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AN APPROACH TO REGION-WIDE URBAN TRANSPORTATION

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16. Abstract

The evolving trends of our urban areas indicate a need for a new kind of urban system in which point-to-point, region-wide service is provided by a mix of conventional transit and flexible route paratransit elements acting cooperatively instead of competitively. In concert with improved automobiles and automobile utilization and management, there appears the promise of improved mobility for both the driver and the non-driver through reduced congestion and increased transportation options, overall reduced energy consumption, and cleaner air.

The principal unknown is how to bring about the evolutionary and incremental implementation of these integrated systems over time. Their operational characteristics appear to be such that increasing ridership and reducing the peak/off-peak ratio will bring about both cost reduction and service improvement. A framework for an implementation strategy is presented.

The implications for federal RD&D are noted for both system development and implementation.

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THIS PAPER PRESENTS THE RESULTS OF A DEPARTMENT OF TRANSPORTATION INTERNAL ANALYSIS. THE VIEWS EXPRESSED DO NOT NECESSARILY REFLECT THE OFFICIALS VIEWS OR POLICY OF THE DEPARTMENT OF TRANSPORTATION.

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FOREWORD

An essential condition for a sensible and coherent program to improve urban transportation is a sense of direction: a vision of where we want to be going and an idea of how to get there. This report is an overview of our thinking relative to future urban transportation systems: the rationale behind the approach suggested, their operational characteristics, their probable evolution, and the implications for the research, development, and demonstration (RD&D) programs appropriate for federal support.

The report concludes that there is a rational basis for thinking that urban transportation can be improved much more dramatically than commonly anticipated, yielding substantial benefits in energy conservation, congestion relief, improved mobility for the non-driver, and cleaner air for all. A central objective should be to test this hypothesis through actual experiments and demonstrations.

INTRODUCTION

Urban travel is dominated by the automobile: typically 95-98 percent of urban trips(1). Our primary problems are the side effects of this dominance: congestion, air pollution, and inadequate mobility for the non-driver. More recently added to this list of problems is energy consumption: as we now perceive the future, the need for conservation may become a dominant force in all our actions. Our goals thus become the general alleviation of these problems.

These goals are at least partially conflicting and, with the exception of the Clean Air Act whose provisions are quantitatively specific, are matters of degree whose resolution hinges less on what is desired than on what is possible. The constraints are technical, economic, and political. What can be done technically and operationally must be perceived by the citizenry to be worth its costs and in consonance with other urban goals and personal values if it is to pass the test of political acceptability. These goals are summarized in Figure 1.

WHAT ARE WE TRYING TO DO?

HELP

- IMPROVE URBAN MOBILITY
  - FOR THE NON-DRIVER
  - FOR THE DRIVER
  - FOR GOODS
- MEET CLEAN AIR STANDARDS
- REDUCE ENERGY CONSUMPTION

} AT A DOLLAR COST THE PUBLIC THINKS IS WORTH IT

--AND WISELY, WITH OTHER URBAN GOALS AND VALUES SUPPORTED

FIGURE 1

The approach being taken to move toward these goals is a three-pronged strategy:

- Improve the car as much as is feasible with respect to energy efficiency, safety, emissions, and economy .

- Improve the attractiveness of alternatives so that the car's role is lessened sufficiently to help relieve congestion and to provide a higher level of mobility to the now transportation disadvantaged.

- Improve the flow management and utilization of all vehicles--public and private, goods and people's--to relieve congestion and improve efficiency.

Insofar as energy conservation is concerned, the improvement of the automobile has by far the greatest potential impact. The Automotive Energy Improvement Program now underway in DOT is aimed at this goal, with due regard to the concomitant considerations of emissions, safety, and cost. Making the inevitable tradeoffs wisely will be a very complex problem, both politically and technically, and represents a major challenge to the government and the involved industry.

But improvement to the automobile itself is alone not enough. Car improvements do not solve the mobility problem for the non-driver. Car improvements cannot cure congestion in high density areas and along the freeways and arterials leading to them. Only a ubiquitous, pleasant, and affordable public system combined with better car and truck utilization can help these problems.

Further, there is an argument, as yet unsubstantiated by detailed analysis, that a major modal shift to public systems could achieve important gains in conservation of energy beyond that achievable through car improvement.

These are the primary reasons for focusing on dramatically improved public systems--the primary subject of this report.

SUMMARY

One essential deficiency--and there are many others--of the fixed route bus or rail typical of today's public transit is the failure to offer good low density service.

For decades the dominant urban growth has been in the low density suburban fringe. Now roughly half the urban population lives in low or medium density suburbs(2). Four out of five trips start or end at the home(3).

The reason for poor suburban service is economics. Good service with fixed route bus implies both good coverage and short headways. In suburbs where ridership density is low, this implies too many buses are running nearly empty. So attempts to improve suburban service generally end up just increasing deficits. It is not surprising that the car that helped shape our cities dominates their transportation.

The root cause of congestion in high density areas and along arterials is in the suburbs: the reason there are too many cars downtown is that no adequate alternative is offered where the trip started in the low density areas of the urban region. Park-and-ride and carpooling can help, but they are only part of the solution.

The taxi offers good suburban service, but it is too costly to substitute for the car on a widespread basis and it cannot, in its typical mode of operation, alleviate congestion. *The importance of taxi variants such as dial-a-ride is that they have helped focus a new perspective on the urban transportation system: the idea of the flexible route paratransit elements and the fixed route conventional transit acting cooperatively instead of competitively to provide region-wide service that is available everywhere, even in low density suburbs.*

The idea "acting cooperatively" is crucial to achieving acceptable overall system costs. While these flexible route systems are the cheapest way to provide service in low density suburbs, they are still too expensive without some subsidy to attract the size market we should be striving for. Otherwise, private taxi operators would have already offered services with a higher degree of ride sharing typical of dial-a-ride, as they have in a few cities where they were not inhibited by regulation(4). While commercially successful, these pay-for-themselves systems do not tap the size market desired nor the potential synergism of cooperative operation.

If, by subsidizing the flexible route suburban services, ridership can be substantially increased on the high density fixed route elements of the system, then the costs per passenger on these latter elements is

decreased. The stage is set for an internal-to-the-system cross subsidy that, by increasing overall ridership, can result in a net lowering of costs per passenger rather than an increase *for all riders, both downtown and suburban.* In Regina, Saskatchewan this approach led to both increased ridership and a decrease in the net total system deficit. But we know too little as yet to extrapolate this experience too far. However, the possibility is real. The idea is illustrated in Figure 2.

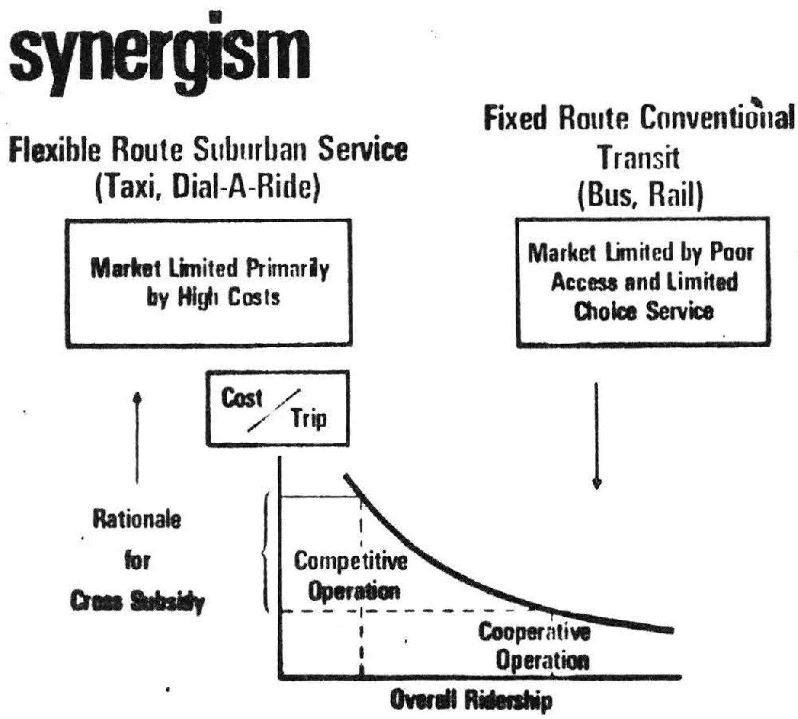


FIGURE 2

These integrated, region-wide systems offer the promise of a level of service completely beyond our current experience. In the suburbs they come to you, you do not go to them. They either take you directly to where you want to go or put you on the express bus (or rail) going downtown or to other parts of the urban area.

Even if such systems are brought into being, it will continue to be desirable to encourage car and van pooling: any approaches that improve car utilization not only also alleviate peak-hour congestion but improve the public system economics by reducing the spread between peak and off-peak ridership. Work hour staggering can also contribute importantly to this last objective.

The systems lend themselves ideally to incremental planning and growth. They require a relatively low level of initial planning detail and resource commitment. Large fixed investments are not needed. If response to initial steps are not as expected, then changes can be made. Because the system gathers origin and destination information as a normal part of operations, it helps plan its own growth, letting actual ridership show when it is appropriate to add new service elements.

Such region-wide, mixed systems appear to be the only logical way to move if we are to substantially improve urban transportation in the next decade. All of the various tools for improving flow such as exclusive bus lanes, improved signalization, etc., can contribute importantly to the functioning of such a system, but unless the primary goals of comprehensive service throughout the region are met, they can provide only marginal improvement to an already marginal public transportation system. The basic goals we are trying to achieve will require a very substantial modal shift, perhaps 20 to 40 percent of all urban trips, and only very substantial improvements can hope to achieve it.

This is an ambitious goal and almost a ridiculous one if held up against our current experience with conventional transit systems. But we are talking about dramatic change over a relatively long time period, perhaps a decade. Past and current experience is not a reliable guide to what can be achieved. The caveats are discussed below.

Implications for Federal RD&D Policy

We know very little about the behavior of these systems, particularly at large ridership. The current operating systems are still too new, too small, and too unique to depend upon completely to supply this knowledge. We don't know what level of service and what fares will attract substantial ridership, what subsidy may be required for how long, or what changes in auto ownership and use patterns are realistic to expect. The only way to really answer these questions is to test the approach in the real world long enough to give our deeply engrained transportation habits a chance to change and under a sufficient variety of circumstances to give credence to the results. The need is sufficiently generic and the risk and cost to an individual city sufficiently high to justify federal support and leadership to testing the reality of the apparent promise of this new approach to urban mobility.

This discussion so far has described what is essentially a promising new operational concept. While it provides the primary focus, it is only the first one of the conditions necessary for the long term improvement of transportation. The five goals are listed in Figure 3.

GOALS LEADING TO IMPROVED URBAN TRANSPORTATION

- TECHNICAL ELEMENTS AND OPERATIONAL CONCEPTS WITH POTENTIAL FOR BETTER SERVICE/COSTS
- EFFICIENTLY AND PROGRESSIVELY MANAGED OPERATING ORGANIZATIONS
- MORE EFFECTIVE CITY/REGIONAL POLICY, PLANNING, DECISION, AND IMPLEMENTATION PROCESSES FOR BOTH PUBLIC AND PRIVATE MODES
- BASIS FOR EQUITABLE, POSITIVELY MOTIVATING FINANCING
- EFFICIENT, INNOVATIVE EQUIPMENT SUPPLIER INDUSTRY

FIGURE 3

Over time, new technologies and new techniques can continue to improve system performance in all its aspects and can contribute to each of these objectives. The Departmental RD&D program can and does support these objectives by improving understanding and knowledge of these systems through analytical research, by funding the development of new technologies and systems where circumstances make it infeasible or undesirable to leave such development to the private sector, and by permitting experimentation and demonstration of new systems, techniques, and operational concepts which appear to have promise.

THE REGION-WIDE SYSTEM CONCEPT

Rationale

This section is a brief review of some of the development trends in our cities and their implications for urban transportation systems. The conclusion is one we already know well: that the Central Business District (CBD) focused, fixed route transit systems common today are badly mismatched to the evolving needs of our increasingly low density and multi-nucleated cities. The principal significance of flexible route systems such as dial-a-ride is that they have caused us to think in new terms about public transit systems permitting new concepts of urban systems. Region-wide, door-to-door systems such as we are beginning to see in a few cities and counties in both Canada and the United States are the leading edge of this trend. The thinking behind it, summarized here, is more fully developed in Reference 5.

Figure 4 illustrates one aspect of the population growth patterns of our urbanized regions. While the figure only illustrates the change for the decade of the 1960's, it is not a new trend. Even if it fails to persist into the future, it has resulted in nearly half the urban population becoming suburban dwellers(6)--an infrastructure that will change only slowly, if at all.

PERCENTAGE GROWTH OF URBANIZED AREA, 1960-1970, FOR A SAMPLE OF OLDER AND NEWER CITIES

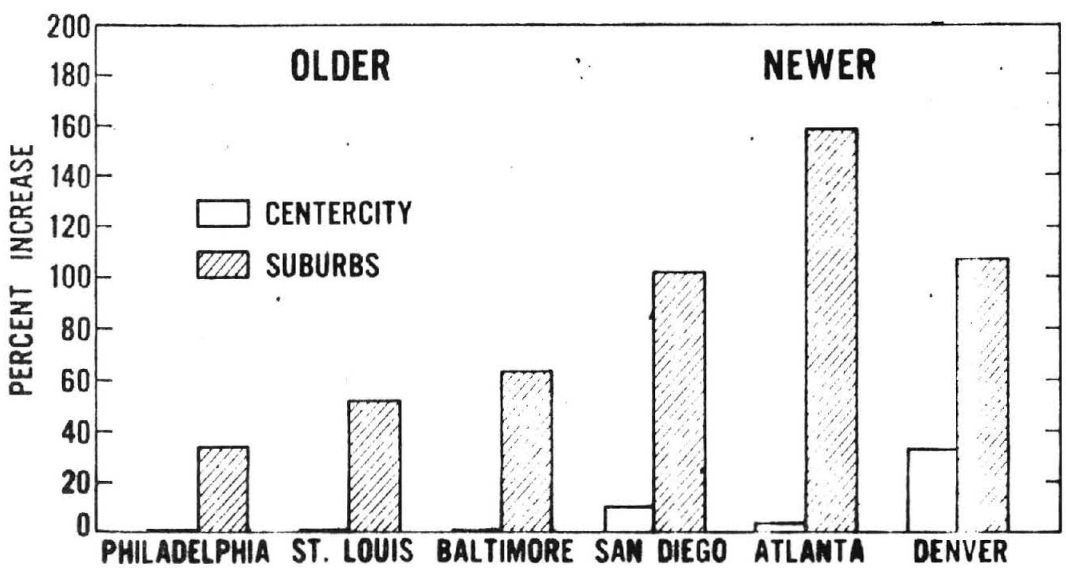


FIGURE 4

A second trend is the multi-nucleation of our urban regions. While in most cases the absolute level of travel into our central business districts has not declined appreciably--and has in some cases actually grown--as a percent of urban travel, it has declined appreciably. Jobs, retail outlets, entertainment, and other activity centers have followed the population to the suburbs, resulting in a much more diffuse pattern of urban trips. Travel is no longer dominated by trips into and out of the CBD. These CBD-oriented trips now typically constitute only 5 to 15 percent of urban trips(7). The point is illustrated by the expected travel patterns in Baltimore in 1980 shown in Figure 5, where the left side shows CBD-oriented travel and the right all non-CBD travel.

It should be noted, however, that congestion is at its worst in the CBD; in spite of the small percentage it contributes to total trips, it is still the largest traffic generator in absolute terms. Thus the congestion relief objective requires focus on the CBD, both the internal circulation as well as access. The same approaches used in the CBD should be equally effective in other evolving high density activity centers. But service for the non-driver requires focus on the total diffuse pattern of travel, if we are to avoid forcing people's choice of dwelling places to be based dominantly on considerations of access to essential services or jobs(8).

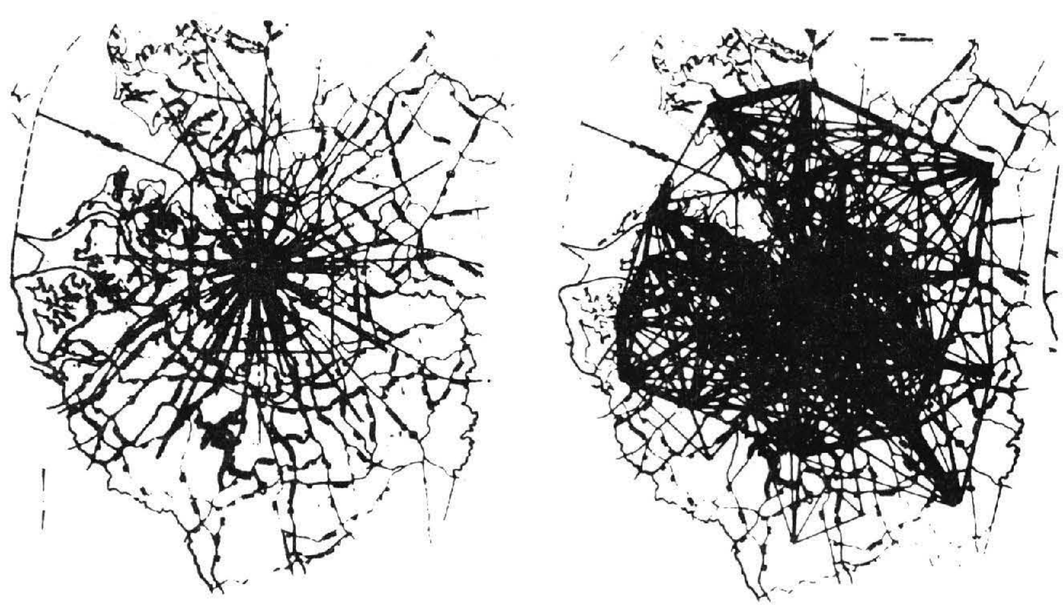


FIGURE 5

Figure 6 illustrates today's typical transit system. It is primarily CBD oriented. The service in the suburbs is poor to non-existent. If it is available it never seems to go where you want it to, and its service frequency is low. Good service with fixed route systems is just not affordable in low density suburbs.

TODAY'S TYPICAL TRANSIT

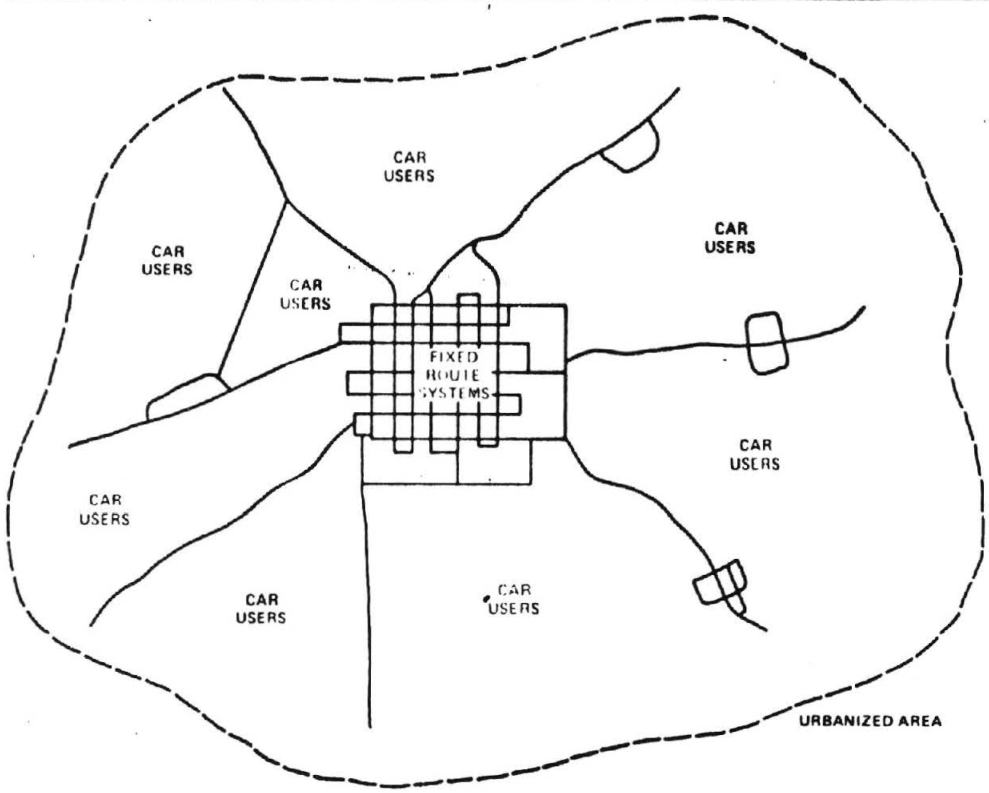


FIGURE 6

Every morning half of the nation's trips start in the suburbs, and they start in a car because, in part, there is not an adequate alternative available. The consequence is too many cars downtown, along arterials, and in suburban high density developments. Figure 7 illustrates the main problems: congestion downtown and in other high density activity centers and inadequate mobility for the non-driver, particularly if he lives in or wants access to the suburbs.

TODAY'S TYPICAL TRANSIT

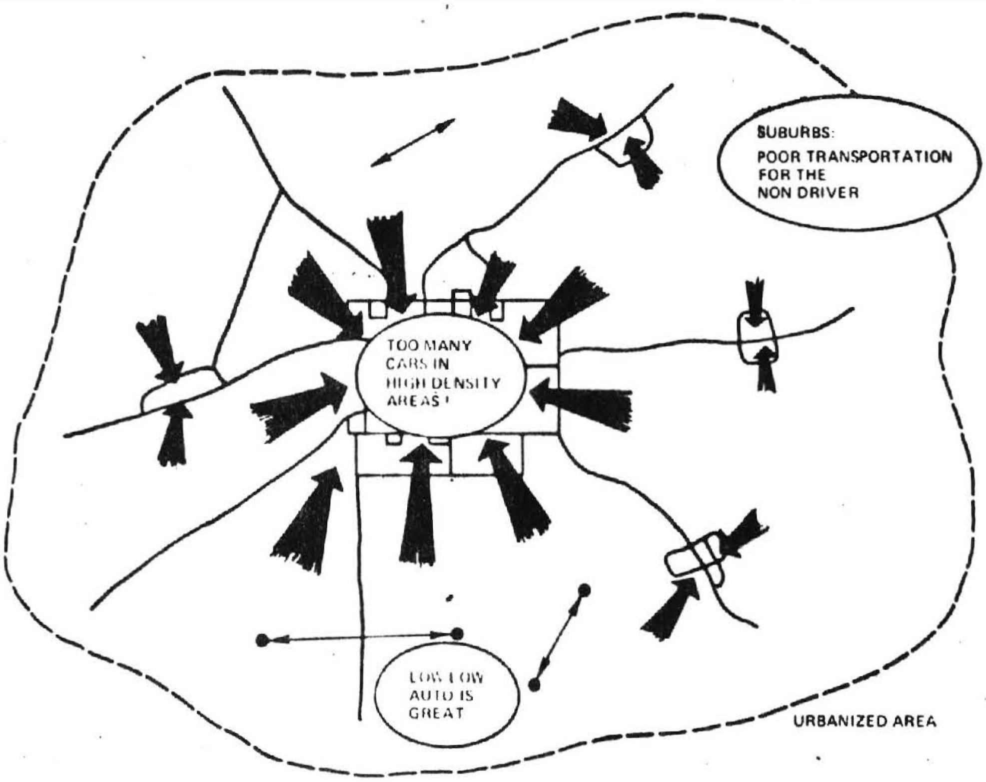


FIGURE 7

The situation is summarized in Figure 8. The car, if you have one, is superb in trips that are confined to low density areas, but, in high density areas where land is at a real premium, it takes up too much space. (Its energy and pollution problems are curable--at a price.) The bus and rail that are much more space efficient are poor at the low density end of the trip. If congestion is to be cured, car usage in high density areas must be reduced. The options to intercept cars coming into the CBD are listed at the bottom of the figure.

	AT THE LOW DENSITY END OF THE TRIP	AT THE HIGH DENSITY END OF THE TRIP
CAR	SUPERB	TOO LAND HUNGRY
FIXED ROUTE BUS, RAIL	EITHER POOR SERVICE OR POOR ECONOMICS	BEST AVAILABLE

OPTIONS

PARK-N-RIDE (NEEDS PARKING, 2 CARS)
KISS-N-RIDE (NEEDS FREE LABOR)
FLEX ROUTE SYSTEM (NEEDS SUBSIDY)

FIGURE 8

All three of these options have their place, and all should be encouraged. Except for the relatively few dial-a-ride vehicles in service, the taxi is the only flexible route system available, but it (in common with any unsubsidized system serving low density ridership) is too expensive to attract the level of ridership for which we should strive. The subsidy issue for both private and publicly owned systems is discussed later.

Figure 8 might appropriately also list controls on car usage--car management--because it is likely to be an important and necessary element in system design. But such controls (or incentives) on car usage are not only undesirable if avoidable but probably not implementable until better alternative transportation service is already in place.

The obvious answer to the problem implied by Figure 8 is a mix of systems, acting cooperatively. These are schematically illustrated in Figure 9, which depicts an expanded fixed route network forming the backbone of the high density service and various variants of flexible route elements serving the lower density suburbs. The alternative of park-n-ride is also offered. Flexible route service would supplement fixed route in the high density areas.

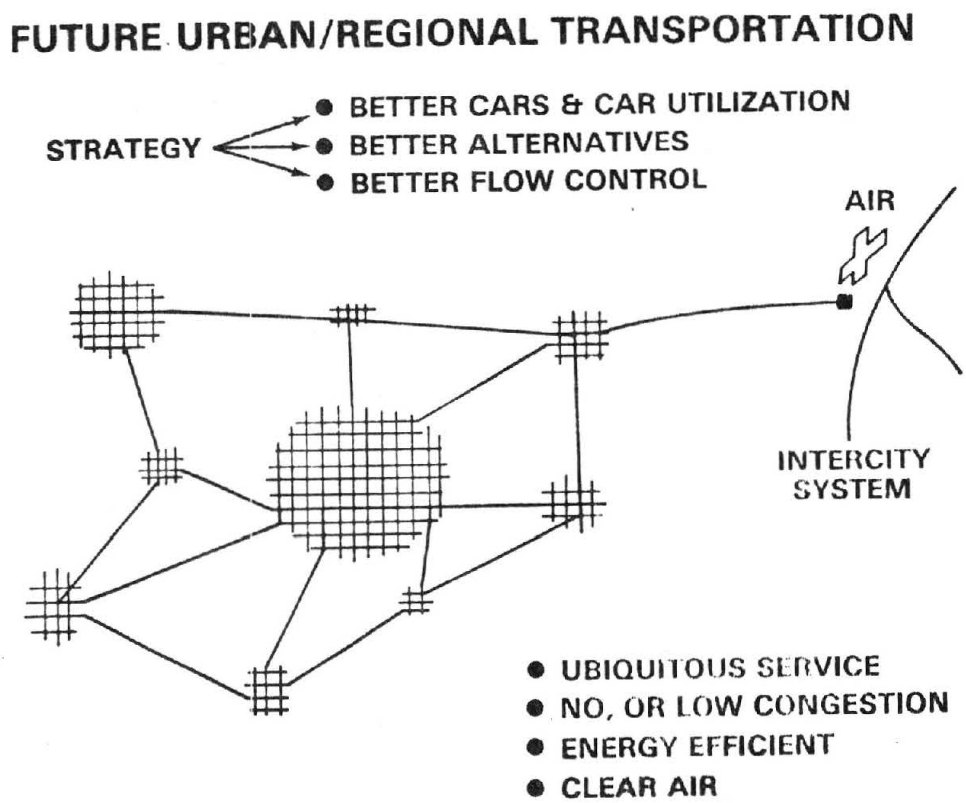


FIGURE 9

Several points are important to emphasize. First, cooperative operation does not imply an absence of competition; there are a variety of organizational arrangements that could be established under an umbrella of a single integrating body, one extreme of which would be common ownership of all system elements.

Second, the target customer is not just the CBD commuter who, while critical to the congestion problem, only makes up on the average about 2 percent of all travel in standard metropolitan statistical areas (SMSA). Acceptable system economics depend not only on the economies of scale of high ridership but of better matching of peak/off-peak loading. This is discussed later, but it implies the need for good service for the non-commuting trip. This non-work travel is about two-thirds of all trips. It can be most economically served using fixed route where ridership density is high and using flexible route service to supplement and to provide accessibility to areas with low density passenger demand.

The total system illustrated in Figure 9 consists of six basic elements.

- The first element has already been emphasized: an alternative to the car that can effectively serve the suburbs. Park-and-ride is not enough. Park-and-ride is little help to the non-driver and the mobility handicapped. This includes more than the aged and handicapped. It includes the non-driving center city dweller who needs access to suburban jobs. It includes the suburban 15-year-old. Overall, only 60 percent of the population are licensed drivers. And park-and-ride does not ease the need for a second car which, for all its potential attributes, still costs money also.

- But ubiquitous and well-designed park-and-ride should be a part of the overall system: the suburban driver who starts his trip in a car should be offered a convenient way to switch to the modes serving destinations in high density areas.

- We also need good alternatives to the car at the high density end of the trip. This high density circulation will, in itself, be a mix of systems, based today on rail, light rail, buses, minibuses, and taxis but evolving in the future to potentially include advanced guideway transit systems, moving sidewalks, and other horizontal elevator-type schemes, ideally integrated into the basic city structure.

- Fourth, the low density suburban system needs to be integrated into the grid of express bus or rail that feeds our high density areas and these, in turn, integrated into the high density circulation systems. This means more than the street corner transfers typical today.

Effective integration implies safe, pleasant, out-of-the-weather transfer points, preferably integrated with shopping malls and other major activity centers, along with good information systems, and convenient total trip ticketing.

- A total vehicle flow management and control system to reduce congestion and increase average flow velocity for higher vehicle productivity and shorter travel times. Preferential bus treatment is a part.
- Last, the institutional framework that will let this system work is needed. This includes a coherent set of policies on such things as parking regulations, priorities for the dedication of streets and lanes for both people and goods movement, private vehicle utilization improvement programs such as car/van pooling, perhaps some land use regulation, and financial and tax programs.

Terminology can be a problem. The term "flexible route systems" is used here to encompass the whole gamut of vehicles ranging from auto through van to minibus operating in either the telephone responsive, pre-arranged (subscription), or the street-hail mode. It includes single passenger taxis at one end of the service scale and many-to-many demand responsive minibuses at the other. These systems are all members of the "paratransit" family which also includes jitneys and various forms of car and van pooling, and this term is often used(9). The basic rationale being developed is not altered.

Here flexible route systems are being looked at not as special market or neighborhood systems but as the enabling elements of region-wide integrated systems consisting of both flexible route and fixed route elements integrated together and acting cooperatively.

As noted, the phrase "acting cooperatively" does not necessarily imply common ownership of all elements nor should the service offered in any particular neighborhood be restricted to a single kind of system element. A neighborhood or area may have many kinds of different transportation needs, and a mix of system variants within that area may be appropriate. It is also meant to imply clearly that system costs should be viewed as total system costs; many individual elements will require internal-to-the-system subsidy for maximum economic efficiency.

No transportation system is neutral with regard to land use; people will always take advantage of improved mobility. These integrated systems are neutral in the sense that the concept can be adapted to any land-use pattern desired. As discussed later, integral land use and transportation planning are probably necessary if congestion relief is to be permanent and other goals such as energy conservation are to be served.

Operational Characteristics

While the operational characteristics of flexible route systems are fairly well known, there is much less information on the behavior of mixed flexible route/fixed route systems. This is especially true for very large modal splits, say, 20-40 percent of all trips that might obtain over time in a full coverage regional system. In the following, some thoughts on this subject are developed and their implications for how the system might evolve are inferred.

Figure 10 is a specific comparison of a flexible route system and a fixed route system offering the same level of service, defined as the ratio of walk, wait, and trip time to the best no-wait direct route. (There is no walk or wait time for the flexible route system, but the route is circuitous.) This figure, based on data developed in Reference 10, is presented here to be illustrative, not definitive. As is clear, at lower ridership densities fixed route bus is much more expensive than flexible route, but the situation reverses as ridership climbs. In general, costs per passenger mile decrease as ridership climbs.

THE FIXED ROUTE/FLEXIBLE ROUTE TRADEOFF

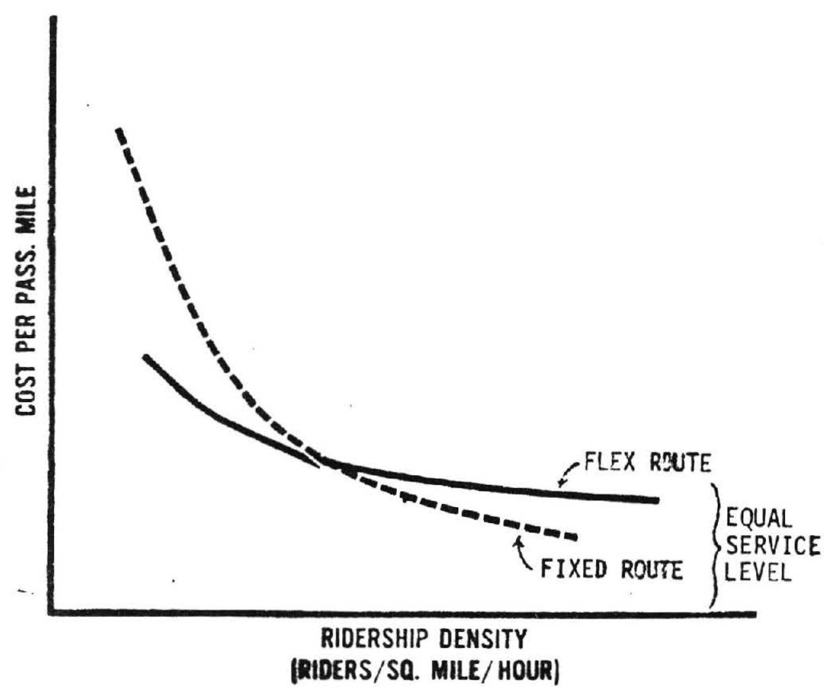


FIGURE 10

Figure 11 adds similar curves for an improved level of service. The principal point is that the range of ridership density where flexible routing is preferred is extended. Thus, at a given ridership density, the curves imply that flexible route elements become, at some service level, preferred to fixed route. Thus the higher the service level, the greater the proportion of flexible route elements in the total system. Not surprisingly, better service costs more money.

THE FIXED ROUTE/FLEXIBLE ROUTE TRADEOFF

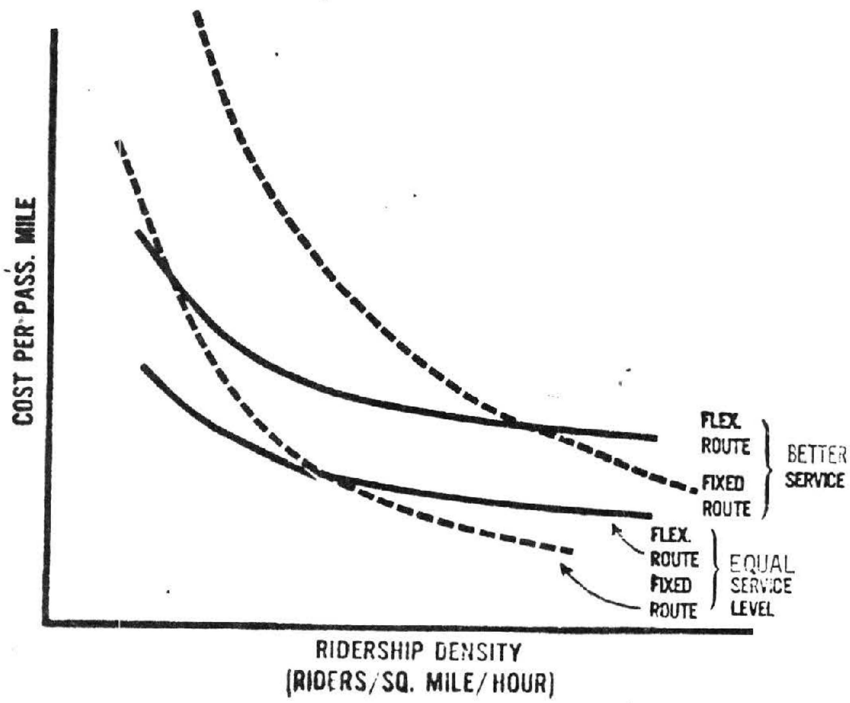


FIGURE 11

Figure 12 is a generalized version of the information shown in Figure 11, except only the preferred modes (fixed route or flexible route) are shown. The curves for fixed route systems are shown at high ridership where these systems are the cheapest and only the flexible route curves at lower ridership density where they are cheapest. From families of curves such as those characterized in Figure 12, several points can be inferred about the operating and evolutionary characteristics of integrated systems.

THE FIXED ROUTE/FLEX ROUTE TRADEOFF

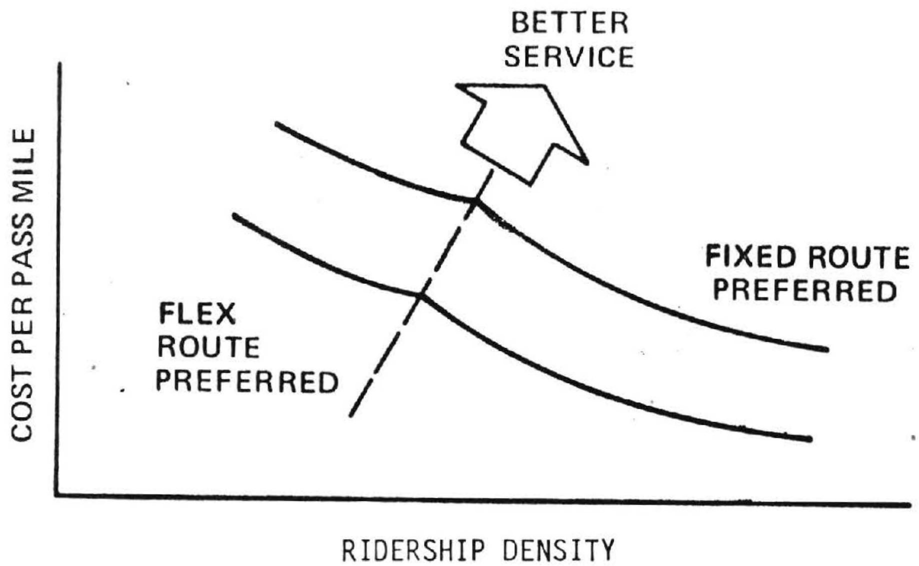


FIGURE 12

In a total region-wide system, there is a distribution of ridership densities that range from very low in sparse suburbs to high in downtown areas and in high density suburban complexes. If the various elements that make up the total system are optimally tailored to the desired level of service for the ridership that exists at that time, every system will be a mix of different variants of fixed and flexible route elements.

As already noted, raising the level of service will increase flexible route elements in proportion to fixed route.

Ridership decreases off-peak, so the distribution of ridership densities that represent the system shift to the left, thus more flexible route elements are appropriate. This suggests that these systems should adapt their mode of operation with the time of day as shown in Figure 13. Since systems are sized largely by peak capacity requirements and off-peak costs are essentially fixed costs, almost any revenue generated off-peak is marginal income and can help overall system economics. By offering improved point-to-point service at low fares midday, these systems have the potential for attracting substantial non-commuter ridership. Work hour staggering and carpooling can help further by reducing peak loads.

Work hour staggering is a trade-off, depending on how it is done. It can hurt carpooling and help transit. According to a DOT Transportation Systems Center analysis(11), staggering is a net benefit from a purely transportation cost point of view. The flex-time concept can potentially help both work hour staggering and carpooling. All of these actions obviously have commercial and other impacts that need to be considered.

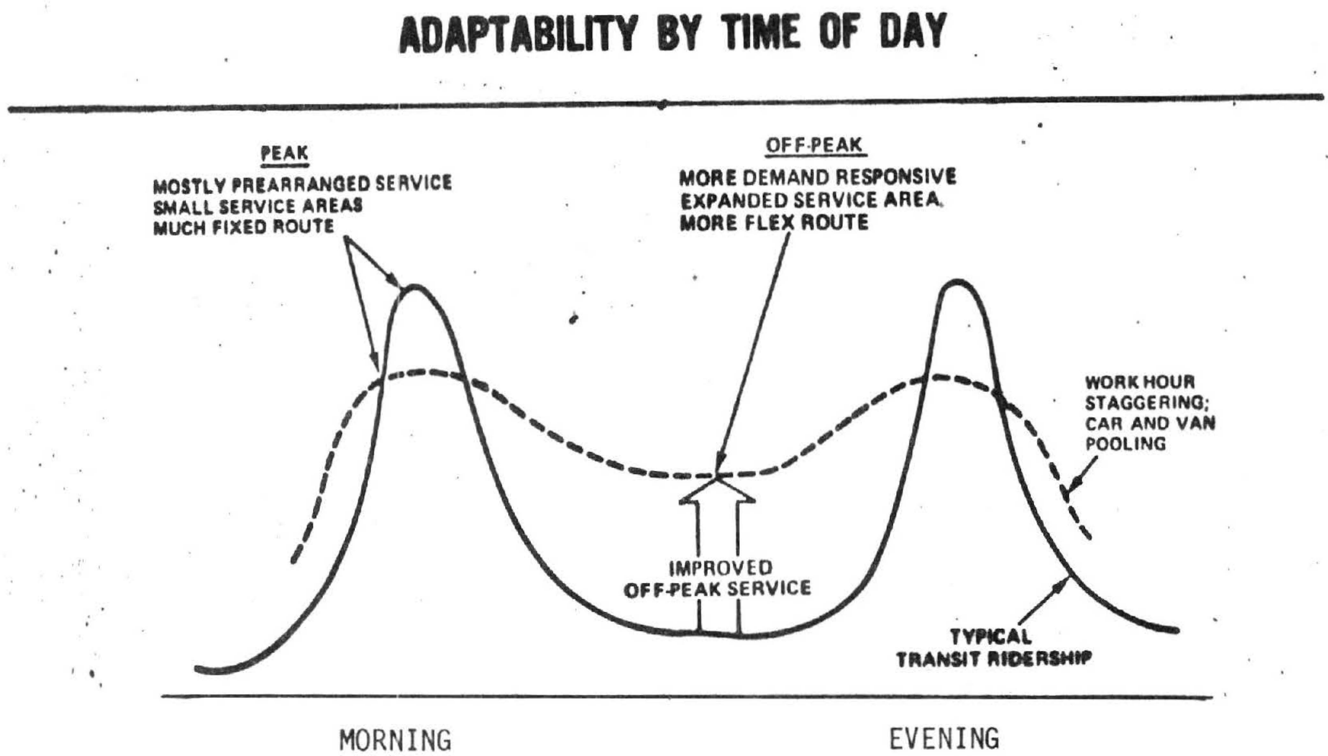


FIGURE 13

The overall problem of cost allocation and fare pricing is a complex one, and a detailed discussion is beyond the scope of this paper. The subject of subsidy for the new flexible route elements does deserve mention. Experience to date suggests that the new flexible route elements cannot pay for themselves and still attract the very much higher level of use we are trying to encourage. Since their introduction permits increased productivity of the high density, fixed route parts of the system, an internal-to-the-system cross subsidy between high and low productivity elements can be rationalized. If there is a single fare for the total trip, then this is accomplished.

There is no inherent reason why private taxi operators could not attract substantially more business and offer more variant service if they are not constrained to price their services to cover costs. If it is accepted that subsidy to the flexible route service in low density areas is necessary to make the whole system work, then the possibility of paying that subsidy to a private operator should be carefully considered(12). This is a complex subject that must be equitably handled to prevent public subsidy from competing unfairly with private capital.

System Evolution

As the system grows, the distribution of route densities discussed in connection with Figure 12 moves to the right, lowering costs and adding more fixed route elements. Thus the dominant growth is in fixed route elements. Inducing this growth and lowering overall system costs is the rationale for cross-subsidizing the suburban service.

The evolution of these systems over time is illustrated in Figure 14. The first phase is that in which coverage of the low density suburbs is being added. The second is the growth phase after complete coverage has been achieved. These two phases are discussed in turn.

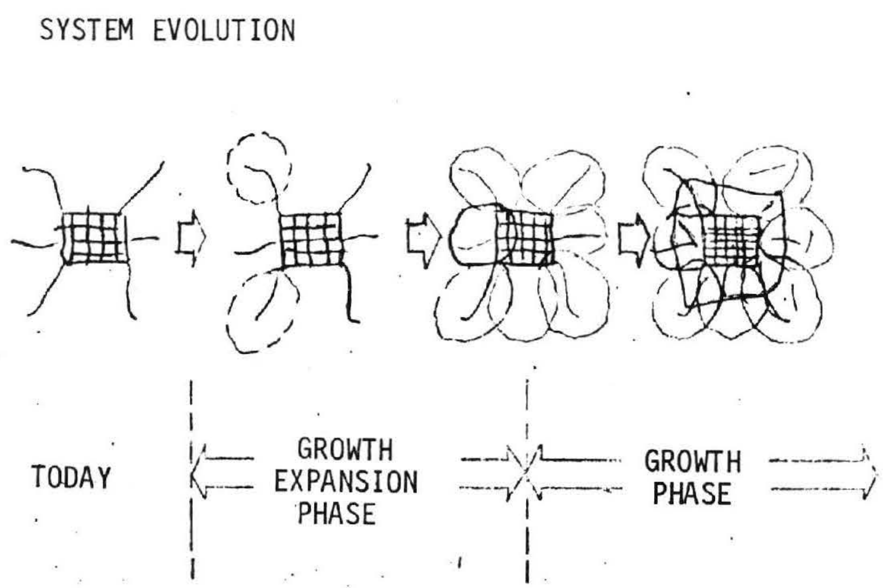
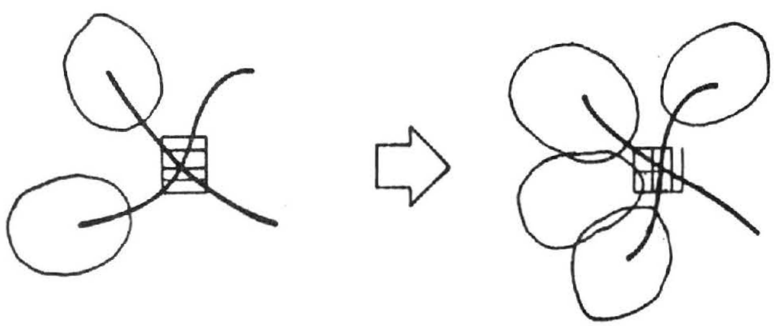


FIGURE 14

Recalling Figure 12, the new flexible route elements that are added in order to evolve from a limited coverage, fixed route system to an integrated, full coverage system have higher costs and lower productivity than the already existing fixed route elements. As noted in Figure 15, without overall ridership growth and/or better peak/off-peak utilization, average costs per passenger will rise. This occurs at the same time as a multitude of new management problems are being experienced. This initial expansion phase is most critical: public attitudes are still largely unconverted, car ownership habits unchanged, management and operators are pioneering innovation, and the overall concept is unproven. It may require a lot of faith on the part of the supporting authorities to survive misjudgments which are very easy to make with our relative lack of experience with such systems, particularly if costs per passenger are rising. It would appear to be very important to select initial flexible route elements where the opportunities for good ridership response are greatest.

(Adding the suburban service is not the only action being taken. Downtown circulation should be concurrently improved, as well as other steps. These were discussed earlier and are illustrated in the section on Implementation.)

SYSTEM GROWTH: COVERAGE EXPANSION PHASE

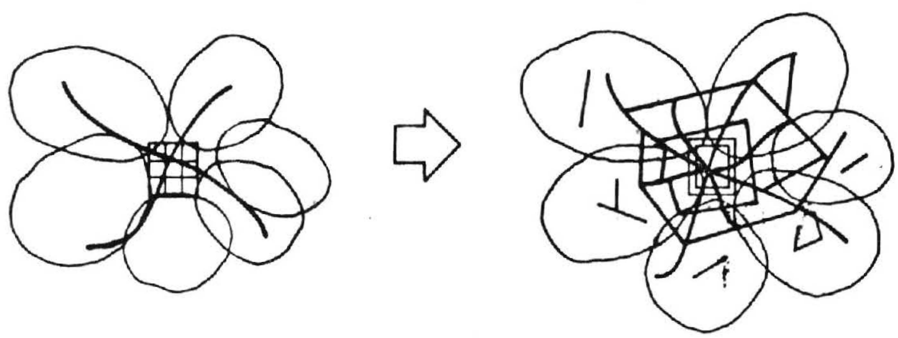


- ADDING LOWER PRODUCTIVITY FLEX ROUTE ELEMENTS: S/PASS MILE RISE
- MAY BE BALANCED BY BETTER OFF-PEAK UTILIZATION, HIGHER OVERALL RIDERSHIP
- MANAGEMENT/CONTROL PROBLEMS GROW FASTER THAN RIDERSHIP

FIGURE 15

In Figure 16, the next phase of growth is depicted. Success is assumed: the system is in place. Growth now occurs not primarily by expansion of flexible route elements (although some may be added in high density areas as supplements to fixed route elements). Now growth provides the opportunity for incremental improvements in service and amenities. Many special point-to-point express elements could become feasible, offering a very high level of continuous service between high and medium density activity centers. These are all high productivity elements so now system economics are improving on a per trip basis.

SYSTEM GROWTH: RIDERSHIP EXPANSION (SUCCESS SCENARIO)



- ADDING HIGHER PRODUCTIVITY FIXED ROUTE ELEMENTS:
  $/PASS MILE DECREASE
- OVERHEAD AMENITY COSTS (TRANSFER FACILITIES, INFO SYSTEMS) SMALLER PERCENT OF PASS MILE COSTS
- MANAGEMENT/CONTROL PROBLEMS MAY GET EASIER:
  MORE MANAGEMENT OVERHEAD AFFORDABLE,
  NUMBER FLEX ROUTE VEHICLES GROW SLOWLY,
  NEW FIXED ROUTES PLAN THEMSELVES.

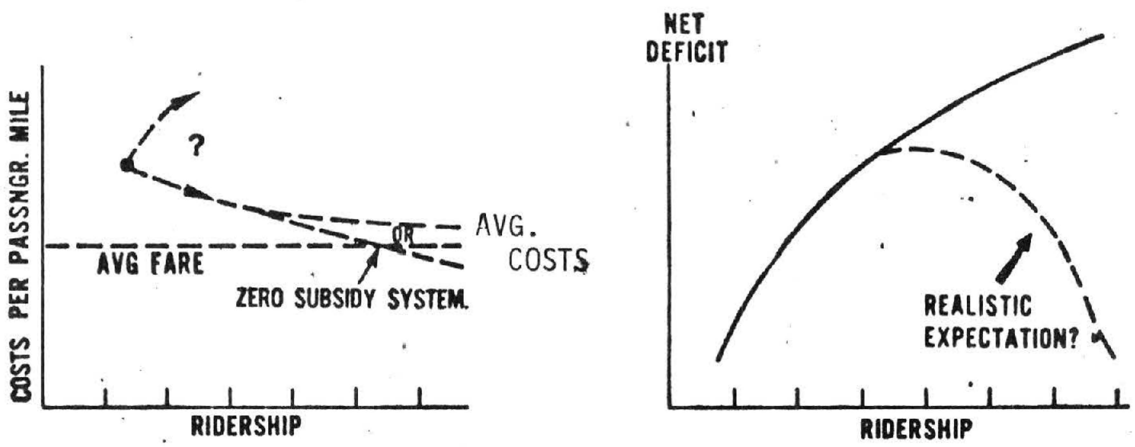
FIGURE 16

This is an important conclusion, because if it is correct, it implies that the vehicle management problem may not be as formidable as often depicted and that ridership growth leads to continually better service and more flexibility of choice, encouraging still further growth. At some point in growth, marked improvements in congestion should begin to appear. Success should breed success.

Figure 16 suggests a rosy picture, but there are several very sticky unknowns, illustrated in Figure 17. When the decision is made to initiate expansion of coverage by adding the higher cost flexible route elements, it is a gamble as to whether overall costs per passenger will rise or whether ridership increases and better peak/off-peak matching will compensate. Assuming the system survives this phase and further growth brings down average per passenger costs, the total deficit will still rise as illustrated. Whether it is realistic to think these costs will decline sufficiently for the overall system to pay for itself is an open question.

THE PROBLEMS

- **ABSOLUTE COSTS MAY LOOM LARGER AND LARGER IN LOCAL BUDGETS**



- **PUBLIC ACCEPTANCE? (Car Disincentives?)**

FIGURE 17

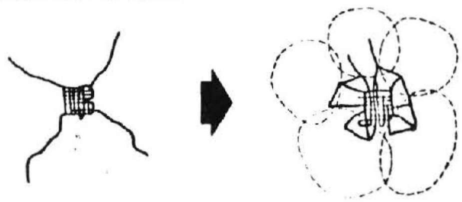
IMPLEMENTATION AND MANAGEMENT

Incremental Planning

These systems lend themselves ideally to incremental planning and implementation. They do not require large fixed investments or a high degree of initial planning detail. The principles suggested are shown in Figure 18.

IMPLEMENTATION PRINCIPLES

1. **ESTABLISH ROUGH IDEA OF FULL COVERAGE SYSTEM CONFIGURATION**



2. **ESTABLISH FINANCING, INCLUDING CONSTRAINTS ON PLANNERS/OPERATORS**
3. **PLAN-IMPLEMENT-FEEDBACK-REPLAN < EXPAND / CHANGE**
   - **PICK FIRST STEPS AS MOST LIKELY TO SUCCEED**
   - **PROVIDE ALTERNATIVES BEFORE APPLYING RESTRICTIONS**
   - **HELP THE SYSTEM PLAN ITSELF**

FIGURE 18

The chart is basically self explanatory except perhaps the phrase "Help the system plan itself." Since origin-destination data is obtained as a part of normal operation, judicious use of this data plus exogenous information can provide a sound basis for planning growth and operating mode optimization (fixed route vs. flex route, service areas, diurnal variations, etc.).

Figure 19 illustrates a sequence of steps over time to achieve the objectives listed on the left side.

EVOLUTION OF THE URBAN SYSTEM

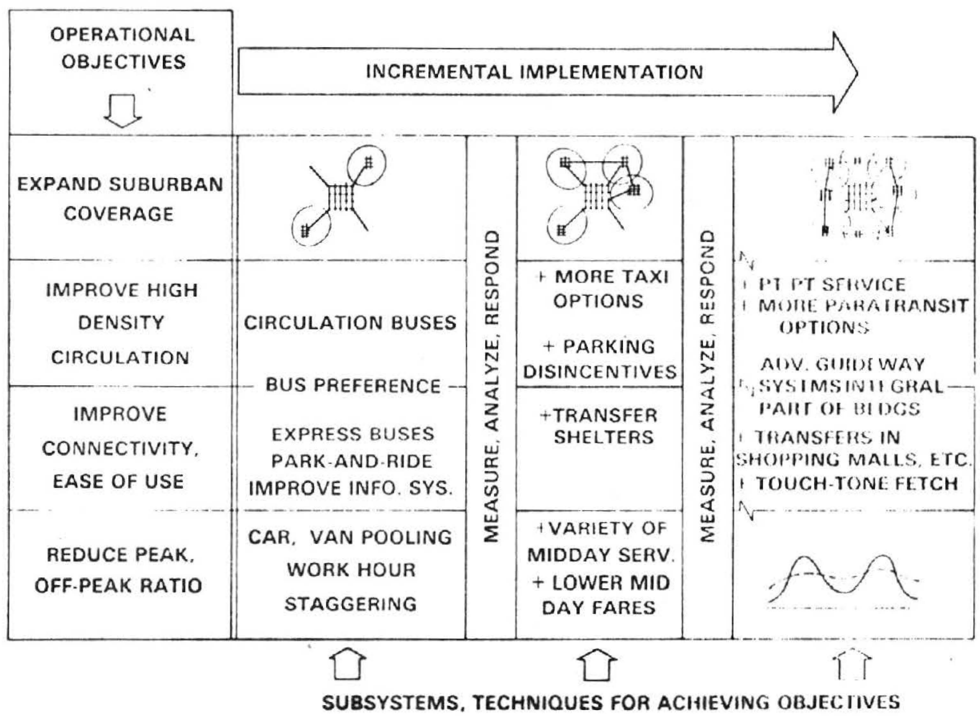


FIGURE 19

It is intended only to suggest how to think about implementation; the specific actions shown are illustrative only.

Customer Information Requirements

The need for information is dramatically different for these systems than conventional transit because, at least in the suburbs, the system comes to the customer, not vice versa, and once in the system, he can be led almost literally by the hand from that point to his destination.

Figure 20 illustrates what the customer needs to tell the system and the information needed in return. Estimated travel time and cost are optional. The last point, that the customer needs to know when the pick-up vehicle has arrived, is less trivial than it sounds; one or two minute prewarnings to reduce pick-up dwell time can pay off in vehicle productivity improvement. Further, horns to signify arrival are both a neighborhood nuisance and are unreliable.

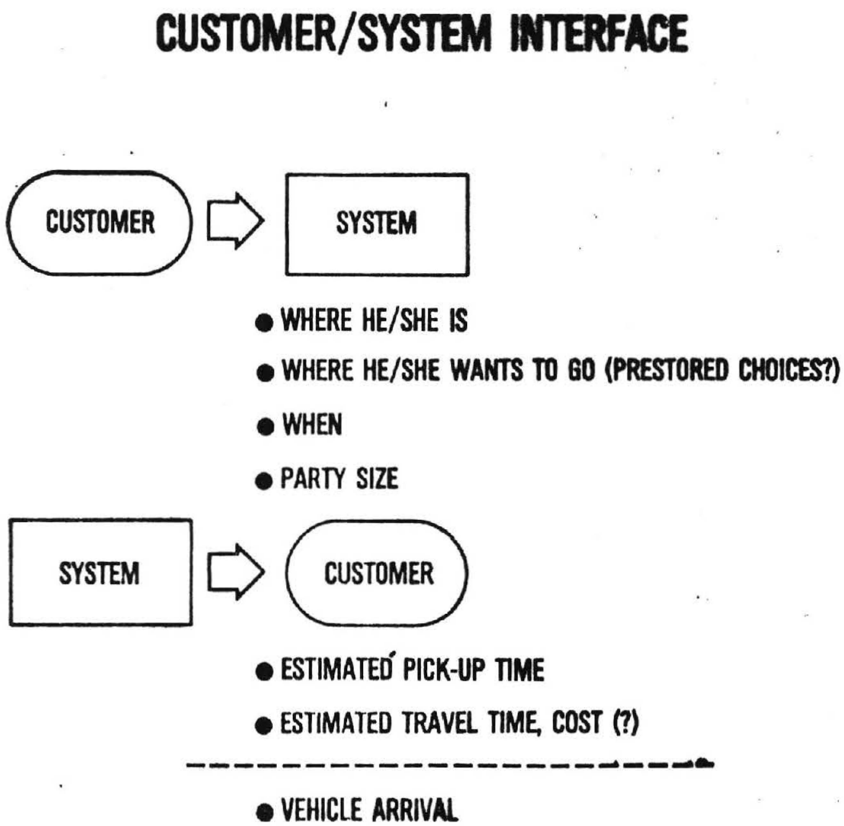


FIGURE 20

Thinking into the farther future one can conceive of schemes to greatly simplify, from the customer's view, the use of the system. For example, one push on a button on a phone can tell the system where the pick-up is. A second push could select by number the desired destination from a list prestored in a computer. If the service was not needed immediately or if the party size was over, say, three, then a third push could establish voice communication. The primary point is that there is ample opportunity for innovation and improvement over today's approaches to such problems.

Figure 21 summarizes most of the critical information the system needs (excluding maintenance data, etc.). *The optimal distribution of duties between man and computer is a fundamental problem.*

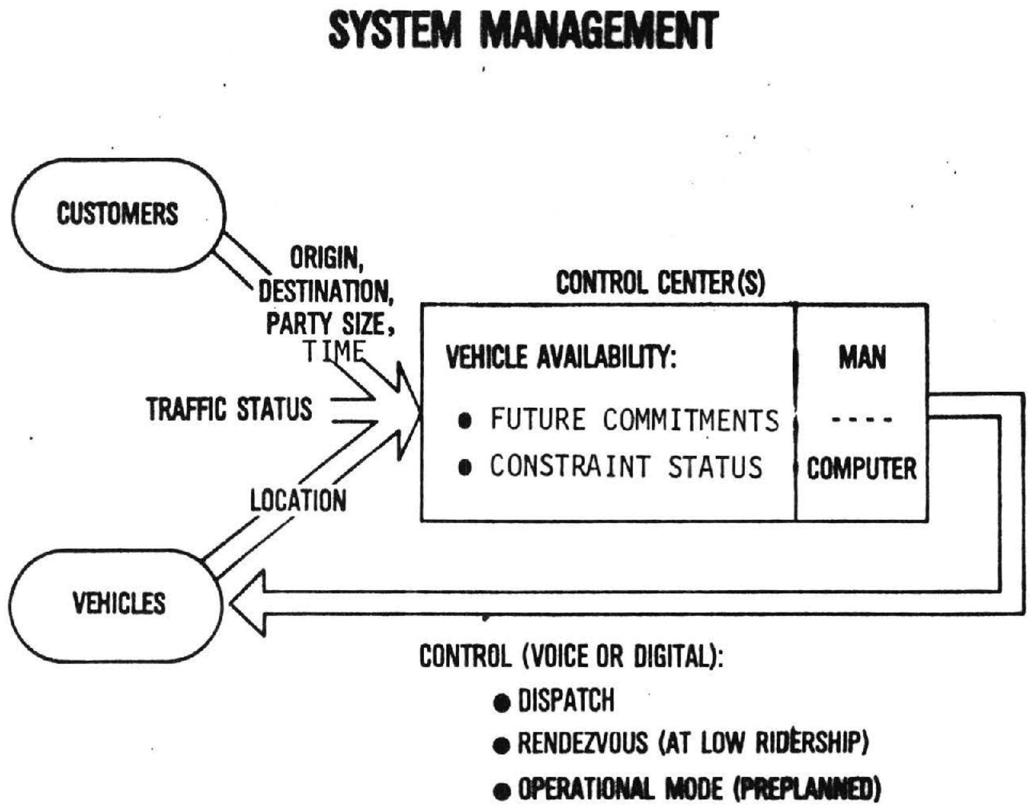


FIGURE 21

The rendezvous problem between two vehicles may disappear as ridership grows and reasonable transfer facilities are made available. If headways are short and there is a nice place to wait, actual vehicle-to-vehicle rendezvous becomes unnecessary.

The operational mode of some vehicles will vary with time of day. This may be either preplanned or adaptive.

An additional management tool that is crucial is a good managerial cost accounting system. The typical systems do not adequately separate fixed and variable costs and identify each to its source. Because the need is generic and not widely recognized, the problem deserves assessment at the federal level.

Long Range Evolution

It is very hard to predict how long it will take just to test the basic hypothesis that sufficient ridership can be attracted to produce attractive system economics. Probably 3-5 years is a minimum test once the full coverage demonstration system is in place.

Given success, subsequent evolution can occur incrementally as new techniques, equipment, or systems become available. New elements, such as advanced guideway transit (AGT) or horizontal elevator systems can be phased in by substitution for the system elements they replace. These are most likely to appear as a part of major urban renewal schemes or new towns but could conceivably be superimposed on existing infrastructure as a means of converting streets into malls.

Even more radical innovations such as dual mode schemes lend themselves to incremental implementation in the context of the mixed system philosophy espoused here. This is most likely to begin with intercity travel and then to remote parts of a single urban region. For example, under the circumstance that the volume of travel were large enough to warrant the investment and the distance long enough to benefit travel time by achieving above-highway speeds, a fixed guideway, high speed pallet link accommodating small urban cars might be installed. This could evolve over time to a backbone high speed system tying very large regions into one economic and social unit.

How the urban system evolves depends at least partially on the long range energy picture. If using electrical energy directly has cost and service advantages over either electric vehicles (because of battery limitations) or internal combustion engines (because of relatively higher costs for petroleum or petroleum substitutes), the fixed guideway systems gain a comparative advantage over roadway systems. Since fixed guideway systems also lend themselves to easier automation, the desire for higher labor productivity could enhance this advantage. The disadvantage is the higher capital requirements associated with new guideway.

System Goals and Impacts

At this time, it is not clear what level of ridership is a realistic expectation. Figure 22 lists some alternative goals, discussed below.

ALTERNATIVE GOALS

1. 99% AVAILABILITY (TIME & SPACE)
2. DOUBLE CURRENT TRANSIT RIDERSHIP
3. FULLY DECONGESTED TRAFFIC FLOW WITHOUT CAR DISINCENTIVES
4. MOSTLY DECONGESTED FLOW WITH SOME CAR DISINCENTIVES
5. TEN TIMES CURRENT TRANSIT RIDERSHIP

FIGURE 22

Criterion 1 implies a system which serves essentially all the urbanized area and provides at least some kind of service on a 24-hour basis; this is what we are trying to do. Number 2, Doubling Transit Ridership, is not enough to really impact our congestion and energy problems because we start from too small a base: typically only 2 to 5 percent of urban trips are now by public mode(13). Further, if we meet Goal Number 1 without getting a much more dramatic increase in ridership than just doubling, poor economics would probably doom the system. Doubling is not likely to be enough.

Number 3, Fully Decongested Traffic Flow Without Car Disincentives, is expecting too much. But it appears that we are getting car disincentives in the form of higher car costs whether we want them or not. Even so, some restrictions or regulations on private car usage in high density areas is likely to be necessary. But such restrictions are unlikely to be acceptable unless reasonably convenient, safe, and pleasant alternatives are made available.

Criteria 4 and 5 recognize that substantial improvement in public systems will likely require some car management, that we are aiming at much larger modal splits than we normally think in terms of, and that the suburban non-driver will finally have a good alternative to staying home or finding a chauffeur.

The level of diversion from auto required to alleviate or cure congestion is a very situation-specific issue, depending on a number of other actions taken in concert. Further, the alleviation is likely to be temporary unless equilibrium between traffic generation and traffic capacity can be maintained; the classes of actions listed in Figure 23, properly balanced, are the tools to achieve this equilibrium. The selection of the proper set of actions is a key part of a site-specific urban strategy. This issue is discussed later in a somewhat different format.

STRATEGY APPROACHES FOR CONGESTION ALLEVIATION

1. INCREASE PRODUCTIVITY OF AVAILABLE SURFACE AREA DEVOTED TO TRANSPORTATION (BETTER NETWORK FLOW MANAGEMENT, AUTOMATED TRAFFIC FLOW, DYNAMIC ROUTING, OPTIMAL LANE ALLOCATION, ETC.).

2. DECREASE TOTAL NUMBER OF VEHICLES (VEHICLE DENSITY) AT TIMES OF CONGESTION (INCREASE AUTO/BUS/RAIL AVERAGE LOAD FACTOR, MODAL SHIFT TO BUS/RAIL, CHANGE TEMPORAL PATTERN OF TRAFFIC FLOW PEAKING, RESTRICT ACCESS).

3. INCREASE THE SURFACE AREA AVAILABLE TO TRANSPORTATION (WIDEN STREETS, ADD ADDITIONAL LEVELS EITHER ABOVE OR BELOW EXISTING STREETS, ADD PARKING).

4. CHANGE LAND USE PATTERNS TO INSURE TRAFFIC GENERATION EQUILIBRIUM WITH AVAILABLE TRANSPORTATION CAPACITY (CHANGE RESTRICTIONS, INCENTIVES).

FIGURE 23

It should also be pointed out that urban goods movement is an important element of the problem. This report has dealt exclusively with new concepts of transit for people: it is possible that new concepts for urban goods movement can be evolved as well. But in the context of the discussion at hand, it is not clear that goods movement is really a separate problem from people movement from the transportation perspective. One can argue that the central inhibitor to efficient urban goods movement is the congestion resulting from both people and goods movement and that the goals of improved mobility for either people or goods requires alleviation of this condition. Otherwise, the structure of the goods movement industry would suggest reasonably good economic efficiency: almost classical competition, involving many units with easy exit and entry, and highly visible costs that clearly impact either competitiveness or profit. Given that congestion is the central source of inefficiency is valid, alleviating it should have a substantial economic payoff to the nation.

The possibility of using the public system for goods as well as people movement is an option that deserves attention and schemes to facilitate it explored. If efficient schemes can be devised, the additional function could further smooth peak/off-peak usage and improve system economics.

Many of the steps that decrease congestion also improve energy conservation. Figure 24 summarizes the impacts. Most of the points are obvious, but several words of explanation may be helpful. The point about trades between frequency of service, load factor, and vehicle size refers to the fact that at low ridership frequency of service is a constraint: if the bus comes only once every 30 minutes at peak hours, for example, load factor cannot be maintained off-peak when ridership drops because cutting frequency only causes ridership to drop still more. But if ridership were higher, requiring, say, 3-minute peak service, then at peak the service could be cut to 6 minutes with only small impact on demand and thus maintain high off-peak load factor. Further, as ridership rises, larger and more productive vehicles can be used and still maintain high service frequency.

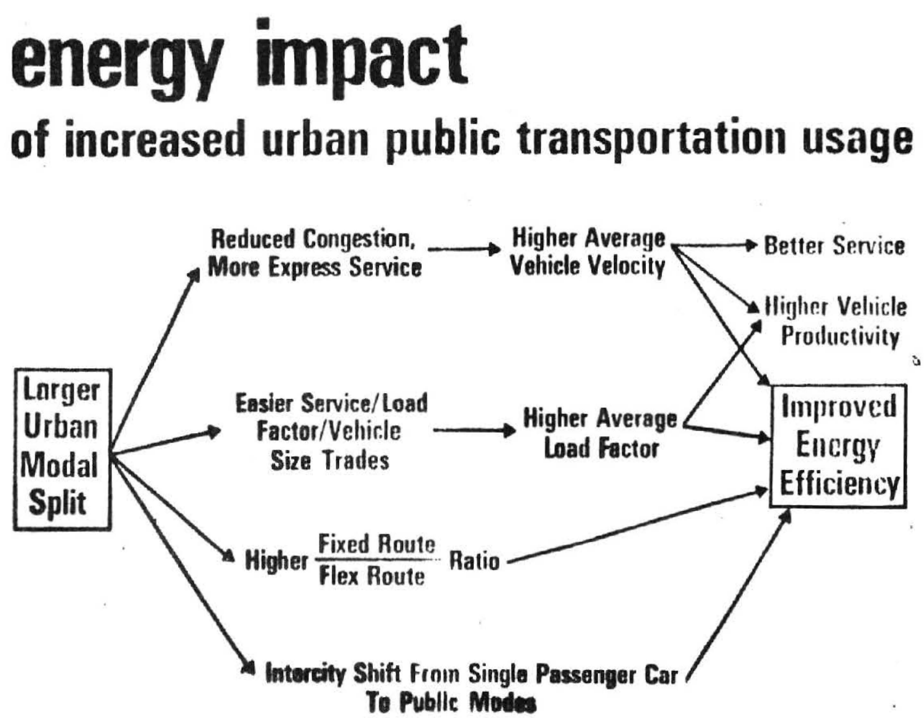


FIGURE 24

The last point referring to intercity modal shift assumes that breaking the car habit intracity will help break it intercity, primarily by diversion from single passenger autos. Again, we do not know the likely magnitude of this effect.

It is worth noting that increasing vehicle productivity (passenger miles/hour) not only lowers costs but also increases energy efficiency and emissions because it implies higher load factors, less congestion, and fewer stops. Many goals are congruent: increasing transit ridership, i.e., producing a large modal split will, in the short term, require higher productivity of existing buses because adding new ones requires time. The interrelationship of the many goals and actions to reach them are illustrated in more detail in the Appendix.

For completeness, it should be noted that policies and incentives for people to live nearer their work will help energy conservation. This is obviously a long range strategy option and one likely to be brought about by market forces if gasoline prices continue to rise.

In conclusion, higher ridership should help service, economics, energy efficiency, emissions, and congestion. While we do not know what is achievable, we clearly should set our sights high. Converting 80-100 percent of all peak period trips that have at least one end in high density areas to either car/van/buspools or public transit in order to relieve congestion and parking pressure is suggested for one aspect of our goals. What is really possible overall is highly conjectural, but a crude goal can be constructed. In 1990 it is expected that 15 percent of the population over 15 will not be licensed drivers and that roughly 40-50 percent of the urban population will still ive in CBD's, where the premium on car ownership is less than in the suburbs. Public transportation service that is very much better than it is today could remove some of the current depressants on non-driver or non-car owner trip taking, as well as producing a more favorable modal split from some of the driving public. Overall, the figure already mentioned of 20-40 percent of all trips by public transportation may not be unreasonable.

The promise of these new systems is great, and success in bringing about a major shift to transit could be of substantial importance to the nation. But it is not going to be easy. We know very little about these systems and the public reaction to the kinds of service we think they can offer, and it may require perhaps a decade to test the hypothesis that it can be done.

The major points are noted in Figure 25. The desirability of the last two points, fewer multicar families and labor intensive systems, lies, like beauty, in the eyes of the beholder. There is little issue with the overall desirability of better public transportation and fewer cars downtown as long as adequate alternatives are available. There will probably be a small net decrease in vehicle investment, but it will happen slowly so that economic disruption is small and may well result in very desirable side effects.

CONCLUSIONS

- FLEX ROUTE SYSTEMS PERMIT A DIFFERENT CONCEPT OF PUBLIC TRANSIT:
  - DOOR-TO-DOOR, INDOORS (ALMOST)
  - REGION-WIDE SERVICE

IF MAJOR PATRONAGE CAN BE ATTRACTED

- GIVEN SUCCESS, IMPORTANCE IS SUBSTANTIAL
  - NATIONAL DECONGESTANT
  - MOBILITY FOR THE NON-DRIVER
  - ENERGY CONSERVATION
  - FEWER MULTI-CAR FAMILIES
  - LOTS OF JOBS

FIGURE 25

Labor intensiveness is a much more debatable subject. It clearly makes the systems vulnerable to labor disruption. On the other hand, from the national view, labor is increasingly becoming a fixed cost. Systems that require only moderate capital (which will continue in short supply) and provide socially desirable, important, and productive jobs may be a plus for the nation's economy. These are policy issues beyond the scope of RD&D, but they may be moot: we know of no other approach to providing the service described except with labor intensive systems for the next several decades, barring some major technological breakthrough.

THE FRAMEWORK FOR AN URBAN TRANSPORTATION STRATEGY

The five goals for the long range improvement of urban transportation were presented in the Summary and repeated in Figure 26.

GOALS LEADING TO IMPROVED URBAN TRANSPORTATION

- TECHNICAL ELEMENTS AND OPERATIONAL CONCEPTS WITH POTENTIAL FOR BETTER SERVICE/COSTS
- EFFICIENTLY AND PROGRESSIVELY MANAGED OPERATING ORGANIZATIONS
- MORE EFFECTIVE CITY/REGIONAL POLICY, PLANNING, DECISION, AND IMPLEMENTATION PROCESSES FOR BOTH PUBLIC AND PRIVATE MODES
- BASIS FOR EQUITABLE, POSITIVELY MOTIVATING FINANCING
- EFFICIENT, INNOVATIVE EQUIPMENT SUPPLIER INDUSTRY

FIGURE 26

It is suggested that these goals can provide a rationale framework for a comprehensive urban strategy, i.e., the definition of a set of actions that lead, over time, to their realization.

It is clear that these goals transcend the RD&D program itself, and it is beyond the scope of this paper to comprehensively discuss the many non-RD&D steps already being taken by the Department of Transportation toward their achievement. But some comments of the RD&D contribution may be illustrative.

Figure 27 depicts the classes of effort that can sensibly support the goals of Figure 26 and help bring into being the kinds of systems described herein. It is not necessarily intended to be exhaustive but only to suggest a set of rationale goals around which specific program objectives can be delineated.

RD&D POLICY IMPLICATIONS

INTERDEPENDENT OBJECTIVES	AREAS OF RD&D APPLICATION	
TECHNOLOGICAL ELEMENTS & OPERATIONAL CONCEPTS	HIGH RISK INNOVATION VEHICLE/FLOW CONTROL TOOLS EXPERIMENTS/DEMONSTRATIONS SIMULATION TOOLS	KNOWLEDGE DISSEMINATION
GOOD OPERATING MANAGEMENT	MANAGEMENT TOOLS MANAGEMENT EXPERIMENTS	
GOOD PLANNING AND IMPLEMENTATION DECISIONS	POLICY/CRITERIA/ALTERNATIVES ANALYSIS TOOLS INCREMENTAL PLANNING TOOLS	
SOUND FINANCING	POLICY/CRITERIA ANALYSIS TOOLS POLICY DEVELOPMENT ANALYSIS	
HEALTHY SUPPLIER INDUSTRY	STIMULATION OF INNOVATION	

FIGURE 27

The improvement of the <u>technical and operational elements</u> is usually viewed as the primary purpose of transportation RD&D, and it does constitute a substantial portion of this Departmental activity. As indicated in Figure 27, it includes the bringing about of innovation--both technical and operational--that involves risk beyond that which can reasonably be expected to be assumed by the private sector or a local government agency(14). Advanced Guideway Transit is an example. Other programs could be listed either here under this objective or under Number 5, Insuring a Healthy Supplier Industry, because they serve them both: the UMTA bus and rail programs and the FHWA traffic flow and space management programs both started under federal funding but are being rapidly picked up by the private sector as the perceived risk is alleviated by growing markets.

The UMTA Service and Methods Demonstration Program and FHWA/UMTA Urban Corridor Demonstration Programs, such as the Shirley Highway experiment, are examples in the demonstration area. Federal support of demonstrations is a growing and important element of the RD&D program: it is often the only way to test the validity of new concepts, and it is expecting too much for a single city to assume the risk of testing a generically applicable concept, often at considerable political peril to themselves. Simulation tools, such as are being developed under the UMTA Area-Wide Demand Responsive Transit Program, can aid in both the design and analysis of such experiments/demonstrations.

RD&D can aid in the encouragement of the second general objective, good operating management, by supporting the development of such management tools as RUCUS (Run Cutting and Scheduling System). It is expected that this area of RD&D emphasis will grow concomitantly with the increased attention being accorded within the UMTA organization.

Objective 3, more effective policy, planning, decision, and implementation processes, is receiving primary attention at all levels of government. A discussion of the numerous disciplines and coordinative mechanisms aimed at furthering the objectives, such as the Intermodal Planning Groups, Unified Work Programs, and alternatives analysis requirements now being promulgated, is beyond the scope of this discussion. The principal RD&D contribution is achieved through the Urban Transportation Planning System of UMTA and FHWA and the policy analyses that guide the general area.

The only role of RD&D in goal four, equitable and positively motivating financing, is the studies and analyses that provide the background perspective for establishing policies which try to insure that the costs of transportation are fairly distributed among the beneficiaries and that subsidies are provided in such a way that efficiency and service are positively motivated. This is not easy.

One would like to hope that success in achieving the first four goals will in time obviate the need for federal stimulus to bring about the fifth, a healthy, innovative transportation equipment supplier industry. It is not now the case, but the combination of good markets, informed buyers, and intelligent regulation should create the financially healthy competitive environment in which innovation will naturally breed.

While not a goal in itself, an absolutely essential ingredient is a program of technology or knowledge sharing: a set of mechanisms to insure a useful two-way dialogue between the important parties in the urban transportation community, both to better bring about desirable innovation and to insure focus to the federally coordinated and performed RD&D programs.

APPENDIX

The Relationship Between Goals and Actions

Figure 19 illustrated the general scheme for incremental implementation of these region-wide systems. This section is intended to depict the interaction between the various urban goals and the specific actions that can be taken to influence them. It is intended to make clearer the interdependence of alternative actions to guide in the selection and implementation of specific combinations as the systems evolve.

Figure A1 indicates on the left the three primary goals of improving non-driver mobility, reducing congestion, and conserving energy. Meeting clean air standards is assumed to be subsumed in these three. The chart shows that these objectives imply subobjectives of a modal shift from auto to transit, particularly where congestion occurs in high density regions, better vehicle specific energy, and an increase in average vehicle occupancy. It further implies that if a major modal shift is to be achieved, two further subobjectives of improving the cost and/or service of the public mode and increasing its capacity to cope with the shift are indicated.

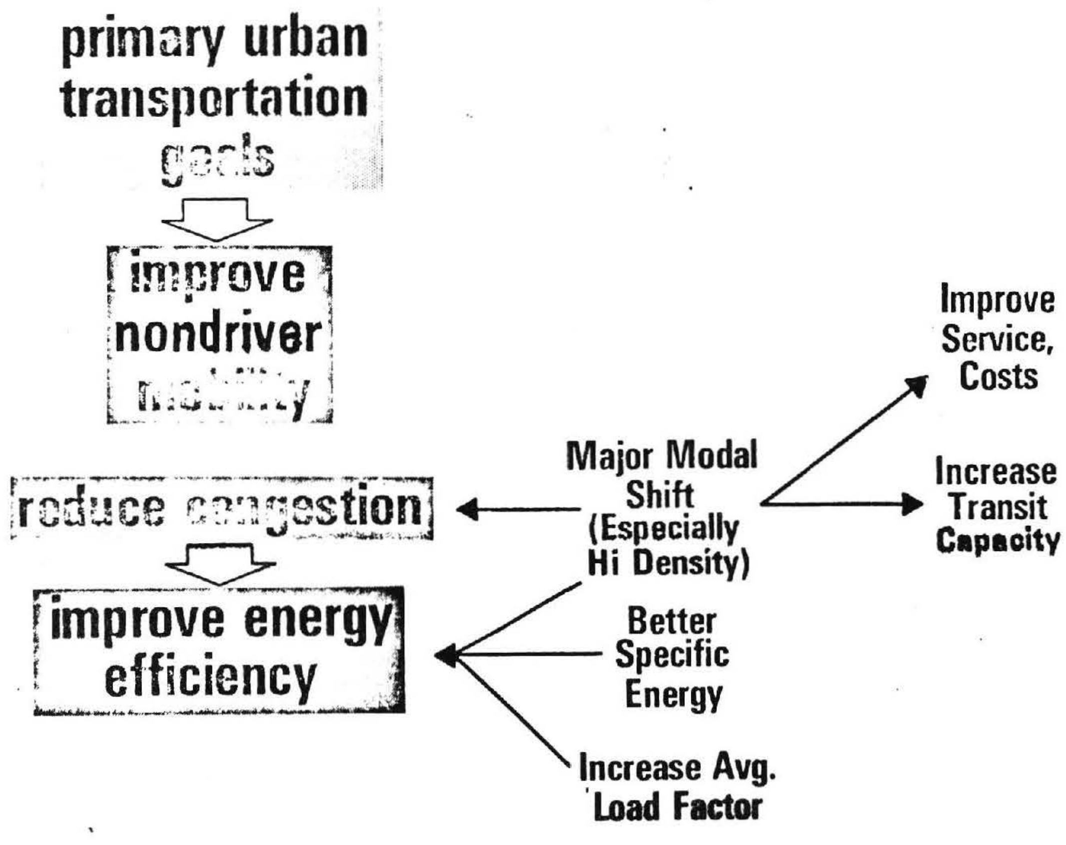


FIGURE A1

All of these relationships are repeated in Figure A2, which is expanded to include other subobjectives as well as specific actions toward their achievement. Specifically, it notes the set of actions that can improve service, costs, and non-driver mobility. It also indicates that transit capacity can be increased by either the specific action of increasing fleet size or by achieving the new subgoal of increasing bus productivity; this latter, in turn, implies higher average velocity and higher load factor.

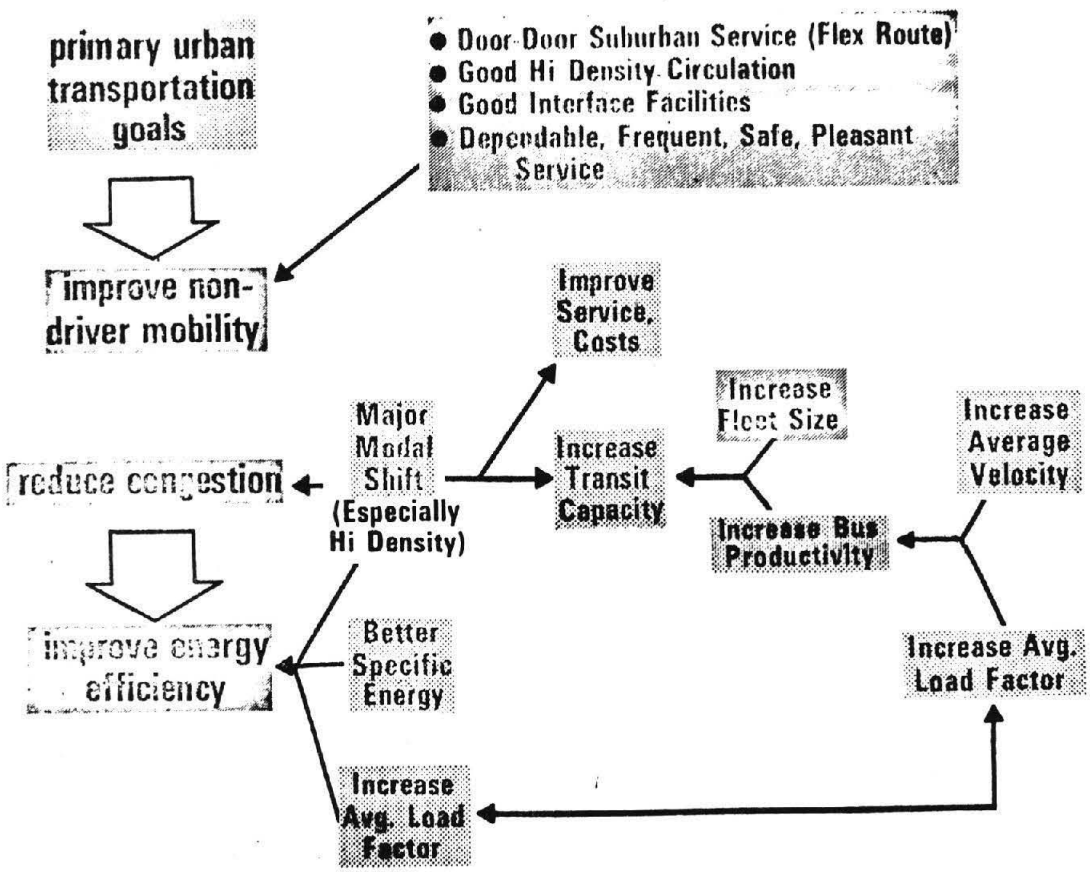


FIGURE A2

Figure A3 further expands the subobjective/action set. It shows that car load factor can be increased by car and van pooling and bus load factor by reverting to demand responsive, flexible route service when ridership density is low. This also provides better off-peak service contributing to the new subobjective of matching peak/off-peak demand by improving off-peak ridership. Car and van pooling and staggering work hours also decrease peak demand and thus also contribute to matching peak/off-peak demand. (The increasing complexity of the charts reflects the fundamental complexity of the problem being analyzed.)

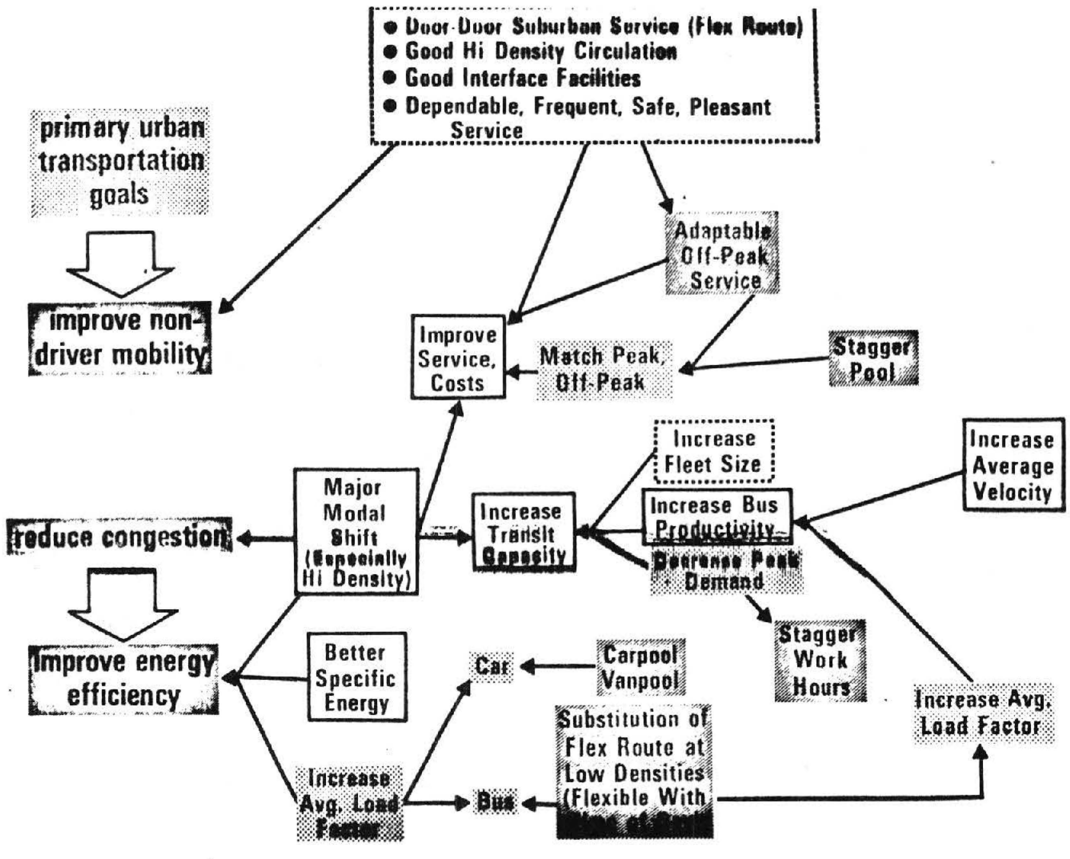


FIGURE A3

Figure A4 adds those additional subobjectives of fewer stops and shorter dwell times to help increase average bus velocity, plus the actions that can contribute to their realization.

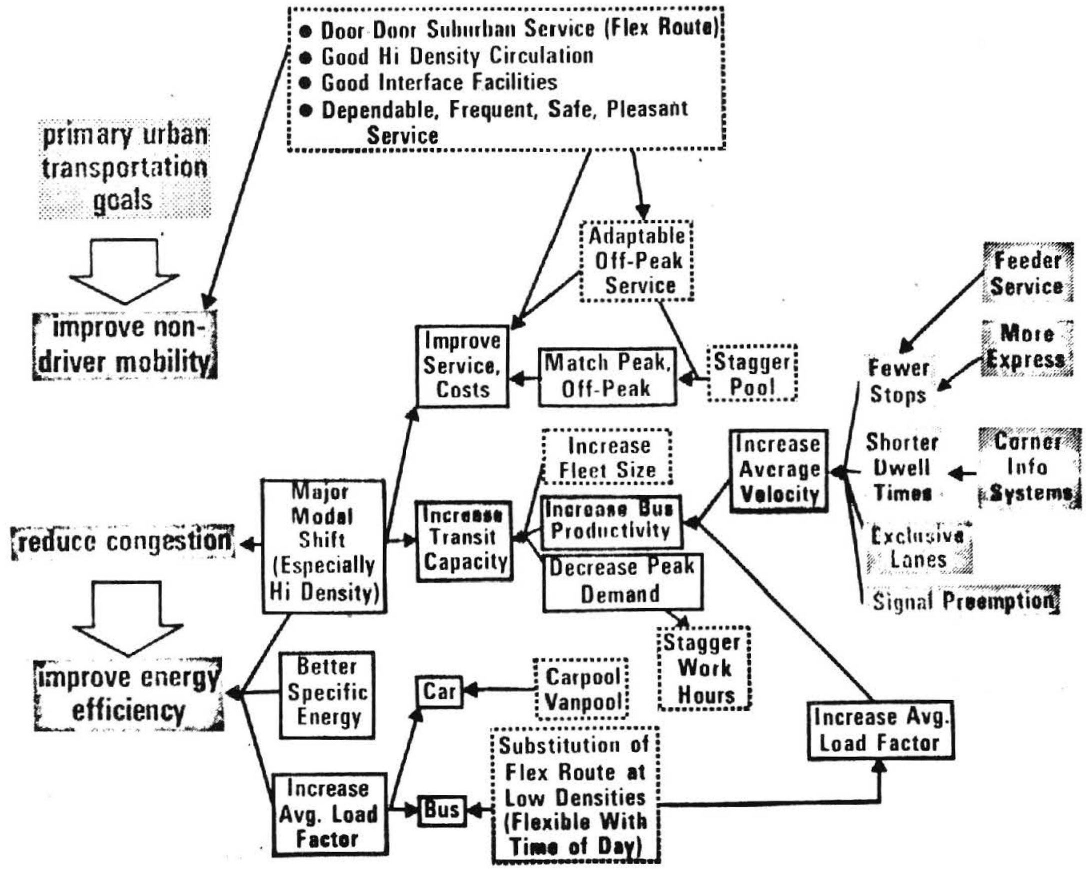


FIGURE A4

Figure A5 illustrates four other actions that can contribute to higher modal shift and reduced congestion.

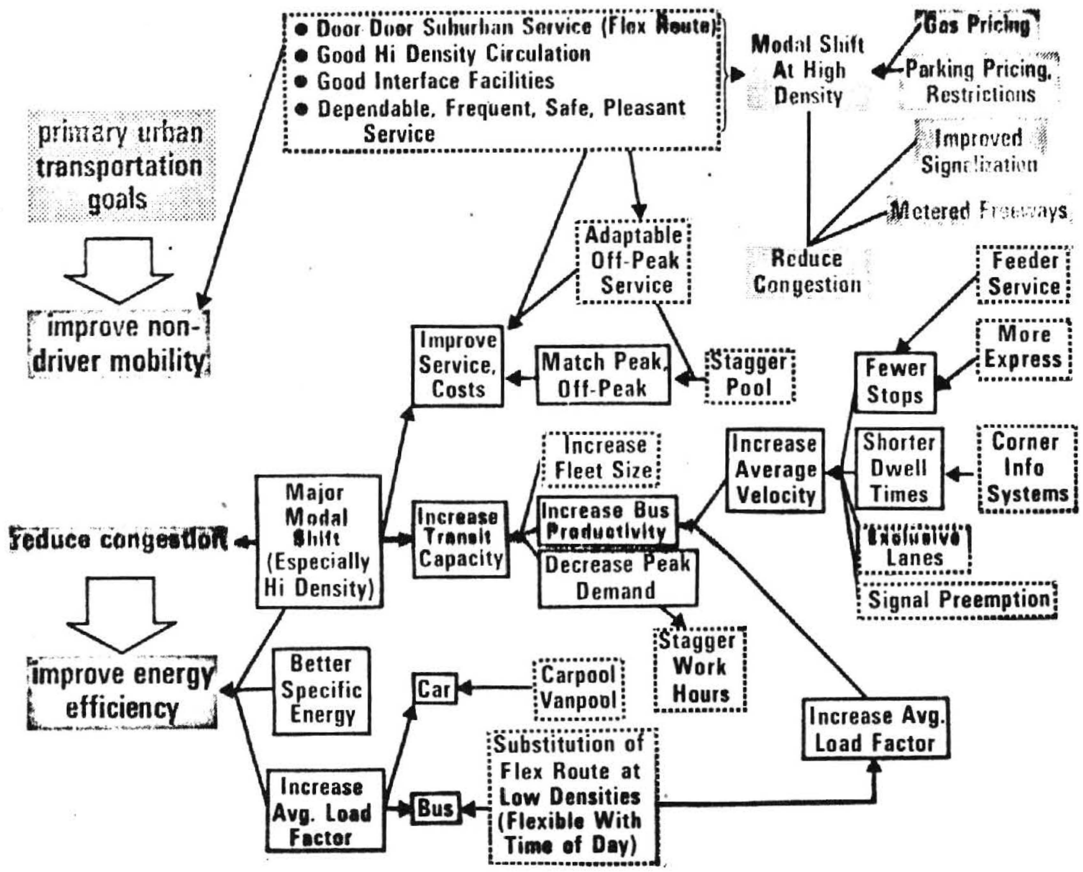


FIGURE A5

These figures get complex because the totality of interactions is complex. But just to convey the general idea, Figure A6 lists only some of the actions and focuses on those that can be implemented in the short term.

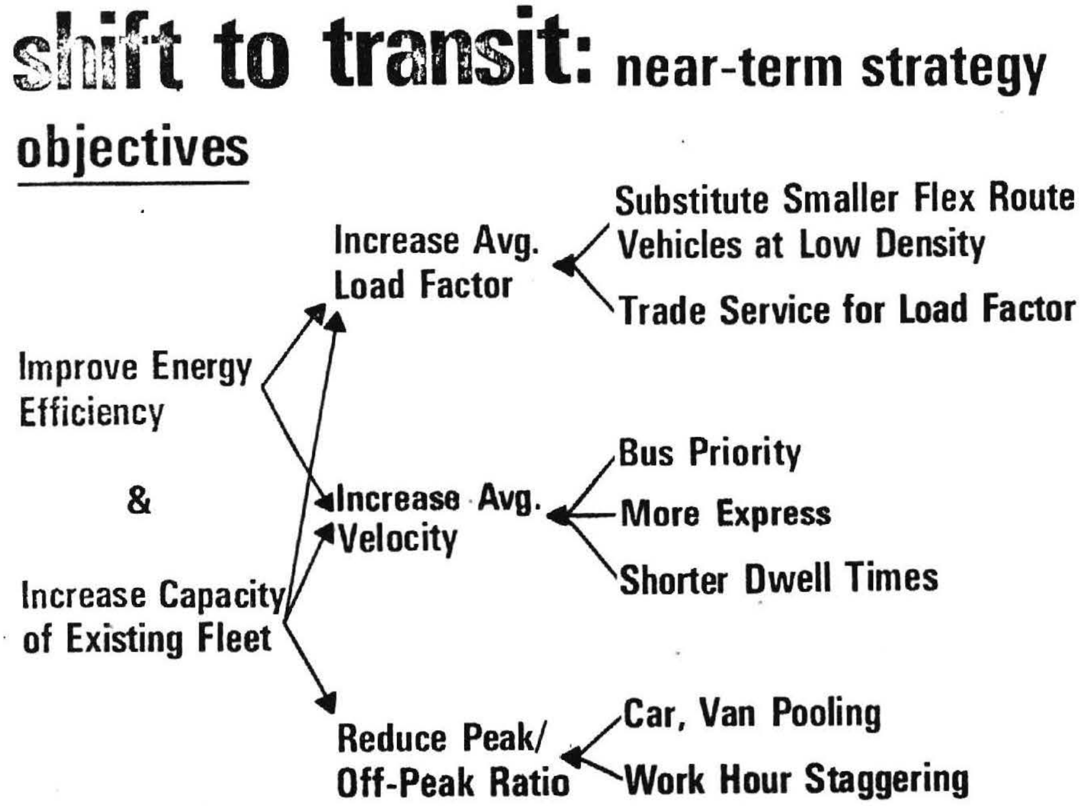


FIGURE A6

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7. 1972 National Transportation Report, Washington, D.C., U.S. Department of Transportation, Office of the Secretary, July 1972, p. 189.

8. One should examine with great care the goals of any transportation system improvements. For example, in Urban Dynamics in Lowell (MIT Urban Dynamics Group, Walter W. Schroeder III), it is recommended that transportation to the CBD be made easy for the non-commuter but difficult for the commuter to discourage the exodus to the suburbs of CBD job holders.

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