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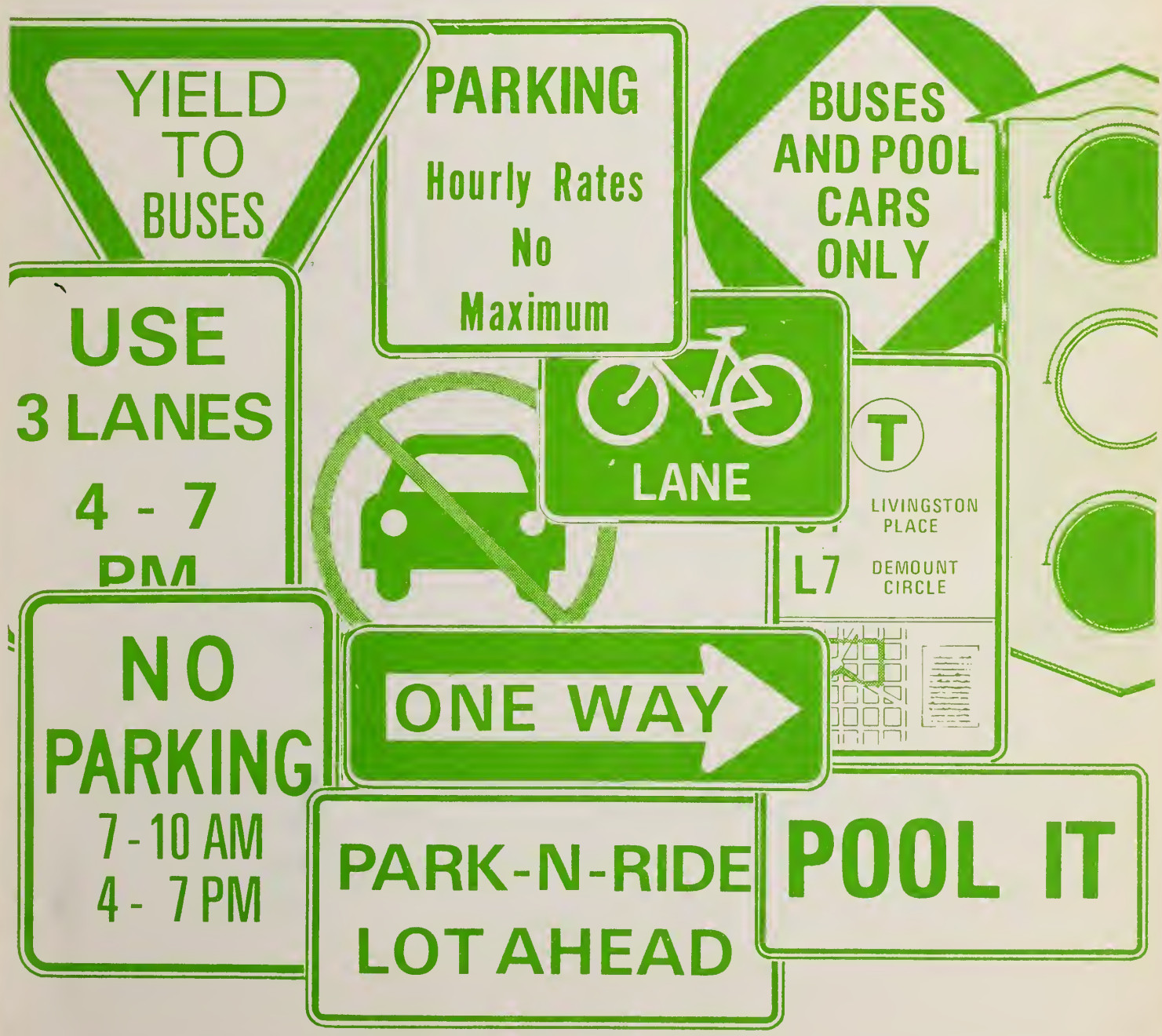
Transportation System Management

Promise, Performance and Prognosis



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16. Abstract

This report is an assessment of the efficacy of transportation system management (TSM) as both a strategy of transportation system improvement and a philosophy of planning administration. The report summarizes the results of two years of technical and institutional studies conducted by faculty and students at the University of California at Berkeley, but in the form of a policy-oriented executive summary rather than an all-inclusive technical summary. The companion technical reports are referenced.

The report is organized into four sections. The first discusses the impetus for TSM and its roots in the recent history of transportation planning and finance. The second section articulates a set of assertions and propositions that are imbedded in the Federal regulations and critiques them in light of the research findings. Section Three reaches conclusions about the efficacy of TSM--as both a transportation improvement strategy and a philosphy of public administration. Section four proposes an "idealized" or "model" TSM planning process that responds to the conclusions reached in the previous sections.

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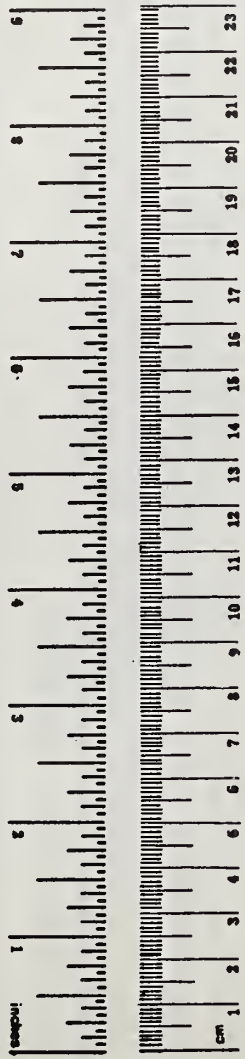
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

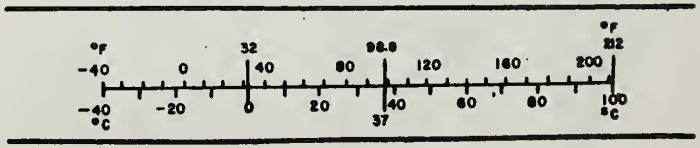
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.96	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

TRANSPORTATION SYSTEM MANAGEMENT: PROMISE, PERFORMANCE AND PROGNOSIS

I. Introduction

In September, 1975, the U. S. Department of Transportation issued regulations mandating metropolitan areas to develop Transportation System Management (TSM) plans.[1] The intent of the regulations--issued jointly by federal highway and transit authorities--was to engage regional planning agencies and local operating agencies in cooperative efforts to make more productive use of existing transportation facilities. The operative language here is an emphasis on both cooperative effort and more productive use of already-committed resources.

Thus, the TSM regulations entail both a philosophy of planning, programming and public administration and an emphasis on operational, regulatory and managerial strategies (as opposed to major capital investment). These two thrusts of TSM--the technical and the procedural--are wed in the notion that decisions about transportation infrastructure, the rules of the road, service schedules, and the tariffs charged for transit and parking should be reached interdependently. In short, infrastructure, work schedules, regulations and tariffs should be planned and managed as if they were components of a single complex system rather than the "private domains" of independent decision-makers. Thus, the regulations declare that:[2]

> Automobiles, public transportation, taxi, pedestrians, and bicycles should be considered as elements of one single urban transportation system. The objective of urban transportation system management is to coordinate these individual elements through operating, regulatory, and service policies so as to achieve maximum efficiency and productivity for the system as a whole.

Consistent with this thrust, the federal regulations locate primary responsibility for the development of TSM plans with Metropolitan Planning Organizations (MPO's)--agencies with an areawide purview and a comprehensive planning orientation. The regulations also confer "shadow" programming authority on MPO's by making federal grants in aid contingent upon the inclusion of reimbursable projects in an areawide investment and improvement program.

At the same time, the regulations "endorse"--subject to local review--a series of action strategies intended to squeeze more productivity from existing

transportation facilities. These tentatively endorsed actions include traffic management, parking management, work schedule management, ride-sharing programs, and paratransit, among others. These actions are typically management intensive rather than capital intensive.

This report amounts to a program evaluation. It is an assessment of the efficacy of TSM as both a strategy of transportation system improvement and a philosophy of planning administration. In a brief, predominantly qualitative format, the report summarizes the results of two years of technical and institutional studies conducted by faculty and students at the University of California at Berkeley. The report is organized in four sections. The first discusses the impetus for TSM and its roots in the recent history of transportation planning and finance. The second section articulates a set of assertions and propositions that are imbedded in the federal regulations and critiques them in light of the research findings. Section Three reaches conclusions about the efficacy of TSM--as both a transportation improvement strategy and a philosophy of public administration. Section Four proposes an "idealized" or "model" TSM planning process that responds to the conclusions reached in the previous sections.

II. The Roots of TSM

TSM is a departure from the idioms of civil engineering and project construction which dominated transportation planning in the first three decades of the post-war era. TSM postulates that operational, pricing and regulatory actions can be used to manage the demand for travel and serve as a first alternative to the construction of new facilities. Thus, the federal regulations posit that:[3]

> Controlling the flow of traffic, influencing the volume, pattern and mix of traffic, and giving priority to buses and other high-occupancy vehicles may be the single most effective set of measures to improve the efficiency and productivity of both mass transportation service and the entire urban transportation system.

This declaration of technical conviction and policy intent signals a change in the planning conventions that make up the informal contract between the users and suppliers of transportation. It can be argued that, stripped of federalese, this statement of policy and procedure sanctions actions that would effectively serve to ration roadspace, discipline mode choices, and

discriminate against single-occupancy vehicles. These are "red flag" words--foreign to the traditional vocabulary of transportation planning. They may not be apt, for described more conventionally, TSM is a search for means to accommodate traffic growth in the absence of a political commitment to major new investment in system capacity.

In fact, TSM can be seen as a response to the increasingly prevalent conviction among transportation planners that:

- The infrastructure of transportation facilities is essentially in place and the system near "complete";
- Financial resources for new construction, system expansion and transit operation will be limited in the extreme;
- Energy and environmental considerations dictate a posture of retrenchment toward personal transportation and the private automobile; and,
- Increments in traffic volume will have to be accommodated by riding rather than driving.

Thus, at heart, TSM is a response to the cost-revenue squeeze in transportation finance and to the accumulation of costs and constraints that have diminished the political acceptability of highway construction in metropolitan areas. That litany of costs and constraints is now familiar:

- The escalation of highway maintenance and construction costs which is diminishing the buying power of highway revenues;
- The high marginal cost of additional peak hour capacity--whether highway or transit;
- The rapid escalation of the tax cost of transit operating losses;
- Costs associated with air and noise pollution;
- Costs associated with urban sprawl and the depletion of open space;
- Costs associated with the displacement of land from productive use and property from the tax roles; and,
- The cost associated with vulnerability to another petroleum embargo and deepening balance of payments deficits.

In the context of these costs and constraints, TSM has been proposed as a strategy to keep options open and accommodate traffic growth without disruptive new construction, while maintaining the accessibility of Central Business Districts.

TSM also has its origins in the convergence of a number of other forces and pressures felt within the U. S. Department of Transportation. Thus:

- TSM offers a means of co-opting and "taming" the process of transportation control planning mandated by the Environmental Protection Agency.
- The TSM regulations are a step in the development of the institutional "machinery" necessary to manage highway/transit investment trade-offs and program the revenues of a multi-modal "transportation trust fund."
- The same institution of machinery is suited to the purchase of paratransit services from private vendors such as taxicab companies.

The TSM regulations also reflect the increasing role of economists in transportation policy-making and UMTA's growing insistence on the formal evaluation and analysis of options and investment alternatives as a condition of grants in aid. The failure to make the most efficient use of existing transportation resources provides the Urban Mass Transportation Administration (UMTA) with a logic for deferring requests for grants to construct major rapid transit systems. In this sense, the TSM regulations embody the Zero-Based Budgeting philosophy of the Office of Management and the Budget (OMB) and reflect the increasing federal emphasis on multi-modal coordination and the documentation of a technically rational priority-setting process.

At the same time, the regulations are a response to UMTA's dissatisfaction with the limited success of MPO's in forging a link between planning and impleme tation. The comprehensive, 20-year systems plans developed by MPO's have nad little impact on the behavior of action agencies or the staging of capital investments. The regulations seek to strengthen the role of comprehensive planning agencies in programming and budgeting federal funds and in coordinating transit services in regions with more than one operating property.

As this discussion suggests, the TSM planning requirement is both a technical and procedural initiative. On the one hand, TSM is a technical response to limited capital improvement budgets and increasingly stringent constraints. On the other hand, it is a step toward the development of an institutional framework more compatible with multi-modal programming, alternatives analysis, and other "rational" planning procedures in the spirit of "zero-based" or incremental budgeting.

III. The 1975 Regulations Restated as Technical Assertions and a Normative Philosophy of Public Administration

Imbedded in the 1975 TSM regulations are an inventory of tentatively endorsed action measures and a normative theory of public administration. In this section, we will restate the content of the federal regulations as propositions, making explicit the U. S. DOT's assertions about the technical merit and cost-effectiveness of various transportation management measures, and, its normative assertions about the appropriate structure and conduct of the planning and programming process. Then we will independently assess the merit of these propositions based on the technical and institutional analyses conducted by the research team.

The regulations make three implicit assertions of a technical character:

Technical Proposition #1: The peaking of work-trip travel and related congestion causes significant inefficiencies--"excess" delay, "excess" capacity requirements, "excess" transit operating expenses, "excess" fuel consumption, and "excess" air pollution. These inefficiencies can be mitigated using traffic management, parking management and work rescheduling strategies.

Technical Proposition #2: Preferential treatment of high-occupancy vehicles may be the single most effective strategy for increasing the efficiency of mass transit and the urban transportation system as a whole.

Technical Proposition #3: It is possible and may be preferrable to manage the demand for travel as a first alternative to increasing the supply of urban transportation facilities.

The regulations also implicitly make five assertions that cumulate toward a normative specification of an "appropriate" planning and programming process:

Procedural Proposition #1: A more balanced attack on the problems of urban transportation can be mounted if local jurisdictions collaborate in cooperative efforts that span the traditional boundaries between modal agencies, between operating and regulatory agencies, and, in the case of work scheduling, between the public and private sectors. Planning for short-range highway and transit improvements should be conducted jointly in the spirit of "continuing, coordinated and comprehensive" planning.

Procedural Proposition #2: The strategy of market segmentation and service differentiation should inform the planning of short-range transit and paratransit improvements.

Procedural Proposition #3: A philosophy of staged or incremental service deployment, market exploration, and market development should inform the implementation of new transit services.

Procedural Proposition #4: Metropolitan Planning Organizations--non-operating agencies that provide a forum for the negotiations of locally elected officials--are the appropriate jurisdictional setting for the coordination of TSM planning and the brokering of investment priorities.

Procedural Proposition #5: Formulating policy objectives and planning goals is an appropriate local responsibility. The federal interest in TSM should be limited to guidance (and remonstrance) on matters of process and procedure rather than policy and priorities.

These eight propositions accumulate to the master assertion that transportation could be delivered more efficiently if decisions about infrastructure, tariffs, regulations, schedules, and land-use were reached interdependently--with demand management evaluated as a potential alternative to new construction.

Evaluating the Eight Implied Propositions: Methods

The process of evaluation requires the statement of objectives and the formulation of measures of effectiveness. In turn, objectives and effectiveness criteria are statements of the goals and values the researcher believes should be pursued in the implementation of public policy. The dilemma faced by evaluators is the political character of values. The choice of evaluation criteria involves a judgment about which values and whose values should prevail when action to be assessed would serve one objective at the expense of another or one class of people at the expense of another.

In pursuing this research, we have taken a multi-values and correspondingly multi-method approach that seeks to assess against a wide variety of decision criteria and social values. The decision criteria and social values include:

- Economic efficiency
- Social equity

- Environmental quality
- Accessibility
- Facility productivity, and
- Political acceptability.

Actions that satisfy one objective may sacrifice another, requiring trade-offs between equity and efficiency, or between mobility and environmental quality, for example. Research cannot seek to resolve these value conflicts but it can hope to alert policymakers to the need for balancing judgments and forced-choice trade-offs.

Thus, it is in this context of a multi-values and multi-method evaluation procedure that the research team has sought to assess the efficacy of TSM--as both a set of discrete techniques and a normative specification of the "appropriate" structure and conduct of the transportation planning process. The technical analyses focused on four classes of TSM strategy:

- Work schedule changes intended to level the peaking of "rush hour" work trips.
- Traffic management measures intended to increase the productivity of existing facilities.
- Traffic management measures intended to achieve environmental and energy conservation objectives through the preferential treatment of high-occupancy vehicles; and,
- Marginal cost pricing strategies (congestion tolls), price subsidies, and surrogates such as parking taxes or fuel surcharges intended to "ration" roadspace more efficiently between modes and across the hours of the day.

The institutional analyses focused on barriers and dilemmas in:

- The coordination of highway and transit improvements;
- The coordination of transit routes, schedules and fares;
- The integration of transit and paratransit services; and
- Collaborative planning efforts between the public sector and major employers.

The institutional analysis is based on site-visits to four major metropolitan areas (San Francisco, Los Angeles, Chicago and Minneapolis-St. Paul), and a review of TSM plans developed by a variety of MPO's.[4] The technical

analyses were conducted using a variety of modeling and analysis techniques including: survey research;[5] a sketch planning model suited to constrained optimization and full-cost accounting;[6] a deterministic traffic simulation model that represents freeway operations, including queueing;[7] an arterial simulation model that can independently treat bus and automobile flows and accomplish multiple-objective optimization;[8] and a family of accessibility measures that permits benefit analysis in the context of individual time budgets, schedule constraints, and available transportation.[9] These estimation and analysis techniques are more fully described in the technical reports which are the companion volumes of this summary report.[4,5,6,7,8,9]

Evaluating the Eight Implied Propositions: Findings on Technical Issues

In this section we will reiterate and expand on each of the eight propositions, testing them against our research findings.

Technical Proposition #1 asserts that the peaking of work trip travel and related congestion causes significant inefficiencies--excess delay, excess transit operating expenses, excess fuel consumption, excess expenditure for infrastructure, and excess air pollution associated with stop-and-start driving regimes. It also asserts that these "excess" costs can be reduced using the techniques of traffic management, peak hour pricing, parking management and work rescheduling. In the case of work rescheduling and peak-hour pricing, the objective would be to induce a temporal shift in the pattern of travel demand sufficient to flatten the "peak" into a "plateau." In the case of traffic and parking management, the intent would be to induce a shift in travel mode so that the secular growth of traffic is accommodated by riding rather than driving.

The magnitude of the excess costs associated with peaking can be estimated, at least on a case-by-case basis, by postulating a "plateaued" pattern of work-trip travel and estimating the differences in user and supplier costs between "peaked" and "plateaued" demand.

In the case of a 10-mile freeway segment in the San Francisco Bay Area serving 33,000 vehicles in a typical evening peak, a plateauing of the temporal distribution of demand could hypothetically:[10]

- Reduce travel time by some 675 vehicle hours each evening or 16%.
- Reduce fuel consumed by more than 100 gallons each evening or some 1.4%.

- Reduce total kilograms of noxious pollution emissions by some 240 kilograms or 5%.

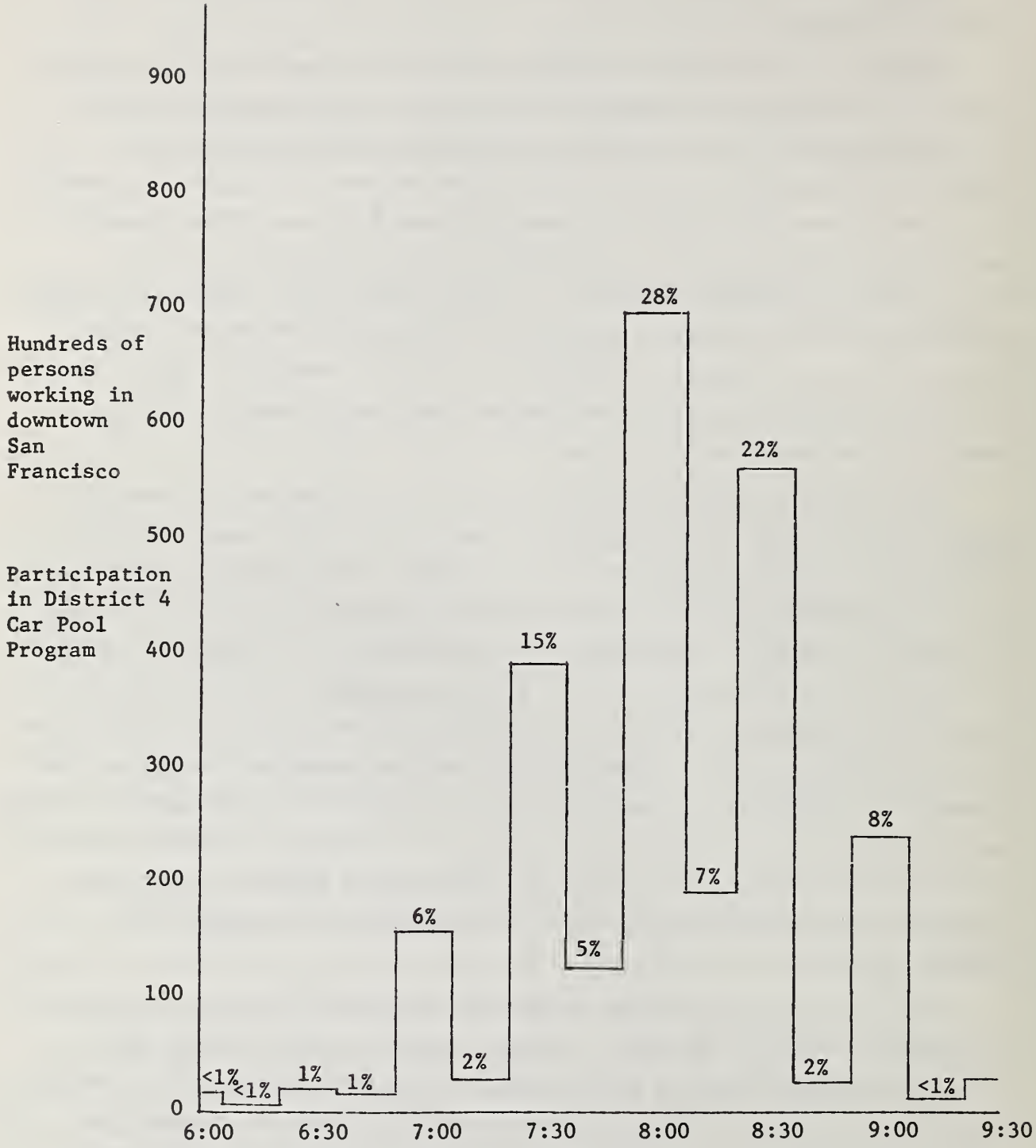
These estimates begin to ballpark some of the more obvious costs associated with peaking.

The degree to which the scheduling of work (as opposed to the supply of facilities and services) is responsible for peaking is illustrated in Figure I. The figure shows that fewer than 14 percent of work start times are scheduled before 7:30 a.m. and that 67 percent of work start times are concentrated in the one-hour time band between 7:30 and 8:30 a.m. These exemplary statistics were derived from an analysis of work-start times in the San Francisco Central Business District.[11] They suggest that a substantial travel-time premium could be realized through the introduction of work scheduling innovations such as flexible or variable work hours. They also suggest that there is substantial "slack" in the system consisting of unused capacity located in the "shoulder" of the peak.

The research indicates that both flexible work hours and differential peak/off-peak pricing offer strategies to make use of this unused capacity. Proposals for time-of-day pricing have foundered on equity grounds, falling prey to the argument that they would "penalize price off the poor."[12] These arguments are weighty. They suggest that distributional concerns should govern the allocation of the revenues collected from peak-hour tolls and that joint introduction of peak-hour pricing and flexible work hours would be appropriate from an equity viewpoint. Implementation, administration and enforcement are dilemmas that confront both flexible work hours and pricing strategies. Average cost pricing is the norm for transit systems, toll bridges and parking lots. On-the-hour or half-hour start times are the norm for American commerce and industry. The research has not resolved the dilemmas of innovation and implementation.

Proposition #1 asserts that "underutilized capacity" is not limited to the shoulder period of the peak. "Excess" capacity or system slack may also be found in arterial streets that parallel major high-speed facilities and in the unoccupied seats of single-occupancy vehicles. Thus, the regulations tentatively endorse actions that would distribute peak traffic loads among parallel routes and encourage travel by high-occupancy vehicle. The objective here, as in temporal demand management, is to make use of system slack and

Figure I



Hours of beginning work, all carpool participants,
10 downtown SF work zones, 2513 total persons

squeeze more productivity from existing facilities.

Ramp metering is a proven strategy for redistributing traffic loads from congested freeway facilities to parallel arterial routes. A simulation of ramp metering operations on two California freeways indicates that the strategy is capable of delivering a net reduction in passenger hours of travel time of approximately 10 percent. A small penalty in energy consumption (+1%) and noxious emissions (+3%) is associated with the increase in stop-and-start driving on arterials and higher freeway speeds.[13]

When ramp metering is combined with meter bypass for high-occupancy vehicles, even greater travel time savings can be realized. The simulation results for a freeway with high-quality parallel routes indicates the potential of a 23 percent reduction in travel time with preferential entry. In the case of the second freeway where parallel routes are limited in capacity, preferential entry was estimated to reduce net passenger hours of travel by only 14 percent. A construction cost penalty is likely to be associated with reconfiguring ramps to accommodate a bypass lane. This cost can be traded off against the favorable performance of preferential entry in terms of fuel consumption (-2% in the "best case") and pollution emissions (-7% in the "best case"). The improvement in fuel consumption and emissions performance is a function of both induced shift toward carpools (+1%) and the elimination of on-freeway queues.

Three controversies are associated with ramp metering--two political and one theoretical. The political controversies associated with ramp metering revolve around "favoritism" to long-distance, frequently wealthier commuters and the additional traffic burden imposed on street systems under local jurisdiction. The theoretical controversy associated with ramp metering is best explained by viewing ramp metering as a pricing surrogate. When ramp meters are installed, users "pay" for freeway access by spending excess <u>time</u> at ramps rather than by paying a monetary price for entry. This excess time is "wasted" at the ramp and then recouped on-line. Economists argue that monetary tolls, unlike time tolls, would not involve the waste of a resource, but rather its conservation in a form--revenue--that can be reused productively.

To the extent that implementation and administration problems can be resolved, ramp metering, preferential entry, flexible work hours, and peak-hour pricing seem to offer promising methods for exploiting system slack and

unused system capacity at a relatively low cost.

Our research also indicates that these strategies are mutually compatible. Flexible work hours could mitigate the equity consequences of pricing schemes; they also seem to be positively correlated with bus and carpool formation.[14] The favorable behavioral relation to carpooling is the result of the ability to form multiple-employer carpools, using the work-arrival-time discretion afforded by variable hours. The favorable behavioral relation to bus use is the result of the ability to avoid crush-load conditions on transit vehicles and to match work schedules more closely to transit schedules.

Technical Proposition #2 asserts that preferential treatment of high-occupancy vehicles may be the single most effective strategy for increasing the efficiency of mass transit and the urban transportation system as a whole.

This assertion views "efficiency" in the same fashion as it was historically defined in discussions of traffic engineering improvements of the TOPICS variety. In our view, this is a limited and most-probably misleading conception of efficiency. Efficiency, in our view, should be reserved to describe total resource cost associated with a given output including supplier costs, user costs, and externalities. Notions of efficiency that focus primarily or exclusively on supplier costs and "thruput" can lead to misallocation in terms of global efficiency. Thus, we prefer to distinguish global efficiency from supply-side efficiency by refering to the latter as "productivity."

This distinction is critical for determinig whether the preferential treatment of high occupancy vehicles is "efficient" in the economic sense. At issue is whether the preference given to high-occupancy vehicles is sufficient to compensate for time penalties imposed on low-occupancy vehicles and the additional access time associated with shared-ride modes. Also at issue is whether the external benefits of carpooling and bus use are sufficient to outweigh the user cost of preferential treatment strategies that impose auto-use disincentives.

The most obvious case of a joint auto-disincentive/HOV-incentive strategy is the reservation of a freeway lane for exclusive use by buses and carpools. Our computer simulation of diamond lane operation on the Santa Monica Freeway suggests that regardless of the measure of effectiveness used--productivity or environmental impact--the dedication of an existing freeway lane to high-occupancy vehicles would (and did) have adverse rather than favorable impact.[15]

A comparable conclusion emerges from the simulation of reserved bus and carpool lane operation on a second California freeway--the Eastshore Freeway in the San Francisco Bay Area. Figure II shows estimated percentage changes in passenger hours of travel time, fuel consumption, and pollution emissions. Emission performance is degraded because the favorable impacts of mode shift are overwhelmed by the stop-and-start driving regime of traffic diverted to parallel routes and "stalled" in the remaining mixed-traffic freeway lanes.

Figure II

	Santa Monica Freeway	Eastshore Freeway
	Reserved HOV lane operation	
Travel time (pass. hrs.)	+98%	+42%
Fuel consumed	- 2%	+ 7%
Pollution emissions	+ 2%	+26%

In contrast, two other preferential treatment strategies--preferential entry and an added HOV lane--are estimated to have favorable impact in terms of productivity, fuel consumption, and environmental impact.[16] Estimated impacts of these alternatives are shown as percentage changes in Figure III.

Figure III

	Santa Monica Freeway		Eastshore Freeway	
	Preferential entry	Added lane	Preferential entry	Added lane
Travel time	-23%	-20%	-14%	-18%
Fuel consumed	- 2%	- 1%	- 1%	- 2%
Pollution emissions	- 7%	- 7%	- 4%	- 6%

When costs--the capital cost of implementation and the ongoing cost of enforcement--are considered, it appears that preferential entry is likely to be a superior option to an added HOV lane in most circumstances. In the case of the Eastshore Freeway, the California Department of Transportation has

estimated the cost of ramp metering (with limited reconfiguration to accommodate high-occupancy vehicles) at $15 million in comparison to $50 million for construction of an added lane extending 10 miles. This analysis suggests that there is a very narrow range of circumstances in which exclusive high-occupancy vehicle lanes or freeways can be considered cost-effective, particularly when compared with preferential entry or pricing measures such as a parking surtax.[17]

A similar conclusion emerges for exclusive and reversible bus lanes on arterial streets.[18] The simulation of traffic flow on Wilshire Boulevard in Los Angeles suggests that signal optimization to minimize passenger delay is superior to bus lane strategies in terms of passenger time, fuel consumption, vehicle emissions, and the productivity of the street network. The findings are shown in Figure IV which compares the effectiveness of exclusive bus lanes and signal timing on two routes in California. Once again, the critical dynamic at work here is the likelihood that mode shift will be insufficient to compensate for the degraded performance of the automobile, particularly where initial mode shares are tilted toward personal vehicles.

Figure IV

Comparative Impact of Signal Timing and Exclusive Bus Lanes

		Wilshire Blvd.		San Pablo Avenue	
		Exclusive Bus Lane	Sign. Opt. Pass.	Exclusive Bus Lane	Sig. Opt. Pass.
Longer Term	Travel Time	+ 2%	+ 1%	0%	+ 1%
	Fuel consumed	+ 3%	+ 2%	+ 4%	+ 3%
	Vehicle Emissions	+ 2%	+ 1%	+ 4%	+ 4%
	Productivity	- 2%	+15%	+12%	+30%

where: Productivity is % change in pass.-mi. of travel on arterial alone

-2% indicates 2% diversion from arterial to parallel surface streets

+15% indicates attracting 15% more pass.-mi. to the arterial from parallel routes.

Technical Proposition #3 asserts that it may be preferable to manage the volume, pattern and periodicity of traffic as a first alternative to major capital investment in the construction of new facilities. Corollary to this proposition is the notion that the physical infrastructure necessary for transportation is essentially in place and that the secular growth of demand can be accommodated by riding rather than driving. This may be the most far-reaching--and controversial--of the technical assertions imbedded in the philosophy of TSM. It is also this proposition that entails the greatest likelihood of conflict between valued objectives. The most significant of these conflicts is political in character: the conflict between voluntarism and regulation. This conflict can be restated as the difficult political choice between accommodating private preferences (and their social costs) or intervening to manage private choices in a manner that, at the core, involves forms of rationing, discrimination, and social regulation.

Because "social regulation" has invidious connotations (it is easy to forget that laws, conventions and many other forms of social control protect as well as constrain liberties), it is appropriate to distinguish between transportation management strategies that rest on voluntarism and those that rest on incentives or penalties. The "promotion" of ride-sharing offers a germane case in point. "Promotion" of ride-sharing can entail a wide range of actions:

- Free matching services.
- Price subsidies for transit users.
- Variable work hour privileges to permit carpool formation across work groups within a single company or between the employees of independent firms.
- Privileged access to company-organized vans for pooling employees.
- Waiting list preference for parking privileges.
- Preferentially located parking for carpools.
- Preferentially priced parking for carpools.
- Preferential treatment on freeway ramps.
- Reservation of freeway lanes for high-occupancy vehicles.
- Tolls, parking surtaxes, and other economic penalties for auto use.

This inventory of ride-sharing "promotion" strategies forms a continuum that extends from information and subsidy, through incentives, to disincentives. At the voluntary end of the continuum, the motivation for ridesharing is associated with economy, the desire to leave a car home for another household

member, or a desire for the social interactions of the carpool. Toward the middle of the continuum, ride-sharing is "induced" or externally motivated by the ability to capture special privileges. Privileges for transit users and carpoolers share toward penalties for sclo drivers as we move down the scale. At the bottom of the inventory is an outright penalty for auto use (with the possibility of some compensation through the return or reuse of these "vice tax" revenues).

Most analysts agree that the more stringent measures toward the end of the continuum would be necessary to obtain a significant percentage increase in ride-sharing.[19] But it is critically important to note that increased ride-sharing (like reduced VMT) is a proxy or surrogate objective that is meant to "stand for" larger social objectives (clean air, energy independence, economic efficiency). Increased ride-sharing is a "worthy" objective only to the extent that the proxy actually does faithfully represent larger social objectives--like social welfare, economic efficiency, social equity, environmental quality, or responsiveness in government. Thus, our analysis focused on whether incentives and penalties that would increase ride-sharing would produce social benefits of a magnitude sufficient to compensate for the loss of "free choice" entailed in the more stringently coercive measures at the bottom of the "promotion" scale.

Using a sketch-planning model, successively weightier penalties for auto use were imposed and a full-cost accounting regime was used to assess their impact on user costs, supplier costs, and external costs. It was concluded that from the global viewpoint of economic efficiency, losses in user benefits (primarily time) outweighed gains in supplier cost and regional air quality for all but the voluntary forms of ride-sharing promotion.[20] This conclusion has significant import. It suggests that actions taken to increase the productivity of facilities may have perverse consequences when viewed in the more global context of economic efficiency criterion that gives "appropriate" weight to the value of travel time.

Issues of national significance--balance of payment deficits, independence in the pursuit of foreign policy, and accelerated conversion of technology to accommodate alternative sources of energy--might dictate a revision of this conclusion. But from the viewpoint of a regional planning agency concerned with the economic efficiency of local and regional transportation services, a penalty-centered strategy of transportation system management

would be difficult to justify on efficiency grounds (even when air pollution costs are considered in the trade-off calculus).[21] This conclusion does not hold for the case of marginal cost pricing which should be distinguished from penalty-centered strategies to increase ride-sharing or stretch the productivity of existing facilities.

The full-cost accounting regime used in the sketch planning analysis argues for a light-handed approach to transportation system management at the local and regional level, with heavier-handed auto-use disincentives reserved for implementation by federal policymakers who can better assess the value of energy independence and balance-of-payments stabilization against the cost of fuel surtaxes or gas rationing. This conclusion appears robust even for regions with significant air pollution problems (provided air pollution is taken as an optimizable cost problem and not a question of inflexible standards).[22]

The combined results of the simulation of freeway operations and the sketch planning analysis argue that economic penalties in excess of marginal cost pricing are (definitionally) inefficient and that only a very few circumstances would justify preferential treatment strategies that impose penalties on the users of single-occupancy vehicles more stringent than preferential entry. Thus, we conclude that preferential entry and privileged treatment of carpoolers (flexible work hours, free matching services, preferential parking) are likely to be the appropriate limit of ride-sharing "promotion" consistent with equity, efficiency, and system productivity objectives given the commuting preferences and mode shares prevalent in most American metropolitan areas today.

Unique local circumstances such as the perennial congestion of Central Business Districts may justify localized measures such as differential time-of-day parking charges or auto-free pedestrian zones, but more stringent disincentive measures at the systems scale would be difficult to justify on economic efficiency grounds. This conclusion is reinforced by the favorable impacts of less coercive measures: selective capacity improvements, voluntary ride-sharing promotion strategies, the relaxation of schedule and accessibility constraints associated with flexible work hours, and the proven potential of ramp metering and preferential ramp bypass for HOV's.

The mutual compatability of flexible work hours, voluntary ride-sharing promotion strategies, and preferential freeway entry suggest these measures can serve as a short-term, first alternative to new construction. Significantly,

we know of no metropolitan region other than Minneapolis-St. Paul which has made a systematic effort to assess and inventory the "slack" or "excess capacity" in the many component elements of the metropolitan transportation system. In the absence of this data base, it is virtually impossible to determine the staying power of TSM measures and the extent of their ability to serve as a short-term, first alternative to the expansion of transportation facilities. The planning and monitoring effort necessary to inventory system slack appears to be an appropriate starting point for a systematic effort to increase the productivity and efficiency of metropolitan transportation systems.

Evaluating the Eight Propositions: Findings on Institutional Issues

As we have noted, the TSM regulations of September, 1975, embody a normative theory of public administration as well as an inventory of potentially effective action measures. The regulations loosely articulate an "appropriate" short-range transportation planning process. At the heart of this sanctioned process are five implicit propositions about the appropriate structure and conduct of inter-governmental planning.

Procedural proposition #1 asserts that a more balanced attack on the problems of urban transportation can be mounted if local agencies and jurisdictions collaborate in cooperative efforts that span the traditional boundaries between modal agencies, between operating and regulatory entities, and between the public and private sectors. This is a common theme in latter-day theories of public administration. It follows from a problem diagnosis which asserts that categorical funding, and the fragmentation, layering and balkanization of authority are significant sources of inefficiency and ineffectiveness in the delivery of public services. In turn, coordination, collaboration and consolidation are seen as appropriate antidotes to the proliferation of special districts and the jurisdictional rivalries associated with the competition for tax base, competition for federal assistance, and simple "turfism." The "ideal" of more collaborative--and therefore more comprehensive planning--has been particularly well articulated in an UMTA memorandum which argues that:

> The key idea in the TSM concept is not the listing of the various parts of the system and the actions that can be taken with respect to each, but the idea that all these pieces should be coordinated through a management process designed to accomplish specific objectives. Each piece of the system--traffic flow, parking, zoning requirements, transit service--is already being managed, but generally according to its own

self-interest rather than in response to community-wide goals established through explicit consideration of trade-offs among different objectives and alternative implementing strategies.

This means that the TSM requirement is much more than individual low-capital, short-range actions being taken to manage each component of the system or even the set of all those actions. More significantly, it is the mechanism established to set objectives for managing the system, the process of selecting specific goals and implementing strategies, and the technical planning activities undertaken to inform that process. This concept of TSM leads to definition of three functional components of TSM:

> institutional arrangements for getting all the relevant actors together and producing viable TSM plans, since no single actor can be given responsibility for all of the pieces;
>
> technical planning activities to monitor system performance, identify problems and opportunities, identify optimal packages of actions associated with possible goals and assess their feasibility, and determine the points of trade-off or complementarity between different goals and actions; and
>
> implementation and evaluation activities that determine and carry out the detailed design and planning for actual installation or initiation of each planned action, and measure the response in order to insure optimal performance with respect to its goals.

This concept of TSM differs substantially from the TSM plans that have been adopted by metropolitan planning organizations across the nation.[23] The plans tend to reflect the project-by-project implementation style of independent modal agencies rather than proposing areawide orchestration of actions to optimize the operating efficiency of the system as a whole. In turn, the plans are a reflection of political cleavage, jurisdictional fragmentation, and dispersed implementation responsibilities.

The regulations endorse planning in the classical goal-defining, systems-planning style of MPO's: a process which begins with the adoption of policy, system and service objectives, proceeds to the identification of system and service deficiencies, then leads to the evaluation of alternative system configurations. MPO planning has typically faltered at this point, unable to bridge the gap between systems planning and implementation planning. In part,

this is because the classical planning style endorsed by the regulations and employed by most MPO's does not match the decision-environment of implementation. Nor does it describe the planning process used in cases where discrete TSM measures have been successfully implemented to date.

The planning style embodied in the federal regulations does not match the negotiated character of implementation planning. Modal agencies--as opposed to MPO's--are staffed and organized to implement projects, not policy. Project outcomes are structured by funding availability, eligibility criteria, design standards, rules-of-thumb, and political give-and-take. They rarely reflect explicit policy objectives or policy trade-offs at a regional or systemwide scale. They more typically reflect ad hoc responses to local pressures than the pursuit of system efficiencies.

Where TSM measures have been successfully implemented, they have not been pursued as a problem in policy implementation, but as the solution of a unique problem or the capturing of a unique opportunity. Thus, cases of successful TSM implementation seem to have evidenced the following characteristics:

1. Projects have been limited in scale, scoped to a manageable political environment.

2. They have generally involved the pursuit of limited, operational goals such as ameliorating specific design deficiencies or achieving savings in travel time.

3. Project implementation has improved the quality of service available without substantially disadvantaging any class of users or political jurisdiction.

4. Project managers have approached implementation with a demonstration philosophy and a readiness to abort or adjust design strategies as problems arise.

5. Project design has been negotiated with affected jurisdictions and interests--a time-consuming process involving intensive liaison and marketing efforts.

6. Project motivation has frequently been provided by the ability to capture federal funds in excess of formula entitlements.

7. The project team has controlled resources which allowed them to make sidepayments to off-set adverse impacts (these sidepayments have typically been of the log-rolling variety: tree planting and beautification have been used to convince merchants to accept bus lanes on commercial streets; states have financed the cost of resetting signals on local streets where ramp metering has been introduced).

Thus, TSM measures have been implemented on a piecemeal, negotiated basis that reflects the diffusion of political power and governmental cleavages within metropolitan areas.

The success of TSM measures of a limited scale and negotiated character does not insure acceptance of TSM measures conceived at a systemwide scale. In fact, it appears unlikely that TSM will be able to assemble the kind of powerful constituency that permitted the construction of freeways and rapid transit lines despite community disruption and localized opposition.

It appears improbable that a similar constituency can be assembled to support systemwide pricing or roadspace allocation with the intent of forcefully discouraging auto use or achieving productivity gains in highway and transit operations. These strategies are currently constituencyless and involve bargaining and sidepayment problems that are beyond the political tolerances and institutional capabilities of most metropolitan areas. In fact, a more sweeping generalization can be made: overt, policy-guided discrimination between classes of citizens--or classes of transportation system users--runs counter to the fair-play, fair-share, equal-treatment philosophy which is so deeply imbedded in the values of American politics. This philosophy--the philosophy of John Locke--may mask systemic disequities and massive inefficiencies and diseconomies in service supply, but it is nevertheless a more compelling canon in metropolitan politics than the allocative efficiency tradition of Adam Smith. Power--of the sort assembled to construct freeways and rapid transit systems--can bend the canon of equal treatment and non-discrimination; but the canon of efficiency is not one that arouses power group support in metropolitan politics.

This analysis begins to suggest that the central problem for TSM planning and implementation is the problem of constituency. Both disincentive measures and collaborative, multi-agency planning efforts encounter the dilemma of finding, first, a jurisdictional constituency and then a public constituency. This dilemma is compounded by the modal segregation and formula structure of most transportation assistance funds and the traditional programming independence of implementing agencies. Independent implementing agencies have cultivated political networks and client relationships that are focused on the development and implementation of <u>projects</u>. The inertia of these constituency relationships and project expectations make the transition from project

development to system management particularly problematic.

In the technical issues section of this report, we emphasized the merit of the temporal management of transportation systems through work-schedule changes. The temporal management of travel demand poses a particularly thorny dilemma in inter-organizational cooperation. Cooperation between the public sector and private employers would be necessary to institute work schedule changes sufficient to make a difference in system performance. There is little history of this cooperation. In fact, public agencies have typically either reactively accommodated private scheduling and location decisions or serviced them actively by providing the infrastructure of urban services on a promotional basis intended to increase jobs and tax base.[24]

A powerful argument for engaging employers in transportation system management can be made readily:

- The location decisions of major firms structure the spatial pattern of travel demand.
- The scheduling decisions of major firms structure the temporal patterns of travel demand.
- Private employers supply the vast majority of parking facilities in metropolitan areas.
- Payroll data is an invaluable source of up-to-date information on the pattern of travel origins.
- The managerial capabilities of private firms are an invaluable asset for carpool matching, vanpool operation, and parking management.

While these factors argue for a more active employer role in transportation system management, engagement will be difficult to accomplish given the established social convention that "getting to work" is not the employer's problem.

A survey of the 150 largest employers in the San Francisco Bay Area suggests that it would be relatively easier to engage firms in carpool matching and work schedule modifications than parking management or vanpooling programs.[25] Figure V shows the percentage of the Bay Area's largest employers that would be categorically unwilling to participate in TSM actions of different sorts.

Figure V

Employer initiatives of the TSM variety	% of respondents viewing this action as "Inappropriate under almost any circumstance."
Carpool matching	10%
Reschedule work hours	11%
Provide preferential parking for carpools	29%
Sponsor a self-financing van pool program	40%
Subsidize a vanpool program	55%
Share cost of a subscription bus service	72%

Figure V suggests that efforts to promote vanpooling may be receiving a disproportionately large budget emphasis in TSM planning, especially when carpooling and work rescheduling are considered as competitors for budget and staffing.

While engaging private firms in the process of transportation system management may be particularly difficult, it appears to be a promising avenue for collaborative planning efforts. In turn, this argues for engaging local chambers of commerce, industrial councils, employee organizations, and zoning and permit boards in planning for traffic mitigation and system management.

Procedural proposition #2 asserts that the strategy of market segmentation and service differentiation should inform the planning of short-range operational planning for highways, transit and paratransit. Examples of market segmentation and service differentiation include:

- Express or subscription bus service to suburban industrial parks (as opposed to conventional arterial bus service).
- Segregation of local and through freeway traffic using express lanes.
- Special lanes for truck access to ports and trans-shipment centers.
- Differential peak/off-peak route and fare structures for mass transit.

- The substitution of van service for bus service where route length makes for low productivity of transit labor and equipment.
- The provision of customized paratransit services for the handicapped and elderly.
- The purchase of peak hour transit services from private vendors to avoid overtime payments and split-shift differentials.

The strategy of market segmentation, service differentiation, and "customized" services is relatively new in transportation planning where highly aggregate analysis procedures have prevailed.

In fact, service differentiation seems to conflict with many of the prevailing methods and regulations which guide and constrain the conduct of transportation planning and programming. These include:

- The emphasis of highway planning on standardized designs.
- The earmarking and segregation of revenue streams.
- The emphasis of transit planners on the consolidation of operations and the non-proliferation of operating entities.
- Broad interpretations of the labor-protective provisions of the Urban Mass Transportation Act.
- The frequent designation of transit properties as the "designated recipient" of UMTA operating subsidies.

UMTA's tentative Paratransit guidelines--with their strong procedural resemblance to the TSM regulations--represent a departure from the conventional idioms of systems planning with their reliance on aggregation, standardization and consolidation. The inclusion of paratransit in the TSM guidelines is significant in itself because service differentiation is the goal of the coordinated/integrated/consolidated philosophy of system management which dominates the regulations.

It is our judgment that service differentiation may offer a more significant opportunity than service consolidation as a strategy for both service improvement and system economy.[26] In particular, the introduction of unpaid drivers (van and carpool programs) and part-time labor (peak-hour transit services and community-level paratransit services) appear to be promising opportunities for economy in public transportation. For these economies to

be realized, it appears inappropriate for transit properties to be designated as the recipients of federal operating assistance. An approach to service procurement which uses the techniques of competitive bidding would seem to be more appropriate in the context of service economy, service differentiation, and system management.[27] This notion of transit planning as a competitive procurement process is compatible with another procedural centerpiece of federal regulations: the assignment of the lead role in TSM planning to non-operating entities without built-in modal biases--Metropolitan Planning Organizations. Given the political fragility of most MPO's and the political influence of transit labor, it appears unlikely that more than marginal gains in service differentiation and economy through competitive procurement can be realized. The more promising avenue for paratransit implementation seems to lie in the use of state transit funds and the social welfare funds of the Department of Health, Education and Welfare.

Procedural proposition #3 asserts that a philosophy of stage or incremental service deployment, market exploration and market development should inform the implementation of new transit services. This assertion marks the point of convergence between the TSM regulations and UMTA's requirement for "alternatives analysis" as a precondition of federal aid for major capital investment.[28] It also marks a critical point of convergence between system management and long-range planning.

Stage deployment and incremental market development entail an evolutionary approach to transit development. Canadian planners have pioneered this strategy of planning by introducing demand-responsive transit services such as dial-a-ride as the first stage in a process that leads to eventual formalization of fixed routes. The dial-a-ride "service" is used to identify travel desires and ridership volumes "experimentally" as opposed to making an early commitment to fixed route service on the basis of planning data.

A similar planning philosophy is imbedded in the transit improvement element of TSM planning. Major capital investment in fixed-rail facilities is viewed as contingent upon the full exploitation of the less costly and more flexible option of corridor bus service. The regulations embrace the philosophy that a succession of corridor bus improvements--scheduled service in mixed traffic, express service in mixed traffic, and express service with HOV land bypass of freeway bottlenecks--should be programmed and evaluated in sequence

as a means of identifying priority corridors for exclusive guideway transit and as a means of developing a transit riding habit. Where the full potential of bus service and traffic engineering improvements has been exploited and exhausted, the higher-capacity capability of rail transit may be justified.

As a planning philosophy, evolutionary market development seems eminently sensible as a risk- and cost-minimization strategy. As a practical matter, the desire of local agencies to be "first in line" for UMTA capital grants and the ability to rally political support for high-technology options (as opposed to buses) have frequently overwhelmed the more prudent approach of risk- and cost-minimization. As a consequence, it appears that the "need" for rapid transit is more closely related to the availability of 80-20 federal matching funds than to "needs" demonstrated by local efforts to obtain the greatest return from a succession of operational improvements.

The future of this component of TSM "philosophy" seems most likely to depend on UMTA's posture toward major capital investment and its willingness to insist on operational exploitation as well as analytic exploration of alternatives.

Our sketch planning analysis suggests that a go-slow approach to rail development is in order and that the transit capacity requirements of most metropolitan corridors can be satisfied with bus-on-freeway operations and selective implementation of HOV congestion-bypass lanes.[29]

Procedural proposition #4 asserts that Metropolitan Planning Organizations--non-operating agencies that provide a forum for the negotiations of locally elected officials--are the appropriate jurisdictional setting for the coordination of TSM planning and the brokering of investment priorities. This assertion is consistent with the view that the objective of TSM is to coordinate investment policy, parking policy, tariff policy, and service policy "so as to achieve maximum efficiency and productivity for the system as a whole." To achieve the desired coordination, the regulations vest MPO's with shadow programming powers by making federal grants in aid contingent upon the inclusion of reimbursable projects in an areawide Transportation Improvement Program that is adopted by the MPO.

The dilemma associated with this approach lies in the weakness of regional planning institutions in most metropolitan areas:[30]

- The ability of MPO's to influence local programming decisions has been vitiated by the formula allocation of General-Revenue Sharing funds.
- Many MPO's have only small staffs and rely heavily on consultant services.
- Most MPO's are staffed by long-range planners with little experience in operations or budgeting.
- The data base of most MPO's is built on census data and often-obsolete travel survey data; the typical MPO does not have the rich information base associated with the day-to-day operations of implementing agencies.
- Most MPO's do not possess taxing powers or formal programming and budgeting authority.
- Most MPO's are not "authentic" political entities in the sense that elected general purpose governments are. Unlike local and state governments, most MPO's do not have established political networks which serve the recruitment of political leadership, the testing of constituency opinion, the maintenance of political discipline, and the coalescing of program consensus through old-fashioned "horse trading." Most MPO's are also councilmanic in structure and lack the executive leadership afforded by a elected mayor or governor.
- Many MPO's were created to satisfy federal certification requirements; few emerged as a response to local problems or power endowments.
- Many implementing agencies view MPO's as encumbrances or as competitors for turf and domain rather than a forum for cooperation and priority-setting.
- The influence of MPO's is limited due to their lack of budget powers or programming discretion. MPO influence is vitiated by both the categorical structure of federal-aid programs, and by the direct "pipeline" arrangement most metropolitan transit operators have cultivated with UMTA.

This is a substantial inventory of liabilities. It suggests that in many metropolitan areas, MPO's will be incapable of the coordinating function postulated in the regulations and that their primary role will continue to be that of documentation. In fact, the evolving powers and orientation of State

Departments of Transportation bear more resemblance to the coordinating and brokering entity visualized in the federal regulations than do MPO's.

For MPO's to develop into authentic political institutions (worthy of a contest for political control), it seems likely that it would be necessary to vest them with substantially greater discretion over the programming and budgeting of federal-aid highway and transit funds.

A model TSM planning process--one which seeks to accommodate the fragility of most MPO's--is developed in the final section of this report.

Procedural Proposition #5 asserts that it is appropriate for locally elected officials to formulate the policy objectives that will guide TSM planning with the federal role limited to guidance on matters of process and planning procedure.

It is difficult to understand how this proposition has operational significance given the federal government's role as the dominant financial partner in the system of fiscal federalism.[31] It is widely agreed by local and regional officials that the structure of transportation finance significantly distorts the local priority-setting process. A number of biases are evident:

- Toward capital-intensive transit improvements, where matching ratios are more favorable than for operational improvements.
- Toward investment in Interstate Highway facilities, where 90-10 matching ratios prevail.
- Toward "high-design" solutions fostered by federal construction standards and related problems of tort liability in cases of "substandard" design.
- Toward established program areas which offer secure formula funding rather than innovative program areas where federal funding is unavailable or subject to annual renewal.
- Toward reconstruction and replacement rather than preventive maintenance.

Within these financial constraints, local policy makers can and do exercise their discretion to establish policy and project priorities. But, what is more interesting is that the structure of inter-governmental finance seems to discourage innovations of the TSM variety and perpetuate the facility and project orientation of post-war transportation planning.

Another dilemma in the rationalization of federal and local roles in TSM planning is posed by the Environmental Protection Agency's draft "Transportation Planning Guidelines" which forcefully identify TSM with air quality maintenance planning.[32]

The most recent EPA guidelines entail an awkward reconciliation of EPA's mandate to enforce the Clean Air Act and its desire to accommodate other social and economic goals valued by local policymakers. Thus, the newest draft guidelines assert that "it is not desirable that measures which create serious hardships be implemented simply because they appear to improve air quality" but they also preserve the requirement of "satisfactory progress toward development and implementation" of air quality maintenance plans.

The uneasy compromise embodied in the draft EPA guidelines may be subject to litigation, further complicating and potentially limiting the ability of local policymakers to assert local goals and objectives in TSM planning.

IV. The Efficacy of TSM

In the pages above, we have assessed the merit of TSM as a set of techniques and as a philosophy of public administration. Footnoted references to more detailed technical studies were provided and our most significant conclusions were presented in summary format. This policy analysis and program evaluation cumulates to a mixed review of TSM's potential and significance:

- It appears that measures to make use of system "slack"--particularly unused capacity in the shoulder of the peak hour -- offer promising opportunities to increase the productivity and efficiency of the transportation system. Most metropolitan regions have not inventoried unused capacity by time of day and do not have strategic plans for responding to the problem of peaking.
- It appears that engaging major employers in the process of transportation planning and traffic mitigation offers a significant opportunity to improve transportation system performance. But most metropolitan areas have not developed outreach programs to engage major firms in carpool matching, vanpooling, work rescheduling programs, parking management, and other "voluntary" actions that would increase the range of commuting options and the flexibility of travel schedules.

- It appears that the value of transit-preference strategies has been overstated. High-occupancy vehicle lanes, in particular, appear to have a narrow range of effective application, given the mode shares prevalent in most American metropolitan areas.

- It appears that service differentiation may be a more promising planning strategy than service integration and consolidation. But, most metropolitan planning and operating agencies have not payed significant attention to market segmentation and disaggregate analysis of "needs" as a strategy of transportation planning.

- It appears that the inefficiency of the automobile has been overstated in most discussions of transportation system performance. When the value of user time is considered, only a small number of TSM measures--preferential freeway entry, flexible work hours, voluntary ride-sharing programs, and peak/off-peak pricing differentials, implemented in composite--seem to offer opportunities to increase the efficiency of the system (as opposed to the productivity of particular facilities). Most TSM plans have focused on the productivity of facilities, ignoring what we view as the more significant issues of global efficiency.

- It appears that MPO's are politically fragile institutions without programming and budgeting powers sufficient to the coordinating and brokering role they have been assigned in the federal regulations. Budgetary discretion--the critical link between planning and implementation--is unavailable to most MPO's. Therefore, it is unlikely that MPO's will be able to discipline the operating costs of public transit agencies or stage the implementation of facilities and services according to regional plan priorities. The authority portfolio of many State Departments of Transportation bears a closer resemblance to the powers necessary for TSM planning than the capabilities of many MPO's.

- It appears that design standards, earmarked funds, and differential matching ratios continue to bias transportation planning and

local decision-making toward capital-intensive responses that short-shrift preventive maintenance, operational improvements, programmatic initiatives such as employer outreach programs, and sufficient (but "substandard") design concepts. (As a corollary to the discussion of design standards and construction bias, we should note our judgment that the private cost of automobile insurance and the public cost of tort litigation are increasingly significant cost elements that deserve attention in discussions of transportation efficiency).

If there is a recommended course of action which falls from this analysis, it would emphasize the potential cost-effectiveness of a package of TSM measures that combines preferential entry, carpool matching, time-of-day pricing, variable working hours, and the procurement of paratransit services through competitive bidding. These actions appear to be mutually reinforcing opportunities to make use of slack or underutilized capacity--in the shoulder period of the peak, in the local road system, and in the equipment of private taxi and charter-bus operators.

If there is a course of action rejected in this analysis, it is the use of heavy-handed, penalty-centered notions of transportation system management intended to discriminate against single-occupancy vehicles. Given the mode shares and land-use patterns prevalent in most American metropolitan areas, it does not appear that taking right-of-way for high-occupancy vehicles would offer benefits sufficient to offset the incremental cost of this stringent disincentive strategy. Selective capacity improvements, traffic engineering measures, localized parking management strategies, and variable work hours appear preferable to reserved-lane strategies in most circumstances (regardless of whether the planning objective is efficiency, productivity, energy conservation, or air quality).

From the viewpoint of both accessibility and system efficiency, temporal management strategies such as variable work hours appear to be the least fully exploited, and therefore potentially most promising opportunity for the improvement of transportation system performance. This judgment leads us to the conclusion that employers, industrial councils, chambers of commerce and local zoning and permit boards have a significant role to play in transportation system management. These are organizations that have not been engaged in current, project-oriented, TSM planning efforts.

V. Toward a Model TSM Planning Process

In most metropolitan areas, MPO's have pursued TSM planning as a list-making endeavor.[33] Typically, MPO's have requested state highway agencies, transit properties, and local road departments to supply on-the-shelf project inventories that can be classified and reported in the categories supplied by the federal regulations: actions to ensure the efficient use of existing road space, actions to reduce vehicle use in congested areas, actions to improve transit service, and actions to increase internal transit management efficiency.

The list-making approach to TSM planning has a number of serious deficiencies. It leads to the neglect of:

1. System- and program-level evaluation.
2. System monitoring and the collection of data necessary to inventory system slack.
3. Opportunities for multi-modal planning, multi-jurisdictional planning, and cross-sector collaboration.
4. Service innovations and "unconventional" opportunities--such as paratransit and work schedule adjustments.

At the same time, TSM as list-making leads to expenditure patterns that continue to reflect the independent agendas of operating agencies rather than the most critical deficiencies in the system as a whole. It also means that the productivity of facilities and services, rather than the efficiency of the system or the unique "needs" of market segments continue to frame "the urban transportation problem."

These procedural deficiencies are remediable if metropolitan areas make a long-range commitment to the process of short-range planning. This would entail a degree of planning for planning that has not yet occurred in response to the TSM regulations. In this sense, the critical innovation implied by TSM is the restructuring of the planning process in a manner that brings to bear the joint powers of transit properties, highway agencies, local road departments, parking authorities, regulatory agencies, and major traffic generators. To date, few of these joint or collaborative planning efforts have been procured or fostered by most MPO's. Thus, most TSM plans propose making use of only a limited and partial set of the potentially available instruments

of system management. As a result, many TSM plans neglect multi-modal alternatives (park 'n ride, preferential entry, HOV congestion-bypass, and parking management) and employer initiatives (vanpooling, carpool matching, variable and staggered work hours, and parking management). Our technical analysis suggests that these are precisely the most promising TSM opportunities--opportunities that have not been fully exploited because they lie at the boundary space between competing public agencies and between public and private sectors.

The challenge of TSM, then, is to restructure the planning process in a fashion that allows these inter-organizational, boundary-line strategies to be more fully exploited through joint action. In turn, this seems to recommend the use of regional planning funds to procure joint planning efforts from consortia of subregional jurisdictions and major traffic generators. In this conception, TSM planning would proceed from "the bottom up." Regional TSM plans would be "built up" through the aggregation and reconciliation of "implementation modules" developed at the scale of 1) the individual firm, 2) the employment center, 3) the subregional activity center, and 4) the corridor. Module development would be "procured" by MPO's by sponsoring and funding subregional planning endeavors that engage employers, local traffic departments, transit operators, highway departments, parking authorities, and public interest groups in collaborative planning studies. It should be emphasized that this is not a short-range approach to short-range planning, but rather that it entails a long-range commitment to the development of both a disaggregate data base and a viable political constituency for TSM. This notion of TSM would also require the development of the public expertise necessary to service transportation planning conducted in the context of the individual firm, the industrial park, and the major activity center. Expertise in carpool matching is currently available, but experience with corporate vanpooling, variable work hours, and subscription bus services remains limited.

This notion of TSM planning--it could be called "corridors, hubs, and nodes planning" to reflect its component elements--would, we think, permit coordinated exploitation of those TSM opportunities that are currently neglected because they fall between the boundaries of the public and private sector or because they require joint action by two or more jurisdictions for successful implementation. At the same time, this notion of appropriate planning procedure seems capable of engaging the local political process as the

constituent setting of a search for system improvements through system management.

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