	2,300	3,200	3,900	5,800
		60	700	1,500	2,600	3,500	4,400	6,200
		90	700	1,500	2,600	3,700	4,500	6,500
	41,250	30	900	2,200	3,700	5,300	6,700	9,800
		60	1,200	2,500	4,300	5,900	7,700	11,500
		90	1,200	2,500	4,300	6,100	7,500	11,300
	48,750	30	1,400	3,400	5,600	8,500	11,200	16,200
		60	1,800	4,000	6,800	9,400	12,700	20,700
		90	1,800	4,000	6,900	9,700	12,200	19,400
	56,250	30	2,100	5,000	8,400	13,300	cong	cong
		60	2,500	6,100	10,400	14,500	20,400	cong
		90	2,600	6,100	10,500	14,800	19,100	32,000
	63,750	30	2,900	7,100	12,200	cong	cong	cong
		60	3,400	9,000	15,500	21,800	cong	cong
		90	3,500	8,900	15,600	22,000	29,200	cong

Notes:
[1]Access point density represents the total number of access points on both sides of the street segment (i.e., a two-way total) divided by the length of the segment (in miles).
[2]Total number of left-turns per hour exiting the major street into an access point in one direction of travel per 1,320-ft length of roadway divided by the total flow rate in that direction (expressed as a percentage).
"cong" = Delays to one or more major-street left-turn movements are in excess of 40 s/v/a leading to congested flow conditions, queue spillback, and possible gridlock.

TABLE 3 Annual Delay to Major-street Left-turn and Through Vehicles for the TWLTL Median Treatment (hours/year) (Reference *10*)

Through Lanes	ADT	Access Pt. Density[1] (ap/mi)	Left-Turn Percent per 1,320-ft Segment Length[2]					
			0	5	10	15	20	30
4	17,500	30	300	400	800	1,000	1,200	1,600
		60	300	400	800	1,000	1,300	1,700
		90	300	400	800	1,000	1,300	1,700
	22,500	30	500	800	1,300	1,700	2,000	2,700
		60	500	800	1,400	1,800	2,200	2,900
		90	500	900	1,400	1,800	2,200	2,900
	27,500	30	800	1,300	2,100	2,700	3,200	4,400
		60	800	1,300	2,200	2,800	3,400	4,600
		90	800	1,500	2,200	2,800	3,400	4,700
	32,500	30	1,200	2,000	3,000	4,000	4,900	6,800
		60	1,200	2,100	3,200	4,200	5,100	7,100
		90	1,200	2,200	3,200	4,200	5,200	7,400
	37,500	30	1,600	2,900	4,300	5,800	7,200	10,400
		60	1,700	3,000	4,600	6,000	7,500	10,700
		90	1,800	3,200	4,600	6,000	7,800	11,200
	42,500	30	2,200	4,000	6,000	8,200	10,500	15,500
		60	2,400	4,300	6,400	8,600	10,700	16,000
		90	2,500	4,400	6,400	8,600	11,200	16,600
6	26,250	30	300	800	1,300	1,800	2,100	3,200
		60	400	900	1,400	2,000	2,400	3,200
		90	400	900	1,400	2,100	2,500	3,400
	33,750	30	500	1,400	2,300	3,100	3,800	5,700
		60	700	1,500	2,500	3,400	4,300	6,000
		90	700	1,500	2,500	3,500	4,300	6,100
	41,250	30	900	2,200	3,600	5,100	6,600	9,600
		60	1,200	2,500	3,900	5,400	7,100	10,500
		90	1,200	2,500	3,900	5,600	7,000	10,400
	48,750	30	1,400	3,400	5,500	8,200	11,000	15,600
		60	1,800	3,700	5,800	8,200	11,100	18,000
		90	1,800	3,800	5,900	8,500	10,900	17,400
	56,250	30	2,100	4,900	8,000	12,700	cong	cong
		60	2,500	5,300	8,400	12,100	16,900	cong
		90	2,600	5,400	8,600	12,500	16,700	28,400
	63,750	30	2,900	6,900	11,600	cong	cong	cong
		60	3,400	7,400	11,900	17,600	cong	cong
		90	3,500	7,500	12,200	18,000	24,900	cong

Notes:
[1]Access point density represents the total number of access points on both sides of the street segment (i.e., a two-way total) divided by the length of the segment (in miles).
[2]Total number of left-turns per hour exiting the major street into an access point in one direction of travel per 1,320-ft length of roadway divided by the total flow rate in that direction (expressed as a percentage).
"cong" = Delays to one or more major-street left-turn movements are in excess of 40 s/v/a leading to congested flow conditions, queue spillback, and possible gridlock.

TABLE 4 Annual Crash Frequency for the Raised Median Treatment (crashes/year) (Reference *10*)

Land Use	ADT	Access Pt. Density[1] (ap/mi)	Property-Damage-Only Crash Percentage[2]		
			55	65	75
			No Parallel Parking		
Business or Office	17,500	40	3	4	5
		65	4	5	6
		90	4	5	7
	22,500	40	4	5	7
		65	4	6	7
		90	5	6	8
	27,500	40	5	6	8
		65	5	7	9
		90	6	8	10
	32,500	40	6	7	9
		65	6	8	10
		90	7	9	12
	37,500	40	6	8	10
		65	7	9	12
		90	8	10	13
	42,500	40	7	9	12
		65	8	10	13
		90	9	12	15
	47,500	40	8	10	13
		65	9	11	15
		90	10	13	17
	52,500	40	9	11	14
		65	10	12	16
		90	11	14	18
	57,500	40	9	12	15
		65	10	14	17
		90	12	15	20
	62,500	40	10	13	17
		65	11	15	19
		90	13	16	21
Residential or Industrial	17,500	<100	2	2	3
	22,500	<100	2	3	4
	27,500	<100	3	4	5
	32,500	<100	3	4	6
	37,500	<100	4	5	6
	42,500	<100	4	6	7
	47,500	<100	5	6	8
	52,500	<100	5	7	9
	57,500	<100	6	7	9
	62,500	<100	6	8	10

Notes:
[1]Access point density represents the total number of access points on both sides of the major-street segment (i.e., a two-way total) divided by the length of the segment (in miles).
[2]Number of property-damage-only crashes divided by the number of reported crashes for the region in which subject street segment is located (expressed as a percentage).
Shaded areas denote traffic volume levels that exceed the range of the database used to calibrate the safety model.

TABLE 5 Annual Crash Frequency for the TWLTL Treatment (crashes/year) (Reference *10*)

Land Use	ADT	Access Pt. Density[1] (ap/mi)	Property-Damage-Only Crash Percentage[2]		
			55	65	75
			No Parallel Parking		
Business or Office	17,500	40	4	6	7
		65	5	6	8
		90	5	7	9
	22,500	40	5	7	9
		65	6	8	10
		90	7	9	11
	27,500	40	7	8	11
		65	7	9	12
		90	8	11	14
	32,500	40	8	10	13
		65	9	11	14
		90	10	12	16
	37,500	40	9	11	14
		65	10	13	16
		90	11	14	18
	42,500	40	10	12	16
		65	11	14	18
		90	12	16	20
	47,500	40	11	14	18
		65	12	16	20
		90	14	18	23
	52,500	40	12	15	20
		65	13	17	22
		90	15	19	25
	57,500	40	13	16	21
		65	14	19	24
		90	16	21	27
	62,500	40	14	18	23
		65	15	20	26
		90	17	23	29
Residential or Industrial	17,500	<100	3	4	5
	22,500	<100	4	5	7
	27,500	<100	5	6	8
	32,500	<100	6	7	9
	37,500	<100	6	8	11
	42,500	<100	7	9	12
	47,500	<100	8	10	13
	52,500	<100	9	11	14
	57,500	<100	9	12	16
	62,500	<100	10	13	17

Notes:
[1]Access point density represents the total number of access points on both sides of the major-street segment (i.e., a two-way total) divided by the length of the segment (in miles).
[2]Number of property-damage-only crashes divided by the number of reported crashes for the region in which subject street segment is located (expressed as a percentage).
Shaded areas denote traffic volume levels that exceed the range of the database used to calibrate the safety model.

As indicated previously, the delay affect factors for the existing operational treatments can be applied to the recurring and/or incident delay as appropriate. For access management, or the presence of a raised median in this case, the delay factor can be appropriately applied to both the recurring and incident delay because the raised median is expected to affect both situations.

Computing Access Management Delay Adjustment Factors

Adjustment Factors for Recurring Delay

The existing operational treatments provide delay reduction by congestion level, which is computed with the ADT/lane. The difference between the annual delays incurred for different operating conditions with a raised median (Table 2) were compared with those of the TWLTL (Table 3). Therefore, the data in Tables 2 and 3 were summarized to allow for a comparison between the two to determine their percent difference. A five percent left-turn percentage was selected because the Urban Mobility Report focuses on peak-period travel when there would be relatively fewer left-turning maneuvers. The density of 30 access points per mile (both directions) was assumed to be characteristic of a low signal density condition (i.e., 3 signals or less per mile). This equates to approximately 350 feet (centerline measurement) between driveways on both sides of the road. Also note that the driveways are located directly across from one another in the analysis. Looking at Table 2 as an example, the average of the density of 60 access points per mile (approximately 180 centerline feet between driveways) and 90 access points per mile (approximately 115 centerline feet between driveways) for a given ADT were averaged and assumed for the high density condition (i.e., greater than 3 signals per mile). Assumptions were made for a low signal density situation to provide additional delay reduction that might be more representative for the areawide applications typical of the Urban Mobility Report—rather than only considering delay reduction for the high signal density situation. The number of through lanes and ADT are also provided, and this allowed Tables 2 and 3 to be summarized by congestion levels (ADT/lane ranges).

An estimate of the delay by congestion level was obtained for both Table 2 (raised median) and Table 3 (TWLTL), and the percent difference in the values was obtained. The percent difference between the TWLTL and raised median condition is shown in Table 6. The percent difference values shown in Table 6 are increases. In other words, going from the TWLTL to the raised median indicates an increase in travel delay. There is no difference at the moderate congestion level (ADT/lane between 5,501 to 7,000). There is a much lower increase on the 4-lane cross section—a maximum of 5 percent at the "extreme" congestion level for higher signal density. For 6-lane facilities with high density, the increase in travel delay is as high as 20 percent for the "extreme" congestion level. Table 7 shows the weighted average (by lane-miles) of the 4-lane cross section and 6-lane cross section. The results were averaged because only 4-lane data were available for the incident delay reduction factors (discussed next).

TABLE 6 Percent Difference (Increase) in Recurring Delay Going from a TWLTL to Raised Median

Congestion Level	ADT/Lane	Signal Spacing			
		4-lane Cross-section		6-lane Cross-section	
		3 Signals or Less per Mile	More than 3 Signals per Mile	3 Signals or Less per Mile	More than 3 Signals per Mile
Moderate	5,501-7,000	0	0	0	0
Heavy	7,001-8,500	0	0	0	7
Severe	8,501-10,000	0	2	2	12
Extreme	10,001 +	2	5	3	20

TABLE 7 Weighted Average of Recurring Delay Percent Increase

Congestion Level	ADT/Lane	Signal Spacing	
		Combined 4 and 6-lane sections	
		3 Signals or Less per Mile	More than 3 Signals per Mile
Moderate	5,501-7,000	0	0
Heavy	7,001-8,500	0	5
Severe	8,501-10,000	1	10
Extreme	10,001 +	3	15

Table 7 indicates that there is actually an increase in the delay reduction factors for through and left-turning traffic when going from the TWLTL to raised median condition as shown by the weighted average (by lane-miles) percent delay reduction factors. This increase is due to the storage limitations of select turn bay locations with the raised median treatment. As the turn bays become full, traffic spills out into the through lanes and increases the delay of through vehicles. As evidenced in Table 7, this situation worsens with increased congestion level and increased signal density. The percent increase factors in Table 7 would be applied to the recurring delay on the principal arterials in the Urban Mobility Report methodology.

Adjustment Factors for Incident Delay

As previously described, raised medians can increase roadway safety by reducing the number of conflict points and managing the location of the conflict points. This benefit of raised medians was also included in the methodology. Tables 4 and 5 showed the annual crash frequency for the raised median and TWLTL median treatment, respectively. Assuming 65 percent property-damage-only crashes, Tables 4 and 5 were summarized and percent differences between the two were determined in terms of crash reduction between the two median conditions. It was assumed that these data applied to 4-lane facilities because it was not specifically indicated. It was also assumed that the percent difference in crashes equated to the same percent difference in delay for the congestion level of interest. Table 8 presents the results of the analysis comparing the two median treatments. The percentages were also adjusted slightly downward because it was expected that incident delay on 6-lane facilities would be slightly lower than 4-lane facilities. Note that all of the delay factors in Table 8 are delay reductions when going from a TWLTL to a raised median condition. These substantial percent delay reductions are intuitive when considered with the safety literature regarding raised median treatments. The percent reduction ranges from 12 percent at low signal density and the lowest congestion level to 22 percent at high signal density and at the highest congestion level. These percent reduction values would be applied to the incident delay on the principal arterials in the Urban Mobility Report methodology.

TABLE 8 Percent Decrease in Incident Delay Going from TWLTL to Raised Median

Congestion Level	ADT/Lane	Signal Spacing 4-lane Cross-section 3 Signals or Less per Mile	 More than 3 Signals per Mile
Moderate	5,501-7,000	12	18
Heavy	7,001-8,500	16	18
Severe	8,501-10,000	20	22
Extreme	10,001 +	20	22

Table 9 shows the net impact in delay reduction when going from a TWLTL to a raised median facility. This is the difference between the delay increase in recurring delay (Table 7) and the delay decrease in incident delay (Table 8). The result is a net decrease in the total delay due to the installation of a raised median (over the TWLTL). This decrease ranges from 7 to 19 percent depending upon the signal density and congestion level.

TABLE 9 Net Percent Decrease in Total Delay Going from TWLTL to Raised Median

Congestion Level	ADT/Lane	Signal Spacing 4-lane Cross-section 3 Signals or Less per Mile	 More than 3 Signals per Mile
Moderate	5,501-7,000	12	18
Heavy	7,001-8,500	16	13
Severe	8,501-10,000	19	12
Extreme	10,001 +	17	7

WHAT IS THE IMPACT OF INCORPORATING ACCESS MANAGENT INTO THE URBAN MOBILITY REPORT METHODOLODY?

This section explores the potential impact of including the existence of raised medians into the Urban Mobility Report methodology. Raised medians can provide for the orderly movement of traffic by managing the location of roadway crossing and turning maneuvers. Research has shown that this reduces the potential vehicular conflict points and reduces crash potential. Recurring delay is increased as left-turning traffic is allowed at only select turn bay locations that can queue into the through lanes, particularly at high volume. The primary benefit of raised medians is the reduction of crash potential as evidenced by the incident delay reduction factors.

Summary of Urban Mobility Report Methodology and Delay Reduction Factor Application

Several steps are applied to the HPMS sample sections for each urban area to obtain the delay and Travel Time Index (TTI) changes. The Travel Time Index is the ratio of the travel rate during the peak period of travel to the free-flow travel rate. Weighted averages of this value can be obtained for different metropolitan area size and/or congestion level. The congestion level for each section is determined by using the ADT per lane for each section. Directional factors are applied to separate the traffic into peak and off-peak volumes. The signal density and median type are determined for each of the sections of roadway. The average speed for each congestion level is calculated once all the sections of roadway are assigned through speed relationships developed with the Highway Economic Requirements System (HERS) relationships (*12*). Finally, the average delay savings are calculated using the delay reduction percentages shown in Tables 7 and 8. This is accomplished by applying the appropriate reduction percentage for each congestion level, signal density and median type to the delay that was calculated for each of those combinations in the preceding step.

Effects of Access Management in All 85 Areas

All 85 urban areas had some level of raised median installation on the principal arterial system. Table 10 presents the vehicle-miles of travel and lane miles of principal arterial streets that included a raised median treatment. As shown by the summarized values at the bottom of Table 10, the 85 urban areas included approximately 302 million daily vehicle-miles of travel (41 percent) occurred on about 42,907 miles of principal arterial streets (39 percent) that have raised medians present.

TABLE 10 Principal Arterial System (P.A.S.) Raised Median Inventory (Reference: 2002 HPMS Data (*11*) and TTI Analysis)

Population Group	Average Covered P.A.S. Travel		Average Covered P.A.S. Centerline-miles	
	Daily VMT (000)	Percentage	Lane-miles	Percentage
Very Large (11)	15,229	48	2,050	46
Large (27)	3,360	37	496	36
Medium (30)	1,145	31	181	30
Small (17)	533	31	91	30
85 Area Average	3,549	41	505	39
85 Area Total	301,652		42,907	39

Table 11 indicates that the presence of the raised median reduced the principal arterial TTI by 0.019 (5.8 percent) and reduced the principal arterial hours of delay by 79 million hours (6.2 percent). Some of the results from the existence of the raised median include (from Table 11):

- The greatest point reduction in the arterial TTI occurred in the Very Large urban areas at a 0.025 reduction. This equates to a 6.5 percent reduction.
- The largest delay savings occurred in the Very Large urban areas with 46.1 million hours of delay (6.8 percent reduction).
- The smallest reduction occurred in the Small urban areas with a 0.006 reduction (3.6 percent) in the TTI and 1.1 million hours of delay savings (3.9 percent).
- The average percent reduction was 6.3 percent. It should be noted that the principal arterial delay is approximately 34 percent of the total delay (freeway and principal arterial). Therefore, the percent reduction is approximately 2.1 for the total areawide delay.

TABLE 11 Principal Arterial Raised Median Presence Effects

Population Group	Principal Arterial Travel Time Index			Principal Arterial Hours of Delay (million)		
	Base	Where Raised Medians are Present	Reduction	Base	Where Raised Medians are Present	Reduction
Very Large (11)	1.383	1.358	.025	682	636	46
Large (27)	1.312	1.295	.017	400	376	24
Medium (30)	1.248	1.236	.012	152	144	8
Small (17)	1.169	1.163	.006	28	27	1
85 Area Average	1.330	1.311	.019	1261	1183	79

DISCUSSION AND CONCLUSION

For nearly 20 years, the Urban Mobility Report has provided an easy-to-understand view of urban transportation congestion issues. In recent years, operational treatments, high-occupancy-vehicle lanes, and public transportation facilities have been incorporated into the study to incorporate the effects of these treatments on mobility. Delay reduction factors have been used for the operational treatments to reduce the incident and/or recurring delay for each of these treatments by an appropriate percentage. Access management is the latest mobility tool to be incorporated into the study.

This paper described the importance of access management and how the use of raised medians, an access management treatment, are being incorporated into the study. Raised medians are a common access management treatment, and the presence of a raised median is included in the HPMS data elements that are collected for the 85 urban areas in the study. Using NCHRP Report 395 as a basis, delay impact factors were computed for the condition with a raised median in comparison to when a TWLTL is present. The delay factors illustrated a slight increase in recurring delay with the presence of a raised median (particularly at higher congestion levels). These relatively small recurring delay increases were more than offset by the more substantial incident delay reduction percentages computed when investigating the percent difference in crashes when replacing a TWLTL with a raised median. Incorporating a raised median resulted in a net delay reduction for every congestion level and high or low signal density. For example, for low signal density and over 10,000 ADT/lane, the net delay reduction is 17 percent. The methodology allows for estimating the impacts of installing raised medians on delay reduction and mobility.

It must be noted that the results of the Urban Mobility Report are most appropriate at the areawide level. For specific corridors, the delay reduction factors for any of the operational treatments may not be appropriate. It is important to realize that the study is also more applicable to comparing year-to-year trends for individual cities, rather than inspecting any individual value for a particular year. Researchers at the Texas Transportation Institute continue to evaluate the delay reduction factors for all of the operational treatments as new literature becomes available.

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