INTRODUCTION TO TRANSPORTATION PLANNIN G

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This chapter provides an overview of transportation planning as it relates to thoroughfare system planning for urban areas, from the perspective of municipal officials and planners who are responsible for the administration and enforcement of the Thoroughfare Plan. Urban transportation planning includes many other topics in addition to the thoroughfare planning aspects which are addressed in this brief analysis. A glossary of transportation planning terminology and a selected listing of other published sources that may be referenced for additional information on transportation planning are included at the end of this chapter.

Thoroughfare System Planning

Thoroughfare planning is the process used by municipalities and other governmental entities to assure development of the most efficient and appropriate street system to meet existing and future travel needs. The primary purpose is to ensure the orderly and progressive development of the urban street system to serve mobility and access needs of the public. Thoroughfare planning is interrelated with other components of the urban planning and development process.

The *Thoroughfare Plan* is the municipality's adopted general plan for guiding thoroughfare system improvements, including the existing and planned extension of city streets and highways. The thoroughfare system is comprised of existing and planned freeways,, expressways, and major streets and highways, which require wider or new rights-of-way and may ultimately be developed as four-lane, six-lane, or wider roadways. Roadway improvements may or may not include esplanades, depending on the city's thoroughfare development policies and standards. The primary objective of the Thoroughfare Plan is to ensure the reservation of adequate right-of-way on appropriate alignments and of sufficient width to allow the orderly and efficient expansion and improvement of the thoroughfare system to serve existing and future transportation needs.

Benefits of Thoroughfare Planning

The benefits provided by effective thoroughfare planning include the following objectives:

- Reservation , of adequate rights-of-way for future long-range transportation improvements;
- Making efficient use of available resources by designating and recognizing the major streets that will likely require higher design of improvements;
- Minimizing the amount of land required for street and highway purposes;
- Identifying the functional role that each street should be designed to serve in order to promote and maintain the stability of traffic and land use patterns;
- Informing citizens of the streets that are intended to be developed as arterial and collector thoroughfares, so that private land use decisions can anticipate which streets will become major traffic facilities in the future;
- Providing information on thoroughfare improvement needs which can be used to determine priorities and schedules in the city's capital improvement program and capital budget; and,
- Minimizing the negative impacts of street widening and construction on neighborhood areas and the overall community, by recognizing where future improvements may be needed and incorporating thoroughfare needs in the city's comprehensive planning process.

Format and Content of Thoroughfare Plans

The Thoroughfare Plan is adopted as an element of the city's Comprehensive Plan, or it may be a separately adopted plan. Requirements and procedures for the development, administration, and enforcement of the Thoroughfare Plan are part of the Subdivision Regulations contained in the city's Code of Ordinances.

Most Texas cities have adopted Thoroughfare Plans that delineate a system of thoroughfare classes, representing the general location, alignment, and functional relationship for different types of roadways including freeways and expressways, arterial streets and, in some cases, collector streets. The Thoroughfare Plan consists of an officially adopted thoroughfare system map, along with supporting documents containing design criteria and implementation policies. Typically, the .thoroughfare system map indicates whether the existing rights-of-way for thoroughfares have sufficient existing width or need to be widened, and shows the planned extensions of thoroughfares on new alignments where right-of-way needs to be acquired in the future. Thoroughfare Plans also include typical roadway cross sections, indicating the desired number of lanes, right-of-way and pavement widths, and other dimensional criteria for city streets.

The location and alignment of streets that are classified as Collectors may or may not be delineated on the thoroughfare system map, depending upon the city's approach to thoroughfare planning and development. It is generally desirable to indicate existing Collectors on the map, but proposed Collectors in newly developing areas should be determined in conjunction with subdivision planning based on site specific conditions. Local Street alignments are not part of the designated thoroughfare system, although existing Local Streets may be shown on the map as background information. The location and alignment of proposed new Collectors and Local Streets are determined as part of the city's subdivision platting and development review process.

Since the Thoroughfare Plan guides the reservation of rights-of-way needed for the future development of long-range transportation improvements, it has long-reaching effects on the growth and development of the urban area: the plan influences the pattern of movement and the desirability of areas as locations for development and land use. While other long-range development plans look at foreseeable changes over a 10 or 20-year period, thoroughfare planning should consider an even longer-range perspective. Future changes in transportation technology, cost structure, service demands for the transportation system, and resulting long-term shifts **in urban** growth and development patterns require a visionary approach to thoroughfare planning decisions.

Thoroughfare Development Requirements and Standards

Under the provisions of Article XI, Section 5 of the Texas Constitution and Title 7, Chapter 212 of the Texas Local Government Code, municipalities may require that all development plans and subdivision plats conform to:

The general plan of the municipality and its current and future streets, alleys, parks, playgrounds, and public utility facilities; and,

The general plan for extension of the municipality and its roads, streets, and public highways within the municipality and its extraterritorial jurisdiction.

In home rule cities, the Municipal Charter may also contain provisions relating to regulation of plats and thoroughfare development.

Requirements of the Thoroughfare Plan for right-of-way dedication and construction of street improvements apply to all subdivision of land within the city's incorporated area and its extraterritorial jurisdiction (ETJ). The Local Government Code permits municipalities to adopt rules governing plats and subdivision of land within the municipality's jurisdiction, and the municipality may, by ordinance, extend those rules to the city's ETJ.

Planning, design and construction of thoroughfares must comply with the development standards which are contained in the city's Subdivision Regulations. Requirements for thoroughfare development typically include standards and criteria governing the following characteristics of thoroughfares:

Location and Alignment of Thoroughfares - The general location and alignment of thoroughfares must be in conformance with the Thoroughfare Plan. Any major changes that are inconsistent with the plan should require the approval of the Planning and Zoning Commission and City Council through a public hearing process. A major **change would** include any proposal that involves the addition or deletion of established thoroughfare designations, or changes in the planned general alignment of thoroughfares that would affect parcels of land beyond the specific tract in question.

Right-of-Way Width - The minimum right-of-way width for thoroughfares and other public streets should conform to city's standards, unless a variance is granted. Plats located adjacent to existing thoroughfares with insufficient right-of-way should be required to dedicate land to compensate for any right-of-way deficiency of that thoroughfare. When new thoroughfares are proposed to connect with existing narrow rights-of-way, transitional areas should be required.

Building Setbacks - Required setbacks from the right-of-way of existing or proposed thoroughfares and public streets.

Horizontal Curvature - Horizontal alignment of streets should comply with design standards such as the minimum radius of curvature and length of tangent separating reverse curves.

Angle of Intersection - Standards prescribe the minimum acceptable angle of intersection for public street intersections. Corner cutbacks or radii should be required at the acute corner of the right-of-way line, to provide adequate sight distance at intersections.

Block Length - The maximum block length for blocks along thoroughfares and public streets should be established.

Geometric Design Standards and Guidelines - Other requirements and guidelines for the geometric design of thoroughfares and public streets should be provided in the Subdivision Regulations or in a supporting document which is referenced in the Subdivision Regulations as part of the adopted Thoroughfare Plan. Typical roadway cross sections for thoroughfares and other public streets should be contained in the geometric design guidelines.

In the administration and enforcement of the Thoroughfare Plan, special cases and unique situations arise where existing physical conditions and development constraints in certain areas conflict with the need for widening of designated thoroughfares to the planned right-of-way and roadway cross section. Such special circumstances require a degree of flexibility and adaptability in the administration and implementation of the plan.

Acceptable minimum design criteria and special roadway cross sections have to be applied in constrained areas where existing conditions limit the ability to meet desirable standards and guidelines. Special roadway cross sections should be determined on a case by case basis when a unique design is needed. The standard roadway cross sections should be used in all newly developing areas and, whenever possible, in existing areas.

Wherever feasible, the existing and planned rights-of-way for thoroughfares should be maintained at the city's standard right-of-way width, in order to accommodate potential thoroughfare improvements as may be needed in future years. The policy of the Planning and

Zoning Commission and City Council should be to maintain the consistency and integrity of the Thoroughfare Plan and, whenever possible, to keep exceptions to a minimum.

Preparing and Updating the Thoroughfare Plan

The Planning and Zoning Commission is responsible for preparation and maintenance of the Thoroughfare Plan, and the plan should be adopted by both the Planning and Zoning Commission and City Council. The plan should be periodically updated to include additional transportation needs of the urban area. In larger cities, amendments to the Thoroughfare Plan are typically considered on an annual basis, although changes may be approved as needed.

Plan Amendment Process - The process for amending the Thoroughfare Plan should be established in the city's Subdivision Regulations. Amendment procedures vary among different cities. Typically, plan amendment requests may originate from local land owners, civic groups, neighborhood associations, developers, other governmental agencies, city staff, and other interested parties. Proposed revisions should be analyzed by the staff, and the proposed changes and staff recommendations should be considered by the Planning and Zoning Commission. The Planning and Zoning Commission conducts a public hearing on proposed plan amendments, including required 15-days public notice in advance of the hearing. Some cities also provide notification to all property owners within a certain distance (typically 200 feet) of a proposed amendment, although such notification is not required by statute. Proposed amendments should be considered in a fair, reasonable, and open process. The burden for proving compelling reasons for and public benefit of any proposed changes should rest with the requesting parties. Decisions and determinations should represent the best interests of the public. The revised Thoroughfare Plan, including any approved plan amendments, should be adopted by the Planning and Zoning Commission and submitted by the Commission for adoption by the City Council.

Initial Development or Major Update of the Thoroughfare Plan - Many diverse and complex factors must be considered in the development and updating of a Thoroughfare Plan. Unless the city staff includes experienced transportation engineers and planners, it is advisable to utilize the services of a qualified transportation consultant to assist the city in the initial development or major revision of a Thoroughfare Plan.

The city's existing street system should be assessed to identify representative thoroughfare: types, and to develop criteria and a systematic rationale for delineating a system of thoroughfare classes, including typical roadway cross-sections which correspond to the different classes of existing and planned thoroughfares. The planning study should take into consideration the existing thoroughfare network and the long-range needs for various classes of thoroughfares in the future.

Specific objectives and steps in the preparation or major update of a Thoroughfare Plan include the following components:

1. Review of the existing thoroughfare system to determine what typical kinds of roadways exist in terms of functional classification, typical sections (right-of-way width and number of lanes), traffic volumes, system relationship, and land access.
2. Analysis of existing physical development and travel patterns within the urban area.
3. Projecting future travel needs and evaluating the adequacy of the existing street system to serve existing and future traffic demands.
4. Assessment of identified classes of thoroughfares to determine their capability to serve the desired mix of access versus traffic movement.
5. Determination of the relationship of proposed thoroughfare classes to transportation needs in terms of roadway capacity, safety and area impacts.
6. Development of the thoroughfare system map for a hierarchical network of thoroughfare classes, based upon identified transportation needs, economic benefits, environmental and land use impacts, construction

costs, and compatibility with other elements of the city's Comprehensive Plan.

7. Development of geometric design criteria and typical roadway cross sections for right-of-way, pavement width, and number of lanes for city streets.

8. Preparation of an implementation program including policies and procedures for effective administration, enforcement, and future amendment of the Thoroughfare Plan.

Thoroughfare Development Constraints

Physical constraints to thoroughfare development must be recognized in the preparation of the Thoroughfare Plan. Existing physical constraints may include:

Topographic constraints such as steep slopes or abrupt changes in elevation;

Railroad crossings require grade separations or at-grade crossing protection, and thoroughfare improvements paralleling a railroad corridor may involve right-of-way constraints;

Existing development presents obstacles to thoroughfare improvement in areas where insufficient right-of-way was obtained when the property was originally platted, or where buildings were constructed with minimal setbacks from the right-of-way;

Public parks and historic sites may be a constraint when a thoroughfare improvement would require conversion of parkland to other uses or impact cultural resources;

Major water bodies such as lakes, reservoirs, rivers, bayous, and creeks and their associated floodplain areas affect thoroughfare alignment and may increase the capital cost of thoroughfare improvements for necessary bridges, causeways or fill sections;

Sensitive environmental areas such as wetlands, prime farmland, or critical habitat areas; Other governmental jurisdictions may pose an impediment to thoroughfare development when another city objects to continuing thoroughfare improvements within its jurisdiction; and, Existing neighborhoods may also present an impediment when residents object to the impacts of a planned thoroughfare improvement within or affecting their area.

Federal **Requirements Pertaining to Transportation Planning and Improvements**

The system of Interstate Highways, U.S. and State Highways, and other Federal-Aid facilities in an urban area comprises a substantial portion of the city's major street and highway system. The Texas Department of Transportation constructs and maintains many of the thoroughfares in Texas cities. Federal requirements governing the planning, development, operation, and environmental impacts of these facilities must be complied with when Federal and State funding is involved in thoroughfare improvements. Federal and State policies relating to funding of transportation improvements affect the amount and timing of highway improvements for Federal-Aid facilities including interstate Highways, the National Highway System, and Surface Transportation Program.

The Texas Department of Transportation (TxDOT) has statewide responsibility for transportation planning, including the development of a long-range statewide transportation plan and transportation improvement program. In urban areas with a population of 50,000 or greater, Metropolitan Planning Organizations (MPO's) are designated by the Governor and are made up of local officials representing the affected areas. TxDOT and the MPO's are required by the Federal Aid Highway Act, As Amended, to maintain a continuing, comprehensive, and coordinated process (commonly referred to as the "3C" process) for transportation and air quality planning. MPO's are responsible for the preparation of long-range (20 years) transportation plans for the designated metropolitan planning areas, and also prepare the annual Unified Planning Work Program (UPWP) and Transportation Improvement Program (TIP) to guide the use of available Federal funding for transportation improvements, consistent with Federal requirements and guidelines. Projections of future traffic patterns and volumes are prepared by TxDOT and MPO's, using computer travel demand models.

Federal-Aid Highway System - The Federal-Aid Highway Program, which is administered by the Federal Highway Administration (FHWA) and the Texas Department of Transportation (TxDOT), is the major funding source for development of highways and many urban arterial improvements in Texas cities. For the past 20 years, the Federal-Aid Highway Program has been directed toward the construction and improvement of the following four Federal-Aid systems:

- Federal-Aid Interstate;
- Federal-Aid Primary;
- Federal-Aid Secondary; and,
- Federal-Aid Urban.

Under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), there are now two Federal-Aid systems: the National Highway System and the Interstate System. The National Highway System (NHS) includes all Interstate routes and a large percentage of urban and rural principal arterials, the Defense Strategic Highway network, and Strategic Highway connectors. The second Federal-Aid system is the Interstate System, **which is** a component of the NHS. A **new** block grant-type program, the Surface Transportation Program (STP), was created by the ISTEA and provides Federal funding that may be used by the State and cities for any roadways (including NHS) that are not functionally classified by TxDOT as local or rural minor collectors.

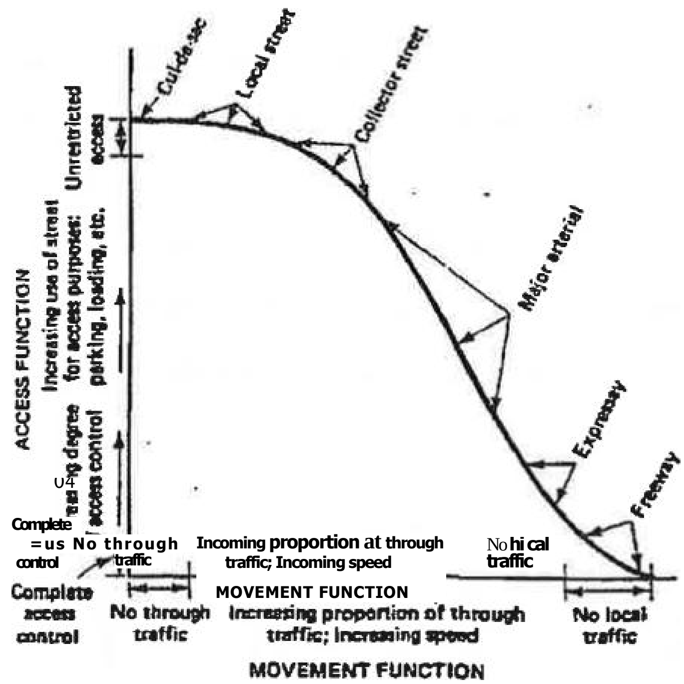
Clean Air Act Amendments - The ISTEA requires that urban areas over 200,000 population be designated as Transportation Management Areas (TMA), and include Congestion Management Systems (CMS) that use travel demand reduction and operational management strategies for effective management of new and existing transportation facilities. In TM.A's classified as Nonattainment Areas for ozone and carbon monoxide (areas that do not meet National Ambient Air Quality. Standards), Federal funds may not be used for transportation projects that would result in a significant increase in carrying capacity for single occupant vehicles unless the project is part of an approved CMS. In such areas, the MPO must coordinate its long-range transportation plan with the Transportation Control Measures (TCM) included in the State Implementation Plan (SIP) for air quality.

Functional Classification

Thoroughfare classification is the process by which streets are grouped into classes according to the character of service they are intended to provide. The Thoroughfare Plan should utilize a *Functional classification* system to delineate different classes of thoroughfares. Thoroughfares are classified according to their functional role in terms of *movement and access.*

Thoroughfare classification is based on transportation planning principles of roadway specialization and hierarchy of movement. *Roadway specialization* means that roadways serve to perform different functions of access or movement, and roadways may be classified with respect to the amount of access or movement they provide. *Hierarchy of movement* means that trips on an urban street system can be sorted into a definite hierarchy with respect to the competing functions of movement and access, ranging from roadways that provide good access but poor opportunity for movement, to facilities that provide good movement by reducing conflicts that would otherwise slow the flow of through traffic. The competing functions of traffic movement and access are inherently incompatible. Movement at reasonable speeds and safe conditions can be achieved only when access is appropriately located and designed. Conversely, high levels of access can be safely achieved only when movement is curtailed.

The relationship between thoroughfare classes and the functions of movement and access are illustrated in the following graph.



RELATIONSHIP BETWEEN ACCCESS AND MOVEMENT FUNCTIONS OF STREETS

SOURCE: Institute **of** Transportation Engineers, <u>Transnortetlon Planning Handbook,</u> 1992.

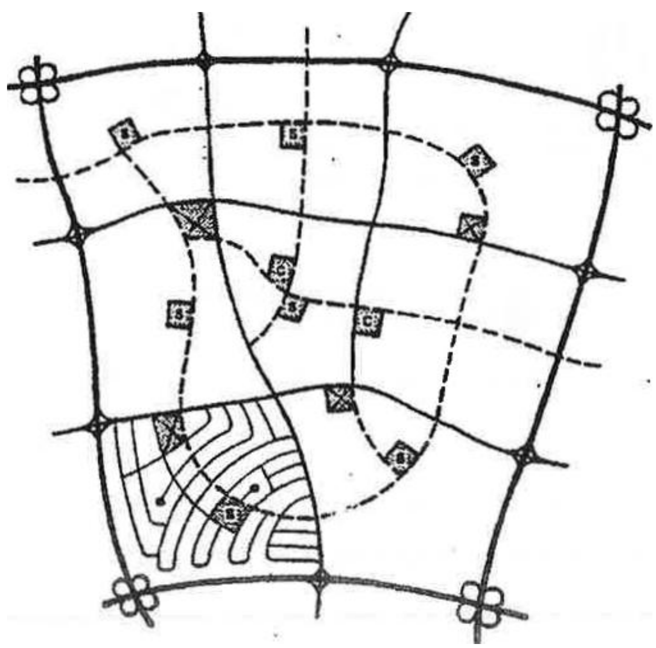
There are no distinct dividing lines between thoroughfare classes; The classes are a continuum representing the extent to which the classes serve different degrees of movement and access A typical thoroughfare classification system includes the following functional classes of roadways, although many cities have adapted their own unique classification systems:

- Interstate Highways;
- Other Freeways and Expressways;
- Principal Arterials;
- Minor Arterials;
- Collectors; and,
- Local Streets.

<u>Interstate Highways</u> comprise the Interstate Highway facilities serving the urban area. These

facilities are constructed and maintained by the Texas Department of Transportation.

Other Freeways and Expressways include other radial and circumferential freeways and expressways which serve high volume, high speed travel within and through the urban area. They are characterized by multi-lane, divided roadways with a high degree of access control and few, if any, intersections at grade. Full control of access distinguishes freeways from expressways. Freeways are devoted entirely to traffic movement with complete access control by grade separated intersections and no direct land access. Expressways may include at grade intersections and limited



Scale:
0 S I
MIles

Shopping center
School
Church

______Freeway System
-------- Major arterial System--------- Collector street worth – ______Local anon system

SCHEMATIC FUNCATIONAL CLASSIFICATION MAP

access to abutting properties.

Principal Arterials are major streets and highways that provide a high degree of mobility, serve the greatest portion of through travel or long-distance trips, are continuous over long distances, and serve trips entering and leaving the urban area, as well as trips within it. These facilities serve high-volume travel corridors that connect major generators of traffic, such as the central business district, other large employment centers, suburban commercial centers, large industrial centers, major residential communities, and other major activity centers.

Principal Arterials form a route system for citywide and regional movement of traffic, including connections to Interstate Highways and Other Freeways and Expressways. Since movement, not access, is their primary function, access management is essential. Intersections with other public streets and private access should be designed to limit speed differentials between turning vehicles and other traffic. Signalized intersection spacing should be long enough to allow a variety of signal cycle lengths and timing plans which can be adjusted to meet changes in traffic volumes and maintain traffic progression (desirably one-third to one-half mile spacing).

SOURCE: Institute of Transportation Engineers, Transportation Planning Handbook, 1992.

Minor Arterials include other arterial streets and highways that serve less concentrated traffic-generating areas such as neighborhood shopping centers and schools. This class distributes medium traffic volumes. Minor Arterial streets serve as boundaries to neighborhoods and collect traffic from Collectors and Local Streets. Although the predominate function of Minor Arterials is the movement of through traffic, they also provide for considerable local traffic that originates or is destined to points along the corridor.. Differentiation between Principal and Minor Arterials may involve selection among similar roadways in areas where closely spaced arterials are nearly equivalent in functional role, traffic volumes, and physical characteristics.

Collectors are the connectors which serve to collect and distribute traffic between Arterials and Local Streets. Collectors serve a wide variety of land uses and their design involves site-specific considerations. They provide direct service to neighborhoods and other local areas. To preserve amenities of neighborhoods, Collectors should desirably be spaced at about one-quarter to one-half mile intervals to collect traffic from Local Streets and convey it to Minor and Principal Arterials. Collectors may or may not be continuous across arterials, depending upon the city's thoroughfare development policies. Since speeds are slower and turn movements are expected, much closer intersection/access spacing can be used than on arterials. Collectors may serve as local bus routes. Direct access to abutting land is essential; parking and traffic controls are usually necessary for safe and efficient through movement of moderate to low traffic volumes.

Local Streets include all other city streets that are not in the higher classes. They allow direct access to residential and commercial properties and similar traffic destinations. Direct access to abutting land is essential, for all traffic originates from or is destined to abutting land. Through traffic should be discouraged by using appropriate geometric designs or traffic control devices. Trip lengths on Local Streets are short, volumes are low, and speeds are slow.

The functional classification of city streets recognizes that the different classes of thoroughfares do not serve travel independently. Trips involve movement along a network of different types of roadways. Each class in the hierarchy serves a collector/distributor function for the next higher class. For example, a Freeway requires a feeder system of Arterials and Collectors in order to efficiently serve the desired movement function. Areas with missing or deficient links in the thoroughfare system will result in deteriorated performance of other thoroughfares, in the form of increased traffic congestion and a higher level of accident exposure.

Classification criteria such as function, system relationship, continuity, roadway length, spacing, traffic volume, and travel speed are used to define thoroughfare classes. The application of these criteria requires experience and judgment in choosing the appropriate classification for each thoroughfare. Each functional class generally includes a range of different roadway cross sections. Traffic volume is not the principal determinant of thoroughfare classification; once appropriate classifications are established for the thoroughfare system, it should not be necessary to change the classification of individual roadways as future traffic volumes increase, unless them are significant changes in the planned pattern of urban development which was considered in the original preparation of the Thoroughfare Plan.

Capacity and Level-of-Service

In addition to functional classification, traffic volumes and roadway capacity are important elements in developing the typical cross-sections and dimensional criteria for thoroughfares. Higher traffic demands require corresponding higher roadway design to provide adequate safety and operational efficiency. Roadway cross sections used in the planning and design of thoroughfare improvements are in large part determined based on the existing and projected traffic volumes, and the desired flow rates, which are dependent upon capacity and Level-of-Service.

Capacity identifies the maximum number of vehicles that can be accommodated by a roadway during a given time period under prevailing traffic and roadway conditions. A roadway's capacity is dependent upon its geometric design configuration, operational conditions, and traffic characteristics. The determination of capacity and Level-of-Service are derived from the Highway Capacity Manual, published by the Transportation Research Board.

The measure used to determine a particular street's ability to accommodate traffic is the traffic volume to street capacity ratio (V/C). The *WC ratio* is determined by dividing the traffic volume by the street design capacity. If the resulting ratio is less than 1.0, the street is assumed to be operating within its preferred design capacity. If the ratio is equal or greater than 1.0, the street is assumed to be operating over its preferred design capacity. The V/C ratio is useful in that it allows a quantitative measure of how well a street is accommodating traffic demand.

Desirable traffic flow rates introduce the qualitative aspect of *Level-of-Service (LOS).* There are six LOS classes ranging from "A" which represents non-congested, light traffic flow, to "F" which represents extremely congested, stop-and-go traffic. Desirable traffic flow rates for each LOS class are termed service flow rates. If the traffic volume using a roadway exceeds the service flow rate for a given LOS, then operating conditions deteriorate and the LOS drops to a lower level. Traffic characteristics for each LOS class are described in the table shown on the following page.

Level-of-Service design guidelines for different functional classes of roadways in urban and suburban areas are recommended in A Policy on Geometric Design of Highways and Streets, published by the American Association of State Highway and Transportation Officials:

FUNCTIONAL CLASSIFICATION	**DESIGN LEVEL-OF-SERVICE**
Freeways	C
Arterials	C
Collectors	D
Local Streets	D

Capacity and Level-of-Service for arterial streets are determined by the capacities of the individual roadway segments or links, and the capacity of intersections within the street network. Level-of-Service on arterial segments or links is related to average travel speeds. For example, average speeds of 35 MPH and higher typically occur at Level-of-Service A, on urban arterial streets outside of the central business district. Average speeds drop below 28 MPH at Level-of-Service C, and below 22 MPH at Level-of-Service D.

LEVEL-OF-SERVICE CHARACTERISTICS
FOR ARTERIAL STREETS AND SIGNALIZED INTERSECTIONS

LEVEL-OF-SERVICE (LOS)	V/C RATIO FOR ARTERIAL STREETS	AVERAGE VEHICLE DELAY AT SIGNALIZED INTERSECTIONS	TRAFFIC CHARACTERISTICS
LOS A:	0.00 0.60	5.0 seconds	Free flow with individual vehicles virtually unaffected by the presence of others in the traffic stream. Very favorable signal progression with most

			vehicles arriving during green signal phase.
<u>LOS B:</u>	0.61 - 0.70	5.1 - 15 seconds	Stable flow with a high degree of freedom to select speed and operating conditions, but with some influence from other vehicles. Good signal progression but higher delays that LOS A.
<u>LOS C:</u>	0.71 - 0.80	15.1 - 25 seconds	Restricted flow which remains stable, but with significant interaction between vehicles in the traffic stream and a significant number of vehicles stopped at intersections. The general level of comfort and convenience declines noticeably at this level.
<u>LOS D:</u>	0.81 - 0.90	25.1 - 40 seconds	Fligh-density flow in which speed and freedom to maneuver are severely restricted and congestion is noticeable, even though flow remains stable. Unfavorable signal progression with longer delays.
<u>LOS E:</u>	0.91 - 1.00	40.1 - 60 seconds	Unstable flow at or near capacity levels with poor level of comfort and convenience. Poor signal progression with many vehicles needing more than one cycle to clear the intersection.
<u>LOS F:</u>	Greater	Longer than	Forced flow with traffic volume exceeding capacity, queues form, and movement is characterized by stop-and-go

SOURCE: Transportation Research Board, <u>Highway Capacity Manual,</u> Washington, D.C., 1985.

When the traffic volume on a roadway increases to a level that additional capacity is needed, a wide range of different types of roadway improvements may be considered. Roadway capacity deficiencies can be solved by new construction or by *<u>Transportation System Management (TSM)</u>* improvements. Adding more travel lanes is an obvious solution; in many instances, widening a two-lane street to four lanes may approximately double the roadway's capacity. Adding two lanes to a four-lane roadway may increase capacity by as much as 33 percent. In addition to widening the roadway, other potential solutions may include TSM-type improvements in traffic operation and street use, such as removing on-street parking (5 to 35 percent increase in capacity), restrictions on driveway access (5 to 10 percent increase), improvements in intersection signalization (10 to 40 percent increase), adding a continuous left-turn lane (20 to 50 percent increase), or changes in traffic operations to create a one-way couplet (10 to 30 percent increase).. These estimated general increases in roadway capacity are based on research studies conducted by the Texas Transportation Institute and Institute of Transportation Engineers.

Capacity of signalized intersections is calculated using two different methods provided in the Highway Capacity Manual, published by the Transportation Research Board. The primary methodology is the operational analysis, which requires detailed information on prevailing traffic, roadway, and signalization conditions, and is difficult to apply when evaluating long-range future conditions. The second methodology is the planning analysis, which requires only geometric information on the number and use of lanes for each approach, and the hourly traffic volume for each movement.

Level-of-Service for signalized intersections is related to the average stopped delay per vehicle. For example, at Level-of-Service A, the average stopped delay for vehicles at an intersection is less than five seconds. Delays of 15 to 25 seconds occur at Level-of-Service C, and longer delays indicate Level-of-Service D or lower. Average delay criteria are shown in the table on the previous page.

A wide range of improvement techniques may be used to increase intersection capacity. Traffic operation and design improvements for intersections include traffic signals, intersection channelization, traffic controls such as turn prohibitions, alternative street use such as one-way or reversible operation, and pedestrian safety features. Alternative types of intersection improvements and the associated potential gain in intersection capacity, based on research studies conducted by the Texas Transportation Institute and Institute of Transportation Engineers, are shown in the following table.

INTERSECTION IMPROVEMENTS

INTERSECTION IMPROVEMENTS	TYPICAL CAPACITY INCREASE[1]
Upgrade Traffic Signalization	10 - 25%
Add Exclusive Right-Turn Lanes	10 - 25%
Add Exclusive Left-Turn Lanes	10 - 40%
Add Dual Exclusive Left-Turn Lanes	10 - 30%
Construct Grade Separation	25 - 50%
Transit-Related Improvements (bus turnouts, far side or mid-block bus stop locations)	3 - 10%

(1) The indicated percentages of capacity increase may vary and are not additive.

Roadway Design Elements

Roadway design elements such as design speed, cross section, and sight distance are generally dependent upon the anticipated roadway, usage. For example, an arterial street with higher traffic volumes and speeds requires flatter grades, smoother curves, and more travel lanes. Roadway design is determined in project planning and design studies for specific improvements, which are beyond the scope of this introductory review. However, a general summary of some of the relevant factors is included to provide a basic understanding of design considerations.

Design Speed - The design speed of a roadway is defined as the maximum safe speed that can be maintained over a specific section of roadway. It is a primary factor used to select the geometric features of a roadways design. For example, sight distance requirements, horizontal and vertical alignments, and traffic control device placement are established based upon design speed. Generally, lower design speeds are applied to local and collector streets and to arterials in urbanized areas; higher design speeds are applied to freeways/expressways and to arterials in outlying areas.

A design speed as high as practical should be used, preferably a constant value for any one roadway. Where physical constraints exist, changes in design speed for some sections of roadway may be necessary. Additionally, less-than-desirable design speeds are sometimes required to avoid disruption of neighborhoods, to preserve major buildings, or to reduce construction costs. Good alignments should be utilized in the design requirements for thoroughfares to improve safety and operating characteristics.

Sight Distance - Sight distance is the length of roadway ahead that is visible to the driver, and is an important element of traffic safety and roadway design. Sight distance is a major element in determining both vertical and horizontal alignments of roadways. Sight distance includes the distance required for the driver to search for, detect, and interpret information; decide what corrective action is needed; initiate action; and, the distance required for a vehicle traveling at the design speed to stop before reaching a stationary object in its path.

Sight distance criteria are determined by a number of factors and conditions, and provide an additional margin of safety, especially in areas where driver information in difficult to perceive, in visually cluttered locations, or where unexpected and unusual actions are required. The **Traffic Engineering Handbook,** published by the Institute of Transportation Engineers, identifies criteria for determining sight distance.

Cross Section Elements - Roadway cross section elements consist of lane widths, cross slope, curbs or shoulders, medians, and borders. Together, these elements determine the right-of-way required for a roadway.

Lane width *is* one component of roadway capacity, operations; and traffic safety. Travel lanes should be either 12 or 11 feet wide for safe and efficient traffic operation. These widths provide freedom and ease of operation consistent with high-volume traffic. Wider outside lanes are desirable to accommodate buses and bikeways. Low-volume streets or streets with restricted rights-of-way may have narrower lanes not less than an absolute minimum of 10 feet wide. Turning lanes at intersections are considered auxiliary lanes and should be as wide as through lanes, but not less than 10 feet.

A *median is* that portion of the roadway separating traffic in opposing directions. The primary functions of a median are to provide:

- Freedom from interference of opposing traffic;
- Transition and storage for left and U-turning vehicles;
- Recovery area, for out-of-control vehicles;
- Assist in minimizing headlight glare; and,
- Open green space for aesthetics.

Medians have varying widths and may be *raised*, *flush*, or *depressed*. A raised median is typically preferred on arterial streets where left-turn movements are regulated. Raised median widths of 18 to 32 feet or more provide space in the median for auxiliary left-turn lanes and a protected area for vehicles in median openings. Raised medians less than 18 feet wide do not provide sufficient space to shield a crossing vehicle at median openings. A flush (paved) median is used to provide a continuous two-way left turn lane on roadway sections where a high proportion of turning traffic must be accommodated. Depressed medians are generally used on divided roadways with open ditch drainage.

Curbs are part of the roadway cross section used to control drainage; to delineate the pavement edge; to deter vehicles from leaving the pavement at hazardous points; to protect pedestrians; and to assist in the orderly development of adjacent property.

Border areas along the side of the roadway, between the back of curb and right-of-way line, serve to separate travel lanes from obstructions outside the right-of-way, and to accommodate sidewalks, utilities, and traffic control devices within the right-of-way. Placement of utilities within border areas permits servicing of utility lines with minimal roadway-traffic interference. Border areas also benefit sight distance at intersections, although corner cutbacks or radii in the right-of-way lines are also required to provide adequate sight distance at intersections.

Utilities - The location and arrangement of existing and planned utilities placed within the street right-of-way are an important consideration in decisions as to right-of-way width and roadway cross section. Utilities should be located to minimize the need for later adjustment, to accommodate future roadway improvements, and to permit servicing of utility lines with minimal interference to traffic. Provision should be made for known or planned expansion of utilities. The border areas located between the edge of the street pavement and the right-of-way line should have sufficient width to accommodate utilities as well as sidewalks, traffic control devices, and sight distance at intersections.

Landscaping - Landscaping within or adjacent to the street right-of-way is used for scenic beautification, and to visibly screen adjacent land uses from the roadway and to reduce traffic noise and headlight glare. Landscape plantings of trees and shrubs within the right-of-way must be compatible with roadway design and safety standards, including maintenance of sight distances and safety areas. A wider right-of-way is generally required when landscaping is included in the roadway cross section.

Access Management

Access control ranges from full control of access for Interstate Highways and freeways, to limited access control for expressways, to Controls over driveway spacing for other public streets. Interstate Highways and freeways have wide spacing of access points and full grade separations to separate opposing traffic flows. Intersections of driveways with public streets create traffic conflicts and the potential for congestion. A functionally designed thoroughfare system recognizes the need for access control to reduce interference and allow movement as the primary function of arterial streets. The predominant purpose of local streets is to provide good access, which is accomplished by having numerous access points that cause interference with through traffic and curtail movement. Access management policies and standards should be included as part of the city's Thoroughfare Plan.

Traffic Control

Traffic signals, signs and markings, and roadway illumination are important parts of the urban street system. The spacing of freeways, arterial and collector streets is important to maintain adequate signal progression in order to facilitate platoon movement of traffic during peak and off-peak periods. Long signal spacings increase the flexibility with which the traffic signal system can be timed to accommodate different traffic demands at various times of the day as well as changing traffic volumes in future years. A one-third to one-half mile spacing between controlled intersections along arterial streets is desirable to maintain flexibility for traffic signal cycle length, efficient traffic progression' , and appropriate speeds in both peak and off-peak periods.

Traffic Safety

Thoroughfare improvements have a significant relationship to traffic safety. If thoroughfare improvements do not keep pace with increases in traffic demand, the resulting deterioration in efficient traffic operations has a detrimental effect on traffic safety. Lack of sufficient capacity on arterial roadways and resulting traffic congestion also create adverse safety effects when through traffic begins using local residential streets.

Higher traffic demand requires a corresponding higher roadway design in order to provide adequate traffic safety and operational efficiency. Traffic management and safety considerations are an integral component of thoroughfare planning and street improvement design and implementation. Traffic management and safety needs incorporated in the Thoroughfare Plan assist in improving traffic safety and operational efficiency of the street and highway system.

School Zone Traffic Safety - Concern for the safety of students going to and from school is a highly emotional and sensitive matter to parents, educators, and city officials. The use of proper school-related traffic control devices is of utmost concern to all. Children face a variety of complex traffic situations while going to and from school. Attention must be given to the hazards caused by vehicular traffic and potential pedestrian-vehicular conflicts.

School zone traffic control devices and traffic operation controls are generally not addressed directly by the Thoroughfare Plan, These determinations require specific studies and analysis on a case by case basis, which are performed as part of the traffic control function of local government.

The type of school area traffic control used must be related to the volume and speed of traffic, street width, and number of children crossing. A uniform approach to school area traffic control must be utilized to assure the use of similar controls for similar situations, which in turn promotes uniform behavior on the part of motorists and pedestrians. The Texas Manual on Uniform Traffic Control Devices (TMUTCD) provides detailed requirements and criteria for determining appropriate traffic control devices in school areas.

Transit Operations and Facilities

Transit routes, bus stop locations, bus bays, preferential treatment, high occupancy vehicle (HOV) lanes, park-and-ride lots, transit centers, and existing or proposed rail transit system development are a few of the transit aspects that must be considered in planning for thoroughfare development.

Thoroughfare planning must take transit operations and facilities needs into account in a more direct and important way than in the past. Federal funding programs for assisting municipalities and transit authorities in the operation and development of public transit systems are administered by the Federal Transit Administration (FTA).

Bicycles and Pedestrians

Bicycles and pedestrians must be allowed to safely circulate on the city street system. Bikeway routes and bicycle facility design criteria are among the features which should be considered in thoroughfare planning and implementation. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) added transportation enhancement activities for bicycles and pedestrians, scenic beautification, and historic preservation as a category eligible for Federal funding as part of transportation improvement projects. Many cities include bicycle and pedestrian facilities as part of their transportation planning process.

Transportation and Land Use

The designation of thoroughfares by the Thoroughfare Plan impacts land use to the extent that such designation gives notice that the municipality plans for a street to serve a higher traffic movement function as part of the overall street network. Such designation also implies that the street will likely receive priority for future thoroughfare improvement through the municipality's capital improvement program, although such improvements are not restricted to thoroughfares.

The relationship between transportation and land use is often characterized as the *"Transportation and Land Development Cycle."* In simple terms, the cycle consists of increased accessibility of areas provided by construction of improved thoroughfares which, in turn, leads to development and increased traffic.

The impact of thoroughfare improvements on land use depends upon the degree to which transportation service and access are improved, and the extent to which improvements create new economic development opportunities. Impacts may be substantial in areas where land is available for development or redevelopment, within a convenient range of access provided by the improvements. Mature neighborhood areas are likely to experience less significant impacts than new developing areas. Land development patterns depend upon a variety of market factors. Transportation and land use are also influenced by changes in transportation technology, costs, and service, as well as governmental policies and changing socio-economic characteristics.

Changes in peak period travel times between residential areas and major employment centers, resulting from construction of thoroughfare improvements, increase the market area accessible to workers residing in the urban area. Improved accessibility can stimulate increased development and redevelopment, which in turn may increase traffic and property values. Unless thoroughfare improvements are made to accommodate growth in travel demand, transportation service and access will be degraded and lead to decreases in accessibility and property values.

Major thoroughfares tend to be desirable locations for nonresidential development, although thoroughfares also border or traverse residential areas in many instances. In the absence of designated thoroughfares, motorists would continue to utilize the most convenient and efficient routes between their origins and destinations. Failure to plan and provide a system of thoroughfares with adequate capacity to accommodate travel demands would contribute to increased levels of traffic congestion and accident exposure occurring on the existing street system.

Relationship of Thoroughfare Plan to Other Planning Activities

Other planning tools used by municipalities to address the land use impacts of thoroughfare development include comprehensive planning; zoning, subdivision regulations and development ordinances; and special studies such as corridor planning and traffic impact analysis. The *Comprehensive Plan* is the primary tool for integrating transportation and land use planning. The *Zoning Ordinance,* combined with effective comprehensive planning, is also an effective tool for integrating transportation and land development. *Subdivision Regulations* have a direct effect on the way in which new development relates to the thoroughfare system and are an effective tool for ensuring that future development is compatible with transportation requirements.

A *Corridor or Subarea Study is* a specialized planning study which addresses a specific transportation corridor or subarea for major improvements such as Interstate Highways, freeways, expressways, and arterials. A *Traffic Impact Analysis (77A) is* another type of specialized study which addresses the impact that a proposed development will have on the surrounding transportation system. Depending on the type and size of development, a TIA may range from a cursory inspection of the site, the projected traffic volumes, and the impacts on adjacent streets, to a full-blown alternatives analysis that includes adjacent streets, regional thoroughfares, and transit. In some cities, requirements for TIM are included in the municipality's *Impact Fee Ordinance. Parking Studies* are conducted to determine existing and projected parking characteristics, inventory existing parking facilities, analyze parking demands and needs, and identify recommended parking improvements and parking management programs.

Conclusion

In summary, thoroughfare planning is intended to guide the orderly development of the city's street and highway system, by ensuring the reservation of adequate rights-of-way needed for future long-range transportation improvements and identifying a consistent plan of needed roadway improvements. Thoroughfare improvements are needed to alleviate street capacity deficiencies, relieve traffic congestion, and improve safety. Access management is necessary to control proliferation of driveway intersections and minimize resulting traffic conflicts. Without effective thoroughfare planning, adequate street improvements, and access management, undesirable transportation impacts will occur, including:

- Inadequate roadway capacity;
- Traffic congestion and reduced travel speeds;
- Insufficient access to neighborhoods and development areas;
- Increased accident exposure; and,
- Limited flexibility for motorists to adjust travel patterns due to changing conditions.

Glossary of Transportation Planning Terms

Acceleration Lane - A speed change lane for the purpose of enabling a vehicle entering a roadway to increase its speed to a rate at which it can more safely merge with through traffic.

Center Line - A line indicating the division of the pavement between traffic moving in opposite directions. It is not necessarily at the exact geometric center of the pavement.

Control of Access - The condition where the right of owners or occupants of abutting land or other persons to access, light, air or view in connection with a highway is fully or partially controlled by public authority.

Deceleration Lane - A speed change lane for the purpose of enabling a vehicle that is to make an exit turn from a roadway to slow to the safe speed on the curve ahead after it has left the main stream of faster-moving traffic.

Design Capacity - The maximum number of vehicles that can pass over a given section of a lane or roadway in one direction on multi-lane highway (or in both directions on a two or three lane highway) during a specified time period while operating conditions are maintained corresponding to the selected or specified level of service.

Design _Speed - A speed selected for purposes of design and correlation of those features of a highway, such as curvature, superelevation, and sight distance, upon which the safe operation of a vehicle is dependent.

Divided Road - A directional roadway on which opposing traffic is separated by a median, either natural or structural.

Free-flow Operating Speed - The operating speed of a passenger car over a section of highway during extremely low traffic densities.

Frontage Road - A road contiguous to and generally paralleling an expressway, freeway, parkway, or through-street and so designed as to intercept, collect, and distribute traffic desiring to cross, enter, or leave such highway and which may furnish access to properly that otherwise would be isolated as a result of the controlled-access feature; sometimes called a service road or feeder road.

Grade Separation - A structure used to separate vertically two or more intersection roadways, thus permitting traffic on all roads to cross traffic on all other roads without interference.

Interchange - A system of interconnecting roadways in conjunction with one or more grade separations, providing for the interchange of traffic between two or more roadways or highways on different levels.

Level of Service (LOS) - A generalized measure of a street's operational characteristics. Six levels, ranging from "A" for light traffic flow "F" for congested traffic flow, are used.

Median - That portion of a divided highway separating the traveled ways for traffic in opposite directions.

Modal Split - The proportion of total person-trips that uses each of the various modes of transportation, e.g. automobile, bus, carpool, transit.

Mode of Travel - The means of travel, such as auto driver, vehicle passenger, mass transit passenger, or walking.

Model - A mathematical formula that expresses the actions and interactions of the elements of a system in such a manner that the system may be evaluated under any given set of conditions (e.g. land use, economic, socioeconomic, and travel characteristics).

Network - A system of roadway links and land use activity nodes (e.g. shopping centers, offices) which make up the transportation system; the skeleton of movement.

Operating Speed - The highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the design speed on a section-by-section basis.

Pavement - That part of a roadway having a constructed surface for the facilitation of vehicular movement.

Peak Hour - That one-hour period during which the maximum amount of travel occurs: Generally, there is a morning peak and an afternoon peak and traffic assignments may be made for each period, if desired.

Person Trip - A trip made by a person using any mode for any purpose.

Reversible Lane(s) - A lane(s) where traffic moves in one direction only during some period of time, then in the reverse direction during another period of time.

Right-turn Lane - A traffic lane within the normal surfaced width of a roadway, or an auxiliary lane to the right of and adjacent to the through traffic lanes, reserved for right-turning vehicles at an intersection.

Roadway - That portion of a road which is improved, designed, or ordinarily intended for vehicular use. Roadways are designed and built as divided, undivided, or one-way roads.

System Analysis - A method by which the transportation system may be studied to determine its effectiveness in meeting the objective of satisfying travel demand.

Traffic Control Device - Any sign, signal, marking, or device placed or erected for the purpose of regulating, warning, or guiding vehicular traffic and/or pedestrians.

Traffic Island - An island provided in the roadway to separate or direct streams of traffic, which includes both divisional and channelizing islands.

Traffic Lane - A strip of roadway intended to accommodate a single line of moving vehicles.

Traffic Model - A mathematical equation or graphical technique which is said to be able to simulate travel patterns, particularly those in urban areas.

Traffic Sign - A traffic control device mounted on a fixed or portable support which conveys a specific message by means of words or symbols, and is officially erected for the purpose of regulating, warning, or guiding traffic.

Travel Forecasting - A method used to predict the future travel patterns on particular roadways or between travel modes by using current counts, predictions of intensity and location of land uses, population growth and availability of transit alternatives.

Trip - A one-directional movement which begins at the origin at the start time, ends at the destination at the arrival time, and is conducted for a specific purpose.

Trip Distribution - The process by which the movement of trips between zones is estimated. The data for each distribution may be measured or be estimated by a growth factor process or by synthetic mode.

Trip End - A trip origin or a trip destination.

Trip Generation - The number of vehicular trips caused by or resulting from a particular land use activity.

Undivided Road A road which has no directional separator, either natural or structural, separating traffic moving in opposite directions.

Vehicle - Any component of wheeled traffic. Unless otherwise qualified, the term vehicle will normally apply to free-wheeled vehicles.

Volume - The number of vehicles that pass over a given section of a lane or a roadway during a time period of one hour or more. Volume can be expressed in terms of daily traffic or annual traffic, as well as on an hourly basis.

Volume/Capacity Ratio - A measure used to determine a street's ability to accommodate traffic. The v/c ratio is determined by dividing traffic volumes by the street design capacity.

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