Street Spacing and Scale

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ABSTRACT

This paper addresses the spacing of streets and its impact on scale. It compares the spacing/design of city streets and suburban highways, identifies the strengths and weaknesses of each, and suggests spacing guidelines for various urban and suburban environments. It shows how providing arterial streets at closer intervals improves access opportunities, reduces traffic concentrations where these streets meet, and allows reduced cross sections.

INTRODUCTION

Street planning and design involves a broad range of considerations. What types of streets are needed and what are the basic functions of each type? How can streets best relate to topography and land development? How can the various users (motorists, bus passengers, commercial vehicles, and pedestrians) be best accommodated? What access (if any) should be provided to adjacent properties? What landscaping and urban design features should be incorporated? How can cost and environmental constraints be reflected? How should the street system be arranged? And what should be the spacing and scale?

Most guidelines for street and roadway design relate to elements such as the number and width of lanes, treatment of right and left turns, horizontal and vertical alignment, and the roadside edge and border. An equally important and often neglected consideration is the spacing of streets. Too many closely spaced street and driveway intersections can increase accidents and delays and preclude effective traffic signal coordination. Too few can inhibit access and overconcentrate traffic.

Street spacing and scale are often limited by history, geography, and settlement patterns. Still, opportunities exist especially in growing suburban areas for better arranging and designing the street system.

This paper addresses the spacing of streets and its impact on street scale. It compares the spacing/design of city streets and suburban highways, identifies the strengths and weaknesses of each, and suggests spacing guidelines for various urban and suburban environments.

BACKGROUND

Our city streets are largely a product of history. Initially developed before the advent of the automobile, they have progressively adapted to the motor age while generally

maintaining their scale in the urban fabric. While street patterns vary among commmunities, they usually embody several common features: a closely spaced network of residential, collector and arterial streets, rights of way of 66 to 100 feet along continuous thoroughfares, and a predominance of four-lane roads. There are curbs, sidewalks, and planting areas.

Chicago's street system is typical of that found in many cities—especially those developed as part of public land surveys. Arterial (and continuous collector) streets are generally spaced at half-mile intervals. This street grid is complemented by a few diagonal streets, a boulevard system, and a freeway system.

The arterial streets are generally located within 66-foot rights-of-way, although rights-of-way range up to 100–120 feet (e.g., North Michigan Avenue). There are sidewalks and planting strips along the curb. On-street parking, where permitted, is sometimes removed during peak travel hours. Left-turn lanes are provided at many intersections—sometimes through flaring; some 50-foot roadways are delineated for five lanes to accommodate left turns. Buses operate on most arterial streets, and a few bus-only lanes operate in the city center. The short crossing distances at most intersections facilitate pedestrian movements.

Traffic signals generally operate on a 65-second cycle and are coordinated to allow a 28-mph progression. Signals are encouraged at the ¼ mile points to maintain the progressive speeds and discouraged at other locations. Two-phase operations dominate. However, longer cycles are found along some heavily traveled roads and major boulevards, and near freeway ramps.

These conditions contrast sharply with the street patterns found in most newer auto-oriented cities and in suburban communities. Contemporary suburban street patterns are characterized by wide spacings of arterials, a lack of continuous secondary streets, and heavy concentrations of through and turning traffic at major road junctions.

The lack of suitable secondary streets requires the arterial roads to accommodate local traffic as well. To serve the heavy traffic volumes, many arterials provide six through lanes, right turn lanes, and single or dual left turn lanes.

Separate phases are provided to accommodate the left turns, with an attendant loss in green time for through movements. Cycle lengths range from 120 to 180 seconds "to provide sufficient capacity" for each phase. These long cycles result in long delays and preclude effective coordination.

Pedestrian circulation and crossings are difficult. Sidewalks are generally lacking. Pedestrians frequently must cross 7- to 9-lane streets, with at best a narrow center median.

Las Vegas Boulevard (Las Vegas) is one example of the "lack of access opportunities" and the concentration of traffic on relatively few major roadways. It is a heavily traveled 6- to 8-lane arterial that crosses similarly wide arterials every mile or two. Left turns are concentrated at major junctions, resulting in multi-phase signal controls, long cycles, and extensive peak hour delays.

Even clearer examples are the road systems in many Asian cities. Bangkok's road system consists of widely spaced multi-lane arterials served by narrow discontinuous streets. Major junctions operate on under police control, with cycle lengths ranging up to 5 minutes.

STREET SPACING STUDIES

Several studies have set forth guidelines for the spacing of freeways and arterial streets. These guidelines consider factors such as population and trip density, construction and operating costs, and design feasibility. A review of principal studies follows.

Peterson, 1960 (*1*)

This study assigned travel in a hypothetical 16-square-mile area to a 4-mile freeway grid. Trips were assigned to freeways and arterial streets with interchanges spaced an average of 1 mile apart. Various assumptions were made for travel speeds on freeways and surface streets, and for typical vehicle-trip generation rates for residential and commercial areas.

For a population density of almost 9,000 people per square mile 38 percent of all trips and 59 percent of the total vehicle miles were assigned to the freeways. The maximum one-way average daily freeway traffic totalled 85,000 vehicles. The analysis indicated that a four-mile spacing of freeways would provide good traffic service with a volume range within the capacity of an 8-lane freeway. It showed that an interchange spacing greater than one mile would produce overload conditions at ramps.

Future Highways and Urban Growth, 1961 (*2*)

This study assumed an average trip length on freeways and an equilibrium between capacity and travel demand. It indicated that "where topographic interferences are not critical, the overall need for and spacing of freeways will depend on the average population densities throughout the urban region." A series of curves showed how the average freeway spacing varies directly with the number of lanes provided, and inversely with the average length of freeway trip and population density. Representative values are shown in Table 1. Thus for an average population density of 10,000 persons per square mile, 8-lane freeways should be provided at 4-mile intervals, while for population densities of about 5,000 to 7,500 persons per square mile, spacing should be set at about 5 to 6 miles. The curves apply to an entire city or urbanized area.

TABLE 1 Suggested Freeway Spacing Based on Population Density (Future Highways and Urban Growth)

POPULATION DENSITY PEOPLE/SQUARE MILE	FREEWAY SPACING (MILES) 4-LANE FREEWAYS	6-LANE FREEWAYS	8-LANE FREEWAYS
4,000	4.5	6.3 - 7.5	9 - 10
6,000	3.5	5.0	6.5
8,000	2.5	3.8	5.0
10,000	2.0	3.0	4.0
20,000	1.0[a]	1.5[a]	2.0

[a] not really practical

Chicago Area Transportation Study, 1962 (*3*)

The Chicago Area Transportation Study developed a mathematical model for determining optimum one–freeway spacing. This model minimized the sum of construction and travel costs. Results of this least cost spacing and the model utilized are shown in Table 2. Spacings varied from 3 miles in the city to 4 to 6 miles in suburban areas. Since the costs vary with the square foot of the ratio of construction costs to trip density, an increase in construction costs relative to trip density would likely result in wider spacings over time.

Values are based on

$$Z = 2.24\sqrt{\frac{C}{DK\left(\frac{1}{V_y} - \frac{1}{V_s}\right)P_s}}$$

where

Z = freeway spacing in miles
C = average freeway construction cost per mile
D = average vehicle trip density per square mile
V_y and V_s = average speed on arterial streets and freeways respectively
K = a constant representing a capitalized travel time value
P_s = proportion of trips with the opportunity to use freeways

Source: (*3*) pp. 42–43

ITE Reports, 1969 and 1997 (*4, 5*)

These Institute of Transportation Engineers reports suggested spacing guidelines for arterial roads based upon travel demand and traffic signal coordination considerations. "Arterials" included all continuous roadways other than freeways and local streets.

TABLE 2 Estimated Least Total Cost Spacing of Freeways for 1980 in the Chicago Metropolitan Area

RINGS IN STUDY AREA(1) COST	1980 VEHICLE TRIP DESTINATIONS PER SQUARE MILE(2)	RELATIVE FREEWAY CONSTRUCTION COST PER MILE (MILLIONS)	ESTIMATED LEAST FREEWAY SPACINGS (MILES)
2	28,700	7	3
3	25,300	6	3
4	19,600	4	3
5	13,400	3	4
6	10,000(3)	2	6
7	7,000(3)	1	6

NOTES:
(1) Rings 0 and 1 (the central business district (CBD) and surrounding areas) were unique and were not computed.
(2) These densities correspond to 1.10 to 1.25 × the population densities in each zone.
(3) Trip densities assume that these rings are 95% developed.

1969 Report

The 1969 ITE report derived the following relationship between traffic demand, arterial grid spacing and daily traffic volumes, assuming uniform trip distributions and arterial loadings.

$$D = 2V/S \tag{1}$$

where

D = the arterial vehicle-miles of travel per square mile
V = the average daily traffic volume per mile of route
S = the distance between adjacent arterials in miles (spacings).

Solving this equation for S, and substituting the average daily capacity for V, a series of curves were prepared showing desired spacings for 2, 4, and 6-lane arterials. These curves were based on Level of Service C (about 5000 vehicles per lane per day). The curves (also presented in the 1997 report) are shown in Figure 1.

The report, drawing upon the Penn-Jersey Transportation study, suggested the following total vehicle travel densities in

Area	VMT/SQ.MI.*
CBD areas	Over 100,000
Urban areas	30,000–100,000
Suburban areas	7,500–40,000
Rural areas	Less than 12,000

* VMT = vehicle miles traveled

It indicated that local streets would typically accommodate 10% of this travel and freeways 30 to 50%, leaving arterial routes with 40 to 60% of the daily VMT.

Traffic signal cycle lengths, spacings, and operating speeds also influenced spacing. Representative spacings, cycle lengths and speeds were:

Area	Spacing	Cycle Lengths (Sec)	Speeds (MPH)
CBD	⅛ mi.	60 - 90	10 - 15
Urban	¼ mi.	60 - 90	22.5 - 30
Suburban	½	90 - 120	30 - 45

Based on typical urban traffic demands, traffic signal timing needs, and the need to interchange with freeway systems, the following spacings were suggested for metropolitan areas.

CBD	⅛ - ¼ mi.
Urban (Central City)	¼ - ½ mi.
Suburban	½ - 1 mi.
Rural	1 - 2 mi.

The longer spacings would apply where multi-lane arterials are provided.

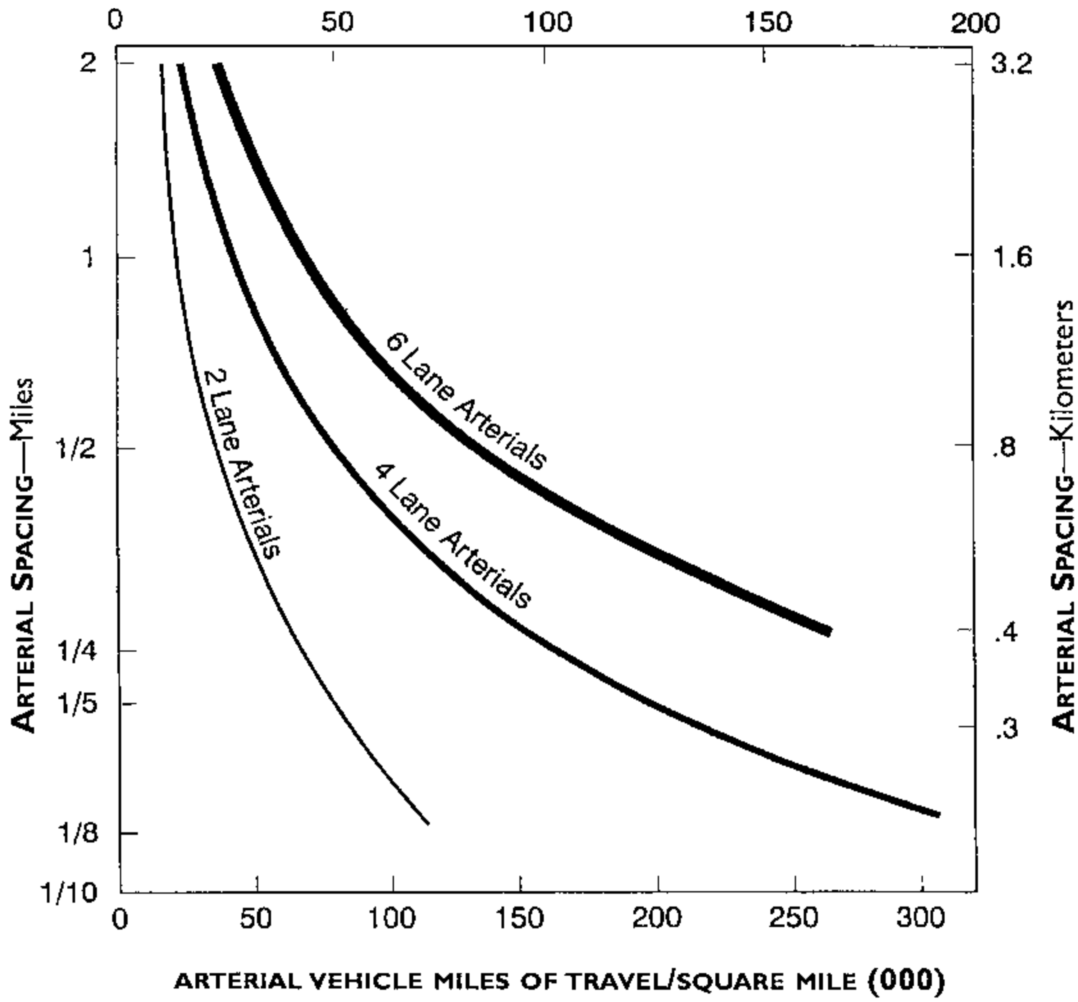

FIGURE 1 Desired spacings for arterials: optimal arterial spacing based on travel demand density.

Source: "System Considerations for Urban Arterial Streets," Institute of Transportation Engineers, 1969.

1997 Report

Since the initial report was prepared, suburban travel demands have increased dramatically, and in many areas freeway systems have been less extensive than initially envisioned. The 1997 report recognizes these factors. It reproduced the 1969 spacing curves and showed how they can be applied. Assuming a suburban residential density of 4,000 persons per square mile, 3.3 trips per person, an average trip length of 5.5 miles, and two-thirds of all travel on the arterial system results in about 44,000 VMT/square mile on arterials. This translates into about 0.3 mile spacing to 2-lane arterials, 1-mile spacing for 4-lane arterials, or 2-mile spacings for 6-lane arterials. Obviously, longer trip lengths would result in closer spacing.

The report suggests the following spacings:

- ¼ to ⅛ mile (0.2 to 0.3 km) in the central business district

- ½ mile (1 km) or closer in the central parts of most urban areas (where daily travel demand exceeds 100,000 VMT)
- 1 to 1.5 mile (1.5 to 2 km) in areas that are primarily residential and
- 1 to 2 miles (1.5 to 3 km) in rural areas. However, some neo-traditional planners have suggested a half-mile spacing to provide a better balance of traffic and allow arterials to be narrower.

Marks, 1974 (*6*)

Marks, in his classic report "Traffic Circulation Planning for Communities," set forth spacing and design guidelines for freeways, arterials, collectors, and local streets. His basic concept called for a "graduated" system of roadways in which each functional class of roads was served only by the next lower class. The basic functional categories and their spacing, access and general design features are shown in Table 3.

Marks envisioned four basic road types: freeway, arterials, short collectors, and local access streets. A "graduated" system of access was proposed in which freeways only served arterials, arterials only served collectors, and all residential access was to and

TABLE 3 Features of Functional Road Categories (*a*)

Item	Facility			
	Freeway (*b*)	Material	Collectors	Access Street
Spacing and Volumes				
Facility Spacing (Miles)	4	1	1/4	1/2
Length	Continuous	Continuous	1/2 MI	500
Operating Volume Range (Veh/Day)	66,000 - 160,000	10,000 - 30,000	2,000 - 5,000	100 - 500
Access Spacing (Miles)	1	1/4	1/2	1/8
Residential Access	Prohibited	Prohibited	Indirect	Direct
Design Features				
Lanes	4 - 8+	4 - 6	2	2
Physical Median	Yes	Yes	No	No
Turn Lane	No	Yes	No	No
Traffic Signals	Yes	Yes	No	No
Parking	Prohibited	Prohibited	Allowed	Encouraged
Pedestrians	None	Few	Many	Frequent
Pedestrian Crossings	Underpass	Signalized	Intersection	Unrestricted
Building Setback	Considerable	Considerable	Moderate	Minimum

(*a*) Source: Marks (*6*, pp. 122, 130).
(*b*) Note: Freeway design features added to Marks' table (*6*)

from collectors. Thus, this system in many respects anticipated contemporary access management standards.

A 1-mile arterial spacing was suggested, based on capacity, cost-benefit, interchange, accessibility, land planning, and turning movement criteria that were drawn, in part, from previous studies.

(a) A design objective was to obtain a balance between the advantages of a widely spaced arterial pattern and the disadvantages of additional travel. An arterial spacing greater than one mile would introduce excessive circuitry.

(b) Spacing intervals of ½ to 1 mile between arterials "normally provide sufficient internal design flexibility for most developments." However, "where there are large concentrations of intensive development, a close (one-half mile) spacing of arterials may be necessary."

(c) A closer spacing of arterials results in a smaller number of turns at each arterial intersection. Where left turn capacity is critical, a half-mile spacing of arterials may be used.

Although Marks opts for a one-mile spacing he indicates that "lesser spacing may be used when needed."

FHWA Studies, 1977 (*7*)

A study by Pearson and Schoener for the FHWA set forth guidelines for correlating arterial street systems with development patterns and densities in representative areas.

- Basic guidelines related areawide suburban development densities, per-mile traffic volumes, and arterial street system lanes and spacings assuming a level of service C. Adjustment factors were given for (1) non-uniform densities, (2) various levels of service, (3) transit utilization, (4) transit utilization, car ownership and income, (5) non-residential–residential activity mix and (6) proximity to freeways.
- A second series of eight charts contained traffic relationships for major traffic generators—airports, industries, universities, offices, government, shopping centers, hospitals and apartment concentrations.

The spacing and lane requirements for various residential and non-residential densities are summarized in Table 4 based on 1.3 autos per household. For current auto ownership rates of about 2 per household, these values should be increased about 50%. Thus, a residential density of about 5,000 persons per square mile would generate about 37,500 vehicles per day—a ⅔ mile spacing of 4-lane arterials or a ¾ mile spacing of 6-lane streets.

FHWA, 1979 (8)

A report by Christopherson and Riddle for the FHWA developed "ideal" street spacing tables for balanced traffic signal progression. The spacings were developed for various

TABLE 4 Road Spacing and Lane Requirements—FHWA Study

A. Residential Development

Gross Residential Persons/Sq.Mile	Average Daily Volume in Mile-wide Corridor in Direction of Maximum Flow	Lanes Per Mile	Spacing (Miles)
Two-lane Streets			
2750	15,000	2	1
6250	30,000	4	1/2
7750	45,000	6	1/3
Four-lane Streets			
3000	12,500	2	2
5500	25,000	4	1
7500	37,500	6	2/3
9500	50,000	8	1/2
Six-lane Streets			
4500	22,000	4	1.5
6500	33,000	6	1
8500	44,000	8	3/4
Eight-lane Streets			
6000	30,000	6	1-1/3
8000	42,000	8	1

B. Major Commercial Development

Total Daily Vehicle Trips	Average Major Generator traffic to and from cardinal direction	Average Number of Access Lanes Required to and from Major Generator in given cardinal direction
20,000	5,000	1
40,000	10,000	1
60,000	15,000	2
80,000	20,000	3
100,000	25,000	1
>100,000	> 25,000	4

Notes: (1) Assumes LOS C
(2) 7% Peak Hour Trips by Transit
(3) 1.3 Autos Per Dwelling Unit
(4) Uniform Grid Patterns of Streets (No Freeways)
Residential Volume Adjustment Factors for 2.0 Cars/household = 1.5

Source: Pearson and Schoener (*7*)

combinations of design parameters, including single and double alternate progression, cycle lengths ranging from 30 to 70 seconds, speeds from 20 to 50 miles per hour, 50/50, 60/40 and 20/30 splits, and both two-phase and multi-phase operations.

TRB Circular 456, 1996 (*9*)

This circular presents street and intersection spacing guidelines that are keyed to traffic signal condition requirements and driver behavior. A ½ mile spacing of signalized intersections was found to permit reasonable travel speeds for cycle lengths ranging from

60 to 120 seconds. Unsignalized access spacing was found to be a function of operating speeds. Full median openings were recommended only for locations that, if signalized, would permit effective coordination.

FURTHER ANALYSIS

Several of the studies have suggested that a one-mile "arterial" suburban street spacing, typically with six-lane roadways, is desirable. However, this spacing has resulted in recurrent peak hour congestion in many suburban settings. Several reasons underly this apparent disparity between theory and practice.

1. Car ownership has increased from about 1.3 to 2.0 cars per household.
2. Suburban residential and employment densities are much higher than they were some 25 years ago. Schools, offices, shops, industries, condominiums, and research parks generate heavy peak-hour volumes today.
3. Trip lengths may be longer than once anticipated because of the growing separation between home and work .
4. The lack of continuous circulation systems in many subdivisions places additional travel on the continuous road system. Often, the arterial roads serve as local collectors.
5. Field observations indicate heavy left turn volumes where two arterial roads cross. This translates into multi-phase signal operations with long cycle lengths and delays.

To accommodate the heavy conflicting volumes at major junctions, right turn lanes and multiple left-turn lanes are frequently provided. This results in 7-lane cross sections for 4-lane arterials and 9-lane cross sections for 6-lane arterials. Often, opposing directions of travel are separated by a narrow median, making pedestrian crossings difficult. And there are the visual and urban design impacts associated with large massing of pavements.

Thus, a major traffic and planning question arises. Should ½ mile spacings be encouraged, with 4 through lanes rather than 6-lane sections spaced a mile apart? The analyses that follow address this question from street capacity, signal coordination and pedestrian access perspectives.

Comparative Volumes and Capacities

The lane-miles of various street widths and spacings provides a broad measure of their relative capacities. Four-lane roads spaced at ½ mile intervals result in 16 lane-miles per square mile as compared with 12 lane-miles per square mile for 6-lane roads spaced a mile apart.

The reductive effect of left turns on intersection capacity can be significant. Where left turn lanes are provided along multi-lane highways, each opposing lane reduces the through vehicle capacity by the number of through lanes it crosses. Where multiple left-turn lanes are provided, the effects are reduced, but not eliminated. Examples of the losses in through capacity per left turning vehicle are as follows:

Number of Left Turn Lanes	Number of Through Lanes	
	2	3
	Losses in Through Vehicle Capacity	
1	2	3
2	1	1.5

If 200 left turns per hour cross three approach lanes, the through vehicle capacity is reduced 300 vph with dual turn lanes and 600 per hour with a single left turn lane. Therefore, reducing the number of left-turning vehicles at any given intersection is desirable.

A peak hour left turn volume of 300 vph—common along many 6-lane suburban arterials with a one-mile spacing—becomes 75 vph when equally distributed over a ¼ mile grid. (Allowing for imbalances among locations, this volume could range up to 100 vph.) Assuming dual left turn lanes on the 6-lane arterials and single left turn lanes on the 4-lane arterials, the aggregate through vehicle capacity loss in each direction of travel reduces from 450 to 300 vph (i.e., 150 vph on each of two streets)

Right turn volumes and hence the need for right turn lanes are also diminished by closer street spacing. A right turn volume of 400 vph with one-mile street spacing becomes 100 vph per intersection when the spacing is reduced in both directions (125 to 150 vph, perhaps when demands are imbalanced). The lower turning volumes reduce pedestrian-vehicle conflicts.

Traffic Signal Implications

The reduced left turn volumes at any specific intersection result in more green time for through traffic and permit shorter signal cycle lengths. Where speeds are less than 35 mph and safety conditions permit, left turns (i.e., 75 to 100 vph) can be accommodated without exclusive turn phases.

This makes it possible to utilize cycle lengths that are of 90 to 120 seconds with arterial progressions of 30 to 45 mph. In urban areas, continuous roads that are spaced ¼ mile apart will permit 22 to 30 mph progression at 60 to 80 second cycles.

Pedestrian Crossings

A 6-lane roadway with right turn lanes and dual left turn lanes results in nine lanes for a pedestrian to cross. A 4-lane roadway with a single left turn lane results in 5 lanes for pedestrians to cross. Obviously, the narrower roads are more pedestrian-friendly.

A Boulevard Design Concept

There will be situations—even with half mile spacings—where 6-lane roadways will be needed. In these cases, the planning of new streets in particular should consider a special “boulevard” design concept that separates opposing traffic flows by a wide, landscaped median. Each street would operate one-way and all left turns would be made via indirect

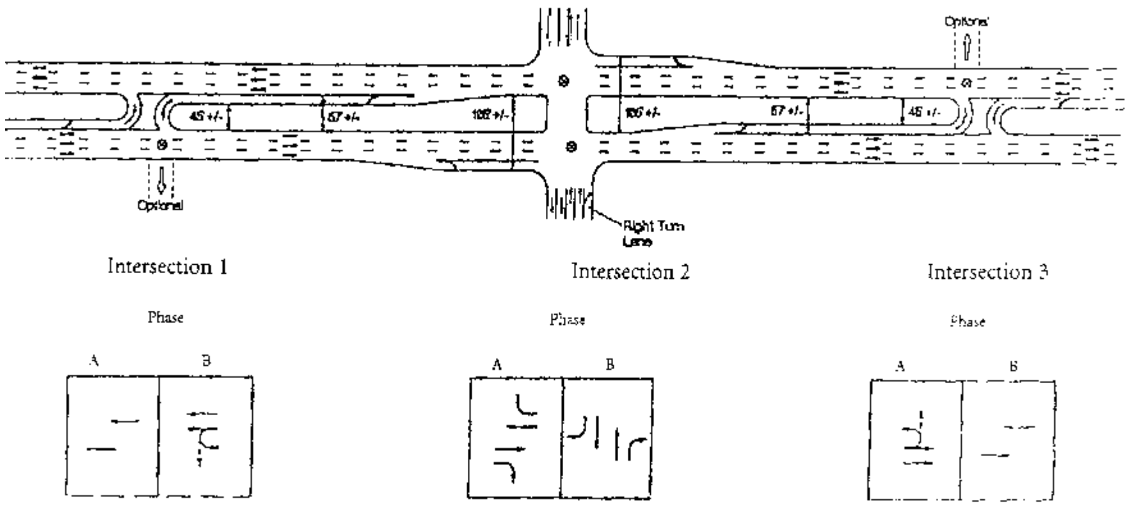

FIGURE 2 "Michigan U" concept.

"U" turns. This concept—commonly called the "Michigan U"—is shown in Figure 2. It provides several desirable environmental, planning, and design features. (1) Removing all left turns from intersections allows two phase traffic signal controls with shorter cycle lengths. This gives more flexibility in developing signal progression. (2) Traffic capacities are increased up to 20% over conventional left turn treatments. (3) Signals can be installed separately as needed along each roadway (where there are no direct crossings). (4) The landscaped median (preferably 40 to 60 feet wide) helps reduce the massing of pavement and provides refuge for pedestrians. (5) The median also can provide opportunities for fly-unders or fly-overs where major roads meet.

The boulevards ideally should be located midway between parallel freeways, and grade separated where they cross each other. Through-lane green time should be at least 50–60 percent of the signal cycle.

Street Scale

The scale (or size) of roads and streets depends upon the amount of roadway and roadside (verge) space, and the adjacent building setback lines. A 4-lane street with single left turn lanes requires much less space than a 6-lane road with right turn lanes and multiple left turn lanes. It fits better into urban and suburban fabrics, and it is also consistent with neo-traditional town design.

A 4-lane road or street with protected left turn lanes requires about 50 to 60 feet of width, depending upon lane width and whether or not a raised median is provided. This allows a street envelope of about 90 to 120 feet. The ratio of road pavement to the entire right-of-way should be about one-half to two-thirds of the right-of-way. Sidewalks and plantings can enhance the street envelope. As shown in Figure 3, a 50-foot property setback from the road center-line provides a good scale for urban and many suburban streets. When shoulders are added at the pavement edge, additional space may be needed. Six-lane arterials increase the right-of-way about 25 feet, and would also call for more overall space.

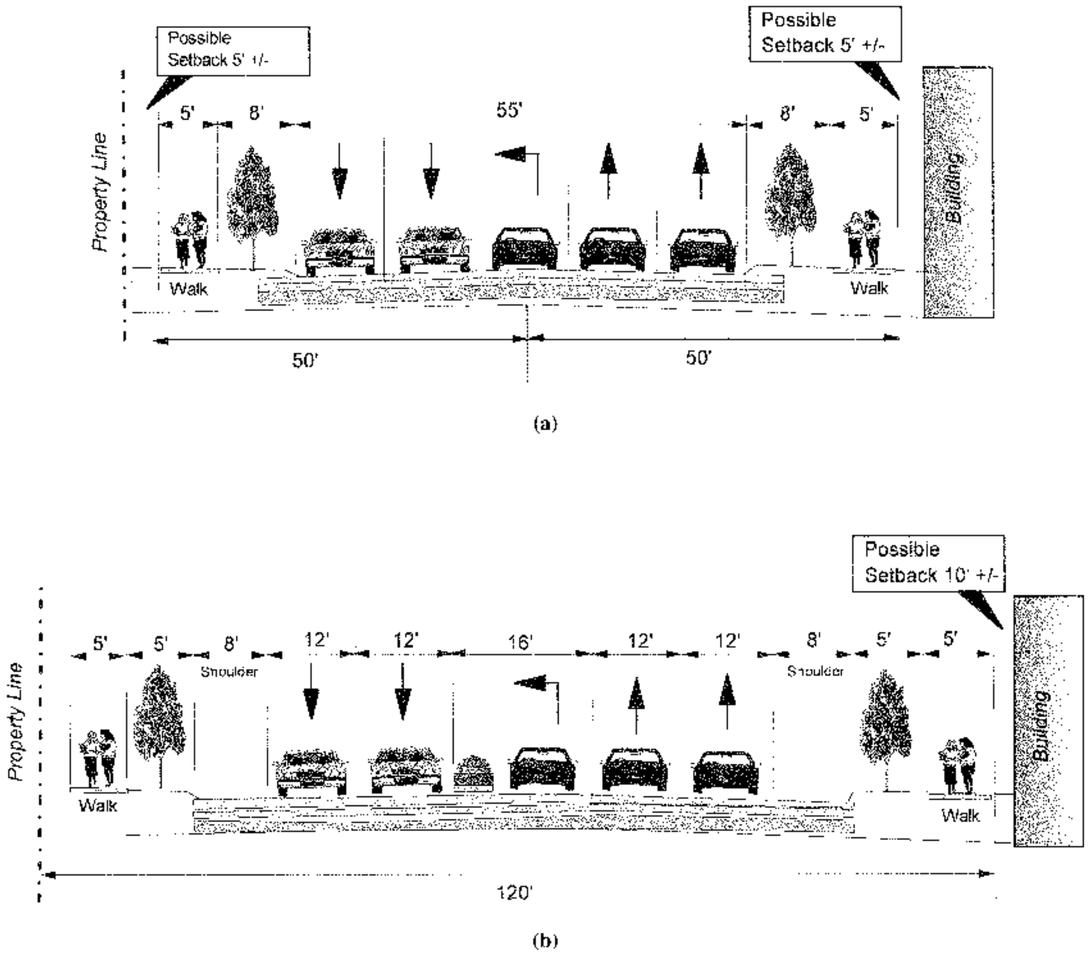

FIGURE 3 Property setback from the road centerline of a typical four-lane street section: (*a*) urban or built-up suburban; (*b*) suburban or exurban.

IMPLICATIONS AND EXTENSIONS

The following street spacing and scale implications emerge from the various studies, field observations and analyses.

1. Existing street systems in most suburban areas do not provide sufficient connectivity. The dramatic shift from too many to too few continuous streets in many suburban settings has limited access opportunities and has concentrated traffic along arterial roadways.
2. There is a need for more complete suburban street systems. Freeways, arterials, collectors, and local streets should form part of an integrated system. Each type of facility

TABLE 5 Suggested Suburban Street Access and Spacing (Illustrative)

Item	A Freeway	B Strategic Arterial (1) "Boulevard"	C Arterial	D Continuous Access Collector	E Local Access Collector	F Local Streets
Access						
Access Control	Full	Partial	Partial	Safety	Safety	Safety
Direct Property Access	None	Right In/ Out (2)	Full (2)(3)	Full	Full	Full
Interchange with:	B, C	A, B, C	A, B, D	B, C, E	D, F	E
Continuity	Continuous	Continuous	Continuous	Continuous	1/2 MI	300' - 1000'
Spacing						
Street Spacing	4 - 6 MI	6 (4)	1 (5)	1 (5)	1/4	1/8 - 1/16
Cross Street Spacing	1 - 2	1/2	1/2	1/4	1/8 - 1/16	100'
Traffic Signal Spacing Based on Through Band Width	-	50 - 60%	40 - 50%	30 - 40%	-	-

Notes:
(1) "Expressways" would have similar features except that there would be no direct property access. Direct property access could be prohibited where reasonable alternative access is available.
(2) Direct property access may be prohibited where reasonable alternative access is available. Residential access would be prohibited.
(3) Left turn exits from developments may be prohibited.
(4) Locate midway between freeway whenever freeway spacing exceeds 5 miles.
(5) Combined spacing of arterials and continuous collectors would be 0.5 miles.

should have its own function, spacing, and scale. Illustrative spacing and scale guidelines are given in Tables 5 and 6 respectively.

3. Major road spacing should vary directly with travel and population density. Spacing should be closer in areas of higher travel density. Suggested continuous street spacing guidelines are:

Area	Person/Sq.Mile	Spacing
Exurban	<2500	1
Suburban	2500–7500	½
Urban	Over 7500	½–¼

Ideally, the arterials and continuous collectors should be interspersed (i.e., for a half mile spacing, both arterials would be placed a mile apart).

4. Uniform locations of signalized intersections at these spacings can allow effective traffic signal coordination. Cycle lengths of 60 to 80 seconds can allow speeds of 20 to 30 mph in urban settings; similarly cycle lengths of 80 to 100 seconds allow speeds of 35 to 45 mph in suburban areas.

TABLE 6 Suggested Suburban Street Scale (Typical)

Item	Facility A Freeway	B Strategic Arterial "Boulevard"	C Arterial	D Continuous Collector	E Local Access Collector	F Local Streets
Physical Medians	Provide	Provide	Generally Provide	Optional	No	No
Number of Through Travel lanes	4-8	6	Pref. 4	2-4	2	2
Provision for left turns	Not Applic-able	Indirect	Direct	Direct	Direct	Direct
Left Turn Lanes	Not Applic-able	Yes	Yes	Optional	No	No
Lane Width	12'	12'	11' < 35' MPH 12' >35' MPH	11'	10'-11'	10'-11'
Shoulder width (where provided)	12'	10'	8'	4'	-	-
Approximate Right-of-Way	250-330'	150-200'	90-120'	60-90'	60-80'	50-60'

5. Street spacing and scale are interrelated. In general more continuous streets (i.e., closer spacing) is better than fewer. A ½-mile spacing of continuous 4-lane roadways gives better traffic performance and distribution than a mile spacing of 6-lane arteries. Turns at intersections are about 25% of those with 1-mile spacing. The 4-lane streets are less intrusive, can better integrate into surrounding areas, and complement neo-traditional design concepts.

6. Although four-lane roads (with protected left-turn lanes) are preferable to wider roads from a pedestrian and community planning standpoint, 6-lane roads sometimes may be needed (especially where freeway development is limited). In these cases, a "boulevard" with a wide median should be considered. The wide median will allow indirect left-turn lanes, and two-phase traffic signal controls, and make pedestrian crossings easier. (About 10 to 30 feet more median space is needed than the traditional dual left-turn arrangement along 6-lane roads). Where two of these roads meet, a grade-separation is desirable to preserve the capacity of both roads.

7. Roadway design should be pedestrian friendly (except perhaps in undeveloped or exurban areas). Sidewalks, planting strips, and adequate setbacks are desirable. Curbs can define edges, and reduce road space in built-up areas.
8. The roadway and the road edge should be perceived and designed as an integral unit. A ratio of arterial (and collector) road space to the right-of-way envelope of about 50 to 65% is desirable. *Where* the adjacent buildings are located will have important bearing on road space and walkability.

Obviously many factors influence street spacing, scale and configuration. These include physical features such as topography and water bodies, residential and commercial development patterns; traffic demands and operations (including traffic signal coordination), public transport and pedestrians, urban amenity, design and costs. Consequently, flexibility and sensitivity are essential in applying spacing and scale guidelines.

The greatest opportunity for applying spacing and scale concepts lies in the undeveloped or developing areas. It is here that roads in our 21st Century suburbs can build upon the best contemporary practice in city street and suburban road planning and design.

ACKNOWLEDGMENT

The insights of Samuel W. Zimmerman are appreciated.

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