Satellite-City Development Through Improved Passenger Transportation Service

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The lack of adequate transportation services has been a major impediment to the development and growth of satellite communities outside of major metropolitan areas. This paper presents an approach for selecting and organizing transportation services for commuting trips between satellite communities and metropolitan areas. The services of interest are designed as "commuter clubs" in which most of the administrative functions are performed by volunteers. This approach allows inexpensive services to be offered when travel demand is low and supports gradual development of services from a small start. An analytical technique that makes use of the commuter-club approach is presented for formulating, describing, evaluating, and comparing alternative transportation services. Analytical results suggest that van-pooling and subscription bus services are attractive for a wide range of satellite cities. Other services—car pooling, commuter rail, and air—can be attractive in special situations. All require a coordinating function for providing advice, support, and help with problems. This function can best be performed within the satellite-city government.

The urbanization of America has proceeded to an extent that many consider dangerous. Crime, pollution, and poverty are often blamed on the difficulties of living in the concentrated population areas that our major cities have become. For more than a decade, imaginative developers have been creating new towns and expanding rural communities that are separated from major cities by rural land or green belts. These communities offer low-density living and some rural amenities and at the same time retain access to the city. They purport to offer residents the best of two worlds—rural and urban.

What we know as new towns are not a new phenomenon. In the late nineteenth and early twentieth centuries, new towns developed along or adjacent to railroad lines. The whole process of railroad commuting developed around these communities. Automobile-related growth and flexibility have allowed the voids between these towns to be filled with many types of developments. Now, we find that we need the open spaces.

Those who tout new towns as the wave of the future have little evidence to support their view. New towns such as Reston, Virginia; Columbia, Maryland; and Peachtree City, Georgia, have not been outstanding financial successes. Homes, particularly townhouses, have sold slowly, which suggests that the combined rural and urban prospects they offer are somewhat less than utopian. Transportation has been identified as a major problem. Many new-town residents are employed in the city. Long automobile trips prove to be unproductive and slow, especially when they enter the stream of urban rush-hour traffic. Other family members are also dependent on automobiles for their mobility; families are thus required to own two and often three automobiles.

The transportation problems of new towns have not gone unnoticed. Several new towns have launched internal bus services to facilitate circulation within the community; these have largely failed. Other new towns have inaugurated bus services to the city; these too have generally failed. Failures have occurred mainly because new-town residents are automobile oriented and have been unwilling to accommodate to inflexible bus service.

The most promising new developments have been generated by new-town residents themselves. From a modest start, the residents of Reston, Virginia, have developed a subscription bus service that now includes 25 buses carrying 1800 persons/d to and from downtown Washington. A van-pool service recently started in Peachtree City, Georgia, has been warmly received and shows promise of growth and success. Both of these services are characterized by a degree of personal accommodation that is not available in conventional public transit.

Improved transportation is likely to enhance the attractiveness of new towns. It may even facilitate the development of new towns on a scale larger than that now possible, thus relieving urban stresses and supporting a new type of urban development. Sufficient evidence exists to support a careful examination of the transportation alternatives that are available to carry workers between new-town residences and central-city jobs. This paper undertakes such an evaluation for communities that have the following characteristics:

1. Each has a high-speed, limited-access highway link between the new town and the metropolitan area.
2. The new town is small, and offers some attractive features to urban residents such as recreational, educational, and commercial opportunities, and has a potential for population growth.
3. The new town is within 162 km (100 miles) of the central city. This type of new town is called a satellite city because of its location near the outer influences of the central city.

The transportation problem is characterized by collection-distribution in the satellite city, a substantial line-haul, and collection-distribution in the central city. In the satellite community, access to transportation is simplified by the size of the town. However, access in the city is complicated by the wide and growing dispersion of jobs.

The massive literature that is developing on urban transportation has little to say about transportation access to new towns. Some general works, like that of Meyer, Kain, and Wohl (1), include techniques that can be applied to a broad range of problems, but they do not treat the unique new-town setting. Pooling proponents such as Dickerson and Goodson (2) have dealt with new-town-like problems, but their approaches are largely parametric. Paratransit investigations such as that of Kirby and others (3) have produced much useful information, but they have not dealt specifically with the new-town problem.

A few site-specific studies have been done that relate to quasi-new-town environments. Alan M. Voorhees and Associates (4, 5) have investigated high-speed service (intercity travel) links for two urban corridors: San Francisco-Sacramento and Atlanta-Macon. These studies focused on high-speed, line-haul service and largely overlooked access problems. Morris (6) examined the internal transportation needs of new towns. In general, site-specific studies err in attempting to place fully developed transportation systems into environments that are not prepared to receive them. The relations between satellite cities and their companion metropolitan areas have yet to be documented and fully understood.

STUDY APPROACH

This paper uses an approach to transportation development that ensures demand responsiveness to the needs of residents of satellite areas. It presents an analytic procedure that can be used to identify transportation services and to compare potential candidate services. The essence of the method is to develop new services on a vehicle-unit basis; the services do not need to be launched on a massive scale. This concept resembles the successful development at Reston and closely parallels car-pool matching efforts that have been undertaken in many communities.

Another essential feature of the approach is an entrepreneur or broker who is needed to promote, coordinate, and monitor the new service. The broker needs to be a full-time employee of the satellite community who combines considerable personal enthusiasm with a sound knowledge of the analytical procedure. Other participants in the program are users (patrons), volunteers, and part-time employees. These people are associated in "commuter clubs" that organize and administer individual services that may use one vehicle or a small fleet of vehicles.

The approach described here differs from past work in several important respects:

1. All services are designed to commence operation on a small scale and to grow in terms of small increments of demand.
2. All services are based on passenger participation to the maximum feasible extent (they thus become variants of paratransit).
3. All services are designed for new-town commuting and, as such, offer attractive pooling potential.

A broad set of transportation alternatives is initially selected for study. A summary of the characteristics of these alternatives is given in Table 1. Other candidate services can be postulated and evaluated by using the same analytical procedure. A key feature of the analysis is that each service alternative is examined in an environment that favors its development, and thus two unlike alternatives are not subjected to requirements that inherently favor one over the other.

BASIS OF SOLUTION PROCEDURE

The solution procedure is based on key approaches to travel demand and service ownership, which are described below.

Demand

Travel demand between satellite towns and adjacent cities is an unknown quantity. Where good highways are available and the new town offers an attractive life-style, some commuting is known to take place. That commuting is performed almost exclusively by automobile because no other attractive service exists. New-town commuting is limited to persons who are willing and able to invest the time and money required for automobile travel. If a new service were established that significantly reduced travel time or user cost, then it would be reasonable to expect more commuters to appear on the scene. Some residents of satellite areas may decide to seek jobs in the city. Some city residents may elect to move to the new town. Both processes are slow, particularly during the critical early days of the transportation service. Once the initial process begins, there is no adequate way to predict how fast the change will happen or how far it will go.

Existing demand-analysis techniques are anchored in current or observable practices. They cannot adequately predict the impact of entirely new services. Moreover, they do not take into account the impact of quality of service on demand. Thus, the transportation entrepreneur who sets out to justify or establish a fully developed transportation service is doomed to failure unless the service can be operated at a substantial loss for several years.

To avoid excessive capital needs, new services that can survive at low levels of patronage should be introduced. Such services must exhibit (a) low capital requirements, (b) low fixed costs, and (c) variable costs per passenger trip that are reasonably constant for wide changes in demand. The first requirement—low capital requirements—suggests that candidate systems must be able to use existing facilities to a large extent. Thus, the service alternatives given in Table 1 use existing highways, railroads, or airways and airports. The second requirement—low fixed costs—suggests that the administrative organization be minimized. This can be accomplished through the commuter-club concept, which is discussed below. The third requirement—proportional variable costs—suggests that vehicle and operator costs somehow reflect the extent of use. This requirement points to part-time drivers, off-hour uses, or some other scheme that takes the burden of fixed working hours off the commuter service. Pooling accomplishes part of this purpose; brokerage also contributes.

If these requirements can be met, the new services will be relatively insensitive to the level of demand. One of these services could then be introduced at a low ridership level and expanded as demand increases without any great sacrifice in operating economies. If the problem of new-town commuting is seen from this viewpoint, it is not necessary to be concerned with the absolute level of travel demand. Service can be initiated at a level of demand that can reasonably be expected to exist.

Commuter Club

The term commuter club is intended to connote a voluntary association of individuals formed for the purpose of providing commuter transportation to members. A club owns or leases assets (vehicles) and enters into contracts for services. In organizational form it need not differ from community swimming pools, participating nursery schools, and other voluntary civic organizations. The commuter club has a board of directors and elective officers who are empowered to bond the organization. It does not have any full-time employees.

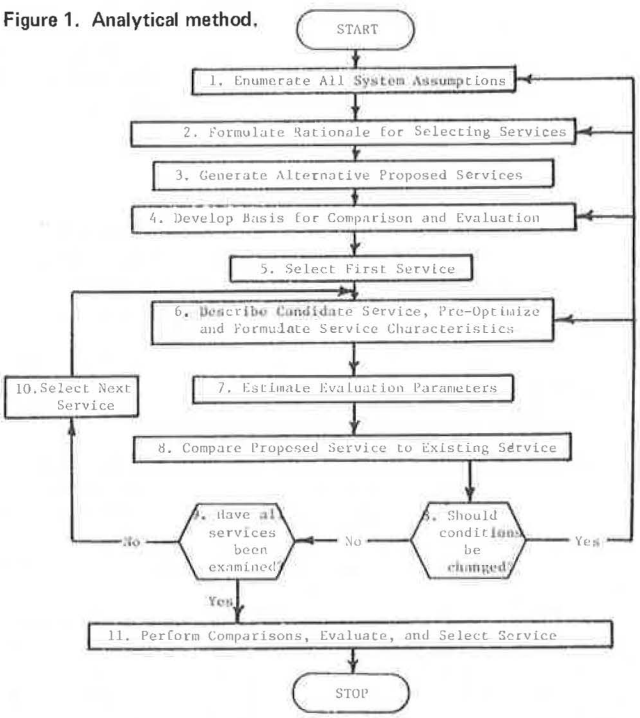
The club designs its own service, including mode, vehicle, route, schedule, fares, and operating practices; executes agreements with its members and collects fares; and contracts for services and pays bills. New members typically pay a membership fee to cover their share of club assets and fares in accordance with their use agreement. Members of a commuter club normally live and work in reasonable proximity to one another so that they can share a common transportation service. As demand grows, a club can expand its area of operation or new clubs can be formed. The use of volunteer labor for administrative chores keeps fixed

Table 1. Comparative summary of service characteristics.

Characteristic	Service Alternative: Automobile	Car Pool	Van Pool	Subscription Bus	Commuter Rail	Commuter Air
Capital cost, $	4100	4100	6500	60 000	1 100 000	2 100 000
Vehicle operating cost,[a] $/km	0.12	0.12	0.18	0.38	1.70	1.24
Maximum operating speed, km/h	88.5	88.5	88.5	88.5	121	322
Practical seating	6	6	15	50	156	60
Mode of access	Residential collection →			Park-and-ride → Kiss-and-ride → Walk or bicycle →		
Distribution subsystem	Same vehicle →			Public transit →		

Notes: 1 km = 0.62 mile.
All costs are expressed in 1975 dollars. Each service alternative is assumed to transport theoretical capacity (100 percent load factor) except for the automobile, which carries 1.5 persons/vehicle (25 percent load factor).
[a] Represents all capitalized costs plus operating costs.

Figure 1. Analytical method.



costs down. Club membership gives each member a stake in the future of the service and a relatively long-term commitment to its success. A club member may also serve as driver at a part-time salary, which further reduces fixed-cost obligations.

Broker

Commuter clubs are not likely to spring up spontaneously in satellite areas around the country. They need to be nurtured, encouraged, stimulated, and guided. These supportive services can best be provided by an employee of the community who is charged with encouraging, forming, and assisting the commuter club, functioning very much like a broker. He or she provides planning support and help with formal club organization, recommendations concerning services and equipment, and financial advice. The broker may also provide analytical support in the form of operating computer matching programs, evaluating services, and advising on insurance and other matters as well as seeking off-hour uses for club vehicles. In general, the broker helps the commuter clubs with their problems and guides and supports them in many other ways.

PROCEDURAL METHODS

The analytical method for formulating and comparing transportation alternatives for commuter service between a new town and a central city is shown in Figure 1. The process is an iterative one, beginning with the enumeration of system conditions and proceeding through the comparison and evaluation of candidate services. Each of the eleven steps in the process is briefly described below.

1. Enumerate systems conditions. The conditions common to all candidate services are described. These include (a) the geographical setting, (b) available guideway facilities, (c) restrictions on routes, (d) available public transit services in the city, (e) admissible interfaces, (f) an interest rate for capital funds, and (g) other factors that constrain all service alternatives.

2. Formulate a rationale for selecting services. A methodology is developed for selecting proposed services. Specific determinants that limit the admissible services include (a) available technologies and equipment, (b) total travel time and total travel cost by the predominant existing mode, (c) available transportation facilities and present travel patterns, (d) the amount of available capital investment, (e) urban-area destinations of satellite-area patrons, (f) distribution capabilities of the proposed service, and (g) ease of implementation.

3. Generate alternative proposed services. A large number of alternative services must be investigated and the more promising possibilities identified. Subject to system conditions and limitations, service alternatives evolve from a screening process that examines the candidate services with respect to (a) guideway, (b) propulsion, (c) equipment (vehicle type), and (d) system control. Guideway is almost always restricted to the facilities that already exist in a serviceable form. Propulsion may consist of any options that are compatible with the guideway. The propulsion system directly influences vehicle type, line-haul travel time, and top speed. The travel-time requirements of the system are determined from the investigation of propulsion and serve to limit acceptable propulsion schemes. Selection of the type of vehicle is thus restricted to candidate vehicles that are compatible with both guideway and propulsion systems. Finally, system control affects travel time and travel cost. The requirements for system control further constrain the service alternatives.

4. Develop a basis for service comparison and evaluation. Evaluation factors are selected for comparing candidate services. A list of possible factors, with suggested units of measure, is given below (1 m = 3.3 ft):

Factor	Unit of Measure
Environmental impact	
Air quality	Grams per passenger kilometer (estimates of vehicle-related levels of hydrocarbons, nitrogen oxides, and carbon monoxide)
Noise	Decibels at 15 m (as result of travel speed, traffic density, and mix of vehicle types)
Energy consumption	Joules per passenger kilometer
Quality of service	
Accessibility	Population or destinations served
Availability	System access time (route geometry)
Comfort	Ride quality, physical comfort, and degree of privacy (vehicle amenities)
Convenience	Number of transfers to destination
Frequency	Departures per unit time
Implementation	Legal and corporate constraints
Safety	Fatality and injury rates per passenger kilometer
Security	Crime rate
Flexibility	Number of potential routes and destinations
Travel time and speed	Door-to-door trip times in minutes
Travel-time variability	Standard deviation of trip time in minutes of delay (service dependability, congestion, system right-of-way)
User cost	Dollars per passenger trip

These factors reflect measures of system use, service quality, transportation costs, and system impacts on nonusers. The analyst is encouraged to tailor these factors to suit local conditions. For example, travel time may be measured as (a) in-vehicle time or (b) door-to-door time if wait time is weighted 2.5 times.

An equitable method for combining such diverse factors as those given in the table above would be impossible to develop. Therefore, for purposes of analysis, candidate systems are ranked in numerical order for each factor. The rankings are then combined in a simple scoring model to give a measure of relative desirability.

5. Select the first candidate service. The first candidate service on the list is selected, and the analysis begins.

6. Describe the candidate service, "preoptimize," and formulate service characteristics. Each service is described in detail from the viewpoints of the travelers and the operator. Service features include (a) the actual route or routes followed, (b) station locations, (c) peak-hour service and service frequency, (d) acceleration rate, (e) deceleration rate, (f) top speed, (g) equipment type, (h) fleet size, (i) load factor, (j) emergency procedures, and (k) maintenance equipment and service and other items. While they are being developed, services are individually preoptimized to ensure that the operation selected is the most suitable for the study conditions. Service alternatives generally have different service characteristics. For example, subscription bus and van pooling would have different station locations, service frequencies and vehicle capacities, and types of operation (such as express, skip-stop, or local running).

7. Estimate evaluation parameters. This step forms the basis for calculating both travel time and user cost plus all remaining evaluation measures. In the computation of service costs, three different options may be pursued: (a) Equipment may be owned by the club; (b) it may be chartered with driver, fuel, maintenance, and insurance provided by others; or (c) it may be leased or rented. Door-to-door travel time is evaluated for each alternative. This factor can be computed by using access time, mode transfer time (including waiting and loading time), distribution time, and walk time. All other evaluation measures are determined for use in the comparative analysis.

8. Compare the proposed service to existing service. Only total travel time and total cost of the candidate service are examined and compared with the predominant existing service—generally automobile commuting. Initially it is hypothesized that each new service can be implemented only if travel time and cost offer favorable improvements over the predominant existing service. This step serves to ensure that that condition is met. If it is not, the proposed service is either deleted from the list of alternatives or revised in a manner that will yield a favorable comparison. Before this step is completed, the following question is asked: Should conditions be changed? A no response transfers control to the next step; a yes response shifts control back to step 1, 2, 4, or 6.

9. Have all services been examined? If one or more services remain to be examined, control shifts to the next step.

10. Select the next service. The process is indexed forward to the next candidate service.

11. Perform comparisons, evaluate, and select a proposed service. The basis for comparing alternatives was established in step 4; now, pairwise comparisons are performed, the results are evaluated, and a service is selected.

SAMPLE COMPARISON

A specific example was developed to demonstrate the analytical method. A satellite area was selected that is 81 km (50 miles) from its companion metropolitan area. The metropolitan area has extensive surface transit service. Five types of commuter service—air, bus, rail, van pooling, and car pooling—were examined and compared with the predominant existing service—the automobile. Table 1 gives the principal characteristics of each service.

Table 2 gives the evaluation summary for the service alternatives. The comparative analysis is based on a comprehensive examination of all system characteristics. The scores indicate only comparative values among the systems studied and do not reflect an overall quantifiable measure of system effectiveness.

Travel cost varied with trip length for each service alternative. Figure 2 compares all six systems for user cost versus trip length. The automobile is without doubt the costliest of all systems but, when fully loaded with passengers, is competitive with other services. Trip lengths more than 100 km (62 miles) from the urban area are least expensive for bus service, and trip distances less than 100 km are most economical for van pool service. The nonlinear relation exhibited by air service results from long takeoff and landing times. For trip lengths well in excess of 162 km (100 miles), bus and air services appear to be competitive with one another.

Figure 3 shows user cost as a function of patronage for an 81-km (50-mile) trip. The steps in the curves reflect the addition of incremental vehicle units as vehicles become fully loaded. The cost of automobile commuting is much higher for all levels of ridership. Although the results presented in Figure 3 apply specifically to an 81-km trip, similar relations exist for other stage lengths. As patronage levels increase, passenger costs are comparable for all systems except the automobile.

Van pools offer travel times comparable to those of buses and, in addition, they offer door-to-door service. However, as passenger collection for van-pooling services approaches 15 persons, convenience is achieved at the expense of longer overall travel time. For very low demand densities (passengers per square kilometer per hour), travel-time differences between systems are negligible.

The automobile and car-pooling and van-pooling sys-

Table 2. Comparative scores of service alternatives.

Evaluation Measure	Service Alternative: Automobile	Car Pool	Van Pool	Subscription Bus	Commuter Rail	Commuter Air
Environmental impact						
Air quality	6	4	2	3	1	5
Noise	1	4	2	3	5	6
Energy consumption	6	4	2	1	3	5
Quality of service						
Accessibility	1	1	1	2	3	4
Availability	1	2	3	4	6	5
Comfort	3	5	4	3	2	1
Convenience	1	1	1	2	3	3
Frequency of service	1	2	3	4	6	5
Implementation	1	2	3	4	5	6
Safety	6	4	5	2	1	3
Security	1	1	1	2	3	3
Service flexibility	1	1	1	2	3	4
Travel time and speed	3	4	5	4	2	1
Travel-time variability	3	3	3	3	1	2
User cost	6	4	1	2	3	5
Total	41	42	37	45	47	58

Figure 2. Total travel cost versus trip length for six service alternatives.

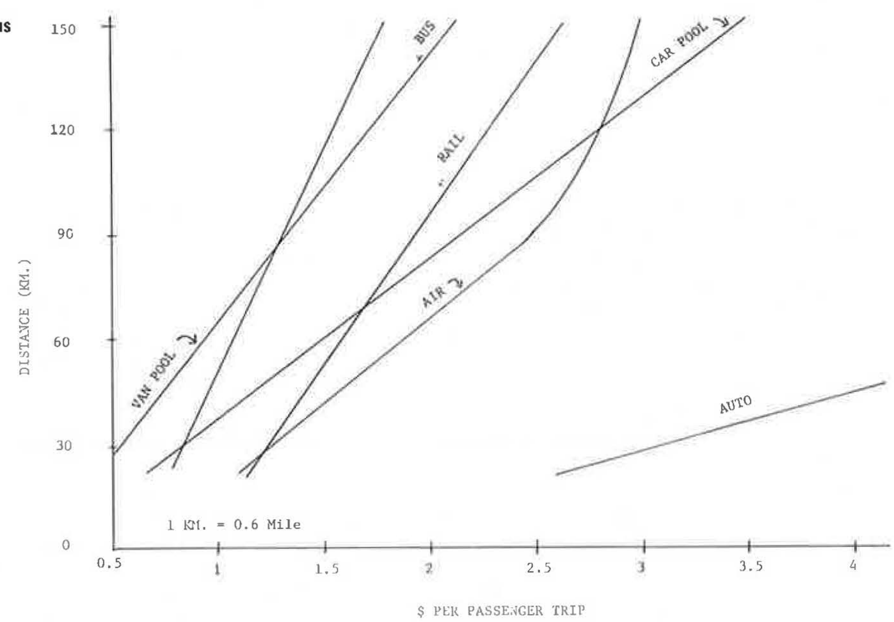
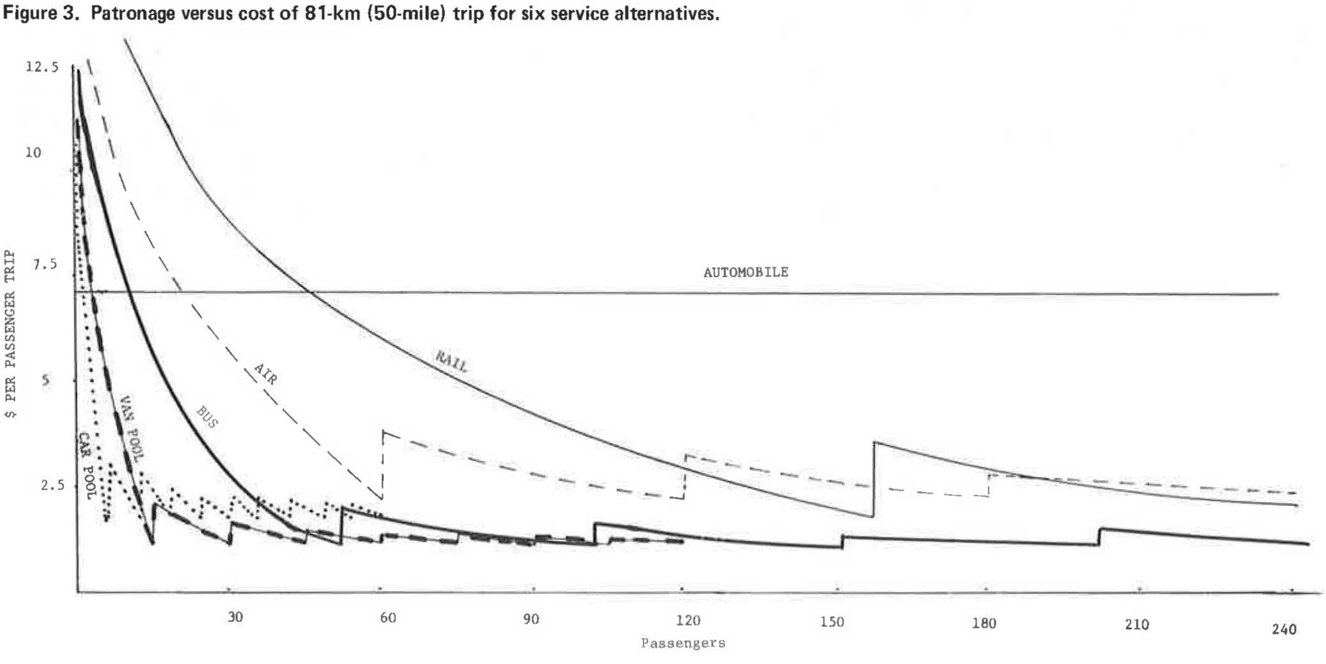


Figure 3. Patronage versus cost of 81-km (50-mile) trip for six service alternatives.



tems provide competitive door-to-door service and are virtually unaffected by rider destination, trip purpose, time period, and trip length, which suggests that subscription, demand-responsive services can effectively compete with automobiles for many commuting trips. Subscription services offer substantially lower travel times and trip costs than conventional transit systems. In terms of travel time alone, trip lengths more than 50 km (30 miles) from the metropolitan area favor air service while shorter trips are faster by rail. Travel speeds by air become constrained as stage lengths decrease. Air and rail services benefit from line-haul speeds and fully controlled right-of-way. For trips longer than 50 km, car pooling, van pooling, and bus services exhibit slightly longer travel times than the automobile. Thus, if public transport services are to be time competitive with automobile travel, they must be given preferential treatment or controlled right-of-way.

Air service is generally inappropriate for medium-length intercity travel and is characterized by relatively high travel costs, low service frequency, and inadequate distribution capabilities. A premium-cost service, air service can be an appropriate alternative under the proper conditions.

CONCLUSIONS

Improved external transportation may well hold the key to the development of satellite areas, but no single transportation alternative is appropriate for all areas. In addition to the example presented here concerning commuting from satellite areas, other site-specific cases (7, 8) have been investigated, and the results of these efforts support the following conclusions:

1. Transportation services for intercity travel to satellite areas develop in much the same way as intracity systems do. Intercity travel can evolve from car-pool or van-pool services. As patronage grows and larger capital-intensive projects become feasible, service can be converted to high-capacity systems such as bus or rail.
2. Difficulties in implementation vary with each service and are of a site-specific nature. Car pools are relatively easy to implement whereas rail and air service may not be achievable. Van pools and buses are typically constrained by regulations. Certificate requirements depend on fare collection and routing.
3. A commuter service can be launched without initial high-volume travel demand. Small units of demand can be accommodated by a successful commuter service.
4. The creation of commuter clubs improves the service that a system can offer by eliminating high organizational and administrative costs. Door-to-door travel time and user cost can be substantially reduced over conventional systems. These benefits are primarily attributed to the demand-responsive, subscription types of services.
5. For stable, low-risk operations, prearranged ride-sharing (subscription) service enables commuters to realize low fares, service longevity, demand-responsive service, and time-competitive travel. Car-pool, van-pool, bus, rail, and air systems offer these benefits. However, for high-risk, nonstable operations, van-pool and car-pool services possess characteristics of low-cost variability.
6. Where a public transportation system exists in the metropolitan area, passenger distribution can be accomplished for each service alternative. Without available public transportation, car pooling, van pooling, and bus service are the only feasible alternatives, particularly for passengers with non-CBD destinations.
7. Subscription services make possible greater use of available seating without sacrifice of service quality or user cost. Ride sharing and risk sharing for intercity travel of this type enable service administrators to capitalize on vehicle efficiencies and to provide low-cost, high-performance service.

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