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BENEFIT-COST ANALYSIS OF INTEGRATED PARATRANSIT SYSTEMS
Volume 2: Introduction and Framework for Analysis

Multisystems, Inc.
Cambridge MA 02138

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FINAL REPORT

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16. Abstract

This study systematically estimates potential impacts of a range of integrated transit/paratransit options and policies in a variety of settings and compares them with impacts of transportation alternatives.

The study concludes that, in general, integrated paratransit with fares closer to fixed-route transit than exclusive-ride taxi will result in net paratransit operating deficits. However, in some instances, the benefits of integrated paratransit options in terms of improved service levels and mobility, reduced auto expenditures and other impacts appear to offset these operating deficits. Necessary factors for this include high paratransit productivities, possibly achieved by implementing hybrid, fixed-route/demand responsive service; and low operating costs, possibly achieved by contracting with private operators. Integrated paratransit was found to have a positive but insignificant impact in reducing automobile usage and ownership, but no measurable impact on vehicle miles travelled, fuel consumption, or emissions. Promising locations for paratransit implementation are those areas with population densities between 3,000 and 6,000 persons per square mile and limited existing transit service. The most promising paratransit concepts appear to be checkpoint many-to-many service, route deviation service, automated doorstop service with high vehicle densities and vanpool service. The results of the study further suggest that paratransit service demand is sensitive to fare; fare increases above $.25 were determined to be counterproductive, while free transfers from feeder services to line haul became an inducement to use paratransit. The study also concluded that digital communications and automated dispatching systems are potentially cost-effective technological innovations.

This is the second volume of the six volume series documenting this study. This volume describes the overall approach and analysis framework.

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PREFACE

Integrated paratransit (IP) service is a concept which involves the integration of conventional fixed-route transit services with flexible, demand-responsive services in order to best serve emerging urban development patterns. Despite the emphasis that has been placed on the analysis and demonstration of paratransit concepts in recent years, there is still considerable confusion and disagreement concerning the impact of paratransit service deployment. To learn more about the capability of IP to meet the transit needs in the urban/suburban environment, the Urban Mass Transportation Administration sponsored a study to identify and define the benefits due to and the costs associated with the deployment of various hypothetical IP systems. The work was performed by Multisystems, Inc. in association with Cambridge Systematics, Inc., and Applied Resource Integration Ltd. under contract to the Research and Special Programs Administration's Transportation Systems Center. Richard Gundersen was Technical Monitor of the study. The Final Report was edited by Larry Levine.

The results of the study are documented in a Final Report which consists of the following six volumes:

- Volume 1 - Executive Summary
- Volume 2 - Introduction and Framework for Analysis
- Volume 3 - Scenario Analyses
- Volume 4 - Issues in Community Acceptance and IP Implementation
- Volume 5 - The Impacts of Technological Innovation
- Volume 6 - Technical Appendices.

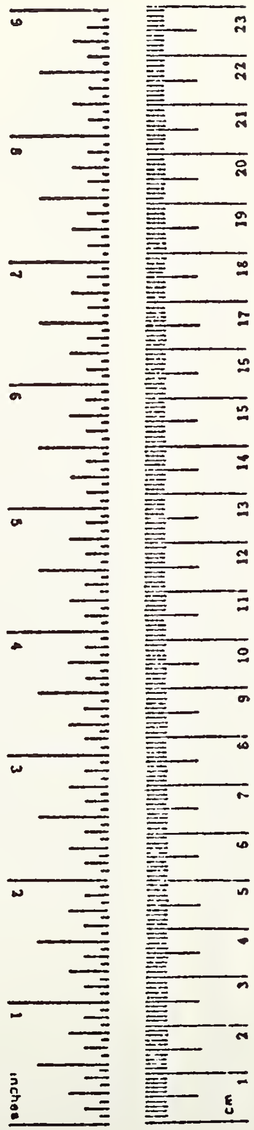
This is Volume 2 - Introduction and Framework for Analysis. Multisystems, Inc. had primary responsibility for this volume, with assistance from Applied Resource Integration Ltd. (ARI), particularly in the work which led to Chapter 2, and from Cambridge Systematics, Inc. (CSI), particularly for the work which led to Chapter 3 and Appendix A. This volume describes the overall approach and analysis framework.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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



Approximate Conversions from Metric Measures

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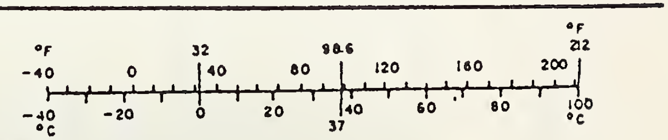
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Chapter 1

Introduction

1.1 The Concept of Integrated Paratransit

Paratransit has been described as the family of transportation services between exclusive-ride automobile and conventional fixed-route transit. This covers a broad spectrum of transportation options, including demand-responsive service, carpooling, vanpooling, and other modes which involve some degree of ride sharing but are more flexible and personal than conventional transit. The jitney and shared-ride taxi are perhaps the earliest forms of paratransit service in this country. More recently, the public sector has become interested in what was formerly a purely privately operated set of services, and has identified flexible paratransit systems as offering potential for:

- serving the low density development patterns common in suburban areas;
- serving the special needs of the elderly and handicapped through door-to-door service; and
- reducing peak hour traffic congestion through vanpooling and other ride sharing modes.

The public sector's involvement in paratransit began in the late 1960's. The early, publicly sponsored paratransit services were typically introduced in small cities or portions of medium size cities; examples include the subscription bus services in Peoria, Illinois, and Flint, Michigan, and the "route deviation" service in Mansfield, Ohio (U.S. DOT, 1974). More recently, the term paratransit has come to include modes such as carpooling; and the private sector has started to become more involved in publicly sponsored services. Vanpooling has been instituted on a private level, (e.g., by the 3M Company in St. Paul, Minnesota) and on a public level (e.g., the vanpool brokerage concept being employed in Knoxville, Tennessee) (Miller and Green, 1976). Public sector/ private sector interaction is becoming much more commonplace; para-transit systems in El Cajon, California; Livonia, Michigan; and Xenia, Ohio, to name but a few, are publicly sponsored but operated under contract by a private operator (Gilbert, 1977).

The concept of paratransit integration has evolved during the past decade, coinciding with the growing recognition that different transit modes and operating policies are most advantageous under different conditions (Ward, 1975). By integrating flexible para-transit and conventional fixed-route services, letting each do what it does best, areawide coverage can be provided. Service may be integrated spatially, such that paratransit service is offered in low-density areas, feeding a network of fixed routes in high-density corridors. Alternatively, integration may be initiated temporally. For example, vanpooling and carpooling might be encouraged during peak hours, when a fairly extensive fixed-route network and demand-responsive feeder service are also provided. During the off-peak, the fixed-route network could be contracted and demand-responsive service expanded to cover a larger area. In some cases, demand-responsive service might be expanded further during the evening hours, providing safer, door-to-door service. Private services might be integrated with public service, e.g., in the form of taxi feeder service.

Some of the earliest attempts at system integration took place in Canada. In 1971, a demand-responsive transit (DRT) service replaced a fixed-bus route in a low-density portion of Regina, Saskatchewan, and served as a feeder to a CBD-bound line haul route (Atkinson, 1972). During the same year, "dial-a-bus" service was initiated in Bay Ridges, Ontario, as a feeder to the Toronto Go-Transit line (Bonsall, 1971).

In the United States, integrated paratransit service has been initiated in a number of cities. For example, UMTA has been funding a demonstration project in Rochester, New York (entitled "Integrated

Adaptable Metropolitan Transit Service") (MIT, 1976). Computer dispatched demand-responsive service is provided in two inner suburban areas, providing home-to-work and school subscription service, local circulation service, special service for the elderly and handicapped, and feeder service to the fixed route bus network. The system has had numerous operational and institutional problems, but these seem to have been overcome. There are current plans to expand DRT service to two new modules, and allow the private sector the opportunity to bid on operating contracts.

A larger scale areawide IP system which operated in Santa Clara County, California, was halted due to operational and institutional problems. In Santa Clara, fixed route and paratransit service were integrated to provide service throughout the 1500 square mile, 1.4 million population county. The entire service was initiated at once; this proved to be one of the major reasons for the operational problems encountered.[1]

The opposite implementation strategy has led to perhaps the most successful areawide IP system to date, which operates in Ann Arbor, Michigan. Paratransit service was implemented incrementally; demand-responsive circulation and collection/distribution service is now provided in a set of zones covering virtually 100% of the city of Ann Arbor. During evening hours and on weekends, the demand-responsive zones are expanded and fixed route service contracted, providing door-to-door service for most trips in the area (Neuman, et al., 1977).

The experiences of paratransit services and, particularly, integrated paratransit services to date, have provided valuable insight into the potential benefits and problems associated with

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[1] Contributing causes to the failure were: (1) a 25¢ countywide fare and a limited vehicle supply, which resulted in serious capacity deficiencies and (2) a successful lawsuit by a local taxi operator who claimed that the service was in violation of a buy-out provision in the Transit District enabling legislation. These issues are addressed in depth in Volume 4 of this report, entitled "Issues in Community Acceptance and IP Implementation."

the IP concept. At this point, it is important to look toward the future of IP, and begin to assess the market potential for the concept throughout the country; and identify its potential impacts. The research described in this final report is aimed at initiating the process of estimating the benefits and costs of integrated paratransit systems.

This study represents the first systematic attempt to estimate the potential impacts of a wide range of IP options in different settings. The output of this study should provide local decision-makers with a better understanding of the varied impacts an IP system might have. In addition, the study has attempted to identify potentially promising IP options and policies (as well as those options which show little promise), which may lead to the next round of paratransit demonstrations. Finally, the study has identified those instances where IP is, and those where it is not, the most appropriate way to improve public transportation services in a given area.

1.2 Approach to Benefit-Cost Estimation

The general approach taken in estimating the benefits and costs associated with IP implementation involved the development and analysis of a set of hypothetical IP scenarios. To ensure that the analysis yields realistic and meaningful estimates of potential IP costs and benefits, the following steps in the scenario analysis process have been taken:

1. An IP service classification scheme was developed. This classification scheme distinguishes between different IP configurations on the basis of a number of key factors. By selecting systems from different classifications, it is assured that as wide a range of IP options as possible are analyzed.
2. Data on existing paratransit systems were reviewed in order to determine: what types of options have been tried and how they have worked; what markets have been attracted to different paratransit services in different settings; and what the potential markets are for areawide IP services.

3. A set of demographic factors felt to be important to IP implementation was developed, and data related to these factors were obtained for all 271 standard metropolitan statistical areas in the United States. A cluster analysis program was used to group together cities which are similar along the dimensions established by these factors. One city was selected to serve as the representative city from each cluster. The scenario analyses were then performed, using these prototypical cities as the IP sites. The purposes of this approach are to:

   a. Ensure that a variety of types of cities are considered in the scenario analysis.

   b. Allow local groups to estimate approximately the impacts of IP by considering the scenario analysis for the cluster which is representative of their city.

   c. Allow the use of real, rather than hypothetical, data for scenario analysis.

4. A number of scenarios were considered for each setting. These were established to test key design variables, e.g., fare policy, dispatch strategy, number of feeder zones, level of service and coverage provided, etc. While no attempt was made to develop optimal IP systems, the scenario analysis resulted in estimates of impacts for potentially successful systems.

5. In addition to the base year analyses (1980) IP scenarios were also developed for each setting for the year 2000. This was done to assess the impacts of IP under changing population, auto ownership, and other demographic conditions.

6. As wide a range as possible of potential benefits and costs were estimated and displayed in an "impact-incidence" matrix format. This allows the different impacts of IP to different groups to be viewed, resulting in a clearer understanding of the overall distribution of IP costs and benefits. This, in turn, enables local decisions regarding the implementation of IP to be based on local objectives regarding different impact groups.

7. Within each setting, a conventional fixed route and a conventional exclusive-ride taxi scenario were analyzed and compared with the IP scenario to ascertain whether IP is, in fact, the best approach for that particular setting.

This volume of the final report describes all of the steps in the study up to the actual scenario analyses themselves. Chapter 2 describes the first components of the analysis framework, including the areas of service classification, and service and market analysis. Chapter 3 describes the city classification analysis and the selection of the prototypical cities. Finally, Chapter 4 describes the identification of impact groups and potential impacts, and includes a brief discussion of the analysis tools which were utilized.

Subsequent project tasks, i.e., "Analysis of Factors Impacting Community Acceptance" and "Analysis of the Impact of Technological Innovation," are described in Volumes 4 and 5.

Chapter 2

Integrated Paratransit: Services and Markets

Introduction

As noted in the previous chapter, this study was viewed as the first systematic attempt to estimate the potential impacts of a wide range of different IP options in different settings. As such, it was felt to be appropriate to begin the study with an identification of the factors that differentiate IP options, and an analysis of the service and market characteristics of different IP systems to date. These steps are described in this chapter.

Before proceeding with a discussion of these steps, however, it is important to understand what is meant by integrated paratransit service. Many different service configurations might be considered IP, and no single narrow definition of the concept has been offered to date. To maintain flexibility in developing alternative IP system designs, while at the same time ensuring that only systems which can be considered IP were analyzed, a set of conditions which must be met by an areawide IP system was established. These "requirements" are:

1. Public transportation coverage should be provided to substantial portions of the urban area.
2. There must be some paratransit service element in the overall transit system.
3. If there are both fixed route and paratransit elements, there must be some degree of integration or coordination between the two.
4. At least some components of the paratransit service must be available for use by the general public.

This "definition" of areawide IP has intentionally been designed to be as broad as possible. This allows many different system designs to be developed and tailored to specific areas based on local conditions and/or concerns.

To somewhat limit the range of paratransit options to be considered, given the above set of conditions, a fifth requirement was adopted specifically for this project. User arranged services, such as carpools and shared-ride auto, are not considered. Note that the requirement of integration all but eliminates these options in any event.[1]

2.1 Integrated Paratransit Service Classification

In order to best differentiate IP options, an IP classification scheme was developed. This scheme classifies IP systems along certain key dimensions, which were felt to be important determinants of IP system performance. The classification was based on current knowledge of, and experience with, paratransit and integrated paratransit systems. The classification scheme is illustrated in Table 2.1.

Since an IP system may consist of a number of paratransit (and fixed route) elements, the classification scheme has been divided into two parts: individual paratransit modules and the global or systemwide environment (i.e., the way in which various system components interact). The interaction of system components is a crucial issue, since it is this element of the araeawide IP concept that sets it apart from earlier, isolated paratransit demonstrations.

The overall classification scheme identifies a number of key factors in system design. For each factor, a number of categories of service have been noted. In addition, in most cases there are a number of subcategories listed; these represent "minor" variations on the same type of service. The intention was to use the

[1] Carpools might be considered to be integrated with other transit modes if, for example, carpools and express buses share a common park and ride lot.

Table 2·1

Areawide Integrated Paratransit System

Classification Scheme

MODULE CLASSIFICATION

Factor	Category	Sub-Category
Service Pattern	Many-to-Many	
	Checkpoint Many-to-Many	
	Limited Doorstep	Many-to-Few Many-to-One
	Limited Checkpoint	Checkpoint Many-to-Few Checkpoint Many-to-One
	Hybrid Doorstep - Fixed Route	Point Deviation Route Deviation
	Hybrid Checkpoint - Fixed Route	Checkpoint Deviation Checkpoint Route Deviation
Dispatch Strategy	Dynamic Dispatch	Advanced Request Immediate Request
	Discrete Run Time	Advanced Request Immediate Call-in Request Immediate Hail Request
	Subscription - Standing Order	
Operating Entity	Municipal	Regional Governmental Body City Transit Authority
	Private	For-Profit Taxi Company Other For-Profit Private Co. under contract to Municipality Non-Profit Agency
Target Market	General Population	
	Special Groups	Elderly and Handicapped

Table 2.1
(continued)

GLOBAL (SYSTEMWIDE) ENVIRONMENT CLASSIFICATION

Factor	Category	Sub-Category
Service Mix	Single Paratransit Concept	Areawide Coverage Partial Coverage
	Single Paratransit Concept with Fixed-Route	Overlay Areawide Paratransit Coverage Non-Overlay Areawide Paratransit Coverage Overly Partial Paratransit Coverage Non-Overlay Areawide Paratransit Coverage
	Multiple Paratransit Concepts	Overlay Areawide Coverage Non-Overlay Areawide Coverage Overlay Partial Coverage Non-Overlay Partial Coverage
	Multiple Paratransit Concept with Fixed Route	Overlay Areawide Paratransit Coverage Non-Overlay Areawide Paratransit Coverage Overlay Partial Paratransit Coverage Non-Overlay Partial Paratransit Coverage
Modularity of Paratransit Service	Single Zone Paratransit	
	Multiple Zone Paratransit	Overlapping Zones Discrete Zones
Integration	Uncoordinated Transfers	Paratransit-Fixed Route Paratransit-Paratransit
	Coordinated Transfers	Paratransit-Fixed Route Paratransit-Paratransit
	Combined Operation	Fixed Route/Collection-Distribution Multiple Paratransit Module Operation Multiple Collection-Distribution/Fixed Route
	Administrative Coordination	

Table 2.1
(continued)

GLOBAL (SYSTEMWIDE) ENVIRONMENT CLASSIFICATION

Factor	Category	Sub-Category
Administration	Publicly Administered-Single Operation	Operator Administered Private Operator Other Public Operator
	Publicly Administered-Multiple Operator	All Public Operators All Private Operators Mixed Public-Private Operation
	Privately Administered-Single Operator	Operator-Administered Subcontracted Operations
	Privately Administered-Multiple Operators	All Operation Sub-contracted Partial Subcontract of Operations

classifications to develop the IP scenario. To ensure that as wide a range of different IP options as possible was tested, the plan was to consider each category of service individually in at least one scenario. Subcategories were taken into account in developing scenarios, but no attempt was made to include all IP subcategories.

Consider first the classification scheme for individual paratransit service modules.[1] This scheme includes two major factors which describe the spatial and temporal responsiveness of the service. The service pattern, which determines the types of trips which can be taken and the geographical coverage of the system, is the determinant of how responsive a service is spatially. The temporal responsiveness of a paratransit system is determined by the dispatching strategy employed. The dispatching strategy specifies the flexibility with which individuals can arrange their trip times and the extent to which service is provided during the designated service hours.

The service pattern categories presented in Table 2.1 are designed to group those services likely to attract similar markets and display similar operating characteristics. Doorstep and checkpoint services are separated primarily to note the different access requirements of patrons. Checkpoint services are also likely to exhibit less circuitous routing, shorter stop dwell times, and higher productivities than the doorstep options. Categories also segregate systems which differ in the extent to which they can respond to a variety of travel orientations. Many-to-many service is fully responsive in this sense, while hybrid services generally can only handle travel oriented within a specific corridor.

Three principal categories have been identified to classify the temporal responsiveness of individual paratransit service modules. Dynamically dispatched systems allow users to call in at the time they wish to travel (or at some short interval prior to their desired departure time) and request a specific trip. This

[1] Note: It is assumed that the reader is reasonably familiar with paratransit terminology, and most concepts will not be defined. A glossary is included in Volume 1, the Executive Summary.

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15. Supplementary Notes

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16. Abstract

Integrated paratransit (IP) service is a concept which involves the integration of conventional fixed-route transit services with flexible, demand-responsive services in order to best serve emerging urban development patterns. To learn more about the capability of IP to meet the transit needs in the urban/suburban environment, the Urban Mass Transportation Administration sponsored a study to identify and define the benefits due to and the costs associated with the deployment of various hypothetical IP systems. This study systematically estimates potential impacts of a range of integrated transit/paratransit options and policies in a variety of settings and compares them with impacts of transportation alternatives. This study concludes that, in general, IP with fares closer to fixed-route transit than exclusive-ride taxi will result in net paratransit operating deficits. However, in some instances, the benefits of IP options in terms of improved service levels and mobility, reduced auto expenditures and other impacts appear to offset these operating deficits. Necessary factors for this include high paratransit productivities, possibly achieved by implementing hybrid, fixed-route/demand responsive service; and low operating costs, possibly achieved by contracting with private operators. IP was found to have a positive but insignificant impact in reducing automobile usage and ownership, but no measurable impact on vehicle miles traveled, fuel consumption, or emissions. Promising locations for paratransit implementation are those areas with population densities between 3,000 and 6,000 persons per square mile and limited transit service. The most promising paratransit concepts appear to be checkpoint many-to-many service, route deviation service, automated doorstop service with high vehicle densities, and vanpool service. The results of the study further suggest that paratransit service is sensitive to fare. Fare increases above $.25 were determined to be counterproductive, while free transfers from feeder services to line haul became an inducement to use paratransit. The study also concluded that digital communications and automated dispatching systems are potentially cost-effective technological innovations. This volume, Volume 2, describes the overall approach and analysis framework.

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dispatching system is characterized by vehicle tours which are constantly changing to respond to demand. Discrete run time strategies specify ahead of time approximately where a vehicle will be. This specification of vehicle location may be as specific as a particular activity center or transfer point, or as general as a relatively small portion of the service area. Systems operated under this dispatch strategy exhibit more predictable levels of service than do dynamically dispatched services. A final category of dispatching strategy is subscription, or standing order, service. Vehicle tours in subscription service can be specified at a single time and remain unchanged for relatively long periods. Changes which are made to these tours often require long times to be implemented. Thus, this dispatching mechanism provides little temporal responsiveness.

Note that the classification scheme thus far does not identify a "specific" system, i.e., there is no mention of specific systems, such as vanpools. Thus, both vanpools and subscription bus service would be categorized as limited doorstep, subscription services. Similarly, shared-ride taxi and "dial-a-bus" services would be treated the same. The differences between these types of services may become apparent when the next key factor, operating entity, is considered.

Existing paratransit systems illustrate that a variety of organizations can be used as service providers. Options range from direct city operation, such as that in Midland, Michigan, to the private, for-profit shared-ride taxi service in Little Rock, Arkansas. The structure selected for a particular situation may directly influence operating costs and the distribution of costs and benefits. Privately run systems will likely be operated at lower cost than those run by public transit authorities, as a result of differences in patterns of labor unionization and labor costs, and the difficulties of running large scale public operations. The impact of IP operations on other local providers will depend on the organization operating the service.

The final module-related factor is the target market segment. While most IP systems will be designed for the general public, some may have components specifically earmarked for a special group. As an example, consider that the Ann Arbor Teltran system includes an areawide, advance request, many-to-many service for the handicapped, in addition to the service for the general public. Recall, however, that one of the conditions established earlier to classify a service as IP is that the entire service cannot be exclusively designed for a special market group.

Consider next the classification of areawide IP systems on a "global" or systemwide level. The global environment in which the elements operate is characterized by four factors: the mix of paratransit and conventional transit provided; the modularity of the various paratransit systems; the overall level of integration between individual paratransit entities; and the administrating entity.

The use of one or more service concepts is an important variable of the service mix; this factor indicates the extent to which services are tailored to the needs of different market segments. In areas with diverse transportation needs, a multiple concept environment is usually most appropriate. In smaller areas, where the diversity of transportation needs are not as great, a single concept may provide adequate transportation for the entire community. The service mix also affects the administrative burden and resource utilization. As a general rule, multiple concept services are harder to administer, often incurring higher control costs. However, better utilization of capital resources may be possible for multiple concept services which serve markets with different peaking characteristics.

The other major factor in the service mix classification is the existence of fixed route service. Areawide IP scenarios which exclude conventional transit are likely to be found only in small areas. As with multiple IP concepts, the existence of fixed routes is expected to impact the administrative and control burdens, and user benefits and costs. Note then, in situations where both transit and paratransit exist, the two components may operate in different areas, or the paratransit service may be "overlaid" on (i.e., operated in the same areas as) the fixed route network (or another paratransit service). This distinction can have significant impacts on system ridership and cost per passenger.

The concept of overlay service is also related to the modularity of service, which is categorized by single and multiple zone operations. Single zone applications are likely to be found in small areas where one comprehensive paratransit service may be expected to provide the best possible service in an efficient manner. Another possible single zone scenario is that of an area with extensive fixed route coverage, except in one community which can better be provided service on a flexible basis. Multiple zone paratransit operations imply additional control requirements, keeping track of inter-zonal trips and identification of the appropriate service areas, and a generally decreased level of service for individuals travelling between zones. The benefit of multiple zone service normally is produced by increased efficiency of operation within the individual modules.

The general level of integration of paratransit service modules and fixed routes is an important factor in terms of both operating characteristics and the level of service perceived by patrons. Except in the case of a single zone system covering the entire area, better service is given to customers at the higher levels of integration. A system based on combined operation of multiple paratransit modules and fixed routes allows individuals to travel without transfer times, but still requires inter-zonal passengers to alight from one vehicle and board another. This results in somewhat longer travel times than would be observed under combined operation. Uncoordinated transfers introduce a major disincentive to travel between zones. Long wait times and larger variance in wait times often produce onerous travel experiences for patrons. Another impact of the level of integration is the constraints placed on the operation of services. The requirement of several vehicles being at the same place at the same time can cause inefficiency of vehicle tours, since some trips may be made when no demand for transfer service exists. In addition, layover time scheduled to insure reliable service reduces effective vehicle speeds.

The final factor in the global environment of IP service is the administrative entity. The administering agency is the highest level local organization which controls the system design and resource allocation decisions. The administration factor is divided into categories of publicly administered single operator, publicly administered multiple operator, privately administered single operator, and privately administered multiple operator. Most systems will be publicly administered, and thus generally have the availability of subsidy. Privately administered systems will usually not be subsidized, since subsidy funds generally must be channelled through a public agency which has control over major decisions.

2.2 Classification of Existing Systems

Once the classification scheme was developed, data were collected from a set of existing paratransit and IP services, and these services were classified. The intention behind this classification was to develop a clearer understanding of which services have, and which have not, already been implemented.

The classification of 21 existing or previously existing paratransit systems is shown in Table 2.2. Where more than a single type of service is provided in a given location, the different service components, dispatch strategies, and target markets of each component are noted. Note that only a few of these systems can be categorized as integrated paratransit systems; the remainder represent services that are not integrated into an overall transportation system.

Consider first the modular service classification. Only a small subset of the possible categorical permutations are represented by the actual systems discussed here. While the group of services considered is by no means intended to be a random, representative list of all paratransit services (and while many permutations are clearly not feasible), this result is striking. Most of the systems are fully flexible, e.g., many-to-many, dynamic dispatch systems for the general public. Both public and private operations are well represented.

Table 2.2

IP Systems Classification (Modular Factors)

System	Service Pattern (Major Service Elements)	Dispatch Strategy (Major Service Elements)	Operating Entity	Target Market
Niles, Mich.	Many-to-Many	Dynamic Dispatch	Private (taxi)	General Population
Knoxville, Tenn.	Limited Doorstep	Subscription	Municipal (city) or U.of T.	General Population (work trip)
3M Vanpool	Limited Doorstep	Subscription	Private (other)	Specialized Market (3M empl.)
Cleveland NET	Many-to-Many	Dynamic Dispatch	Municipal (city)	Specialized Market (elderly & handicapped)
Santa Clara County Santa Clara County	Many-to-Many Limited Doorstep	Dynamic Dispatch Subscription	Municipal (transit auth.) Municipal (transit auth.)	General Population General Population
Merrill, Wisc.	Hybrid Doorstep-Fixed Route	Discrete Run Time	Municipal (transport. dept.)	General Population
Ann Arbor, Mich. Ann Arbor, Mich. Ann Arbor, Mich.	Many-to-Many Limited Doorstep Many-to-Many	Discrete Run Time Discrete Run Time Advanced Request	Municipal (transit auth.) Municipal (transit auth.) Municipal (transit auth.)	General Population General Population Specialized Market (hnd)
Haddonfield, N.J. Haddonfield, N.J.	Many-to-Many Limited Doorstep	Dynamic Dispatch Dynamic Dispatch	Public (management co.) Public (management co.)	General Population General Population
Batavia, N.Y. Batavia, N.Y.	Many-to-Many Many-to-Many	Dynamic Dispatch Subscription	Municipal (transit auth.) Municipal (transit auth.)	General Population General Population
El Cajon, Calif.	Many-to-Many	Dynamic Dispatch	Private (taxi under contract)	General Population
Columbus, Ohio	Hybrid Checkpoint-Fixed Route	Discrete Run Time	Private (other: non-profit)	General Population (Model City residents only)
Merced, Calif. Merced, Calif.	Many-to-Many Limited Doorstep	Dynamic Dispatch Subscription	Municipal (city) Municipal (city)	General Population General Population
Midland, Mich. Midland, Mich.	Many-to-Many Hybrid Doorstep-Fixed Route	Dynamic Dispatch Discrete Run Time	Municipal (city) Municipal (city)	General Population General Population
Davenport, Iowa	Many-to-Many	Dynamic Dispatch	Private (taxi)	General Population
Denver handyRide	Many-to-Many	Subscription	Municipal (transit auth.)	Specialized Market (eld & hnd)
Rochester, N.Y. (Rochester, Rochester, N.Y. Greece, Rochester, N.Y. Irondequoit) Rochester, N.Y.	Many-to-Many Limited Doorstep Hybrid Checkpoint-Fixed Route Limited Doorstep	Dynamic Dispatch Subscription Discrete Run Time Advanced Request	Municipal (transit auth.) Municipal (transit auth.) Municipal (transit auth.) Municipal (transit auth.)	General Population General Population General Population Specialized Market (hnd)
Xenia, Ohio	Many-to-Many	Dynamic Dispatch	Private (taxi)	General Population
LaHabra, Calif. (Orange LaHabra, Calif. County)	Many-to-Many Limited Doorstep	Dynamic Dispatch Subscription	Private (other) Private (other)	General Population General Population
Naugatuck Valley, Conn.	Many-to-Many	Dynamic Dispatch	Municipal (transit auth.)	Specialized Market (eld & hnd)
Oneonta, N.Y.	Many-to-Many	Dynamic Dispatch	Municipal (city)	General Public
Richmond	Many-to-Many	Dynamic Dispatch	Municipal (transit auth.)	General Public

Table 2.2 (Continued)

IP Systems Classification (Systemwide Factors)

Location	Service Mix	Modularity	Integration	Administration
Niles, Mich.*	Single DRT Concept	Single Zone	No Integration	Public-Single
Knoxville, Tenn.	Single DRT Concept	Single Zone	Administrative	Public-Single
3M*	Single DRT Concept	Single Zone	No Integration	Private-Single
Cleveland*	Single DRT Concept	Multiple Zone	No Integration	Public-Single
Santa Clara	Multiple Concept-FR	Multiple Zone	Transfer-Uncoord.	Public-Single
Merrill, Wisc.*	Single DRT Concept	Single Zone	No Integration	Public-Single
Ann Arbor, Mich.	Multiple Concept-FR	Multiple Zone	Coordinated Transfer	Public-Single
Haddonfield, N.J.	Multiple Concept-FR	Multiple Zone	Coordinated Transfer	Public-Single
Batavia, N.Y.*	Multiple Concept	Single Zone	No Integration	Public-Single
El Cajon, Calif.*	Single Concept	Single Zone	No Integration	Public-Single
Columbus, Ohio*	Single Concept	Single Zone	No Integration	Public-Single
Merced, Calif.*	Multiple Concept	Single Zone	No Integration	Public-Single
Midland, Mich.	Multiple Concept	Multiple Zone	Coordinated Transfer	Public-Single
Davenport, Iowa*	Single Concept	Single Zone	No Integration	Private-Single
Denver*	Single Concept	Single Zone	No Integration	Public-Single
Rochester, N.Y.	Multiple Concept-FR	Multiple Zone	Uncoord. Transfer	Public-Single
Xenia, Ohio*	Multiple Concept	Single Zone	No Integration	Public-Single
Orange Co. (Includes La Habra)	Multiple Concept-FR	Multiple Zone	Uncoord. Transfer	Public-Multiple
Naugatuck Valley, Ct.*	Single Concept-FR	Single Zone	Uncoord. Transfer	Public-Single
Oneonta, N.Y.	Single Concept	Single Zone	No Integration	Public-Single
Richmond, Calif.	Single Concept-FR	Single Zone	Uncoord. Transfer	Public-Single

*does not represent Integrated System
FR = Fixed-Route

Interestingly, only four services (Haddonfield, Denver, Batavia, and Ann Arbor) include concepts with either many-to-many service or dynamic dispatch, but not both. (In the cases of Batavia and Ann Arbor, these two services are operated concurrently with other services). Table 2.2 also indicates that there is little difference between the type of services being operated by municipal and private operators; each operates both highly flexible and less flexible services. This suggests that there is no need to design a system's spatial and temporal characteristics based on the operating entity. The specification of operating entity can be based entirely on the need to consider impact on benefits and costs.

The classification suggests that attention needs to be paid to less flexible systems. Potential categories not represented by the above existing systems include all checkpoint many-to-many and limited checkpoint services. An overview of paratransit history indicates that the concept of limiting origins to a large number of points has not yet been adequately tested.[1]

Next consider systemwide classification factors. Note that only a few systems qualify as integrated paratransit systems according to the conditions established earlier. In Niles, Michigan; Merrill, Wisconsin; Batavia, New York; El Cajon, California; Columbus, Ohio; Merced, California; Davenport, Iowa; Denver, Colorado; Xenia, Ohio; and Oneonta, New York, there is only a single paratransit module and no integration. The 3M vanpooling program is limited to a single employer and has no integration. The Knoxville vanpooling program, on the other hand, may be considered an integrated system, by including administrative integration in the definition of integration, (since the Knoxville vanpooling program is administered by a city sponsored "broker" who does coordinate with the transit system). The Richmond system did involve integration between the fixed route transit and paratransit, but paratransit service was limited to a very small percentage of the metropolitan (San Francisco/

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[1] Checkpoint many-to-many service has been offered in Germany, and to a limited extent, in the Boston suburb of Natick, Mass. (Teal, 1977)

Oakland) area population; as such, it was felt to violate the condition of "coverage to a significant portion of the urban area." The Cleveland system is truly areawide, but is limited to a single special group (elderly and handicapped) and offers no integration between paratransit transit and transit elements or between paratransit modules.

Since so few of the existing paratransit systems are actually areawide integrated systems, very few of the possible permutations of systemwide classification factors have actually been represented. Thus a wide range of areawide IP system designs are yet to be tested in actual application.

2.3 System Characteristics

The data on existing paratransit systems was used not only for classification, but also to develop profiles of system operating characteristics. These profiles were then used to assist in both designing scenarios and estimating scenario demand and other impacts.

Selected characteristics of the paratransit systems considered are displayed in Table 2.3. Major sources of data used in developing this table were Ewing and Wilson (1976) and USDOT (1974). Note that, in Table 2.3, the services are identified by their specific system type (i.e., the type of service most commonly identified with those systems).

Interesting observations which can be made from these data are:

1. Only a few of the systems have been implemented in urban areas with populations exceeding 250,000. Of the few that have, three (El Cajon, La Habra, and Santa Clara) have been implemented in parts (or all) of major suburban California counties which constitute SMSA's. A number of the systems were implemented in communities with populations below 50,000. It would appear that there is still much to be learned about integrated paratransit systems operating in large SMSA's.
2. Most of the systems have operated on a very small scale. Excluding the vanpool programs, only the Ann Arbor system and the (now defunct) Santa Clara System have operated with more than 20 paratransit vehicles. Again, there appears to be little available information on large-scale systems.
3. There is a clear cost differential between union and non-union labor systems.

Table 2.3: Paratransit System Characteristics

System	Generic System Type	Urban Area Population	Service Area Population	Vehicles in Service	Fare Structure	Approximate Daily Ridership	Cost per Vehicle-Hour	Date of Data
Ann Arbor, Michigan	Zonal feeder service	143,000	106,000	48 Para. 32 F.R.	25¢ 12.5¢ E&H	2,250	$19.85 U	1977
Cleveland, Ohio	E&H zonal dial-a-ride	1,960,000	17,500	14	10¢	425	U and NU	1977
Columbus, Ohio	Point deviation	790,000	37,000	7	25¢ 10¢ children	480	$15.24 U	1975
Davenport, Iowa	Shared-ride taxi	266,000	100,000	15	Zone fare ≃$1.50	900	$ 5.75 NU	1976
Denver, Colorado	E&H subscription	1,050,000	1,200,000	12	25¢	200	$13.23 U	1977
El Cajon, California	Shared-ride taxi	1,200,000	61,000	18	50¢	620	$ 8.16 NU	1976
Haddonfield, New Jersey	Many-to-many dial-a-ride and subscription	-	44,000	19	30¢ 15¢ E&H	1,200	$18.52 U	1974
Knoxville, Tennessee	Vanpool	700,000	700,000	51	Cost shared	1,200	-	1977
La Habra, California	Many-to-many dial-a-ride	8,350,000	47,000	7	50¢ 25¢ E&H	390	$15.97 NU	1975

Table 2.3: Paratransit System Characteristics

(continued)

System	Generic System Type	Urban Area Population	Service Area Population	Vehicles in Service	Fare Structure	Approximate Daily Ridership	Cost per Vehicle-Hour	Date of Data
Merced, California	Many-to-many dial-a-ride	30,000	30,000	4	25¢	335	$10.43 NU	1976
Merrill, Wisconsin	Point deviation	9,600	9,500	2	25¢ to 50¢, depending on deviation	280	$10.95 NU	1977
Midland, Michigan	Many-to-many dial-a-ride	35,000	35,000	9	50¢ 25¢ E&H, children	460	$ 9.17 NU	1975
3M Vanpool Minneapolis, Minnesota	Vanpool	-	10,000 employees	92	varies with distance; ≈$1	2,060	-	1977
Naugatuck Valley, Connecticut	E&H many-to-many dial-a-ride	-	74,000	7	variable - average fare 69¢	90	$11.53 NU	1975
Niles, Michigan	Shared-ride taxi	13,000	13,000	5	50¢ 25¢ E&H, children	260	$ 9.40 NU	1975
Oneonta, New York	Many-to-many dial-a-ride subscription	16,000	16,000	4	65¢ 25¢ E&H 35¢ children	350	$11.88 NU	1974

Table 2.3: Paratransit System Characteristics

(continued)

System	Generic System Type	Urban Area Population	Service Area Population	Vehicles in Service	Fare Structure	Approximate Daily Ridership	Cost per Vehicle-Hour	Date of Data
Richmond, Cal.	Many-to-many dial-a-ride	2,990,000	44,000	13	25¢ adult	800	$22.35 U	1975
Rochester (GREECE)	Many-to-many & Many-to-few	703,000	72,000	9	1.00 MTM .85 FEEDER .80 MTF	830	$16.21	1976
Santa Clara County, California	Zonal feeder and subscription	1,028,000	1,028,000	90	25¢ 10¢ E&H, children <18	6,400	$20.06 NU	1975
Xenia, Ohio	Shared-ride taxi	686,000	29,000	6	50¢ to $1, depending on time of day and advance notice	280	$ 8.07 NU	1977

NOTE: U = union labor; NU = non-union labor.
Haddonfield part of Philadelphia SMSA but not of urbanized area.
Xenia part of Dayton SMSA but not of urbanized area.

ABBREVIATIONS:
F.R. = fixed route
E&H = elderly & handicapped
MTM = Many-to-many
MTF = Many-to-few
U = union labor
NU = non-union labor

2.4 Market Characteristics

As a final element of the analysis of existing systems, an in-depth review of the market characteristics of these systems was undertaken. This effort was aimed at developing a better understanding of the markets that have used or, might potentially use, IP in general, and identify how different systems serve different market groups.

Unfortunately, detailed market analysis data were readily available for only a subset of the paratransit systems considered.[1] When coupled with the fact that most of these services were not implemented in major metropolitan areas, this situation limited the extent to which strong conclusions could be drawn. Nevertheless, the data did allow a number of inferences to be drawn. In general, the markets served by paratransit systems are similar, but not identical, to the markets served by conventional transit systems. Furthermore, the market characteristics of some varied paratransit services were not very different although the markets for vanpools and more "general" systems are very different and are described separately. Specific market characteristics are discussed below.

2.4.1 Trip Characteristics

Trip Purpose

With the exception of the vanpool systems considered, (which are oriented 100% to the work trip) the paratransit systems in general serve fewer work trips (as a percent of total) and more shopping trips than conventional transit. On average, under 30% of the paratransit system trips were work trips, while the work trip percentage for four conventional transit systems considered (Boise, Idaho; Eugene, Oregon; Salem, Oregon; and Boston, Massachusetts)

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[1] For this reason, the set of systems included in the market analysis is not directly comparable to the set considered for the previous service analysis. Some market data were available for the Rochester, Batavia, Oneonta, Richmond, Ann Arbor, Merrill, Merced, El Cajon, Knoxville, and Naugatuck Valley Systems. Data sources included unpublished survey results for Batavia and Rochester.

ranged from 34% (Eugene) to 60% (Boston). Note that the share of work trips attracted to transit typically increases with city size; thus part of this result can be attributed to the size of the paratransit settings. Nevertheless, the data suggests that a potential new market for paratransit systems integrated with conventional transit is the work trip. This becomes even more apparent when one considers that in Ann Arbor, the only large scale IP system considered, work trips comprised a larger percentage of trips than they did in most of the other paratransit systems.

One interesting side issue is that data available for a number of taxi systems indicated that paratransit systems have trip purpose characteristics "midway" between conventional taxi and conventional fixed route systems. (Gilbert, 1976) This simply bears out the definition of paratransit as a hybrid "bus/ taxi system.

Time of Day

Again excluding the vanpool systems, paratransit systems exhibit time of day peaking characteristics similar to, but less marked than, conventional transit systems (and more marked than taxi systems). This reflects, at least in part, the impacts of the work trip share of travel.

2.4.2 User Characteristics

Age

Elderly persons and young persons are heavy users of general paratransit services. This is true for regular transit systems as well, but these groups are even more represented on paratransit services. The "propensity ratio" (i.e., percent of passengers in a given group to their percent in the population)[1] for travel by these groups, on transit and selected paratransit systems, is shown in Table 2.4. While the difference between transit and paratransit systems is in part a reflection of the fact that most of

[1] Thus, a propensity >1 implies that a particular group is more likely to use the service than you might intuitively expect, while a propensity <1 implies the group is less likely to use the service.

the paratransit systems have been implemented in smaller cities and serve fewer work trips, characteristics of the paratransit systems themselves also play a role. The door-to-door nature of most of these systems make them ideally suited to the elderly (who have difficulty walking) and the very young (who may not be old enough to walk, on their own to conventional bus stops). Note that the high ridership by young persons suggests that paratransit systems replace many "chauffeur trips," thus relieving parents of the need to drive their children. This is an important market to consider when analyzing IP systems.

Note that the only paratransit system that appears to display markedly different characteristics in terms of elderly ridership is Ann Arbor, where the elderly propensity ratio was only .70.[1] Ann Arbor is a university community, and it is possible that many elderly persons view the service as youth oriented (indeed 60% of the passengers are under the age of 24) and do not use it. An alternative explanation is that most transit trips in Ann Arbor require transfers, which may be very difficult for senior citizens. The problem of transfers for senior citizens is noted by a number of researchers, including Golub and Gustafson (1971). Data obtained in telephone conversations on two Canadian feeder systems would seem to support this contention. In Regina, Saskatchewan, approximately 6% of the population and 6% of the passengers are elderly; in Bay Ridges, Ontario, the figures are 5% and 2.7%. This hypothesis has clear implications for the design of IP systems.

Auto Ownership/Availability

As might be expected, the general paratransit systems considered draw a large portion of their ridership from persons who do not have access to an automobile. Automobile ownership of users of a number of paratransit systems is shown in Table 2.5. Of the five general systems for which data are available, 0-car households are heavily represented in all but Oneonta. The difference in Oneonta is difficult to explain; one explanation might be that many Oneonta users are

[1]In Merced the ratio given in Table 2.4 is .79, but that is for persons over the age of 50, rather than 65.

Table 2.4

User Age Characteristics

	Youth, ≤ 24		Elderly, ≥ 65	
	Pct. of Passengers	Propensity	Pct. of Passengers	Propensity
Rochester	36.7%	1.37	13.5%	1.54
Batavia	38.4	1.57	20.5	1.22
Oneonta	45.6	1.21	23.0	1.36
Haddonfield	33.0	1.30	13.0	1.63
Richmond	58.0	2.19	16.0 [1]	1.54
Ann Arbor	60.0	1.71	4.0	0.70
Merced	34.0	1.74	23.0 [2]	0.79
Transit (Fixed Route Bus)	29.6	1.32	9.4	0.85

[1] Statistic is for persons over the age of 60

[2] Statistic is for persons over the age of 50

college students who provided data on their families' auto ownership, rather than on their personal auto availability.

One striking observation from Table 2.5 is that persons from 2-car households appear to be as represented or better represented than persons from 1-car households. This appears to run counter to the general belief that non-working members of 1-car households are transit dependent and hence more likely to use paratransit service. The explanation might lie in the fact that paratransit is viewed as a high quality service, similar to taxi, and thus used more frequently than conventional transit by higher income persons. In addition, the use of paratransit to replace chauffeur trips might account for some of the use by persons from 2-car households.

As might be expected, the more specialized paratransit services, such as work trip oriented vanpools, attract persons from very different socioeconomic backgrounds than do generally oriented operations. The three vanpool programs shown in Table 2.5 all draw over 90% of their riders from households which own at least one car. Thus different paratransit services can be expected to serve different markets. It is clear that 2-car households represent an important target market for integrated paratransit systems.

Sex

Finally it should be noted that females were the dominant users of the systems considered. Ridership by females ranged from 63% of the total in Ann Arbor, to 88% of total riders in Batavia. While females may be slightly more overrepresented on paratransit systems than on transit systems, the propensity ratios are not markedly different for paratransit services than they are for conventional transit systems operating in similarly sized communities.

Table 2.5

User Automobile Ownership

Auto Ownership

	0		1		2+ Cars	
System	Percent	Propensity	Percent	Propensity	Percent	Propensity
General Systems						
Rochester	33.1%	5.1	35.0%	0.56	31.9%	0.9
Batavia	42.0	2.3	34.0	0.60	24.0	1.2
Oneonta	11.7	0.5	47.8	0.80	40.5	1.7
Haddonfield	24.0	3.4	40.0	0.90	36.0	0.7
Ann Arbor	26.0	2.8	35.0	0.74	32.0	0.4
Vanpools						
TVA (Knoxville) Vanpool	1.8	0.08	33.5	0.74	64.7	1.9
Knoxville Commuter Pool	8.0	0.38	51.2	1.13	40.8	1.2
Commute-a-Van Minneapolis	2.0	0.09	43.0	0.82	55.0	2.1

Chapter 3

City Classification

Introduction

As part of the development of IP scenarios, it was necessary to establish a mechanism for selecting and characterizing the settings in which the IP systems would be implemented. The approach selected was to identify a group of prototypical cities, each representative of a larger group of cities which display similar characteristics. As part of the approach, all 271 Standard Metropolitan Statistical Areas (SMSA's) in the United States were classified along a set of characteristics, as will be discussed below. Subsequently, one city was selected as the prototypical city from each grouping, and the set of selected cities served as the IP setting. The objectives behind using this approach were to:

1. Ensure that different types of cities are considered in the scenario analysis, by selecting one city from each group or cluster.

2. Allow local groups to estimate the approximate impacts of IP in their community by considering the scenario analysis for the cluster which is representative of their city.

3. Allow the use of real, rather than hypothetical, demographic data for the scenario analysis.

As noted above, the analysis focussed only on SMSA's (i.e., urban areas with populations over 50,000). Smaller cities were excluded for a number of reasons:

1. The major potential for integrated paratransit systems exists in larger cities with fixed-route transit. Smaller cities are more likely candidates for single zone systems.

2. The majority of people in the U.S. live in SMSA's.[1]

3. The inclusion of all smaller cities would have made data acquisition and analysis extremely difficult and expensive.

The analysis procedures and results are described briefly below.

3.1 Analysis Approach

The approach used to classify cities was a statistical technique known as "Howard-Harris cluster analysis."[2] This technique, described more fully in Appendix A, classifies objects into groups based on their similarities along a set of dimensions determined by the factor's input to the analysis.

An initial set of over twenty variables was developed to describe urban areas; these variables are measures of the following factors which are thought to be important to IP and transit use in general.

1. City size (population and density)
2. Extent of suburbanization of population and employment
3. Socioeconomic characteristics of the population
4. Transportation characteristics

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[1]In 1970, there were 129,512,000 persons, or 62% of the population, living within the urbanized portions of the 271 SMSA's.

[2]The basic approach outlined here was proposed in E. T. Canty and T. F. Golob (1971). A similar technique has been used by many researchers. An excellent reference on city classification analysis, with an extensive annotated bibliography, is Lake, et al. (1977).

After deciding (a priori) which data were most important, identifying the data that were readily available (through the census), and identifying highly correlated data items (through judgment and preliminary cluster analysis runs), the set of over twenty variables was reduced to the nine factors shown in Table 3.1.

Table 3.1: Factors Included in Cluster Analysis

1.	Urban area population
2.	Central city family density
3.	Percent of urban area families living in single-family dwellings
4.	Percent of urban area population in central city
5.	Urban area population over 65 years
6.	Median urban area family income
7.	Percent of urban area families in 0-car households
8.	Percent of urban area employment in central city
9.	Percent of urban area workers using transit to work (week of 1970 census)

Census data (1970) were obtained for all 271 SMSA's in the United States. The data base and the cluster analysis program used are described more fully in Appendix A.

Before the results of the cluster analysis are described, it is important to understand the way in which the procedure should be interpreted. The cluster analysis served as a computer-based aid to organizing and systematizing the judgments as to what would constitute a representative range of cities in which to conduct the scenario analysis. Given the large number of variables which can be used to describe a city, it is very difficult to decide a priori which cities are similar. Cluster analysis aids the process by applying formal criteria which approximate the way an individual would make judgments if he/she could digest the large number of factors.

Clearly, the results of the analysis are highly dependent upon the factors used. An attempt was made to identify factors felt to be related to the potential for transit in general and paratransit in particular. The selection of factors was constrained by the necessity to limit the set to data available from the census, for reasons of consistency across areas and resource constraints. There is no guarantee that the factors selected are the most important factors related to paratransit. Furthermore, the cluster analysis program, as applied, weighted each factor[1] equally, since there were no apparent reasons to weight one factor more heavily than another. In addition, the use of 1970 census data distorts present realities since, in some cities, there have been significant changes during the last seven years. Despite these limitations of the procedure, the cluster analysis approach does provide a better basis for distinction between urban areas than would be obtained from segmentation of a more simplistic nature, based solely, for example, on population or geographical location. Indeed, the results of the analysis which, in many cases appear most logical (in retrospect), bear out the advantages of the cluster analysis approach.

3.2 Results of Classification Process

The SMSA's were grouped into two to twelve clusters, and the results of each grouping were reviewed. Analysis of the results indicated that no major differences were observable in going beyond ten clusters. Thus, it was decided to proceed with a 10-group classification. The cities included in each cluster are shown in Table 3.2.

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[1] All variables are input in normalized form.

Table 3.2

City Classification

Cluster 1	Cluster 2	Cluster 2 (cont)	Cluster 5 (cont)	Cluster 6
Albany, Ga.	Augusta, Ga.	Las Vegas, Nev.	Great Falls,Mo.	Akron, Ohio
Altoona, Pa.	Birmingham, Ala.	Madison, Wis.	Greensboro, N.C.	Appleton, Wis.
Asheville, N.C.	Charleston. S.C.	Meriden, Conn.	Huntsville, Ala.	Aurora-Elgin,Ill.
Brownsville, Tenn.	Charleston, W.V.	Nashua, N.H.	Jackson, Miss.	Bakersfield, Cal.
Duluty-Sup.,Min/Wisc.	Chattanooga, Tenn.	New Britain, Conn.	Jacksonville,Fla.	Baton Route, La.
Dirham, N.C.	Columbia, S.C.	Norwalk, Conn.	Lafayette, La.	Bay City, Mich.
Evansville, Ind.	Fayetteville,N.C.	Pittsfield, Mass.	Lake Charles, La.	Canton, Ohio
Fort Smith, Ark.	Greenville, S.C.	Reno, Nevada	Lawton, Okla.	Dallas, Tex.
Gadsen, Ala.	Harlingen-San	Rochester, Minn.	Lubbock, Tex.	Dayton, Ohio
Galveston, Tex.	High Point, N.C.	Stamford, Conn.	Midland, Tex.	Denver, Colo.
Knoxville, Tenn.	Huntington-Ash,Tex.		Nashville, Tenn.	Eugene, Ore.
Laredo, Tex.	Little Rock, Ark.	**Cluster 4**	Newport News, Va.	Flint, Mich.
Lynchburg, Va.	McAllen, Tex.	New York, N.Y.	Odessa, Tex.	Fort Worth, Tex.
Macon, Ga.	Monroe, La.		Provo-Orem, Utah	Fresno, Cal.
Memphis, Tenn.	Norfolk-Ports., Va.	**Cluster 5**	Pueblo, Colo.	Grand Rapids,Mich
Mobile, Ala.	Pensacola, Fla.	Abilene, Tex.	Salinas, Cal.	Green Bay, Wis.
Montgomery, Ala.	Petersburg-Col	Albuquerque, N.M.	San Angelo, Tex.	Jackson, Mich.
Owensboro, Ky.	Roanoke, Va.	Amarillo, Tex.	San Antonio, Tex.	Joliet, Ill.
Pine Bluff, Ark.	Sherman-Denison, Tex.	Anderson, Ind.	Simi Valley, Cal.	Kalamazoo, Mich.
St. Joseph, Mo.	Texarkana, Tex.	Austin, Tex.	Sious Falls, S.D.	Kansas City, Mo.
Savannah, Ga.		Beaumont, Tex.	Tallahassee, Fla.	Lafayette, Ark.
Shreveport, La.	**Cluster 3**	Billings, Mont.	Tucson, Ariz.	Lansing, Mich.
Sioux City, Iowa	Ann Arbor, Mich.	Biloxi-Gulfport,La.	Tulsa, Okla.	Lorain-Elyria,Cal
Springfield, Mo.	Boulder, Colo.	Boise City, Idaho	Typer, Tex.	Modesto, Cal.
Tampa, Fla.	Bristol, Conn.	Bryan-Col Sta, Tex.	Wichita, Kansas	Muskegon, Mich.
Terre Haute, Ind.	Brockton, Mass.	Colorado Spr., Col.	Wichita Fls, Tex.	Ogden, Utah
Tuscaloosa, Ala.	Champaign-Urbana, Ill.	Columbus, Ga.		Okla. City, Okla.
Waco, Tex.	Columbia, Mo.	Corp. Christi, Tex.		Orlando, Fla.
Wilmington, N.C.	Danbury, Conn.	El Paso, Tex.		Oxnrd-Ventura,Cal
Winston-Salem, N.C.	Fargo-Morehead, N.D.	Gainesville, Fla.		Peoria, Ill.
	Fitchburg-Leom., Mass.			
	Honolulu, Hawaii			

Table 3.2 (Continued)

City Classification

Cluster 6 (cont)	Cluster 7 (cont)	Cluster 8	Cluster 9 (cont)
Phoenix, Ariz. Port Arthur, Tex. Portland, Ore. Sacramento, Cal. Saginaw, Mich. Salt Lk City,Utah San Bernadino, Cal. San Diego, Cal. San Jose, Cal. Santa Barbara, Cal. Seaside-Mntry, Cal. Seatl-Ever, Wash. South Bend, Ind. Tacoma, Wash. Texas City, Tex. Vineland-Cal. V Waterloo, Iowa Wilmington, Del.	Fort Wayne, Ind. Hamilton, Ohio Houston, Tex. Indianopolis, Ind. Kenosha, Wis. La Crosse, Wis. Lexington, Ky. Lima, Ohio Lincoln, Nebr. Mansfield, Ohio Muncie, Ind. Omaha, Neb. Oshkosh, Wis. Racine, Wis. Raleigh, N.C. Rockford, Ill. Salem, Ore. Santa Rosa, Cal. Spokane, Wash. Springfield, Ill. Springfield, Ohio Steubenville, Ohio Stockton, Cal. Toledo, Ohio Topeka, Kansas	Atlantic City, N.J. Fall River, Mass. Fort Lauderdale, Fla. Lawrence-Hav., Mass. Lewiston-Aub., Maine Manchester, N.H. New Bedford, Mass. Portland, Maine St. Pete, Fla. Scranton, Pa. Springfield, Ill. Utica-Rome, N.Y. Waterbury, Conn. W. Palm Beach, Fla. Wheeling, W. Va. Worcester, Mass.	Milwaukee, Wis. Minneap-St. Paul,Minn. New Haven, Conn. New Orleans, La. Pittsburgh, Pa. Prov-Pawtucket, R.I. Reading, Pa. Richmond, Va. Rochester, N.Y. St. Louis, Mo. Syracuse, N.Y. Trenton, N.J. Wilkes-Barre, Pa. York, Pa.
Cluster 7		**Cluster 9**	**Cluster 10**
Allentown-Bethlm,Pa. Bloomington, Ill. Cedar Rapids, Iowa Charlotte, N.C. Columbus, Ohio Davenpt-Rock Is Iowa Decatur, Ill. Des Moines, Iowa Dubuque, Iowa Erie, Pa.		Albany-Schenec., N.Y. Atlanta, Ga. Baltimore, Md. Binghamton, N.Y. Bridgeport, Conn. Buffalo, N.Y. Cincinnatti, Ohio Cleveland, Ohio Harrisburg, Pa. Hartford, Conn. Johnstown, Pa. Lancaster, Pa. Louisville, Ky. Lowell, Mass. Miami, Fla.	Boston, Mass. Chicago, Ill. Detroit, Mich. Los Angeles, Cal. Philadelphia, Pa. San Francisco, Cal. Washington, D.C.

The cluster analysis program provides, as output, the "standard deviation from the mean for all cities" that each group of cities yielded for each input factor. This output, which is explained in more detail in Appendix A, makes it possible to characterize the clusters. Based on this information, the following generalizations can be made about each cluster.[1]

Cluster 1. Moderately small, primarily southern cities, with low central city density and high concentration of single-family housing in urban areas, moderately high central city population and employment, low income, and low auto ownership. "Most representative": Knoxville, Tennessee.

Cluster 2. Moderately small, primarily southern cities, with low central city density and high urbanized area single-family dwelling composition, low central city population, relatively young population, and low income. "Most representative": Augusta, Georgia.

Cluster 3. Small city, with a moderately low central city density but also a low percentage of single-family dwellings, very low elderly population, high auto ownership, and low transit use. Many of the cities are college towns. "Most representative": Reno, Nevada.

Cluster 4. New York City - by itself.

Cluster 5. Small to medium-sized cities, predominantly southern and southwestern, with low central city density, high percentage of single-family dwellings, high central city population and employment, high auto ownership, and low transit usage. "Most representative": Albuquerque, New Mexico.

Cluster 6. Medium-sized cities, with low central city population and high percentage of single-family dwellings, high auto ownership, and low transit usage. Very "average" characteristics in general. "Most representative": Grand Rapids, Michigan.

Cluster 7. Medium-size, primarily midwestern cities. Slightly higher central city density than Cluster 9, but similar average characteristics. "Most representative": Des Moines, Iowa.

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[1] Also shown is the city that was "most representative" of each cluster, i.e., the city with factors most similar to the mean for each cluster.

Cluster 8: Moderately small, primarily northeastern manufacturing cities, with low percentage of single-family dwellings, very high elderly population,[1] low auto ownership, relatively low income, and relatively high transit use. "Most representative": Portland, Maine.

Cluster 9. Fairly large, primarily midwestern and northeastern older cities with high central city family density, low central city population (as percent of total), fairly large elderly population, fairly low central city employment, and relatively high transit usage. "Most representative": Cincinnati, Ohio.

Cluster 10. Major metropolitan areas with large populations, high density, moderately low single-family dwellings, low auto ownership, and high transit use. "Most representative": San Francisco, California.

One striking result of the analysis is the clustering on somewhat of a (but not exclusively) geographic basis. The fact that this was an output of the cluster analysis, rather than an input, lends further support to the use of census factors to classify cities.

Upon reviewing the results of the city classification analysis, it was decided to reduce the total number of clusters in the following manner, and for the following reasons:

1. It was decided to ignore New York City, because of the obvious uniqueness of that setting. It was felt to be inappropriate to utilize limited project resources to analyze a setting which yielded no transferability to other settings.

2. It was decided to combine Clusters 1 and 2 into a single cluster. These clusters had very similar characteristics, except for the percentage of employment and population in the central city. Because the designation of central city/non-central city is often dependent upon the definition of municipal boundaries rather than on inherent city/suburban differentiation, it was felt that Clusters 1 and 2 could not really be distinguished.

3. For similar reasons, it was decided to group Clusters 6 and 7 together.

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[1] Three Florida "retirement communities" with very high elderly populations separated into their own group as part of the twelve cluster results. Since that would have represented a very small cluster, it was decided that it would be inefficient to consider a separate scenario.

Thus Clusters 1 and 2 became "Group 1," Cluster 3 became "Group 2," Cluster 5 became "Group 3," Clusters 6 and 7 became "Group 4," Cluster 8 became "Group 5," Cluster 9 became "Group 6," and Cluster 10 became "Group 7." Following these decisions, one city was selected from each of the seven groups to serve as a setting for the scenario analysis. To avoid identification of the hypothetical scenarios with actual cities, and to establish the fact that each setting is to be representative of a larger group of cities, individual cities selected are not identified. Instead, a pseudonym which suggested one of the characteristics common to many of the cities in the group was adopted for each of the cities.

Chapter 4

Estimation of Benefits and Costs

Introduction

Benefit-cost analysis is a frequently used methodology for evaluating alternatives involving the investment of resources. Traditional benefit-cost analysis evaluates all benefits of a proposed project at market values during the time period in which they occur, discounts all future costs at an appropriate interest rate, sums all costs and benefits for all periods, and compares the two sums to determine the advisability of the project. The net economic benefit of the project is the present value of the benefits minus the present value of costs.

The application of benefit-cost analysis to the evaluation of public system alternatives, such as areawide integrated paratransit, is not that straightforward. Generally, benefit-cost analysis rests on two fundamental assumptions which do not hold in this particular application:

1. Monetary values can be obtained for every aspect of the project.

2. These values accurately reflect the real value to society.

Clearly, some of the benefits associated with IP cannot readily be assigned a monetary value. For example, how does one assign a monetary value to "increased mobility" for the handicapped?

Estimates may be made of the monetary value of reduced travel times, but how closely do these estimates reflect the real value to society? Furthermore, the introduction of IP may result in a range of different types of benefits. Is it meaningful to try to combine "reduced air pollution" and "decreased automobile costs" into a single measure of benefits?

Another major consideration is the <u>distribution</u> of benefits. Decisions about the overall benefits of a project which impacts different groups differently must consider an overall objective function that assigns relative utilities to benefits to different impact groups. As part of the distribution problem, consider that a single impact of IP may yield benefits to one group and disbenefits to another. For example, IP may benefit the elderly by increasing their mobility and reducing their transportation costs, while simultaneously reducing the revenues of local taxi companies which have had passengers diverted.

The problems introduced in trying to estimate the benefits of IP are common to many projects involving the estimation of social benefits. An entire field of economics (welfare economics) is devoted to problems of this sort.

To understand the potential impacts of IP fully, it is important to identify all groups which stand to be impacted and to isolate all potential benefits and costs. A single net benefits measure is neither feasible to obtain nor meaningful, since the distribution of benefits is, in itself, a measure of overall impact. For this reason, the potential impacts of IP are presented here in an <u>impact-incidence matrix</u> format, such that the costs and benefits accruing to different groups are identified. While this approach makes it somewhat difficult to compare alternatives,(since one must compare along many different dimensions) it does allow judgments about the overall impacts of IP to be based on individual objectives regarding transportation service.

The cells in the impact-incidence matrix which are assigned values in the scenario analyses are listed in Figure 4.1.[1] The impact groups noted in this figure are discussed in Section 4.1, while the impacts themselves are discussed in Section 4.2. The basic methodology used for developing impact estimates is described in Section 4.3. Finally, impacts which were considered for the analysis, but eventually excluded from the analysis, are described in Appendix B.

4.1 Impact Groups

The groups that have been identified as potentially being impacted by IP services are identified and discussed below:

4.1.1 Users

Clearly, one group which will be impacted by IP is the group of service users. Since IP service may impact different groups of users differently, to adequately measure the full array of impacts, the following market groups have been identified.

1. Elderly
2. Transportation handicapped
3. Persons from zero-car households
4. General public (everyone else)

The first three groups were selected to represent various segments of the transit-dependent market. The elderly segment includes all persons over the age of 65. The transportation handicapped are a specific group, composed of elderly and non-elderly persons, who are defined as "unable to use public transit without difficulty." Members of 0-car households are obviously transit dependent. Note that the three groups overlap. Results are presented for each group, but double counting is avoided when totals are developed.

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[1] The cells presented here represent the impacts developed for the IP scenarios. While most of the same impacts are also developed for the extended fixed route and extended taxi alternatives, there are some differences. Those are addressed in Volume 3 of this set of reports. Some measures of effectiveness which may comprise a relation between impacts (e.g., net total cost per new transit trip) are also developed for each scenario.

Figure 4.1: Impact-Incidence Matrix Cells

IMPACT GROUP: USERS
- Mobility (by market segment)
  - New transit trips
  - Induced trips
- Change in consumer surplus (by market segment)

IMPACT GROUP: COMMUNITY
- Coverage (by market segment)
  - Spatial
  - Temporal
- VMT
- Fuel consumption
- Emissions
- Employment opportunities (by employment sector)
  - Jobs
  - Payroll
- Automobile expenditures
- Chauffeur trips eliminated

IMPACT GROUP: IP OPERATOR
- Costs (by operator)
  - Gross operating
  - Net operating
  - Gross capital
  - Net total (subsidy)
  - Management fee (for private operators only)

IMPACT GROUP: COMPETING TRANSPORTATION PROVIDERS
(taxi industry, parking lot operators, social service agencies)
- Passengers (where appropriate)
- Revenue (where appropriate)
- Profit (where appropriate)
- Opportunity cost (where appropriate)

IMPACT GROUP: MAJOR EMPLOYEES
- Parking requirements
- Cost
- Opportunity cost

IMPACT GROUP: LOCAL GOVERNMENT
- Operating subsidy
- Capital subsidy
- Parking revenue lost

IMPACT GROUP: FEDERAL GOVERNMENT
- Operating subsidy
- Capital subsidy
- Total subsidy

The 0-car households will serve as a surrogate for low-income households, since the demand modelling framework used in the analysis was not able to stratify results on the basis of income level. Note that numerous studies have shown auto ownership, rather than income, to be the dominant factor in determining tripmaking characteristics, with incomes simply serving as a determinant of auto ownership.[1]

4.1.2 Community

The "community" has been identified as an impact group, to cover the range of impacts that benefit (or cost) the community as a whole, rather than any specific group(s). One example might be a change in vehicle-miles travelled and the resultant changes in air pollution and energy consumption. In some cases, community impacts may be stratified by the same market groups identified under users.

4.1.3 IP Operators

The operator of the IP system service is clearly impacted by the initiation of service. In cases where the operator of the paratransit system components is not the same as the operator of the transit components (or where there is more than one operator), the impacts on both groups are computed separately.

4.1.4 Local "Competing" Providers

Any new transportation service is likely to impact existing transportation suppliers in the area. The following specific impact subgroups have been identified:

1. Taxi industry - Many taxi operators have claimed that paratransit services impact their businesses; some operators have filed suit to stop paratransit service. In other cases, taxi operators have been selected to operate paratransit service; the resultant impact on the private sector is very different in these cases. Note that the impact on the exclusive-ride taxi business is estimated separately even if the taxi company serves as the IP operator.

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[1] See, for example, Dajani and Sullivan (1976).

2. Parking lot operators - These stand to be impacted by diversion of autos from the CBD.

3. Social service agency providers - Many social service agencies for whom transportation is not a prime service offer transportation to their clients because limited means of public transportation are available. The initiation of large-scale paratransit systems can impact them somewhat.

Note that other private operators, such as school bus or charter bus services (or private city bus lines), have been ignored; in all cases, because of the nature of IP service, impacts on these groups were felt to be minor. In addition, chair carriers (private operators providing specialized service to severely handicapped persons) have not been considered because of the lack of data on these operations.

4.1.5 Major Employers

Major employers in the area who, in some way, pay for parking spaces for employees, also may be affected by IP alternatives which impact automobile usage.

4.1.6 Local (Non-Federal) Government

Lumped together in this impact group are all branches of (non-federal) government (e.g., city, county, and state) which are involved in supporting some form of transportation service.

4.1.7 Federal Government

The federal government, which is a major source of public transportation capital and operating assistance, is clearly an important IP impact group.

Before proceeding to the discussion on impacts, it should be noted that even this breakdown of impacts by impact groups does not give a true picture of the full distributional impacts of IP or other transit services. For example, the "community" designation is a very broad one; some impacts will accrue to only subsets of the population. Similarly, lumping together "taxi operators" as a single impact group ignores the fact that, in some cases, one taxi operator may be impacted to a significantly greater extent than another. Because of difficulties in measuring impacts on such a micro-level, issues such as these are ignored in the impact analysis.

4.2 Impacts: IP Benefits and Costs

For each of the impact groups discussed in the previous section, one or more potential impacts have been identified. These are discussed in the following paragraphs. Note that all impacts are measured as the marginal annual change over the base case. When appropriate, the percent change will also be presented.

4.2.1 User Impacts

Mobility

The expanded mobility resulting from IP for each market group is, in itself, a benefit; indeed, mobility is the basic goal of transit service. Two measures of mobility are computed. The first is the increase in the number of <u>transit</u> trips. This measure is important, since an obvious objective of any new transit service is to increase transit ridership. Note that "total transit ridership" on the IP (or other alternative) system and the measure "increase in transit ridership" may not be the same, since the IP (or other) alternative may divert some passengers from other transit modes.

The increase in transit trips does not provide a complete measure of the mobility impacts on the users, since many of them may have had equal mobility before, in terms of total tripmaking. In other words, new transit riders include both persons diverted from other modes, such as auto or taxi, and persons who would not have been able to make the trip without the (IP) service. The latter subset of trips is commonly referred to as <u>induced trips</u> (since the new service induces the persons to travel). The number of induced trips is used as a second measure of mobility.

Consumer Surplus

Consumer surplus is a concept widely used in economics. The classic definition of consumer surplus is the "difference between what an individual consumer is willing to pay for a good or service and what s/he actually does pay at market equilibrium." When a new "production process" (or, in this case, transportation system) which reduces the cost (and hence price) of providing the goods (or service) is introduced, there is a net change in consumer surplus (Wohl and Martin, 1967).

The measure of consumer surplus has been fairly widely used to evaluate large-scale public capital investments (such as highways), where the change in consumer surplus, suitably discounted over time, serves as an estimate of a portion of the benefits of a particular alternative. The use of consumer surplus for the evaluation of public transit options has been relatively minimal; most such applications have involved a major capital improvement, such as the construction of heavy rail transit, which has some basic economic similarities to highway construction.

The utilization of consumer surplus for the analysis of IP options requires a reinterpretation of the supply curve traditionally used in economic literature. The supply curve in the latter case indicates the quantity of goods (or services) a producer is willing to offer at a given price. In the context of IP, the supply curve represents the "cost" of serving a given demand, where "cost" is a measure of the performance of a transportation system. This cost measure is, in fact, an aggregated measure of a vector of service qualities such as fare, out-of-vehicle time, in-vehicle time, etc. The change in consumer surplus is dependent upon the "cost" of IP (expressed as a function of out-of-pocket cost and in-and-out-of-vehicle time) and the cost of competing modes, as well as the "quantity" of passengers, in terms of induced and diverted passengers. Consumer surplus is a measure of the overall "cost" saving resulting from IP.

The concept of consumer surplus and the approach used to estimate consumer surplus are discussed in detail in Volume 6 in this series of reports. It is important to note here that the methodology involved a departure from more traditional approaches, and is based on recent research in disaggregate choice models (Ben Akiva and Lerman, 1977). It draws upon utility theory and, in this application, incorporates the utility functions of the demand models being used. The utilities of the various transportation modes, a function of the same vector of service qualities noted above, are used as surrogates for system cost. A change in overall system utility, resulting from the introduction of IP or some other alternative, is interpreted to result in a change in consumer surplus.[1] Consumer surplus is provided an economic interpretation, representing the change in the actual cost of transportation service, plus the change in components of travel times multiplied by the "value" of those components as appearing in the utility function. Although an economic interpretation is offered, it must be recognized that consumer surplus does not represent an actual economic benefit, in that no dollars actually change hands. Consumer surplus merely represents an attempt to place some value on the reduction in "cost" seen by the transit user.

4.2.2 Community Impacts

Coverage

The availability of transit service also can, by itself, be considered a benefit of a transit system. Thus, the change in coverage of the system is proposed as a benefits measure. Spatial coverage is defined as the percentage of the general population living within 1/4 mile of a fixed route, the percentage of elderly persons living within 1/8 mile, and the percentage of the transportation handicapped living within 1/16 mile.[2] Door-to-door service is assumed to involve 100% coverage. Temporal coverage is defined as the hours of service and days of service (and is the same for all market groups unless the system design specifically calls for differences).

Vehicle-Miles Travelled

A reduction of the amount of vehicle-miles travelled (VMT) and the resultant impacts on congestion, pollution, and energy consumption are national goals. The impact of IP on VMT is estimated and is considered a community impact. However, recognize that a decrease

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[1] Note that, using this formulation, only the change in consumer surplus is meaningful.

[2] Note that transportation handicapped persons who are homebound or unable to travel are excluded from all coverage estimates.

in VMT is not, of itself, a real benefit. It is the related impacts that actually matter. VMT is presented simply because it is a widely used surrogate for these other impacts. As will be shown in the analyses, theuse of VMT as a surrogate for fuel consumption or emissions is not always correct.

Fuel Consumption

The change in fuel consumption is measured in gallons of fuel.

Emissions

The change in emissions of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x), the three main automobile pollutants, is measured in units of 1,000 kilograms.

Chauffeur Trips

One recognized impact of many paratransit and new transit systems is that they eliminate the need to "chauffeur" persons who do not have access to an automobile. In many cases, this will involve children too young to drive, although others may also be transported by "serve passenger" trips. While the benefit to the former passenger is incorporated within the consumer surplus and mobility measures, the benefit to the former provider is not, and, therefore, it is included as a community impact.

The "benefit" of an eliminated chauffeur trip can be thought of as comprising reduced out-of-pocket costs and reduced costs in terms of time to the former driver, plus reduced VMT. The latter impact is incorporated in the VMT impact. As a surrogate for the two former components of the benefit, the number of (eliminated) chauffeur trips is utilized as the impact measure.

Employment

The introduction of IP can have direct employment impacts on the provider of the service and competing providers. These employment estimates (total jobs and total payroll) are incorporated in the impact-incidence matrix. Other potential employment impacts which have not been considered are discussed in Appendix B. Note that employment is considered a community benefit. Employment costs are incorporated as part of the operator and competing provider impacts. No attempt is made to distinguish between public and private sector employment impacts on the basis of the fact that the latter may have a bearing on corporate taxes. The impact on profits of private operators is considered separately.

Automobile Expenditures

The introduction, or improvement, of a public transportation system has been shown to impact automobile ownership. Persons who use the service regularly are able to eliminate a car, perhaps even a "first" car. However, the availability of service can result in other persons eliminating extra cars whose major function was to fill in for the primary car when it was unavailable, or to make trips which can now be made by transit. Since users are not the only persons impacted, the change in automobile expenditure (capital and operating) is included as a community impact.[1]

4.2.3 IP Operator Impacts

Capital Cost

The initiation of IP service will result in a change in (annualized) capital cost for the service provider.

Operating Cost

Similarly, IP will impact annual operating cost.

Revenues

IP service will also result in a net revenue change.

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[1] Note that the inclusion of this measure might result in some overcounting, since some of these savings are incorporated in consumer surplus. However, only a small portion of automobile cost savings accrues to users directly from diverted trips now taken by IP; the remainder accrues either to non-users or to users who eliminate trips not taken by IP (because of eliminated autos). Further, only out-of-pocket costs are incorporated in the consumer surplus estimate. Thus, the amount of overcounting should be rather small. More importantly, note that no attempt is made to sum across impact groups; thus, there is actually no overcounting at all. Consumer surplus affects tripmakers for trips made on IP. Auto operating cost changes affect the community in general.

Subsidy

Note that, in most cases, the net cost of IP operation will be borne by the local and federal governments. However, the total subsidies will also be noted. Local and federal governments are separate impact groups, and the effect on them will be treated separately.

Management Fee

In cases of private operation of the paratransit elements, management fees (i.e., profits) will also be estimated.

4.2.4 Local Competing Providers

Revenue

If IP diverts passengers from either taxis or (private) parking lots, there will be an impact on total revenues collected.

Net Profit

To simply list revenues is an insufficient measure of impact, since costs may change as well. Thus, change in net profit (return) is also included as an impact measure, for taxi operators only.

Opportunity Cost Savings

For social service agencies, none of the above measures is actually relevant. Instead, assuming that the IP system diverts passengers from a human service agency system, the net impact is measured as reduced operating cost and can be interpreted in a number of ways:

1. System operating costs can be reduced proportionately to the reduction in ridership. This could be considered a direct monetary benefit to the provider. However, since costs can probably not be reduced proportionately (because of integer numbers of vehicles and drivers), and since most of these services are "supply constrained" and hence would simply serve other persons, this direct benefit would probably not occur.

2. This same savings in operating cost can be reinterpreted as the opportunity cost associated with serving an additional number of passengers who can now be served because of the diversion of passengers to IP.

3. This potential savings can be considered as the opportunity cost associated with the agency's ability to expand its primary service because of reduced transportation needs.

Since the way in which the agency utilizes its "savings" is not really relevant, any of the interpretations can be accepted.

4.2.5 Major Employers

Reduced Parking Requirements (Opportunity Costs)

Major employers located in non-dense (i.e., non-CBD) areas frequently have large parking lots for employees. If auto drivers are diverted to IP, parking requirements may be reduced. The land saved could conceivably be sold or used to erect new employment facilities. Thus, a direct monetary savings to employers can be computed. Many employers in dense CBD areas currently lease parking space for their employees. For these employers, a change in parking requirements can also result in a direct monetary savings. The specific measures listed are: parking space requirements, cost, and opportunity cost savings.

4.2.6 Local (Non-Federal) Government

Share of Transit Operating Deficit (Local subsidy)

Changes in the non-federal share of the operating deficit (paid for by any local subsidy mechanism) are provided.

Share of Transit Capital Costs (Local subsidy)

Changes in the non-federal share of capital costs are provided.

Parking Revenues

Local governments which provide municipal parking lots might also lose revenue if auto traffic is diverted.

4.2.7 Federal Government

The federal government impacts are fairly straightforward:

- federal share of transit operating deficit (Federal subsidy)
- federal share of transit capital costs (Federal subsidy).

Other federal costs, such as costs of demonstration projects, technical studies, and administration related to IP, are ignored because of the lack of a basis for estimation. Note that some of the impacts related to federal objectives, e.g., increased mobility for the elderly and reduced VMT, are considered earlier for the impact group to which they more directly relate.

4.3 Approach to Impact Estimations

The estimation of the various impacts was based on the combined utilization of empirical data and the state of the art in transportation modelling. Details of the approaches used for estimating all impacts are included in Volume 6 of this series of reports, along with specifications for all models. In this section, these approaches will be discussed very briefly.

Since the projection of demand for IP service is a central element in the estimation of benefits, this issue will be considered first. A disaggregate demand model specifically designed for demand-responsive transportation analysis was utilized (Lerman et al., 1977). The model, which was modified during the course of the study to allow market segmentation, was calibrated with data from the Rochester, New York, DRT system. It has been validated against a number of other paratransit systems, including those in Davenport, Iowa; La Habra, California; and Ann Arbor, Michigan, and found to be accurate within the range of ± 0-30%. These results suggest that this model is significantly more accurate than all other demand modelling procedures; the model also appears to be readily transferable (from one system to the next). Thus, the use of this model should provide the best possible estimates of IP demand. Nevertheless, it must be understood that a model is nothing more than a tool to be used to assist in the analysis. Consideration of the results must take into account that the demand numbers used are not absolute figures but are the best estimate of demand, which should be within a reasonable range of the value used. The use of a single modelling methodology also allows for consistent comparisons between scenarios. In all cases, demand projections were compared for reasonableness with empirical data on existing IP systems. Some sensitivity analysis on the impact of demand variation on costs and benefits was performed and discussed in Volume 6.

The demand model system used is part of an equilibrium model--a critical factor since, in paratransit service (unlike conventional transit), supply and demand are generally highly interrelated. A supply model for a many-to-many service was developed as part of the original demand model design. Other supply models, drawn from a variety of sources or developed specifically for the project, were also employed. Volume 6 describes the models used.

The same modelling framework used to project IP demand was modified to allow projection of demand for the extended fixed-route and taxi alternatives. These modified models were validated prior to use in the analysis.

The only other sophisticated modelling tool used was an automobile ownership model (Cambridge Systematics, 1976). This model predicts automobile ownership as a function of, among other factors, transit level of service.

Among the empirical data used for estimating other impacts were the following:

- Surveys of existing paratransit systems were used to estimate the former mode of travel. Supplementary data on diversion from taxis were obtained directly from a number of impacted taxi operators.

- Data on existing vanpool programs were used to estimate vanpool participation rates.

- Data on parking, including local data on costs and national data on duration of parking by city size, were used to estimate impacts on parking lots.

- Local data were used for computing transit operating costs.

- National data on taxi revenue and ridership, and local data on the taxi industry, were used to estimate impacts on local taxi operation.

- A simple model relating energy consumption and pollutants to VMT was used to estimate these impacts.

These and other procedures are discussed in more detail in Volume 6.

Appendix A

Background Information on City Classification Analysis

The goal of the city classification analysis was to choose a representative group of cities which spanned the spectrum of urban types in the U.S. and which could be used, with appropriate aggregation techniques, to develop national estimates of the cost and benefits of integrated paratransit services. Given the large number of potential urban areas in the U.S., the large number of variables which can be used to characterize cities, and finite study resources, it was felt that it would be desirable to utilize a systematic technique, termed cluster analysis, to assist in this classification.

As used in this study, cluster analysis served as a computer-based aid to organizing and systematizing our own judgment as to what would constitute a representative but wide range of cities in which to conduct an analysis of integrated paratransit services. The cluster analysis procedure, and other key elements of the overall analysis are discussed below.

The Cluster Analysis Procedure

In this procedure,[1] each city was described by a set of attributes such as population, employment density, average household income, etc. Ideally, one would like to choose variables which are independent and truly characterize or differentiate a city from other

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[1]The procedure used for the cluster analysis was originally developed at the University of Pennsylvania by Howard and Harris. See Howard, N., and B. Harris, "A Hierarchical Grouping Routine, IBM 360/65 FORTRAN IV Program", University of Pennsylvania Computer Center, 1965.

cities. In practice, one is limited by interdependencies, by lack of data on one or more variables, and by a lack of consistency among several data sources.

If there were K such attributes for each city, then one can think of each city as a plotted point in a K-dimensional space. The cluster analysis procedure seeks to divide the points into a given number of separate clusters such that each point is associated with one and only one cluster, and such that the sum of the squared "distances" (in K dimensions) between each point and the centroid of its respective group is minimized.

Mathematically, this can be formalized as follows. Let $X_i = (X_{i1}, X_{i2}, X_{ik})$ be the vector of attributes associated with the i-th city. Let P be the number of clusters desired and let S_p be the set of points (i.e., cities associated with the p-th cluster. For any particular cluster, the vector representing the zone centroid, is simply

$$C_p = \frac{\sum_{X_i \varepsilon S_p} X_i}{N_p}$$

where N_p is the number of cities in the cluster. Moreover, the sum of all the distances between the points in S_p and their centroid is

$$d_p^2 = \sum_{X_i \varepsilon S_p} |X_i - C_p|^2$$

where

$$|X_i - C_p|^2 = \sum_{k=1}^{K} (X_{ik} - C_{pk})^2$$

In this notation, the clustering problem can be expressed as follows.

If $\mathbf{U}$ is the set of all cities, select P subsets S_p of $\mathbf{U}$ such that

(i) $S_i \cap S_i \neq \emptyset$ (the null set) $\forall$ $i \neq j$

(ii) $S_1 \cup S_2 \; . \; . \; . \; S_p = \mathbf{U}$

(iii) $\sum_{p=1}^{P} d_p^2$ is minimized

The intuitive interpretation of the criterion of minimizing the sum of the squared point-to-centroid distances is that the distance measure in some sense represents the extent to which two cities are "similar". More formally, the sum of squared distances, d_p^2, in a particular cluster is proportional to the "within group" variance, and thus the clusters are chosen so as to minimize this variance, and thereby maximize the "between group" variance.

<u>The Clustering Program</u>

The Howard-Harris program is a heuristic approach to the problem stated above. (No computationally feasible algorithm exists to solve the clustering problem as described above, and use of heuristic approaches are therefore essential). The procedure begins by first considering the entire universe of cities, U, as a single cluster (i.e. P=1). It then solves the cluster problem for P+1 by applying the following procedure:

1) Examine all current clusters and select the one with the greatest value of d_p^2
2) for the chosen group, compute

$$V_k = \sum_{X_i \varepsilon S_p} (X_{ik} - C_{pk})^2 \quad \text{for } k=1, \ldots, K$$

Take the component k for which V_k is a maximum, and divide the chosen cluster into two clusters, S_p' and S_{p+1}, such that

$$S_p' = \left\{ X_i \mid X_i \varepsilon S_p \text{ and } X_{ik} \quad C_{pk} \right\}$$

$$S_{p+1} = \left\{ X_i \mid X_i \varepsilon S_p \text{ and } X_{ik} \quad C_{pk} \right\}$$

3) Using the new set of P+1 clusters, compute the distance from each X_i to each of the new centroids. Shift points and recompute centroids until no possible change reduces the value of $\sum_{p=1}^{P} d_p^2$

The solution procedure (yielding two clusters) above is then reapplied for P=3,4 ... up to some pre-specified limit.

Step 3 involves only changes in one city at a time, and it is possible to show by counter-example that this algorithm may produce a locally, rather than globally, optimal solution.[1]

The actual program has a number of possible clustering options. First it can work directly with the raw data values, X_i. This, however, makes the final clustering extremely sensitive to how the X_i's are measured, since the value of the variance of any single component k in σ_i increases as the square of the scale in which X_{ik} is measured. A much more reasonable approach is to standardize each component of X_i by subtracting its means and dividing by its standard error, i.e. use

$$X'_{ik} = \frac{X_{ik} = \overline{X}_k}{\frac{1}{N} \sum_{X_i \varepsilon \mathbf{U}} (X_{ik} - \overline{X}_k)^{2\frac{1}{2}}} \quad \forall\ k$$

$$\text{where } N = \sum_{p=1}^{P} N_p \text{ and } \overline{X}_k = \frac{1}{N} \sum_{X_i \varepsilon \mathbf{U}} X_{ik}$$

This avoids the problem associated with different units of measurement in the components of X_{ik}.

It is also quite common to begin by applying factor analysis to the X_i's, and then clustering on the factor scores. This avoids any problem of collinearity in the original X_{ik}'s, since the factors are by definition orthogonal.[2]

For reasons of time and budget, (as well as some methodological debate regarding the appropriateness of factor analysis in this context) factor analysis was not used in this study. Instead, the original K components of X_i were selected to be reasonably independent of one another. All clustering was performed on standardized values without weighting the components in X_i differently.

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[1] Local optimality is defined here as a solution for which no single city can be switched to a different cluster without increasing the value of $\sum_{p=1}^{P} d_p^2$. See Howard and Harris (1965).

[2] Collinearity may tend to place more weight on some components of the X's. At the extreme of perfect collinearity, the two collinear variables act to double the effect of a particular dimension in the clustering process. This can at least heuristically be compensated for by weighting some components of X_i more than other. The program allows for a different weight in each of the K dimensions.

The original program was modified slightly to provide additional outputs and to expand the number of X_i's and components that could be clustered from 120 and 16 respectively to 280 and 25.

Data Processing Steps

An attempt was made to minimize the problems of variable definition and data management by carefully choosing the variables and by using a single data source, the U.S. Census City and County data tables for 1972.

The most significant decision made in using the tapes was the choice between using SMSA (Standard Metropolitan Statistical Areas) or Urbanized Areas. The former is a definition based on the city labor market, and always defines city boundaries along county (or in New England, town) lines. The latter city definition is based on a more realistic areal definition of the city, and eliminates vacant land at the periphery of the SMSA.

Both the SMSA and the Urbanized Area data were abstracted from the tape. Each resulting data file was then further processed to define the X_i's used in the city classification. The Urbanized Area data ultimately was judged to be superior, particularly for variables such as employment and population density, where areal definitions greatly alter observed measures.

The variables were originally selected to reflect the following features of potential IP markets:

1. City Size
2. Extent of suburbanization of population
3. Market characteristics (socioeconomic description of the city)
4. Extent of suburbanization of work force
5. Transportation characteristics

An initial set of variables was developed, and subsequently reduced to the set of nine variables listed in Table A.1, because of apparent collinearity between certain variables.

Table A.1

Urban Area Variables Used in Final Cluster Analysis

Variable	Mean in all cities	Deviation
1. population	477,904.	*
2. central city (CC) family density	1,010.2	725.
3. urban area (UA) % of families in single family dwellings (SFD)	68.6	11.3
4. % of UA population in CC	67.7	21.8
5. UA population % over 65	9.4	2.8
6. UA median family income	9,726.	1,405.
7. UA % families in 0 car households	15.6	5.2
8. % of UA employment in CC	68.4	21.9
9. UA % using transit to work	5.47	4.8

*Not calculated due to limitations of cluster analysis program.

Evaluating the Cluster Analysis Output

The cluster analysis program provides a substantial set of outputs which can be used to interpret the final clusters. In addition to a listing of the original and standardized values of X_{ik}, the program provides the following:

1) the assignment of each city to the clusters;

2) the value of $\sum_{p=1}^{P} d_p^2$;

3) the distance of every city to its respective cluster centroid;

4) the coordinates of each centroid in all K dimensions;

5) the within group variance for each cluster.

Furthermore, since the program must construct the optimal clustering for 1,2,....,P-1 clusters in order to determine the optimal P clusters, the additional cost of obtaining the above data for lower level clusters is extremely small. Therefore, it is cost-effective to set P to the highest value one might be interested in working with, and then examine the output and select the desired level of clustering. For this analysis, P was set to 12. The decision as to what number of clusters to use in the final classification was based on the following criteria:

1) How much did further levels of clustering reduce $\sum_{p=1}^{P} d_p^2$?

2) To what extent did further levels of clustering substantially alter the entire clustering pattern? (i.e. did later clustering tend to totally rearrange the cities, or did they generally just divide one of the clusters into two, somewhat similar groups?)

3) Did the cities in later clusters seem qualitatively different than those earlier clusters?

4) Were the later clusters large enough (in the sense of N_p high) to warrant separate treatment in the study?

Ultimately, these criteria led to the choice of the 10 level clustering results. The use of less clusters seemed undesirable due primarily to criteria (1) and (3); the use of 11 or 12 clusters produced some very small groups. (Los Angeles and Chicago were a distinct cluster of the 12 level, as were Fort Lauderdale, St. Petersburg and W. Palm Beach).

The second facet of evaluating the output is characterizing any particular cluster. This was done using primarily the centroid coordinates in their normalized form. Each cluster (for any particular number of clusters) has a centroid, and the value of the centroid, for any particular component is the number of standard deviations (either positive or negative) the cluster average differs from the mean of all cities.

For example, suppose there were three variables (population, percent of population over 65, and percent of households in single family homes). Suppose further that there were four clusters with the following centroids:

CLUSTER	POPULATION	% OVER 65	% IN SINGLE FAMILY HOMES
1	3	-.1	-1.0
2	0.75	-.85	0.5
3	-0.1	4.6	-0.36
4	-1.0	0.6	-0.05

In this example, the first cluster would be characterized as very large, only slightly younger than average and multifamily dwelling oriented. (These values are typical for a cluster with major cities such as Boston, Chicago, Detroit, Los Angeles, Philadelphia, San Francisco and Washington). Similarly, cluster 3 might be characterized as average in size with a major elderly population and somewhat multifamily dwelling oriented. (These values would characterize a cluster consisting of Fort Lauderdale, St. Petersburg, and West Palm Beach.)

This type of analysis was formalized by plotting the centroid values for the most important variables. These values are presented in Tabular form in Table A.2. In addition, many clusters have a distinct geographical character. The combination of an analysis of centroid coordinates and the geographical consistency of the clusters was used to generate the characterization of the final clustering results discussed in Chapter 3.

Table A.2

Cluster Characteristics (Standard errors)

Cluster	UA Pop.	CC Family Density	% of UA Pop. in Sgl. Fam. Dwelling	% of UA Pop. in CC	% of UA Pop. Over Age 65	UA Median Family Income	% of UA Fam. w/ 0-Cars	% of UA Employment in CC	% of UA Workers Using Transit
1	(-0.26)	(-0.42)	0.53	0.93	0.38	(-1.17)	0.91	0.91	0.05
2	(-0.22)	(-0.42)	0.70	(-0.90)	(-0.26)	(-1.11)	0.45	(-0.85)	(-0.17)
3	(-0.27)	(-0.33)	(-1.22)	0.52	(-0.40)	1.23	(-0.50)	0.52	(-0.20)
4	11.96	8.08	(-3.14)	1.36	0.40	0.98	4.36	1.34	6.99
5	(-0.23)	(-0.51)	0.66	1.04	(-0.77)	(-0.53)	(-0.83)	1.08	(-0.45)
6	(-0.63)	(-0.17)	0.47	(-0.68)	(-0.32)	0.50	0.50	(-0.81)	(-0.69)
7	(-0.18)	(-0.09)	0.14	0.52	0.17	0.30	(-0.16)	0.51	(-0.19)
8	(-0.19)	(-0.21)	(-1.64)	(-.43)	1.96	(-0.31)	1.11	(-0.45)	0.23
9	0.21	1.30	(-.79)	(-1.15)	0.41	0.50	0.70	(-1.19)	1.01
10	3.03	2.51	(-1.06)	(-1.36)	(-0.11)	1.38	0.99	(-1.36)	2.34

CC = Central City

UA = Urban Area

Parentheses used to highlight negative numbers.

Appendix B
Other Potential Impacts

In formulating the impact-incidence matrix, a range of additional potential impacts was considered and rejected for inclusion within the matrix. Most of these impacts were fairly indirect. Rejection was typically based on either the inability to provide any measure of the benefit or, more frequently, preliminary analysis which suggested that the extent of the impacts would be extremely limited. Each of the other potential impacts considered is discussed below.

1. Employment Opportunities for Low-Income and Handicapped Persons

Numerous studies have suggested that the lack of adequate transportation services hinders the ability of low-income and handicapped persons to find and keep a job. Thus, the potential impact of IP service on employment was considered. It was found that actual experience indicated that improvement to transportation service actually had little impact. Nevertheless, an attempt was made to estimate increased employment for low-income persons, using an accessibility model which appeared in the literature. (Falcocchio et al., 1974) The results for one setting appeared extremely high, perhaps because the model had been calibrated with data from an extremely poor inner city neighborhood.

Further consideration of the question raised doubts about the basic hypothesis. In fact, what accessible transportation service does is increase the competition for available employment, or perhaps redistribute the jobs geographically. Unless one could argue that, despite the overall unemployment rate, transportation allowed persons to find jobs which could not previously be filled, accessibility cannot be considered a major force behind job development.

For this reason, this impact was eliminated from the impact-incidence matrix. Nevertheless, the possibility that improved transit can result in increased employment must be considered a potential impact of IP.

2. Impacts on the Elderly

It has been suggested that transportation can benefit the elderly person in a number of quantitative and non-quantitative ways:

1. it links elderly persons to, possibly less expensive, goods and services.
2. it permits interaction with other persons.
3. it results in greater independence, and hence less idleness, less loneliness, and greater self-esteem.
4. it results in greater volunteerism, thus benefiting society.
5. it allows elderly persons to remain in a home environment longer, thus benefiting the elderly and society.
6. it results in increased use of social welfare programs, lowered rates of institutionalization and, possibly, lowered rates of victimization.

At least one researcher has tried to measure the impact of transportation on the "life satisfaction" of the elderly (Cutler, 1975). Such measurement, however, is at best arbitrary and, at worst, infeasible. Because many of the impacts of transportation on the elderly are psychological, it was felt to be impossible to even begin to capture them in this analysis. For this reason, the change in consumer surplus for elderly persons, as well as the change in mobility, were viewed as sufficient surrogates for the impact of transportation on the elderly.

3. Safety

Two components of safety received consideration. First was a change in accident rates, resulting from a change in VMT. Second was increased perception of safety during evening hours, for persons who receive door-to-door service after IP implementation. After preliminary analysis, the former measure was dropped from consideration, since the estimated change in VMT times the rate of accidents per VMT was extremely small. The second measure was dropped because of an inability to measure it in any way. One might argue that perception of safety was incorporated inherently in the consumer surplus formulation (since it was based on a utility function calibrated from actual ridership on a door-to-door transportation system, although there is no factor explicitly considering safety).

4. Impact on Auto-Related Industry

A reduction in automobile sales, considered a benefit to the community, might also result in a disbenefit to the auto and related industries. Data developed by Chrysler Corporation (Chrysler Corp., 1976) indicate that a reduction of sales of 1,000 cars will result in a reduction in employment of about 150 jobs throughout the auto and related industries. Data from one scenario indicated that approximately 100 cars per year would be eliminated after IP implementation. Aggregating to a national level, assuming this scenario had 1/500 of the national SMSA population, maximum national impact would be 7,500 jobs lost. Since the auto and related industries currently employ almost 7,000,000 persons, this was felt to be an insignificant impact. The national impact on the motor vehicle manufacturers alone (employment 800,000) is estimated at 2,500 jobs lost. Note that some of these lost jobs would be replaced by increased employment in the manufacture of paratransit vehicles.

5. Change/Redistribution in Retail Sales

Improved transit service could result in greater travel to the CBD and increased retail sales. A more likely impact of area-wide IP would be geographic redistribution of retail sales, since accessibility to other parts of the urban area are likely to increase as, or more, greatly than accessibility to the CBD.

Because of the difficulty in projecting what would happen, this impact measure was dropped from further consideration.

6. Reduced Highway Construction Requirements

It might be hypothesized that large-scale IP systems could reduce the need for additional highway construction in some urban areas. Preliminary assessment of potential VMT changes, however, suggested that IP systems will have virtually no impact on highway needs. Similarly, IP cannot be expected to have a major impact on congestion.

7. Increased City Tax Base

Reduced parking requirements (municipal and private) has been cited as a potential benefit of IP. The reduced need for parking spaces could result in additional real estate development, which increases the city's tax base and tax revenues. However, because of the small magnitude of the potential change in parking requirements, and because of uncertainty regarding the construction of other facilities in such locations, it was decided not to estimate potential tax revenue changes.

8. Change in School Bus Costs

The availability of improved, in some cases door-to-door, public transportation could allow some localities to place greater emphasis on public transportation for getting students to school, increase the mileage restriction on school bus use (i.e., the minimum distance which a child must live from school in order to receive school bus service), and hence reduce transportation cost. Because of the many uncertainties regarding the use of public transit by students (and the general inability to estimate demand), and the constrained capacity of most IP paratransit system components (except checkpoint to few subscription service, which is the type of service represented by school bus service) and the potential impact on private operators, it was decided not to pursue this measure any further.

9. Ability for Social Service Agencies to Expand Primary Service

Many social service agencies provide transportation service out of the need to bring their clients to their facility for other, primary services. The potential direct savings to these agencies of diversion of passengers to IP was addressed earlier. An additional, potential benefit to these agencies results from usage of IP to access the human service agencies by persons who formerly did not make such trips. This allows the agencies to expand their primary service delivery. This is a potential benefit of IP which has not been researched at all, and would make an interesting separate study. Because of the lack of any data on the subject, the potential impacts are not considered. However, this does not imply that such impacts may not, in fact, occur.

10. Multiplier Effect

The general methodology employed in nearly every impact study involves a calculation of three sets of impacts: (1) direct impacts, which refer to the immediate gains or losses associated with the project being studied; (2) secondary impacts, which are the sum of the indirect effects on the community (or region) resulting from infrastructural changes brought about by the direct impacts; and (3) induced impacts, which are the sum of the dynamic effects (generally income) induced through the community or region by direct and secondary impacts.

The multiplier effect refers to the overall cumulative secondary or tertiary impact on regional (or national) benefits resulting from a change in primary or direct benefits (i.e., income injection or withdrawal) to a region. A regional multiplier is a frequently used economic tool for measuring and assessing the overall, total impacts of potential economic and transportation projects and policies. (Isard, 1975)

A considerable amount of the economic literature has been devoted to regional and local studies which have estimated multipliers for a wide variety of policy alternatives. These studies vary in scope, objectives, and methodologies, using techniques ranging from elaborate input/output methods to simple mail questionnaires. While many earlier studies had centered on the impacts of change in railroad service, an increased number of recent studies have focused on urban land development and local transportation policies (Matthew et al). Despite the variety of approaches taken in the literature to estimate the magnitude of the multiplier value (i.e., the value by which income injection is multiplied to give total benefit) the final estimated values for k_r tend to group in a fairly narrow range: from 1.5 to 2.3 for regional studies (and lower for local). Therefore, it should be noted that it is possible that the overall benefits (or losses) (associated with integrated paratransit) can be much higher (or lower) than direct impacts would indicate. However, because the multiplier effect really is a tertiary impact, it has not been considered in this study.