Regional Arterial (Super Street) Concepts

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Freeways in urban areas routinely experience significant traffic congestion during several peak demand hours. Construction of additional freeway lanes could solve this problem, but because of economic, political, and social constraints, this is not always feasible. Diversion of short trips from freeways to arterial streets could help solve the problem without construction of new freeway lanes. However, such diversion will occur only if the traffic speed and capacity of selected urban arterial streets can be improved significantly. The regional arterial, or super street, is proposed as a class of facility that would have the continuity, speed, and capacity characteristics to attract short and medium-length trips. Through several research efforts, design and operational guidelines for regional arterial (super) streets have been developed. These are conceptually described and evaluated in terms of significance to the success of the regional arterial concept. A case study of potential impacts of several alternative regional arterial networks for the Houston/Harris County, Texas, area is described. Within the limitations of simulation, using a large network modeling package, the alternative case study network effects are compared.

During the past three decades, urban areas have experienced extensive growth in population, land area, and traffic congestion. Past approaches to maintaining urban mobility relied on constructing new lane miles of freeways, highways, and streets. The costs of such construction in terms of social, environmental, and political impacts, as well as monetary requirements, have prevented construction activities from keeping pace with urban growth. Today there is little probability that large quantities of lane miles of new facilities will be constructed in congested urban areas. Therefore, there is a great need for new concepts that will enhance the functionality and increase the capacities of existing facilities. The regional arterial or super street is one such concept.

BACKGROUND

A regional arterial as envisioned here would consist of an upgraded arterial street with certain distinct design and operating characteristics. It would have design speeds of 40 to 50 mph, grade separations at railroads and some cross streets, partial access control, and favored treatment for arterial traffic at nongrade separated intersections. Additionally, it would include median barrier separation, very few or no left turns, and an auxiliary or collector-distributor lane to the driver's right functioning as a speed change lane for entering and exiting traffic. However, the key element that is necessary to produce successful regional arterial implementation is a highly disciplined operating policy that guarantees that these features are maintained.

The regional arterial concept is not a freeway, although it has many similar characteristics. The primary differences are lower design speeds, partial access control, and infrequent nongrade separated intersections.

In the worst case, estimated costs of regional arterials are less than half the cost of new freeways, but they would provide half to two-thirds the traffic productivity of a freeway having the same number of lanes. Most regional arterials would be upgraded versions of existing arterials and might require little new construction. Another extremely significant advantage for the regional arterial concept is that the right-of-way requirements for new alignments would be less than those of a freeway with the same number of lanes.

Regional arterial streets can be viewed from two different but complementary contexts. First, they may serve as surrogates for new freeway lane miles that will never be built because of economic, social, environmental, and political constraints. Second, they may serve as a new functional class of urban street that can provide much more appropriate and efficient use of other facility classes.

An ideal representation of urban trip length versus facility class is shown in Figure 1. This figure indicates that the shortest trips would ideally use local streets, and successively longer trips would use successively higher functional facility classes. Freeways, the highest functional class, would serve only for the longest trips. Due to a lack of route continuity, inadequate potential travel speeds, and capacities, arterial streets are typically unable to attract appropriate numbers of intermediate-length trips. Thus, large numbers of short trips are frequently diverted to freeways, the next-higher facility class.

One result of the lack of continuity and the inherent unacceptable travel speeds on nonfreeway routes is the diversion of much more than a proportional share of all travel to the urban freeway system. The ratio of daily vehicle miles of travel (VMT) and facility centerline mileage in the Houston/Harris County area is shown for three facility classes in Figure 2.

The two nonfreeway facility classes noted in the figure are those that provide continuous routes of more than 4 mi and those with less than 4 mi of route continuity. The figure presents the expected conclusion that freeways carry the vast majority of the daily VMT (DVMT) in this automobile-oriented area. Specifically, freeways carry almost 80,000 DVMT/centerline-mi, whereas the facilities with less than 4 mi of continuous routes carry only about 1,600 DVMT/centerline-mi. However, Figure 3 shows the percentage of DVMT for each facility class and the percentage of total highway centerline miles represented by each class. The figure shows that although freeways represent about 2 percent of the total cen-

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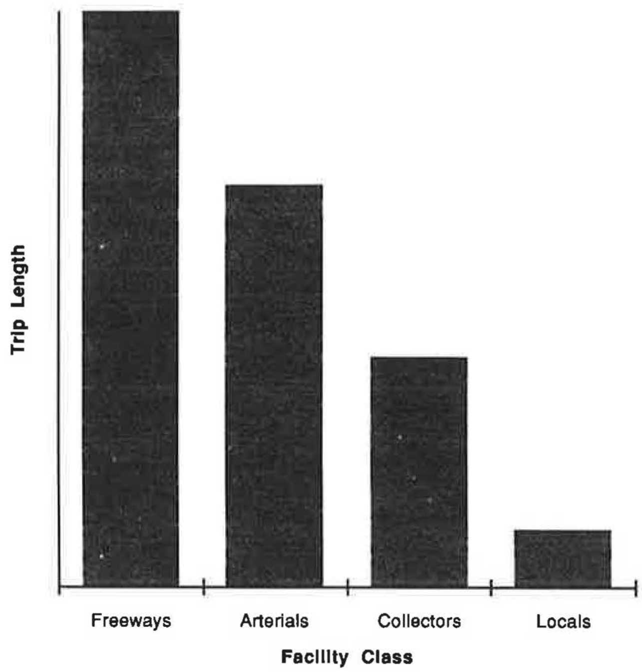

FIGURE 1 Ideal trip length versus facility class.

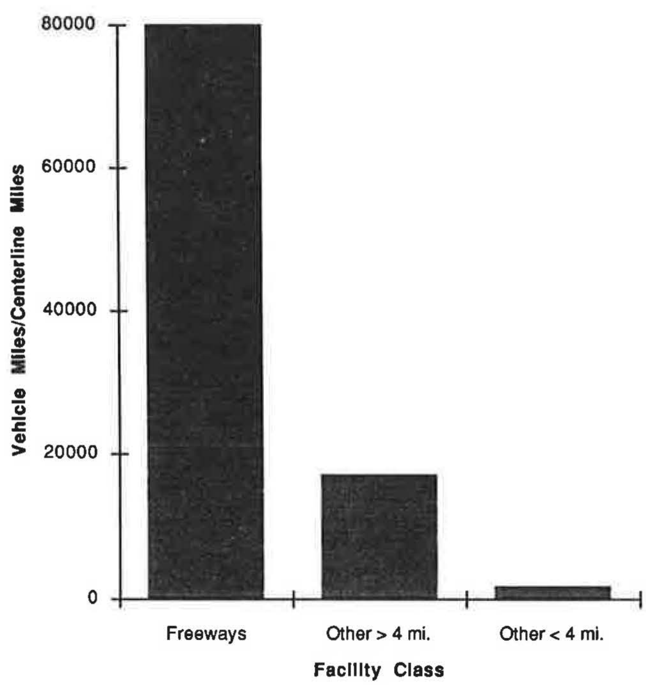

FIGURE 2 Daily vehicle miles per centerline mile by facility class.

terline miles of highway facilities, they carry 40 percent of the DMVT.

Diversion of many short trips to freeways degrades freeway traffic flow capabilities by abnormally increasing entrance and exit operations. Freeway flows are limited almost always by weaving section capacities near entrance and exit ramps. If short trips could be attracted to a lower functional facility

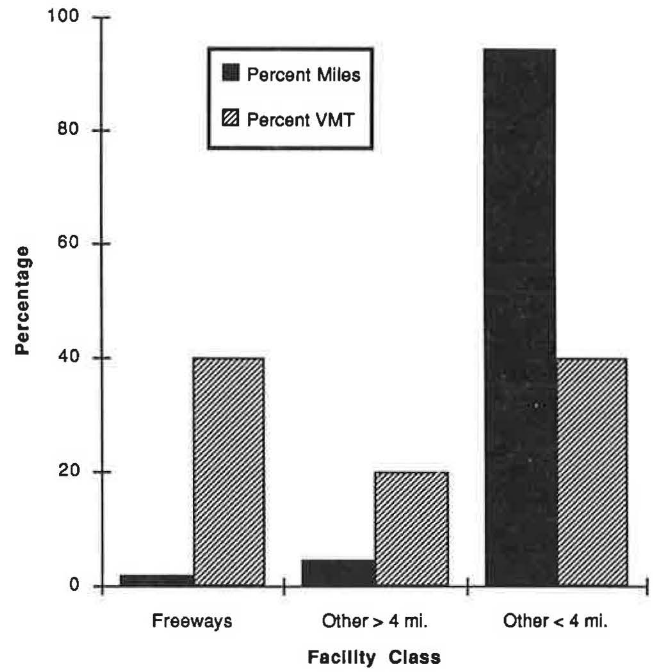

FIGURE 3 Percentage centerline miles and VMT by facility type.

class, away from freeways, the traffic movement capability for the long trips for which freeways were really designed could be enhanced. The regional arterial is proposed as a new facility class that would provide the continuity, travel speed, and capacity that could attract short trips away from freeways.

DESIRABLE DESIGN AND OPERATING CHARACTERISTICS

Two research studies (*1*,*2*) and several years of gathering and analyzing information about regional arterial, strategic arterial, or super streets have produced a compendium of desirable design and operating characteristics.

Continuity

Lack of continuity is one of the most significant problems plaguing arterial streets. Texas cities are notorious for this lack of continuity. In Austin, Texas, for example, it is not possible to travel from east to west between the corporate limits of the city along one arterial street. On the other hand, Houston does have long arterials, but geometrics and traffic control features are so variable along most routes that traffic flow continuity is not maintained.

Regional arterial streets and networks composed of these types of facility must provide sufficient continuity to attract travelers making trips of a length at least equivalent to the average areawide trip length. This will obviously vary among cities depending on many factors; however, it is typically from 5 to 12 mi. A 1984 regional telephone survey of Houston travelers (*1*) indicated the average vehicular trip length was 7 mi and the average commute trip was 11 mi. It is apparent that if a regional arterial is to be effective, it must provide continuity for at least the average trip length.

The concept of route continuity envisioned here is more than a continuous alignment with a common or appropriate geometric cross section. The concept also includes traffic control features necessary to provide continuous high-speed travel.

Signal Timing Policy

The capacity of any approach to a signalized intersection primarily depends on the percentage of the available green time provided to that approach or the effective green time to cycle length (g/C) ratio. If a regional arterial street is to have the potential to carry large volumes of traffic over long continuous street sections, the g/C ratios for all intersection approaches must be appropriately established by operating policy. This policy must clearly establish traffic operations on the regional arterial as preferred movements. A policy of providing 70 percent of the available intersection green time to movements on the regional arterial is considered the desirable minimum.

Because of the relative ease with which signal timing can be changed, the difficulty of maintaining this recommended policy is certainly recognized. Cross streets that do not have regional arterial designation will obviously be penalized; this will clearly create user complaints. However, somewhat like ramp metering on freeways, this policy can produce huge overall user benefits despite increased delay for some users. User complaints and increased delay can be ameliorated through designation of a network of regional arterials and the self-leveling effect of users seeking the fastest, least time-intensive travel paths.

Geometric Design Standards

Geometric design standards for regional arterial streets must be appropriate for high-volume, relatively high speed facilities. Minimum design speeds of 40 to 50 mph should be adopted and strictly maintained. Grade separation structures should be provided for all existing at-grade railroad crossings. Geometric features should be provided to prohibit left-turns from all cross streets and abutting property. In addition, where left-turns are allowed from the arterial, appropriate storage such as turning bays or lanes should be provided. A median barrier for the arterial is recommended as an effective left-turn control measure that enhances overall safety but does not consume extensive, scarce right-of-way areas.

Mass Transit Operations

The high operating speeds and continuity of regional arterials make them ideal for public transportation routes. However, buses stopping in the travel lanes for passenger loading and unloading would be highly disruptive to the advocated kind of traffic service. Therefore, all public transportation passenger boarding and deboarding operations should be performed while buses are in appropriately designed bus turnouts.

Access Control Standards

Positive control of turn movements is a primary element of the regional arterial philosophy of favoring long through trips. As noted previously, median barriers are an excellent means of controlling left turns from the arterial and allowing them only at carefully selected locations. Additionally, right turns from the arterial should be separated from through traffic. One highly desirable means of accomplishing this is the use of collector-distributor lanes from which all turns must be made. Geometrics of the paths to be followed by vehicles making right-turn movements into and off the arterial should resemble freeway entrance-exit ramps—that is, these facilities should follow gradual tapers permitting exits at arterial speeds and appropriate acceleration distances for entering vehicles.

Right-of-way For Undeveloped Areas

Most lane miles of regional arterial streets that are developed in the near future will be in developed areas where right-of-way (ROW) is probably scarce and new acquisitions are very expensive economically, socially, and environmentally. However, where regional arterials are designed for extensions into undeveloped areas, ROW specifications should be developed around desirable, not minimum, standards: when given the chance to do it right, designers should take advantage of the opportunity.

Intersection Grade Separations

Existing and certainly future traffic demands will justify construction of grade separation structures at some locations. Two observations about grade separations are extremely important. First, the regional arterial concepts described here do not assume construction of grade separations at all cross-street intersections. They should be considered only where the crossing traffic volumes are large enough that a critical user delay problem exists and cannot be solved by any less expensive measure. Such locations will be few when the typical regional arterial is first designated and constructed. In other words, the inability of constructing grade separations should not preclude design and implementation of regional arterial streets. Second, whereas AASHTO policy demands very long vertical curves for grade separations, minor changes to these specifications can produce much shorter curves that can be designed to fit between existing intersections. Thus, grade separations can be constructed so that they do not entirely preclude desirable access to abutting property.

CASE STUDIES

The potential impact of a network of regional arterials on a typical large, automobile-oriented urban area was examined through a simulation study of the Houston regional urban area. The simulation was performed using the Texas Large Network Computer Package running on the Texas Department of Transportation mainframe computer system. Assigned traffic consisted of the forecast year 2010 daily highway volumes and the planned 2010 regional highway system.

The simulation consisted of only a very general set of modifications to the planned 2010 regional highway system. These included

1. Addition of links composing 15 and 62 new centerline-mi for the 350- and 600-mi strategic arterial systems, respectively.
2. Speed increases of 5 or 10 mph (two different cases) on the links of the strategic arterial systems. These increases were applied to the normal arterial speeds.
3. Appropriate capacity specifications for the links of the strategic arterials (this generally involved increasing capacity specifications simulating the addition of lanes or modified signal timing).
4. Decreases in link capacities for links crossing the strategic arterials. This represented an effort to simulate effects of signal timing strategies favoring arterial traffic.

Several regional arterial improvement concepts were not simulated. These included control or prohibition of left turns, and grade separations. Additionally, simulation of the 70 percent arterial green recommendation was not attempted.

The simulation case study represented an approximate potential effects worst case. The modeling system used was based on daily traffic, not hourly demands. Therefore, simulation of certain details of regional arterial concepts was somewhat difficult.

Summary statistics for the two alternative regional arterial systems that were examined are presented in Table 1. As indicated in the Table, the approximate 350-mi strategic arterial system was composed of 337 mi of upgraded existing street alignment with only 15 new centerline mi. The more extensive, roughly 600-mi system included 519 mi of upgraded street and only 62 new centerline mi. Thus, both alternatives represented very modest new alignment additions.

Effects of the 350-mi strategic arterial system on other facility classes are presented in Table 2 and Figure 4.

Table 2 indicates that 5 and 10-mph levels of increase compared to existing conditions were simulated for the strategic arterial links. As expected, the 10-mph increase for regional arterials, which produced weighted average speeds of 48 mph, caused more diversion from freeways and other facilities to the regional arterial facility class. Figure 4 compares percentages of centerline miles for each facility class to DVMT before (base) and after (strategic arterial system, or SAS) the strategic arterial addition. The chart indicates the 350-mi system would reduce freeway DVMT by 3 to 4 percent, have minimal impact on other facility classes, and double DVMT on the facilities redesignated as regional arterials. Almost 20 percent of the 1,042 freeway links included in the simulation had daily traffic volumes reduced by more than 10,000, which may be far more significant than the DVMT reductions.

A similar presentation of effects due to the alternative 600-mi strategic arterial system is included as Table 3 and Figure 5. For this system, which featured only 62 lane-mi of new alignment, freeway DVMT was reduced roughly 6 percent, and nearly 30 percent of the 1,042 freeway links had average daily traffic volume reductions of 10,000 or more.

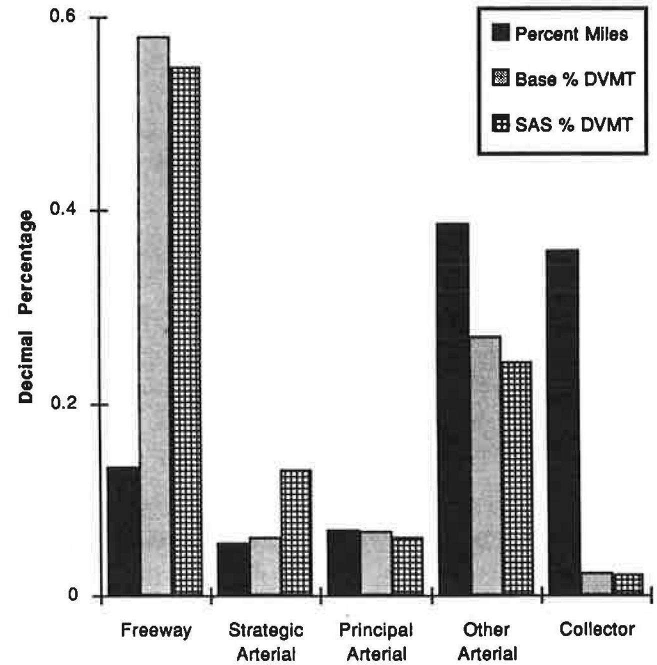

FIGURE 4 Percentage centerline miles and daily vehicle miles for base and 350-mi strategic arterial system networks—Houston/Harris County, Texas, region.

TABLE 1 Alternative Regional Arterial Network for Houston Region

Facility Class	350 Mile Strategic Arterial System Total Centerline Miles	600 Mile Strategic Arterial System Total Centerline Miles
Freeway	875	875
Facility to be upgraded to Strategic Arterial	352[a]	581[b]
Principal Arterial	447	440
Other Arterial	2546	2428
Collector	2352	2294

[a] Includes 15 miles of extended and 337 miles of upgraded facilities.
[b] Includes 62 miles of extended and 519 miles of upgraded facilities.

TABLE 2 Effects of 350-mi Strategic Arterial System

	Assigned Daily Vehicle Miles of Travel (000's)		
		Strategic Arterial Mileage = 350	
		Speed Increase (MPH)	
Facility Class	Base Network	+5	+10
Freeway	55,426	52,655	51,860
Strategic Arterials	5,831[a]	10,827	12,347
Principal Arterial	6,347	5,737	5,753
Other Arterial	25,690	23,528	22,950
Collector	2,132	2,019	1,984

[a] Facilities to be expanded to Strategic Arterial status

TABLE 3 Effects of 600-mi Strategic Arterial System

	Assigned Daily Vehicle Miles of Travel (000's)		
		Strategic Arterial Mileage = 600	
		Speed Increase (MPH)	
Facility Class	Base Network	+5	+10
Freeway	55,426	50,798	49,583
Strategic Arterials	7,939[a]	15,729	17,899
Principal Arterial	6,255	5,598	5,568
Other Arterial	23,872	20,715	20,126
Collector	1,934	1,610	1,577

[a] Facilities to be expanded to Strategic Arterial status

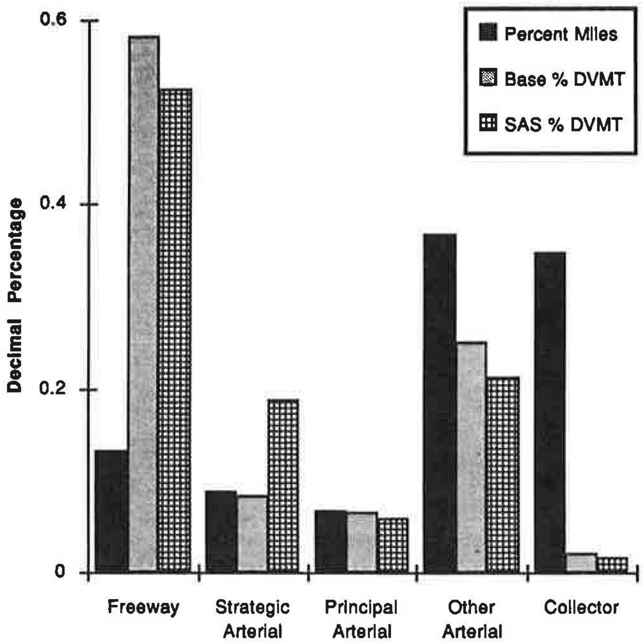

FIGURE 5 Percentage centerline miles and daily vehicle miles for base and 600-mi strategic arterial system networks—Houston/Harris County, Texas, region.

SUMMARY

This paper has summarized regional arterial street concepts that are practically implementable and offer great potential highway user benefits. The concept consists of

- An upgraded, or extended, arterial street with distinct design and operating characteristics that must be maintained through a disciplined policy;
- Design speeds of 40 to 50 mph;
- Grade separations at railroads and some cross streets;
- Partial access control;
- Favored treatment for arterial traffic at nongrade separated intersections;
- Median barrier separation;
- Very few or no left turns; and
- An auxiliary or collector-distributor lane to the driver's right functioning as a speed change lane for entering and exiting traffic.

The key element, however, is a highly disciplined operating policy that guarantees the maintenance of these features.

Estimated costs of regional arterials are, in the worst case, less than half the cost of new freeways, but the arterials would provide half to two-thirds the traffic productivity of a freeway having the same number of lanes. Most regional arterials would be upgraded versions of existing arterials and might require little new construction. Another extremely significant advantage for the regional arterial concept is that right-of-way requirements, for new alignments, would be less than that of a freeway with the same number of lanes.

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