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BENEFIT-COST ANALYSIS OF INTEGRATED PARATRANSIT SYSTEMS
Volume 1: Executive Summary

Multisystems, Inc.
Cambridge MA 02138

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FINAL REPORT

Trans Systems Center

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
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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 first of six volumes documenting this study. This volume is intended to serve as a summary of the entire study.

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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.

The Final Report has been divided in this manner because of the sheer bulk of the material covered. The reader interested in obtaining a complete understanding of the study is urged to read all six volumes. However, each of the volumes is designed to serve as a stand-alone document.

A complete Bibliography is included in Volumes 1 and 3.
A Glossary of Items is included in Volume 1.

This is Volume 1 - Executive Summary and was prepared by Multisystems, Inc. It is a summary of the entire study.

Summary of Conclusions

Integrated Paratransit (IP) is a concept which involves the integration of conventional fixed-route transit with flexibly routed paratransit services to provide the most effective area-wide transit coverage. The "Benefit-Cost Analysis of Integrated Paratransit Systems" systematically estimates the benefits and costs associated with different IP options in different settings and compares these results with those of other transportation alternatives.

Based on the results of the various components of analysis in this study, a variety of conclusions about IP service can be reached.[1] The conclusions suggest that in some circumstances integrated paratransit may be an effective strategy for improving overall mobility. The conclusions presented here are abbreviated answers to the first 14 questions about IP service and its alternatives posed in Chapter 6 of this volume. The reader is directed to Chapter 6 for a complete set of questions and answers.

1. Generally, IP with fares closer to transit than exclusive-ride taxi will result in net paratransit operating deficits.

2. In a number of settings considered, the benefits of IP, such as reduced auto expenditures and increased employment, appear to offset the deficits. However, this result is dependent upon relatively high productivities of at least 9 passengers per vehicle-hour and/or low operating costs of under $11. per vehicle-hour.

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[1] The reader is cautioned to recognize that the answers provided are based on a limited set of analyses. Although the study has attempted to consider as wide a range of service and setting types as possible, clearly not all possible permutations have been tried. As a result, some conclusions may not prove true in all cases.

3. Checkpoint many-to-many service, route deviation service, automated doorstep many-to-many service with high vehicle densities, and vanpool service appear to be among the most promising paratranist concepts.

4. The elderly and persons from zero-auto households are major markets served by IP. Persons with two or more automobiles would receive all of the benefits of reduced auto expenditures if IP were implemented.

5. At population densities between 3,000 and 5,000 persons per square mile, IP service appears superior to fixed route service. Between 5,000 and 6,000 persons per square mile, the advantages appear to be equal. Below 3,000 persons per square mile, transit cannot be economically provided, in general. Above 6,000 persons per square mile, fixed route service appears to be more cost effective than paratransit service.

6. Implementation of IP service in areas previously unserved by transit is institutionally easy and tends to achieve a significant increase in mobility. Replacement of unproductive fixed routes with IP can be extremely cost-effective but may be institutionally infeasible. The provision of overlay fixed-route/paratransit service results in high quality service but may result in high costs per marginal passenger.

7. Raising fares (probably beyond $.25 per trip) may be counterproductive. Free transfers from feeder services to line-haul services encourage paratransit use, but general provision of free transfer may cause the feeder services to be overutilized.

8. Given present population densities and automobile operating costs, IP did not reduce automobile usage by more than 1 or 2 percent. However, IP did substantially increase total transit ridership, by up to 70 percent in some cases.

9. IP will not have a <u>significant</u> effect on vehicle-miles travelled, fuel consumption or air pollution.

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15. Supplementary Notes Other volumes in the study are 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;" and Volume 6: "Technical Appendices", with respective report numbers of UMTA-MA-06-0054-79-6 through UMTA-MA-06-0054-79-10.

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 report, Volume 1, is the first of six volumes documenting this study. Volume 1 is intended to serve as a summary of the entire study.

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10. Paratransit can play a significant feeder role in a system with coordinated transfers. Such a service works best with feeder trip lengths which are short as compared to the line-haul trip length.

11. The introduction of IP service may reduce taxi industry revenue (approximately 10 percent) and profit (30-40 percent). Contracting with the private sector to provide portions of IP service, however, should more than offset this loss of exclusive-ride business in most cases.

12. Although user-side subsidies for exclusive-ride taxi service are generally quite expensive, such subsidies for the elderly and handicapped may prove less expensive on a per-passenger basis than specialized services exclusively for those groups.

13. Urban areas with population under 500,000 may be more likely to institute large scale IP systems because of lower wage levels, less severe institutional constraints, and less extensive existing fixed-route service. However, in larger urban areas, IP may be viewed as the best way to equitably serve suburban areas.

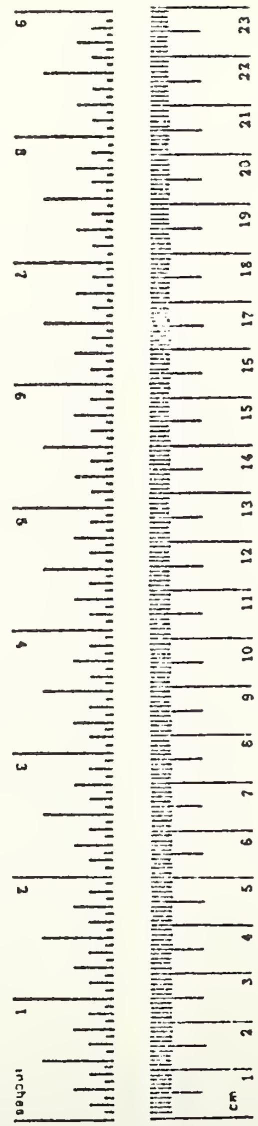
14. Given current economic and demographic projections, the impacts of IP will be very similar to those predicted for 1980.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

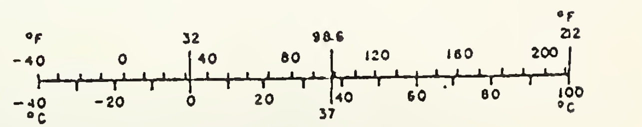
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	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
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Chapter 1

Introduction

1.1 Study Objectives

Paratransit, the "family of transportation services between exclusive-ride automobile and conventional fixed-route transit," is a concept which has become increasingly popular over the past decade. Paratransit services have been identified as offering the potential for serving low density development patterns, meeting the mobility needs of the elderly and handicapped, and reducing peak-hour congestion through ride sharing. The concept of integrated paratransit (IP) has evolved with the recognition that different transit modes and operating policies are most advantageous under different conditions. By integrating paratransit services with conventional fixed-route services, letting each do what it can do best, effective areawide coverage transit may be achieved.

Many different types of paratransit services have been implemented over the past ten years. A variety of transit/paratransit integration strategies have been attempted or suggested. The experiences to date have provided valuable insight into the potential benefits and costs associated with IP. The study reported here was designed to utilize these experiences to begin to assess the potential impacts of integrated paratransit services implemented on a wide scale. Specifically, this study represents the first systematic attempt to estimate the benefits and costs of a wide range of different IP options in different settings. The output of this study is intended to identify promising IP concepts and strategies and guide local decision makers toward rational decisions regarding IP implementation.

1.2 Study Methodology

The basic approach utilized in estimating the benefits and costs associated with IP implementation involved the analysis of a range of IP and conventional transportation service scenarios (i.e., hypothetical systems) in a variety of settings. The settings selected were actual urban areas, each representative of a larger group of areas. The seven settings are intended to be representative of all standard metropolitan statistical areas (SMSA's) in the United States, with the exception of New York City. The IP scenarios developed for each setting were based on local setting characteristics. However, the motivating force guiding the development of the scenarios was the necessity to test different IP service concepts and configurations. No attempt was made to design the "best" scenario for each setting, but different alternatives (i.e., different system designs) were analyzed within each setting. Data on the market characteristics of existing paratransit and integrated paratransit systems, as well as data on the relationships between system and setting types, were used in the generation of scenarios. A classification scheme, distinguishing IP systems on the basis of a number of key factors, was used to ensure that as wide a range of IP options as possible was analyzed. This is described in detail in Volume 2 of this series of reports.

In addition to the IP scenarios, conventional fixed-route bus and exclusive-ride taxi scenarios were designed and analyzed for each setting. Each fixed-route alternative was designed to result in either comparable coverage, cost, or patronage to the corresponding IP alternative, in order to determine the circumstances under which fixed-route service is superior to IP and vice versa. The taxi alternatives were designed to determine the extent to which expansion of, or improvement to, taxi service can reduce the need for expanded mass transportation services.

A number of modelling tools, combined with a base of empirical data, were used to project costs, ridership, and other impacts of these scenarios. These impacts are presented as a set of benefits and costs of the alternatives. The analysis is not a traditional benefit-cost analysis; no attempt is made to calculate a single "net-benefits" figure or "benefit-cost ratio." Because the implementation of a transportation service impacts a number of different groups differently, it is neither possible nor desirable to add or subtract different costs snd benefits. Instead, the impacts are displayed in an "impact-incidence matrix" format. This allows the various impacts to different groups to be viewed, resulting in a clearer understanding of the overall distribution of the costs and benefits. This, in turn, will enable local decisions regarding IP service implemenation to be based on local objectives concerning different impact groups.

To better understand the factors that influence the implementation of IP services on a local level and to provide a better basis for projecting the "penetration" of IP services, a series of seven in-depth case studies of actual IP system implementations was carried out. These analyses led to the identification of a set of recurring themes which seem to influence IP implementation.

As a final element of the study, the impacts of a variety of technological innovations on IP service were assessed.

All results are summarized in the remainder of this volume. Section 2 discusses the impact-incidence/benefit-cost framework. The scenario analyses are summarized in Section 3. Issues in community acceptance are discussed in Section 4. The impact of technological innovation is discussed in Section 5. Finally, major conclusions of the project are summarized in Section 6.

Chapter 2

Estimation of Benefits and Costs

The major outputs of this study are estimates of the costs and benefits of different integrated paratransit systems and alternatives to IP. As noted in the previous section, however, this study does not involve traditional benefit-cost analysis, since no single net benefits estimate or benefit-cost ratio is produced. The decision to implement an IP system cannot be made solely on the basis of such a single measurement. Instead, a decision maker must weigh the impacts of IP on a variety of different segments of society, within both the public and private sectors. As such, the results are presented in what is traditionally known as an "Impact-Incidence Matrix," or a cross-tabulation of impacts by impact groups. In this study, because each impact group sees very different impacts, the results are actually presented in a listing rather than a matrix. Figure 2.1 lists the impact groups and impacts considered. This list of impacts was selected from a wider list initially considered, with the selection based on computability, a priori judgment of which impacts would have significant values, and preliminary analysis which indicates that other impacts were extremely small. Thus, rather than being a list of all possible impacts of IP and other services, the list contains a variety of potentially major impacts. All impacts computed are marginal impacts, representing the change from the base case brought about by changes in the transportation system. Where meaningful, the percent change has been calculated. All impacts are presented as <u>annual</u> values.

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

Figure 2.1

Impact-Incidence Matrix Cells

As an example of why it is important that all impacts be delineated, consider that a local city government may be interested in:

- the change in mobility, particularly by the elderly;
- the change in vehicle-miles travelled, fuel consumption, and emissions;
- the change in employment opportunities, and;
- the required local subsidy.

The local government may or may not be interested in impacts such as the change in consumer surplus,[1] the number of chauffeur trips eliminated, the change in automobile expenditures, and the change in taxi industry revenue and profit. This will depend on local objectives and perceptions of the importance of such measures.

For its part, local transit management may be interested only in the number of new transit trips, the change in net operating and total cost (and the net costs per new transit rider), and the impact on employment within the transit industry. Conceivably, transit management would protest the implementation of a system if it reduced transit employment, even if the overall employment in the community were to increase. Of course, the importance placed on a particular impact, even by a single group, may vary from setting to setting.

Note that some impacts are assigned to more than one impact group. For example, the operating deficit is assigned to the IP operator, while the local and Federal shares of the subsidy are assigned to the local and Federal governments respectively. Similarly, lost taxi revenue may be projected as a cost, while the same value is a component of the overall consumer surplus benefit. To avoid double counting, it is important to consider each of the impact groups independently, and not add impacts across groups.

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[1]The change in consumer surplus is a measure often used in benefit-cost and other economic analysis. Used in the context of this study, it provides a measure of the change in overall transportation cost, reflecting both travel time and fare changes, seen by the users of a newly introduced (or improved) transportation service. A more complete description of this measure can be found in Volume 6 of this series of reports.

Chapter 3

Scenario Development and Anlaysis

3.1 The Settings

A total of seven settings was selected for the scenario analysis. Each setting is intended to be prototypical of a larger group of urban areas which share some basic similarities. The groups of similar urban areas were developed, using a cluster analysis approach. Essentially, this approach groups together areas which display similarities along a set of predefined dimensions; in this case, such factors as population, transit usage, etc. (This task is described fully in Volume 2 of this series of reports.) The seven selected settings combined are intended to be representative of all standard metropolitan statistical areas (SMSA's) (urbanized areas with populations greater than 50,000) in the United States, with the exception of New York City. The general characteristics of the seven groups of urban areas are described in Table 3.1.

In keeping with the concept of each setting representing a prototypical urban area, the settings are not identified. Instead, a set of pseudonyms have been adopted. These names are intended to convey some information about one of the characteristics which is common to many, or all, of the urban areas in the represented group. For example, since virtually all of the cities in Group #1 are located in the south, this setting has been named "Southern Belle."

Despite the use of pseudonyms, all site descriptive data utilized were real data. In addition, the base case transit system for each setting is the actual system in operation in that setting. Some key characteristics of each of the settings are presented in Table 3.2 and the setting are illustrated (all to the same scale) in Figure 3.1.

Table 3.1

Characteristics of Urban Area Groups

Group	General Characteristics
Group 1	Moderately small, mostly southern cities, with low central city density; high concentration of single-family housing in urban area, and low income. "Most representative": Augusta, Georgia.
Group 2	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.
Group 3	Small to medium-size cities, predominately southern and south-western, 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.
Group 4	Medium-size cities, with low to medium 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.
Group 5	Moderately small, mostly northeastern manufacturing cities, with a low percentage of single-family dwellings, very high elderly population, low auto ownership, relatively low income, and relatively high transit use. "Most representative": Portland, Maine.
Group 6	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.
Group 7	Major metropolitan areas with large population, high density, moderately low single-family dwellings, low auto ownership, and high transit use. "Most representative": San Francisco, California.

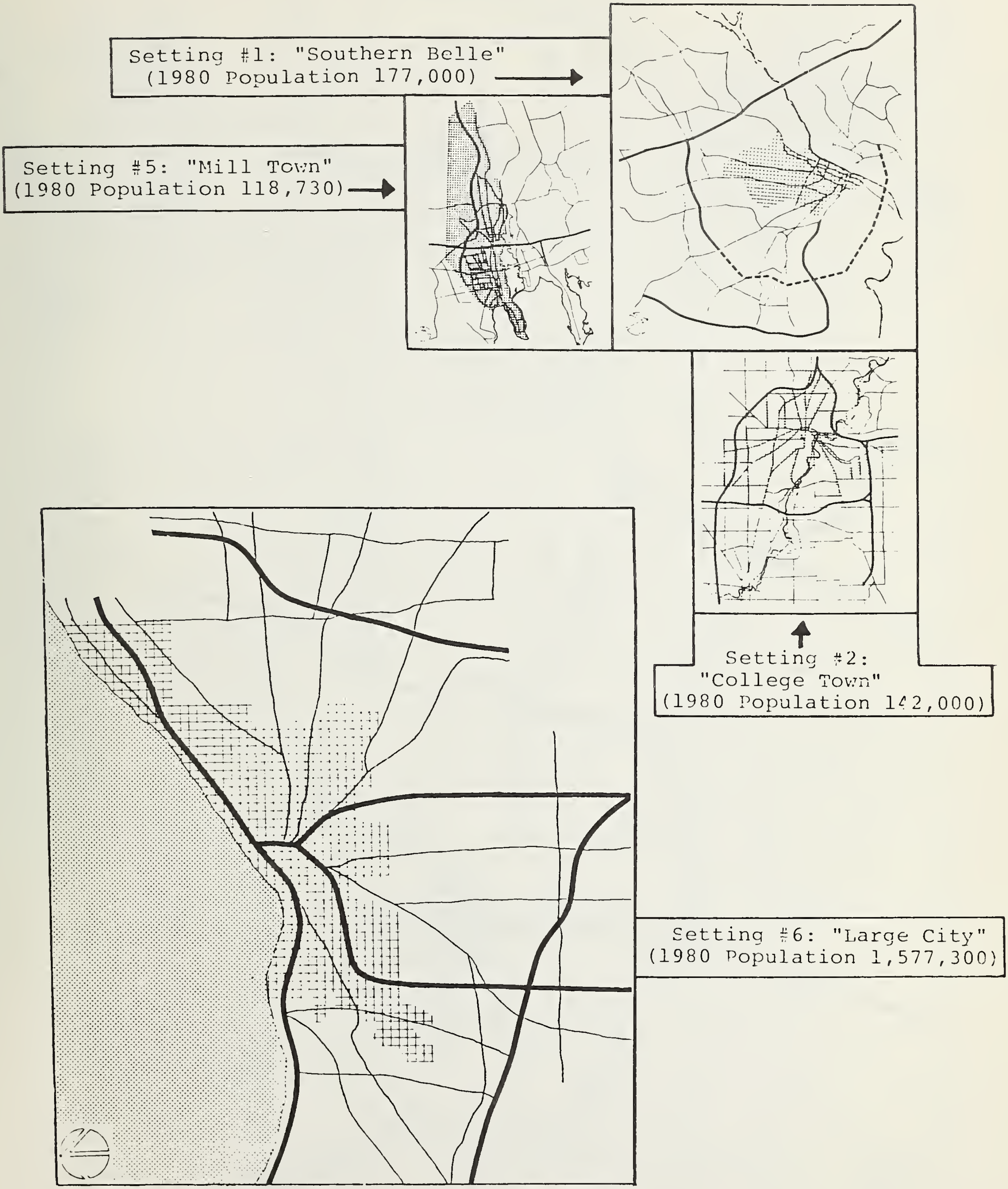
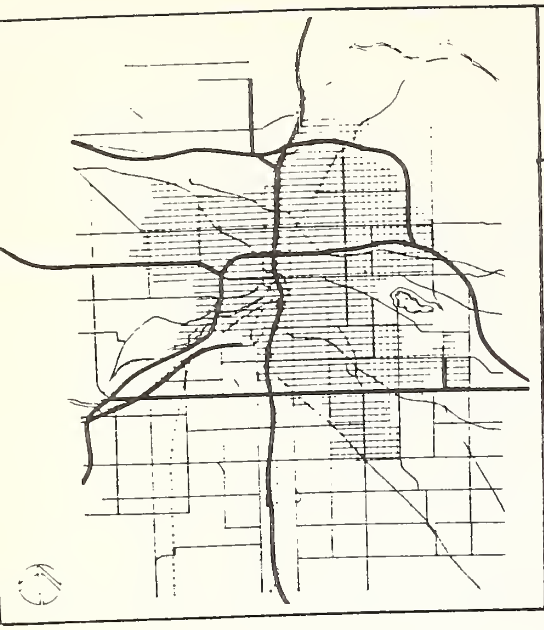


FIGURE 3.1 SCENARIO ANALYSIS SETTINGS

(Scale: 1" = 6 mi.) (shaded areas represent central cities)

Left: Setting #4:
"Mid-American City"
(1980 Population
339,000)



Right: Setting #3:
"Sun City"
(1980 Population
460,800)

Below: Setting #7:
"Metropolis"
(1980 Population
2,408,000)

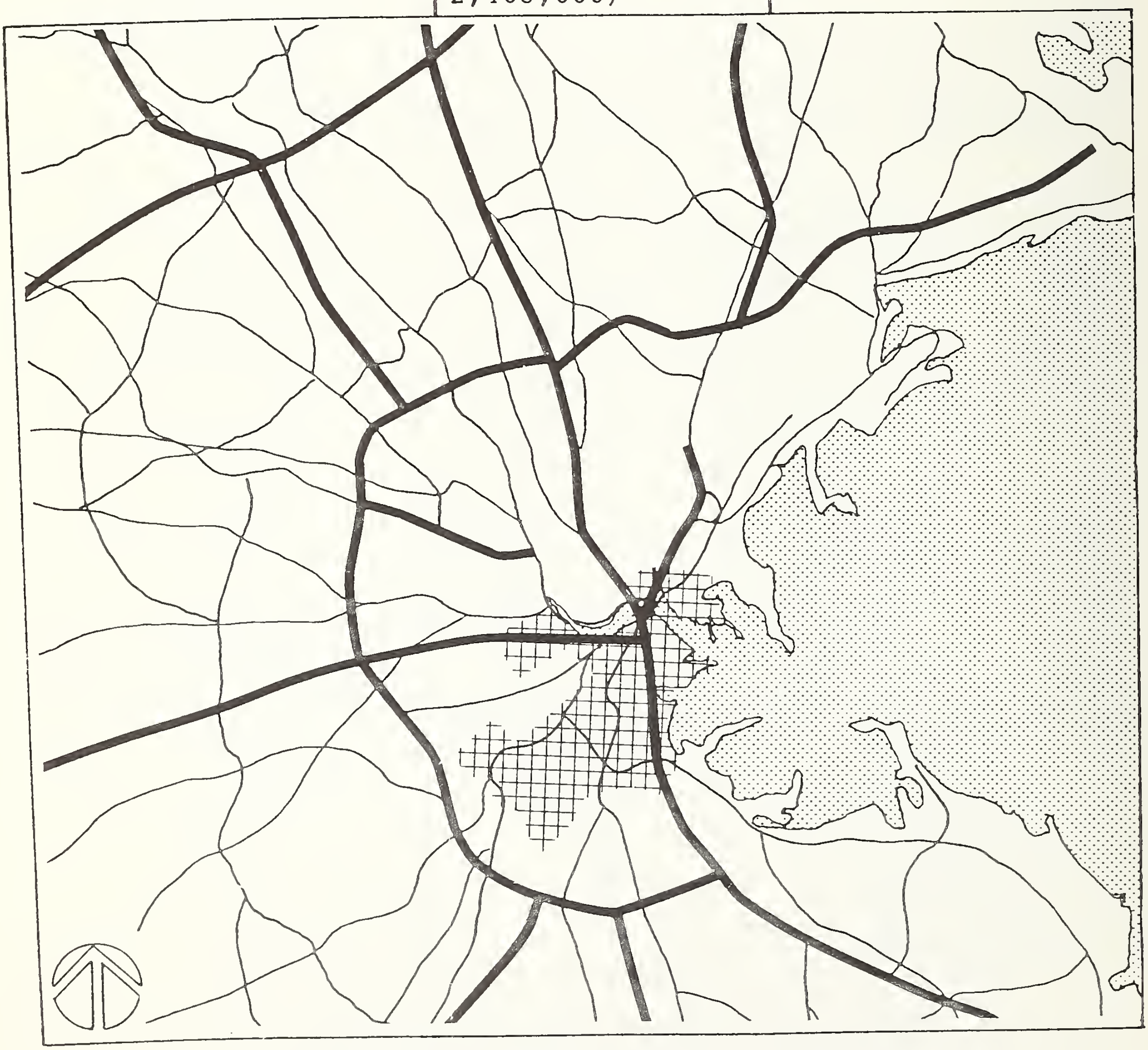


FIGURE 3.1 SCENARIO ANALYSIS SETTINGS (CON'T.)

Table 3.2

Key Setting Characteristics

Setting	Projected 1980 Central City Population	Central City Pop. Density (persons/sq mi)	Projected 1980 Urban Area Population	Urban Area Pop. Density (persons/sq mi)	1980 % Elderly (Urban Area)	Annual Transit Ridership (1976)
1: "Southern Belle"	55,300	5530	177,000	3210	8	1,910,000
2: "College Town"	100,000	5260	142,000	3260	5	1,815,000
3: "Sun City"	408,442	4300	460,800	3460	6	3,720,000
4: "Mid-American City"	202,447	4509	339,000	3025	12	2,920,000
5: "Mill Town"	93,850	6900	118,730	4240	13.5	2,860,000
6; "Large City"	586,000	7720	1,577,300	3535	13	92,944,578
7: "Metropolis"	609,000	13200	2,408,000	4816	10	140,000,000

3.2 IP Scenario Development

A minimum of two IP scenarios was developed for each setting for the year 1980. The design of the IP systems to be tested in each setting was based on rough guidelines concerning population density, the nature and extent of fixed-route transit service, and the location of employment and other major activity centers. However, the motivating force guiding the development of the scenarios was the necessity to test different IP service concepts and configurations. Each of the scenarios developed is "reasonable," in the sense that the levels of coverage, vehicle densities, service concepts, etc. are not too dissimilar from those of existing or proposed services. No attempt was made to develop "best" or optimum systems for each setting. In the first place, such a development effort would have requied intimate familiarity with the service area and sufficient resources to test a wide range of options, neither of which could be achieved within the context of this study. Secondly, it is unclear whether the development of "optimum" systems would have resulted in realistic projections of impacts since, in all likelihood, many of the systems which actually would be implemented in a given city would not prove to be the best possible design. Moreover, the intention of the study was to assess the impact of different IP systems designs and policies, rather than to design the best IP system for each setting. Bear in mind that at least two IP scenarios were considered for each setting and that the dominant alternative has been identified. Furthermore, comparisons across settings will allow additional conclusions to be drawn regarding the types of services which may make more sense in portions of a given area; e.g., comparisons may be made between different areas with similar population densities. Thus although no explicit attempt is made to develop optimum alternatives, the analyses do identify preferable options for each setting. Some scenario/setting characteristics are provided in Table 3.3, while the scenarios are more fully described in Table 3.4.

Table 3.3

Comparison of 1980 IP Setting/Scenario Characteristics

	1980 Urban Area Population	1980 Population of Paratransit Service Areas	Area of Paratransit Service Areas (sq. mi.)	Service Area Population Density	Number of Paratransit Vehicles
"Southern Belle"	177,000				
Scenarios A, B		100,700	31.6*	3,111	46*
"College Town"	142,000				
Scenarios A, B, C		78,000	16.5**	4,730**	42**
"Sun City"	460,800				
Scenario A		100,000	26.7	3,745	16
Scenario B		100,000	26.7	3,745	19
"Mid-American City"	339,000				
A, B, C, D Peak		54,000	26.1**	2,070**	26**
A, B, C Off-peak		151,000	55.2	2,735	31
D Off-peak		304,000	84.3	3,606	53
"Mill Town"					
Scenario A	118,730	18,400	14.1	1,305	6
Scenario B		12,500	9.8	1,275	4
"Large City"	1,577,300				
Scenarios A, B		1,577,300	434.8	3,627	229
"Metropolis"	2,408,000				
Scenario A		85,926***	52.0	5,265	38
Scenario B		156,044***	108.0	4,913	70

* Vanpool excluded

** Special areawide TH service excluded

***Includes only eligible population (i.e., TH in one zone)

Table 3.4

Characteristics of 1980 IP Scenarios

Setting	IP Scenarios
1: "Southern Belle"	A: Checkpoint many-to-may service in 3 suburban zones. Checkpoint route deviation service in fourth zone. Publicly operated. B: Doorstep many-to-many service in 3 suburban zones. Doorstep route deviation service in fourth zone. Publicly operated. Vanpool to major employers in A and B.
2: "College Town"	A: Cycled many-to-one service in 14 zones throughout central city, feeding four fixed routes. Publicly operated. B: Doorstep many-to-many system (flat fare) overlaid on fixed route. Publicly operated. C: Doorstep many-to-many system (mileage based fare) overlaid on fixed route. Privately operated.
3: "Sun City"	A: Route deviation replacing 6 parallel fixed routes in 1 zone. Doorstep many-to-many replacing some fixed routes in 2nd. Publicly operated. B: Services same as in A. Many-to-many service privately operated.
4: "Mid-American City"	A: Peak hour cycled many-to-one feeder service in 4 suburban zones. Some fixed routes shortened. Off-peak many-to-many service in expanded zones. Fixed routes cut back. 25¢ paratransit fares. Publicly operated. Privately operated areawide door-to-door service for TH. B: Services same as A. Paratransit fare increased to 75¢. C: Services same as A. Paratransit fare increased to $1.25. D: Peak hour service and fare as in B. Off-peak DRT service expanded throughout area, fixed route substantially cut back.

Table 3.4 (Cont.)

Characteristics of 1980 IP Scenarios

Setting	IP Scenarios
5: "Mill Town"	A: Checkpoint cycled many-to-one feeder service in four suburban zones. Jitney shuttle replaces 1 fixed route. Publicly operated. B: Doorstep many-to-many in 1 large suburban zone. Jitney service as in A.
6: "Large City"	A: Doorstep many-to-many service overlaid on fixed routes in many zones throughout urban area. Inner zones publicly operated, outer zones privately operated. No free transfer. B: Service same as in A, but free transfer allowed.
7: "Metropolis"	A: Various DRT services in two suburban zones. TH subscription service in inner-city area. All privately operated. B: Expansion of A, including: Privately operated feeder to commuter rail in two suburban zones, with off-peak circulator service in one. Publicly operated rapid transit feeder and off-peak circulator in one inner suburban zone. Taxi company operated shared-ride feeder to express bus in one inner suburban zone.

3.3 Alternatives to IP

In addition to comparing the impacts of different IP services, the study compared the impacts of IP systems with the impacts of more conventional fixed-route and exclusive-ride taxi services.

The fixed-route bus alternatives were introduced in the service areas in which paratransit services were analyzed. Extended fixed-route bus options range from fairly low coverage and frequency to fairly high coverage and frequency, in an attempt to emulate IP service quality. The intention of the analyses is to help identify the circumstances in which fixed route service is superior to IP, and the circumstances in which IP is superior. In most cases, the fixed-route alternatives were compared to the "best" of the IP scenarios considered. The extended taxi options included alternatives with no public involvement (e.g., expanded vehicle fleet size) as well as alternatives with some public involvement (e.g., user-side subsidy, capital grants). The alternatives developed for all settings are characterized briefly in Table 3.5

3.4 Year 2000 Scenarios

In addition to the year 1980 analysis, a number of IP scenarios were specified for each setting for the year 2000. These analyses were intended to consider the potential impact of IP in the (near) future, when population density, household characteristics, age characteristics, and transportation costs can be expected to change. In some cases, the year 2000 IP scenario was assumed to be a continuation of the 1980 system. The intention behind these scenarios was to test whether the same IP concept will have different impacts under future conditions. In other cases, the systems were changed slightly in response to projected development patterns and/or the ability of paratransit to act as a stimulant of transit demand leading to the need for a higher capacity system.

Table 3.5

Characteristics of Alternatives to IP

Setting	Extended Fixed Route	Extended Exclusive-Ride Taxi
1: "Southern Belle"	Radial routes extended to suburbs.	Area wide user-side subsidy. General public fare reduced 25%; elderly fare reduced 75%.
2: "College Town"	Extensive city-wide net work. Radial and crosstown.	Capital subsidy for taxi fleet expansion.
3: "Sun City"	Extensive coverage in two service areas.	Effective user-side subsidy in two service areas. Fare reduced to 35¢.
4: "Mid-American City"	Expanded coverage in suburban areas, including crosstown routes.	Low-interest loans used to aid industry in expanding fleet.
5: "Mill Town"	Expanded coverage into portion of suburban areas.	Subsidized taxi feeder service in three suburban zones.
6: "Large City"	Expanded service in suburban areas. Expanded frequency in central city.	User-side subsidy. Fare 25% within community zones.
7: "Metropolis"	Expanded service in suburban portions of urban area.	User side subsidy to provide feeder service to major rail transit and express bus service for a 25¢ fare.

The analysis of year 2000 scenarios required many assumptions about future conditions. To the fullest extent possible, other studies which focussed on future conditions were used to estimate the extent of changes that will occur by the year 2000. Local projections of demographic characteristics were used for each setting, although, in some cases, the projections were updated by the study team. Because of particular uncertainty about future energy availability and its influence on automobile costs and ownership, two different alternative futures were considered for each setting. The first, or base case, assumed that auto ownership patterns do not change dramatically between now and 2000. The second, or "reduced auto ownership" case, assumed that energy supply constraints and/or auto use disincentives drive up the cost of automobile operations by 40%. Projections for both of these alternatives are taken from a report prepared for the Office of Technology Assessment of the U.S. Congress.[1] Year 2000 setting/scenario characteristics are summarized briefly in Table 3.6.

3.5 Summary of Scenario Analysis Results

Key impacts of each of the 1980 IP scenarios are compared in Table 3.7, while the impacts of the alternatives to IP are summarized in Table 3.8 and the impacts of the year 2000 IP scenarios are listed in Table 3.9. Although single values are presented, these should be interpreted as representing a mean value with a range around the value shown.[2] All economic impacts shown are in 1977 dollars.

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[1]System Design Concepts (1977), Technology Assessment of Changes in the Use and Characteristics of the Automobile: Draft Final Report, prepared for the Office of Technology Assessment, U.S. Congress.

[2]The sensitivity of the results to variations of certain key impacts is discussed in Volume 6.

Table 3.6

Comparison of IP Setting/Scenario Characteristics, Year 2000

	Urban Area Population	Avg. Autos per Household Level 1	Avg. Autos per Household Level 2	Population of Paratransit Service Areas	Area of Paratransit Service Areas (sq. mi.)	Population Density	Number of Paratransit Vehicles
"Southern Belle"	226,000	1.20	1.10	85,800	37.2*	2,306*	33*
"College Town"	177,000	1.67	1.60	122,000	22.5**	5,420**	65**
"Sun City"	692,690	1.61	1.47				
Scenario A				195,000	41.9	4,650	40 (58 in A-2)
Scenario B				68,000	21.5	3,160	36 (42 in B-2)
"Mid-American City"	389,000	1.29	1.18				
Peak				74,000	26.1**	2,835**	26**
Off-Peak				184,000	55.2	3,333	31
"Mill Town"	127,736	.98	.89	27,300	18.5	1,475	8
"Large City"	1,623,100	1.17	1.07	1,029,000	361.1	2,850	100
"Metropolis"	2,690,000	1.12	1.03	135,000	27.5	4,900	28

* Vanpool service excluded
**Specialized transportation handicapped (TH) service excluded

Table 3.7

Comparison of Year 1980 Scenario Results

Impact/Measure	"Southern Belle"		"College Town"			"Sun City"		"Mid-American City"				"Mill Town"		"Large City"		"Metropolis"	
	A	B	A	B	C	A	B	A	B	C	D	A	B	A	B	A	B
Change In Consumer Surplus ($000)	+734.8	+493.2	+160.5	+186.4	+149.3	+114.1	+114.1	+224.8	+167.6	+144.6	+267.7	+33.1	+13.1	+2,719.1	+2,772	+185	+660
New Transit Trips (000)/% increase	1280/ +67 (+251 vp)	1140/ +59.7 (+251 vp)	487/ +34.3	880/ +62	689/ +48.5	186.8/ +5.8	186.8/ +5.8	761/ +26	675.2/ +23	634.5/ +22	875/ +30	143/ +5.0	72.3/ +2.6	4,205.1/ +4.6	4,253/ +4.6	234/ +0.2	808/ +0.6
Induced Trips (000)	131	81	97	176	138	26.6	26.6	166.2	146.8	137.8	171.7	37	22.4	846.1	820.9	84	112
VMT (000 mi)/% change	-2498/ -0.8	-2172/ -0.7	+568/ +0.6	+220/ +0.2	+350/ +0.4	-352/ -0.04	-216/ -0.02	-95/ +0.01	+86/ +0.01	+167/ +0.02	+114/ +0.02	+10/ +0.01	+10/ +0.01	-3,064/ -0.06	-3,228/ -0.07	+538/ +.0007	+755/ +.015
Fuel Consumption (000 gal.)	-64.4	-41.7	+102.2	+79.9	+87.6	-33.8	-27.4	+48.6	+62.7	+67.5	+83.7	+7.5	+3.9	+131.9	+125.7	+87.9	+165
Employment: Jobs/Payroll ($000)	+70/ +568	+81/ +642.8	+77/ +920.6	+85/ +1000	+86/ +473.7	+8/ +91.5	+10/ +60	+61/ +671.3	+71/ +688.6	+72/ +695.1	+91/ +984.5	+7/ +93.8	+5/ +74.5	+316/ +3,907.8	+320/ +3,933.7	+47/ +533	+119/ +1675
Auto Expenditures ($000)	-322	-226	-380.6	-692.6	-590.7	-182	-182	-369	-299	-153	-738	-51	-23	-3,330	-3,687	-173.1	-319
Transit Operating Cost ($000)	+934	+1,002	+2,498	+2,698	+878	+128	+138	+1,140	+1,140	+1,140	+1,540	+172	+121	+9,376	+9,376	+692	+2,165
Net Transit Operating Cost ($000)	+279	+426	+2,377	+2,152	+270	+89	+162	+933	+842	+784	+1,140	+146	+114	+7,640	+7,887	+526	+1,780
Net Transit Total Cost ($000)	+559	+706	+2,686	+2,486	+604	+145	+172	+1,206	+1,115	+1,057	+1,566	+174	+132	+8,280	+8,527	+753	+2,250
Net Operating Cost/Net Total Cost per New Transit Trip	.22/ .44	.37/ .62	4.88/ 5.52	2.45/ 2.83	.39/ .88	.48/ .77	.87/ .92	1.23/ 1.58	1.25/ 1.65	1.24/ 1.67	1.31/ 1.79	1.02/ 1.22	1.58/ 1.83	1.82/ 1.96	1.85/ 2.00	2.25/ 3.22	2.20/ 2.78
Net Total Cost per Induced Trip	4.27	8.72	27.69	14.13	4.38	5.45	6.46	7.26	7.60	7.67	9.12	4.70	5.89	9.79	10.39	8.96	20.09
Taxi Industry Revenue ($000)/ % Change	-241/ -10.7	-190/ -9.5	-86.3/ -10.1	-101.7/ -11.9	+787.5/ +92.2	-75/ -7.4	+235/ +23.2	+41.8/ +3.4	+70.6/ +5.7	+81.5/ +6.6	+18.6/ +1.5	-60.1/ -6.3	-27.6/ -2.9	+3,439.2 +46.4	+3,482.7/ +47.0	-50/ -0.05	-100/ -0.1
Taxi Industry Profit ($000)/ % Change	-38.3/ -40.2	-34.1/ -35.8	-15.4/ -37.9	-18.2/ -44.7	+63.6/ +156.2	-13.4/ -27.8	+49.6/ +102.9	-15.2/ -25.6	-10.1/ -17.1	-8.1 -13.7	-19.4/ -32.8	-10.7/ -23.6	-4.9/ -10.8	+713/ +203	+720.7/ +205.2	-9/ -0.2	-17.9/ -0.4
Parking Spaces Required	-650	-605	-67	-92	-70	-25	-25	-162	-141	-133	-208	-17	-8	-175	-185	-63	-375

vp = vanpool

Note: All results represent annual change from the base case.

Table 3.8

Comparison of 1980 Alternatives to IP

Impact/Measure	"Southern Belle" Extended Fixed Route	"Southern Belle" Extended Taxi	"College Town" Extended Fixed Route	"College Town" Extended Taxi	"Sun City" Extended Fixed Route	"Sun City" Extended Taxi	"Mid-American City" Extended Fixed Route	"Mid-American City" Extended Taxi	"Mill Town" Extended Fixed Route	"Mill Town" Extended Taxi	"Large City" Extended Fixed Route	"Large City" Extended Taxi	"Metropolis" Extended Fixed Route	"Metropolis" Extended Taxi
Change in Consumer Surplus ($000)	+152.4	+13.3	+117	+39	+117.1	+53.8	+439.5	+378.9	+38.5	+11	+3,996	+1,194	+383	+373
New Transit Trips (000)/% increase	607.4	NA	712.4/ +50.2	NA	194.5/ +6.0	NA	+1,143.6/ +39.2	NA	61.5/ +2.2	NA	6,449.7/ +7.1	NA	+416/ +0.4	NA
Induced Trips (000)	54.7	20.4	106.9	5.0	17.6	12.8	171.4	27.1	10.5	10.3	838.5	325.8	25	22
VMT (000 mi)/% change	-263/ -0.08	+602/ +0,02	+980/ +1.1	+1000/ +1.1	+113/ +0.01	+178/ +0.02	-704/ -0.1	+1900/ +0.3	+35/ +0.02	+61/ +0.05	+4000/ -0.08	+4200/ +0.08	+191/ +0.004	+1,644/ +0.02
Fuel Consumption (000 gal.)	+75.8	+69	+250.6	+101.9	+63.5	+20.6	+130.9	+210.9	+10.3	+7.6	+203.8	+453.6	+56.7	+171.3
Employment: Jobs/Payroll ($000)	+56/ +435.6	+23/ +314	+156/ +176.7	+31/ +53.5	+25/ +238.9	+13/ +88.6	+68/ +820.9	+74/ +583.8	+6/ +77.1	+6/+45	+312/ +5950	+218/ +1200	+42/ +840	+75/ +644
Auto Expenditures ($000)	-49.1	-94.8	-496	0	-44.7	-43	-170.1	0	-49	-5.8	-2460	-115	-523	-46
Transit Operating Cost ($000)	+789	NA	+2,574	NC	+507	NC	+1,791	NA	+129.4	NC	+9660	NC	+1,450	NC
Net Transit Operating Cost ($000)	+637	NA	+2,390	NC	+446	NC	+1,414	+40	+121.3	NC	+8150	NC	+1,316	NC
Net Transit Total Cost ($000)	+858	+1,211.7	+2,900	+52	+527	+128	+1,798	+40,000	+166.4	+49.9	+9280	+2820	+1,583	+957
Net Operating Cost/Net Total Cost per New Transit Trip	1.05/ 1.41	NA	4.07	NA	2.29/ 2.71	NC	1.24/ 1.57	NA	1.97/ 2.71	NA	1.26/ 1.44	NA	3.16/ 3.80	NA
Net Total Cost per Induced Trip	15.69	59.40	27.13	10.48	29.88	10.04	10.49	1.48	15.80	4.84	11.06	8.64	63.32	43.50
Taxi Industry Revenue ($000)/ % change	-66.4/ -3.3	-542/ +26.2	-94.8/ -11.1	+89/ +10.4	-63/ -6.2	+147.7/ +14.5	-244.7/ -19.6	+972/ +66.3	-16.5/ -1.7	+55.8/ +5.8	-1870/ -25.3	+3420/ +44	-51.8/ -0.1	+1,083/ +1.2
Taxi Industry Profit ($000)/ % change	-11,900/ -12.5	+131.6/ +138	-17/ -41.8	-16/ -30.2	-11.3/ -23.4	+35/ +72.5	-43/ -73.9	+45/ +61.6	-3/ -6.6	+2.6/ +5.7	-334/ -95.1	+128/ +32.2	-9.3/ -0.2	+25/ +0.6

NA = Not Applicable
NC = Not Calculated

Note: All results represent annual change from the base case.

Table 3.9

Comparison of Year 2000 Scenario Results

Impact/Measure	"Southern Belle"		"College Town"		"Sun City"				"Mid-American City"		"Mill Town"		"Large City"		"Metropolis"	
	A-1	A-2	A-1	A-2	A-1	A-2	B-1	8-2	A-1	A-2	A-1	A-2	A-1	A-2	A-1	A-2
Change in Consumer Surplus ($000)	+607.0	+632.7	+564.8	+605.3	+556.5	+622.4	+492.4	+721.6	+49.9	+13.1	+36.2	+46			+490.5	+672.3
New Transit Trips (000)/% increase	940.5/ +38	+1,069/ +43	1,680.5/ +72	1,788.1/ +76	570.1/ +12.1	786.6/ +15.5	484.9/ +10.8	701.3/ +13.8	870/ +30	982/ +34	174.1/ +5.9	170.9/ +5.8	1,590.6/ +1.7	1,579.3/ +1.6	289.4/ +0.2	361.8/ +0.3
Induced Trips (000)	104.9	+120.7	362	370	65.2	95.3	58.2	92.8	141	164	41.5	37.1	261.8	307.7	10.6	13.2
VMT (000 mi)/% change	-2,592/ -0.5	-3,200/ -0.7	-1,544/ -0.5	-1,711/ -0.6	-2.2/ 0.1	-2.7/ -0.1	-2.0/ 0.1	-2.8/ -0.07	-2000/ -0.2	-2000/ -0.2	-391/ -0.2	-259/ -0.1	-2360/ -0.04	-2110/ -0.04	-1269/ -0.01	-6961/ -0.007
Fuel Consumption	-53	-55.5	-10.8	-4.9	-60.7	-56.1	-54.4	-57.5	-35.1	-26.4	+5.1	+9.8	-40.5	-20.2	-10.5	+16.8
Employment: Jobs/Payroll ($000)	+65/ +499.5	+61/ +469.5	+100/ +886.2	+98/ +871.9	+71/ +222.4	+25/ +321.2	+14/ +169.2	+22/ +275	+93/ +1,028	+90/ +993.8	+10/ +120.7	+9/ +117.6	+99/ +1,048.4	+86/ +915.9	+40/ +706.2	+49/ +866
Auto Expenditures ($000)	-326	-481	-696.6	-804	-463.1	-630.9	-486.6	-688	-733	-756	-132	-94	-1,110	-1,070	-462.8	-288.8
Transit Operating Cost ($000)	+769	+796	+1,827	+1,827	+669	+877	+524	+750	+1,574	+1,574	+231	+231	+3,018	+3,018	+584	+725
Net Transit Operating Cost ($000)	+402	+351	+987	+964	+441	+563	+330	+470	+1,167	+1,040	+198	+192	+2,130	+2,113	+432	+519
Net Transit Total Cost ($000)	+629	+578	+1,387	+1,364	+419	+541	+316	+456	+1,438	+1,311	+256	+250	+2,357	+2,340	+576	+679
Net Operating Cost/Net Total Cost per New Transit Trip	.43/ .67	.33/ .54	.60/ .80	.52/ .74	.77/ .73	.72/ .69	.68/ .65	.67/ .65	1.34/ 1.65	1.06/ 1.34	1.14/ 1.47	1.12/ 1.46	1.34/ 1.48	1.34/ 1.48	1.49/ 1.99	1.43/ 1.88
New Total Cost per Induced Trip	6.00	4.79	3.83	3.69	6.42	5.68	5.43	4.91	10.20	7.97	6.17	6.74	9.00	7.60	54.34	51.44
Taxi Industry Revenue ($000)/ % change	-186.9/ -4.8	-215/ -5.5	+1,556/ +126	+1,533/ +124	+565.4/ +23.1	+753/ +30.6	+434.4/ +17.4	+622.7/ +25.5	-12.7/ -0.7	-69.9/ +3.9	-90.7/ -7.7	-102.3/ -8.6	+2,064/ +20.2	+1,843.5/ +18.5	-35.2/ -0.03	-55.5/ -0.05
Taxi Industry Profit ($000)/ % change	-33.5/ -18.0	-38.5/ -20.7	+117.7/ +200	+113.4/ +193	+195.4/ +167.7	+296.1/ +255.1	+161.8/ +139.2	+260.1/ +224.4	-28.6/ -33.6	-38.8/ -47.7	-16.2/ -28.8	-18.3/ -32.5	+419.3/ +88.0	+379.8/ +79.8	-6.3/ -0.1	-9.9/ -0.2
Parking Spaces Required	-510	-570	-278	-275	-52	-52	-38	-37	-148	-175	-16	-16	-71	-65	-35	-44

Note: All results represent annual change from the base case.
Scenarios numbered 1 (i.e., A-1, B-1) represent base auto ownership cases.
Scenarios numbered 2 represent reduced auto ownership case.

To provide some indication of the results of the analysis, a brief summary of key results for each setting is provided below. The reader is cautioned, however, that it will probably be somewhat difficult to fully understand the results without reading the detailed scenario descriptions in Volume 3. For the most part, explanations of the results are not provided below, but are included in Chapter 6, "Conclusions."

3.5.1 Setting #1: "Southern Belle"

The checkpoint many-to-many service considered in IP Scenario A appeared to have greater positive impacts than the doorstep service provided in Scenario B. The deficit generated by IP Scenario A may be justified by the positive impacts from the overall viewpoint of the public sector, given the few negative impacts. The alternative resulted in a small energy savings but reduced taxi industry revenue by 10%.

The fixed-route alternative was unable to generate the same transit ridership increase[1] as IP, had less of an impact on consumer surplus, and resulted in a slight increase in fuel consumption. In general, the fixed-route alternative appeared to be less effective than IP Scenario A.

The user-side taxi subsidy generated many fewer trips than either IP or fixed-route and proved to be extremely expensive on a per-induced-trip basis.

Finally, the impacts of IP in the year 2000 did not appear to vary markedly from the impacts in 1980. The impacts were generally greater under the reduced auto ownership scenario; but even then, no significant differences emerged.

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[1]New transit trips represent all trips diverted to transit from other modes plus trips which previously had not been made at all (i.e. induced trips).

3.5.2 Setting #2: "College Town"

In this setting, areawide doorstep many-to-many service was shown to be a more effective alternative than cycled many-to-one services serving as feeders to a fixed-route network and, as such, had a lower net operating cost per new transit rider. The elimination of the transfer requirement served to increase both effective vehicle speeds and ridership in this setting. The extensiveness of the system, in terms of vehicles per squre mile, made it extremely expensive, except under conditions of private operation (Scenario C). In the latter case, the positive benefits could possibly be interpreted as offsetting the total deficit in the absence of other real costs.

An equally extensive fixed-route alternative appeared to be able to generate comparable ridership and have other impacts generally similar to those of IP. The net operating costs were approximately the same as in the publicly operated IP case.

The extended taxi alternative, in which only a capital subsidy was introduced, was projected to have only minor impacts. The taxi industry was projected to actually lose money in the short run, because of overexpansion, although this impact would probably be negligible once the system reached an equilibrium state.

As was the case in "Southern Belle," the impacts of IP are not projected to change markedly by the year 2000, even under the reduced auto ownership case.

3.5.3 Setting #3: "Sun City"

In this setting, route deviation seemed to be an extremely effective alternative in one area; the replacement of six, tightly spaced fixed routes with route deviation service reduced costs and increased ridership. The replacement of underutilized fixed-route service by many-to-many DRT service in another area also increased ridership, but at an increase in cost. Overall, the positive impacts of this relatively small-scale IP system appeared to justify the total deficit. Private operation in this case did not appear to be less expensive than public operation, partly because the public system has a relatively low hourly operating cost and partly because the demand levels made the 5-passenger vehicles used by the private operator less productive than the 12-passenger vans used by the public operator.

Expanded fixed-route service in this setting was able to attract the same ridership as IP but at a significantly higher cost.

The limited area user-side taxi alternative was not as expensive (even on a "per induced passenger" basis) as the areawide user-side subbsidy in "Southern Belle," but this alternative was still relatively more expensive than the IP scenario.

In this setting, at least one component of the IP system, the route deviation portion, was found to be less effective in the year 2000. The increase in population density to 6,200 persons per square mile (in the service zone) made fixed-route service less expensive to provide than route deviation service. Many-to-many service continued to be less expensive than fixed route, on a cost-per-passenger basis, in a second service area with a projected density of 4,600 persons per square mile.

3.5.4 Setting #4: "Mid-American City"

In this setting, providing extensive paratransit service in suburban areas, particularly during off-peak hours, proved to be very expensive. In the case of maximum off-peak coverage (Scenario D), the net marginal cost per new transit passenger was the highest of the scenarios, although this alternative also had the greatest impact on auto ownership. The benefits of IP in this setting, for any scenario considered, do not appear to be able to justify the fairly expensive deficit. The analyses seemed to suggest that, given the overall impacts of IP, increasing the paratransit fare beyond 25¢ in this setting was counterproductive.

The impacts of the fixed-route alternative appear fairly comparable to those of IP in this setting; the deficit of the fixed-route alternative also appears to be unjustified by the associated benefits. Both the extended fixed-route and the IP scenarios are projected to have a significant impact on the relatively weak taxi industry. The fixed-route alternative is projected to decrease taxi revenue and profit by 19.6% and 73.9%, respectively; in the IP case, this negative impact is offset by a contract with the industry to provide part of the IP service.

The extended taxi alternative in this setting, which simply involved the encouragement of additional licenses through low interest loans, is an extremely low cost option, with a small transit revenue decrease the only public cost. The overall impacts of the alternative are correspondingly small. Nevertheless, the alternative suggests that, in areas with low taxi availability, public action to increase the taxi supply may prove beneficial to both the users (who experience improved service levels) and the taxi industry (which may experience some economies of scale).

The results of the year 2000 analysis suggests again that fixed-route service is more effective than paratransit service beyond a certain density level. In this case, consumer surplus for non-work trips actually declined when the fixed-route service is replaced by paratransit in relatively dense inner city areas during off-peak hours.

3.5.5 Setting #5: "Mill Town"

The primary conclusion from this setting is that, in service areas with very low population density (1,300 persons per square mile in the 1980 scenarios), no relatively high quality transit service can be readily justified from a benefit-cost standpoint. Checkpoint many-to-one service proved more effective than either many-to-many service or exclusive-ride taxi feeder, and all of these proved "superior" to fixed-route service. In all cases, however, the net cost per new transit passenger was relatively high. The situation was projected to improve somewhat, but not substantially, by the year 2000 when the population density will be 1,600 persons per square mile.

3.5.6 Setting #6: "Large City"

In this setting, the expansion of a paratransit system for the elderly and handicapped (serving approximately 190,000 persons) into a system for the general public in the same 434 square mile area (serving over 1.5 million persons) was found to be able to sharply reduce the cost per passenger and significantly increase elderly and handicapped ridership, although the cost per hour to provide the service does not measurably change. The service was able to generate considerable ridership; however, the net benefits do not appear to be able to offset the substantial deficit.

On an overall basis, the fixed-route alternative in this setting appeared to be slightly "better" than the IP alternative, in that it generated higher ridership at roughly the same cost and with roughly the same values of other impacts. The taxi alternative in this case was actuallly an alternative to the base case paratransit systems for the elderly and handicapped. The results of that analysis suggest that a user-side taxi subsidy for the elderly and handicapped may prove to be much loss costly, on a per-passenger basis, than the establishment of a separate paratransit system.

The year 2000 IP scenario in this setting points out that a shift in paratransit service from dense inner city areas (over 8,000 persons per square mile) to less dense (average density under 3,000 persons per square mile) suburban areas with less extensive fixed-route service can result in a decrease in the IP net cost per marginal transit passenger.

3.6.7 Setting #7: "Metropolis"

In this setting, paratransit service was provided in only three small service areas in Scenario A and four additional areas in Scenario B. The resulting impacts of this small-scale system were relatively small. Because service was provided in either low-density areas or to limited markets (e.g., transportation handicapped or express bus passengers), productivities were generally low. As a result, revenues accounted for only 16% of the operating cost and the other positive impacts do not obviously offset the remaining deficit.

The extended fixed-route bus alternative proved to be more costly than IP because of transit authority operation. In general, IP appeared to be a more effective alternative in the suburban service areas, all of which had population densities below 4,000 persons per square mile. Paratransit also was seen to be less expensive on a per-passenger basis than fully accessible fixed-route service as a means of serving the transportation handicapped. A user-side taxi subsidy for feeder service once again proved to be relatively expensive.

By the year 2000, IP service was projected to be relatively more effective in serving one high-density (7,000 persons per square mile) inner suburban area and some other medium-density (4,500 persons per square mile) suburbs. Part of the change by the year 2000 can be attributed to the elimination of two high-cost service elements (a TH service and a feeder service operated directly by the transit authority) which were offered in 1980.

Chapter 4

Community Acceptance

The previous section described the results of a series of scenario analyses designed to determine the impacts of various IP configurations in different settings. These analyses did not, however, address the question of whether or not a given community would implement an IP system. In order to assess the overall potential impacts of the IP concept, it is important to understand the factors that influence the decision to implement IP service. This information is useful both for projecting the "penetration" of IP systems and, in cases where IP is felt to be suitable, directing the policies that will result in IP implementation.

To develop an understanding of the factors which influence IP implementation, a series of case studies was undertaken. These studies, designed to identify recurring themes which impact IP implementation, considered the events surrounding the implementation of the following well-known paratransit and IP systems:

1. Ann Arbor, Michigan - TELTRAN
2. Michigan statewide DART program
3. Rochester, New York - PERT system
4. Cleveland, Ohio - CRT system
5. Orange County, California (La Habra, Orange, and Fullerton)
6. AC Transit (Richmond, Newark/Fremont, California)

These sites were selected for study because: (1) some (Ann Arbor, Santa Clara, and Orange County) represent the most extensive IP systems implemented to date; (2) both "successes" (e.g., Ann Arbor) and "failures" (e.g., Santa Clara and Richmond) are represented; (3) there was a substantial amount of information available about most of the systems; (4) examples of both publicly and privately operated systems, as well as large- and small-scale systems, are included; and (5) the sites include a number of systems (Michigan DART and Newark/Fremont) whose implementation depended upon voter referenda and which thus are true indicators of community acceptance.

Key results of the case study analyses included the following:

1. Demonstrations or pilot projects, which involved little if any local funding for the first year of service, were instrumental in obtaining community acceptance for continued IP operation. A glaring counter example was the Santa Clara County system, which began without a prior demonstration and was discontinued within six months. Federally sponsored demonstrations focussing on research appear to have been somewhat less successful than locally sponsored demonstration at generating community support.

2. Equity in the distribution of transit resources is important if local sales or property tax funding are used. IP can potentially provide a more even distribution of services than totally fixed-route services. The political necessity of providing some transit service to the suburbs, particularly in larger metropolitan areas, may be a motivating force for providing paratransit service. This factor may make the desired staged expansion of service (starting with a pilot area) difficult to achieve, as was the case in Santa Clara County.

3. Paratransit service is often viewed as primarily for the transportation disadvantaged. However, this view is more prevalent in smaller communities than in larger communities, where paratransit/transit integration is involved. Elderly and handicapped groups have been, and probably will continue to be, supportive of paratransit service.

4. Other public attitudes which have contributed to political support for IP in some communities include environmental concerns, concerns over the use of the automobile, and general concerns for public welfare. The actual need for or use of IP service is not a requirement for support, although the inability to use the service when desired would negatively influence support.

5. Failure to involve the private (taxi) sector in the planning and implementation of IP service ha led to lawsuits and delays. This tendency of taxi companies to seek legal action is likely to increase over the next few years. Contracts with the private sector would avoid these problems, eliminate a negative impact on the private sector, and probably reduce costs overall.

6. The practice of "route rationalization" (replacing underutilized fixed routes with paratransit) could hinder the implementatin of IP. Users of the fixed-route service may find IP a less desirable service and may protest. This situation occurred in both Rochester and Santa Clara County. In the latter case, the protests contributed to the elimination of the service; in the former case, the majority of the fixed routes have been reinstated. Suggestion that route rationalization is infeasible is not intended; however, areas implementing IP should recognize that paratransit may not always represent an improvement in service for all people.

7. Transit labor could conceivably delay or act as a barrier to IP implementation. In the cases studied, transit labor did not object to route rationalization, since in those cases, it was the transit system which operated the paratransit service. There are cases, however, in which labor has blocked or delayed the implementation of IP service, usually (but not always) because the service was to be contracted to a private operator (e.g., an approved UMTA-sponsored demonstration in Nassau County, New York).

8. The cost of service (e.g., cost per passenger) will play a role in community acceptance, once a system is no longer a demonstration; but it need not always be the deciding factor. For example, the IP system in Richmond, California, was discontinued in part because of a $3.77 cost per trip. In Cleveland, the cost per trip is $4, but this figure is apparently locally acceptable for a service for the elderly and handicapped.

9. Individual proponents of paratransit in decision making positions have played a major role in initiating paratransit service in a number of communities studies. These "strong men and women" may play less of a role in future IP implementation, since the concept of paratransit has become more widespread and better known.

These results suggest that those IP systems which have relatively low costs, involve the private operator, and involve little if any route rationalization, have the greatest probability of community acceptance. Likely areas for paratransit expansion in the near future are the suburbs of larger urban areas, in cases where the regional transit authorities are trying to satisfy the concerns of communities which seek to receive equitable transit coverage. The eventual acceptance of any IP system is more likely it there is an initial opportunity to demonstrate the concept. In general, the results suggested that the probability of implementation of IP in a given area will depend upon: the attitudes of local decision makers and the elements of the local planning and decision making process; the attitudes of local transit labor; the financial condition and attitudes of the local taxi industry; the existence and strength of (pro and con) advocacy groups; the source of local transit funding; the willingness of individuals in the community to support public services from which they (as evidenced by prior actions) do not personally benefit; and the extent and quality of the existing fixed-route transit system.

Chapter 5
Technical Innovations

A number of new technologies have been implemented with, or proposed for, paratransit systems. As part of the overall IP benefit-cost study, the potential impacts of two such technologies, digital communications and computer dispatching, were analyzed in detail. In addition, some preliminary analyses were conducted on the potential impacts of computer-aided dispatching, computer control of radio channels, automated control-to-passenger communications, automated passenger information systems, automated vehicle monitoring, and a new paratransit vehicle. The results of these assessments are summarized below.

5.1 Digital Communications

Digital communications involve the transmission of data digitally, rather than vocally. Digital communications systems have been implemented in the Rochester, New York, and Ann Arbor, Michigan, IP systems. Potential benefits of digital communitions include reduced vehicle fleet size or hours of service because of increased vehicle speed, reduced frequency requirements, and reduced control room staffing requirements.

The analysis indicated that digital communications may be cost-effective for dynamic dispatch many-to-many DRT systems with as few as eight vehicles service six demands per vehicle per hour. Annual dollar savings could be as high as $188,000 for a 32-vehicle system (which would have a base annual operating cost of about $2.2 million).

5.2 Computer Dispatching

Computer dispatching involves the use of a computer to make routing and scheduling decisions. Fully computerized dispatching systems have been implemented in the IP systems in Haddonfeld, New Jersey, and Rochester, New York. In both of these cases, automation reduced passenger wait time and the variability of wait and ride times. Potential benefits of computer dispatching are reduced vehicle fleet size or hours of service, reduced conrol room staffing requirements, and improved reporting capability.

The results indicate that the combination of computer dispatching and automated dispatching is more beneficial than automated dispatching alone. The combination may be cost-effective in a dynamic dispatch, many-to-many DRT system with vehicle fleets of about twelve vehicles serving eight demands per vehicle-hour. The net benefits of the technology tend to increase with increasing system size. With 32 vehicles, up to $444,406 in annual cost reduction may be observed for a system iwth a base annual operating cost of $2.2 million.

5.3 Other Technologies

Computer Control of Voice Radio

This technology involves the use of a computer to ensure that only the desired (first on line) vehicle receives messages. The concept appears to have limited application to IP systems, but is more promising for an exclusive-ride taxi operation, where there may be a problem of dispatcher favoritism or driver "pirating" and where a "first in, first out" dispatching formula can be more readily followed.

Computer-Aided Dispatching

With this technology, a computer is used to assist in the dispatching or scheduling process, but does not make any scheduling decision. The primary economic benefit of this innovation is probably in the area of improved reporting capabilities. However, continued experimentation is needed to help estimate benefits.

Automated Control-to-Passenger Communication

The only system of this sort to receive considerable application to date is an interactive tape recording system. The primary potential for this technology would appear to lie with exclusive-ride taxi operators, where this component of communication is usually fairly straightforward.

Automated Passenger Information System

This type of technology would go somewhat beyond that of the previous one by providing information on service characteristics, (dynamic) system status, vehicle schedule at specific stops, and passenger-specific status in the queue. Given the present state-of-the-art, only simple technologies based on tape recorders are likely to be reasonably inexpensive. Passenger-specific status information would not be available from such simple technologies.

Automatic Vehicle Monitoring (AVM)

AVM, in which vehicle locational information is provided on a continuous basis, is presently receiving a thorough testing by UMTA in a fixed-route application. Preliminary consideration suggests that an increase in productivity of up to 5% may be achievable in a many-to-many DRT system, but further experimentation or analysis must be undertaken before this benefit can be verified.

Paratransit Vehicle

A new paratransit vehicle could potentially reduce paratransit operating costs and, hence, local and federal subsidies, decrease fuel consumption, and improve service reliability. Based on ballpark estimates of IP penetration, it was estimated that a new vehicle could eventually save $3.2 to $10.7 million in subsidy annually on a national level and reduce fuel consumption by 3.2 to 10.7 million gallons.

Chapter 6
Conclusions

The "Benefit-Cost Analysis of Integrated Paratransit Systems" systematically estimates the benefits and costs associated with different IP options in different settings and compares these results with those of other transportation alternatives. Based on the results of the various components of analysis in this study, a variety of conclusions about IP service can be reached.[1] The conclusions suggest that in some circumstances integrated paratransit may be an effective strategy for improving overall mobility. These conclusions are presented as answers to the following fourteen questions about IP service and its alternatives.

1. <u>Can Break-Even Operation Be Achieved in an IP System?</u>

The answer to this question in most cases is <u>no</u>. In certain circumstances, the replacement of fixed route service with paratransit in one area may actually reduce costs (e.g., "Sun City"). Furthermore, some paratransit services (e.g., vanpool) can be initiated with no public deficit, while high fare, privately operated services, such as shared-ride taxi, may still achieve break even. In general, however, one must expect that IP systems with fares closer to transit than exclusive-ride taxi fares, will result in a net increase in transit deficit.

2. <u>Can the Deficit of an IP System be Justified by the Positive Impacts Generated?</u>

The answer to this question, in some instances, is <u>yes</u>. In a number of the settings considered, the net positive impacts of IP, such as the reduction in auto expenditures, the increase in consumer surplus, and the increase in employment, appeared to be able

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[1] The reader is cautioned to recognize that the answers provided are based on a limited set of analyses. Although the study has attempted to consider as wide a range of service and setting types as possible, clearly not all possible permutations have been tried. As a result, some conclusions may not prove true in all cases.

to offset the deficit.* In these cases the total net cost per marginal transit passenger was relatively low (under $.80) and, correspondingly, the revenue-to-cost ratio relatively high. This was the result of either, or both, of two factors: (1) relatively high productivities and (2) relatively low hourly operating costs of under $11.00 per vehicle hour.

High productivities can be achieved in one, or both, of two ways. First, "hybird" services, such as checkpoint or route deviation, yield higher productivities than doorstep services. Second, vehicle density significantly impacts achievable productivity for most paratransit service; vehicle densities of more than one vehicle per square mile would help achieve high productivities.

Relatively low operating costs can be achieved in those urban areas with low prevailing wage rates and in all urban areas through contracts with the private sector. It should be noted that the costs of both public and privately operated transit services have been increasing rapidly in recent years. If the private sector continues to become involved in contract services for the public sector, there is a chance that pressures will be brought to bear by labor to begin to close the gap between private and public wage levels. Thus, it may become increasingly difficult to keep operating cost levels below $11.00 per hour.

3. Which IP Configurations Appear to Be Particularly Promising?

The results suggest that hybrid services, which combine the characteristics of fixed route and paratransit and thus have relatively high capacities, are among the most promising. Check-point many-to-many service, in which pick-ups and drop-offs are made on demand only at designated checkpoints scattered throughout the service area appeared to offer higher service levels and productivities (and therefore generate greater demand) than a comparable

* In these cases, there appeared to be no significant negative impacts of IP, other than cost, except, in some cases, a reduction in taxi industry revenue and profit. That negative impact could be alleviated or reversed through contracting with private operators for IP service. See the answer to question 11 for further discussion of taxi industry impacts.

doorstep service. This concept should now be demonstrated to determine whether, in fact, passengers are willing to walk short distances to a checkpoint. The results of the "Southern Belle" analysis suggest that one good location to demonstrate checkpoint many-to-many service would be a relatively dense (3500-5000 persons per square mile) inner suburban area with minimal existing transit service and a number of dispersed activity centers. Route deviation service seemed to be potentially more cost-effective than tightly spaced parallel fixed routes in areas with moderate population densities (4000-5000 per square mile). Doorstep many-to-many service may have greater impacts than demonstrations to date would suggest, if high vehicle densities (over 1.5 vehicles per square mile) and greater reliability (perhaps through computer dispatching) can be achieved.

Ride sharing services such as vanpools received less consideration in the analysis, partly because they do not represent public service in the same sense as demand-responsive modes, and partly because of the lack of equivalently tested demand projection techniques. The analysis that was performed suggested that vanpools have potential for attracting a significant portion (10 percent or more) of work trips to major employment sectors. Vanpools serving a single large employer, in which the employer is active in vanpool administration and promotion, appear to offer the greatest potential for attracting large market shares.

4. What Market Groups are Served by IP?

Persons from zero-car households and the elderly clearly are among the primary market groups served by IP. The type of service does not influence the extent to which non-elderly persons from zero-car households use IP. In all cases, persons from zero-car households were overrepresented in ridership (i.e., were a higher percent of riders than population). For example, in "Mid-American City," where zero-car households represent only 14.3 percent of service area households, and all persons from zero-car households represent only 11 percent of the total persons, this latter group accounted for 30 percent of all new transit trips in Scenario D.

Persons from zero-car households are even more overrepresented in the consumer surplus benefit since many persons in this group depend on transit to get to work. For example, in "Mid-American City" (Scenario D), persons from zero-car households receive 39 percent of the overall consumer surplus benefit.

The elderly are overrepresented in ridership figures, although, because of reduced overall tripmaking, not always to the same extent as persons from zero-car households. In "Mid-American City" (Scenario D) for example, the elderly comprised 28 percent of total new transit ridership and only 9 percent of the popluation. This overrepresentation increases dramatically in instances where service is provided free of charge. In "Mill Town," the elderly comprised 62 percent of total ridership in Scenario A and only 16 percent of the population. Because of mobility problems, the elderly are also particularly overrepresented in the induced trip category; in "Mid-American City" (Scenario D) the elderly represented 42 percent of all formerly latent demand.

Since the elderly are overrepresented in ridership, they are generally overrepresented in the consumer surplus benefit. However, since only a small percentage (20 percent on the average) of elderly persons work and the majority of consumer surplus benefit is acculdated on work trips, they are not overrepresented to the same extent as persons from zero-car households.

Service type will influence benefit to the elderly. This was shown in "Southern Belle," where the change in consumer surplus for the elderly was greater in the doorstep service scenario than in the checkpoint service scenario, despite higher overall ridership in the latter. Unfortunately, the hypothesis that elderly persons are much more reluctant to transfer, introduced in Volume 2 and supported by some empirical data, could not be substantiated because of a lack of sensitivity to this component of travel time on the part of the model system used.

Persons from households owning two or more automotiles were underrepresented in all ridership projections. Bear in mind, however, that these persons receive <u>all</u> of the savings in automobile expenditures.

The Transportation handicapped (TH) were projected to make only limited use of the IP services. Ridership by the TH was considerably higher in situations with a separate, areawide service for the TH, particularly in cases of unconstrained vehicle fleet size. For example, in one such case ("Mid-American City"), the TH comprised almost 17 percent of total new transit ridership in a system with a $1.25 fare for the general public and no fare for the TH. Even in that case, however, the net operating cost per TH passenger was $2.62 compared to a net operating cost per induced general public passenger of $.94, even though the former was privately operated and the latter was publicly operated. Thus, a separate service for the TH can prove to be extremely expensive on a per passenger basis. Note that a separate service for the elderly and handicapped in "Large City" was found to be much more expensive on a per passenger basis than a general public service. Other than these analyses, the issue of special services for the elderly and handicapped versus accessible general public services was not addressed in this study. That issue, and the related issue of the role of human service agencies vis a vis IP, introduce many questions beyond the scope of this study.

Youth represent another group often cited as receiving major benefit from paratransit service. Youth (typically defined as persons below driving age) comprise a very small component of paratransit ridership in some cases, and a very large component (up to 50) in others. The level depends on a variety of factors, including fare, the availability of service to school, and the availability of alternative school services. Because of a lack of an adequate data base, youth could not be separated out in the analysis framework used (see Volume 6, Appendix 1). As such, no new definitive statements can be made about the youth market; this is area for future research.

Finally, it should be pointed out that it need not be only "special" markets which benefit from IP. For example, in "Southern Belle," where checkpoint service is provided in fairly dense inner suburban areas and vanpool service is offered to one major employer, work trips constitute a significant portion (60 percent) of all IP trips. Thus, workers, including those from 1-, 2-, and 3-car owning households, receive a substantial portion of the benefit from IP services.

5. Are There Certain Population Densities at Which IP is More Advantageous Than Fixed Route, or Vice Versa?

Although the differences between scenarios reflected differences in service type and scale as well as setting size, some patterns relating service type to population density seemed to emerge. At population densities below 3000 persons per sq mi (e.g., 1500 persons per sq mi in "Mill Town") no transit service appeared to make sense from a financial standpoint. At a population density range of 3000-5000 persons per sq mi ("Southern Belle" and "Sun City") IP service appeared feasible and more cost-effective than fixed route. At population densities of 5000-6000 persons per sq mi ("College Town") there are trade-offs between fixed route and IP service, and neither option seemed to dominate. At population deisnties above 6000 persons per sq mi ("Large City" and "Sun City" year 2000), fixed route service became more cost-effective than paratransit service. These results tend to confirm the conventional wisdom about the population densities at which paratransit service is most cost-effective. This analysis, however, represents one of the first attempts to systematically identify the actual numerical ranges. It should be noted that population density on its own is not the sole determinant of system type. The location of major activity centers, the existence travel corridors and the demographic characteristics of the population are also key factors in determining what type of system is most advantageous.

6. How Do Different "Implementation Strategies" Determine the Impacts of IP?

A variety of IP "implementation strategies" were considered in the analysis. The results suggest that the implementation of service in areas previously unserved by transit tends to maximize the change in mobility and consumer surplus. If the density in a new service area is high enough, as it was in "Southern Belle," an IP system might prove to be extremely "cost-effective." Furthermore, the lack of any existing service might make the implementation of the service very easy since there are not likely to be vested interests in maintaining the status quo transportation system and since the local residents are likely to desire service. It is unclear, however, how many areas remain in the country with sufficiently high densities that are unserved by public transportation.

A second strategy involves the replacement of ineffective fixed route service with paratransit. This approach utilized in "Sun city," may result in only small net cost increases if the paratransit system offers better service than the fixed route system. However, the elimination of existing services may be extremely difficult. Transit labor may object if they view the change as a possible threat to jobs; this is a particular problem if a private operator is to be involved in the service. In addition, residents of the area who were able to use the fixed route service may protest if they perceive the new system as decreasing their service levels. As will be seen in Volume 4, protests such as these were instrumental in stopping IP service in Santa Clara County, and in reinstating fixed route service in Rochester, N.Y.

A third strategy, which involved the augmentation of fixed route service with overlay paratransit service (utilized in both "College "Town and "Large City"), tends to maximize coverage, level of service, and the reduction in automobile ownership. However, this approach is likely to have relatively small impacts on mobility and change in consumer surplus. It will also generally result in the greatest diversion of fixed route passengers. While the results do suggest that many new transit trips will be generated, the cost per passenger can be very high because of "competition" between the transit modes.

Other, "opposite" implementation strategies considered were implementation of paratransit service on a very limited basis ("Sun City" and "Metropolis") and implementation of paratransit service on an areawide basis ("College Town" and "Mid-American City"). The former allows for the selection of service areas where paratransit service can be most effectively utilized. The latter allows no such distinctions and, as the scenarios for "Mid-American City" suggest, can result in very high costs per passenger.

As will be discussed in Volume 4, the areawide approach may be dictated by political concerns in some cases. If the "equitable" provision of paratransit service is an issue in a region in which the suburbs are taxed to support regional transit, some form of transit may need to be implemented in all areas. While paratransit may be more cost-effective than fixed-route service in some low density areas, it is conceivable that service will need to be provided even in areas where no service makes sense. In "offering" service to suburban areas, a regional transit authority may find that 100 percent coverage paratransit service is the simplest way of achieving, or seeming to achieve, equitable service.

While the need for an equitable distribution of service may, in some cases, make initial implementation and subsequent expansion of a pilot project difficult, there is no reason to believe that this approach cannot be followed. In terms of generating operating experience, fine tuning system design, and gaining continued community acceptance, the review of existing services strongly points to the advantages of the staged implementation approach.

A final implementation strategy worth noting is the use of paratransit service as a pilot project to serve as a generator of transit demand and to identify travel corridors which may be more effectively served by fixed routes. This strategy has been discussed in the literature but has seen little experimentation to date.[1] This approach may make most sense in growing areas, where paratransit service can be used until the population and demand densities are great enough to support fixed-route service.

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[1]Ann Arbor tried instituting fixed routes in corridors identified by their DRT service. However, since the DRT service was not eliminated and the DRT and fixed-route fares were the same, the fixed routes attracted little ridership.

7. <u>What Are the Impacts of Different Fare Structures on IP?</u>

A vanity of IP fare structures were tested in the scenario analyses. The results of the analysis of fares ranging from $.25 to $1.25 suggest that paratransit service is sensitive to fare. Despite greater revenues at higher fares, increasing fares beyond a certain level (probably $.25) may be counterproductive. Such factors as the change in consumer surplus and the change in auto expenditures are also sensitive to fare. Under some circumstances, the decrease in these benefits may more than offset the increase in revenue.

Free fares were concidered in two settings ("Mill Town" and "Large City") but only for elderly and handicapped persons. In both cases, extremely high patronage by these groups was projected. In "Mill Town" (Scenario A), the elderly accounted for 62 percent of all trips; in "Large City" elderly ridership comprised 66.7 percent of the ridership.

In "College Town," a $.25 fare and free transfer were offered between paratransit feeder service and fixed route in one scenario. A $.50 fare for "overlay" paratransit service was offered in another. The results suggest that the free transfer priviliege in the first scenario induces many passengers to use the feeder service even when they could readily use the fixed route service alone (as they do in the second scenario). This type of fare structure could result in excessive demand on the paratransit component of an IP system, in which service quality is highly dependent upon demand levels. This is exactly what occurred in the Santa Clara County system, which had the identical fare structure as "College Town" Scenario A.

8. <u>Can IP Service Achieve Significant Modal Shifts From Auto?</u>

On an absolute level, the answer to this question is <u>no</u>. In none of the cases analyzed did IP reduce automobile usage by more than 1-2 percent. The capacities (i.e., achievable productivities) of the paratransit systems are too low to result in significant diversion from auto at any reasonable vehicle fleet size, given present population densities and automotile operating costs. On a relative level, however, IP could substantially increase total transit ridership. In some cases considered, transit ridership increased by over 70 percent with the initiation of IP service.

9. What Impact Does IP Have on VMT, Fuel Consumption, and Air Pollution?

Previous studies have suggested that paratransit has a negative impact on VMT and fuel consumption.[1] This study, which is the first to consider large scale systems and the impact on auto ownership, does not lead to the same conclusion. In most, but not all, cases, IP was projected to decrease VMT and fuel consumption. However, in no case was the impact more than 0.7 percent of the area's VMT and fuel consumption. Emissions of carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x) increased in some cases and decreased in others; again, however, the percentage changes were well under 1 percent. (Note that the fixed route alternatives generally increased VMT and fuel consumption, although by less than 1 percent, and decreased some emissions. The exclusive-ride taxi alternatives resulted in the highest increase of all three categories.) Thus, for all practical purposes, one must conclude that IP will have no noticeable effect on VMT, fuel consumption, and air pollution.

10. Can Paratransit/Transit Integration Be Achieved Such that Paratransit Service Is Used Extensively as a Feeder Mode?

There have been questions asked about the ability of paratransit services to act as a feeder to line haul. The data suggested that, depending upon system design, paratransit can function in a feeder mode to an extent greater than that experienced in most systems to date. The key factors in determing the extent of feeder service are the service configuration and the extent of transfer coordination. For example, in "College Town," over 60 percent of the paratransit passengers were feeder/distributor

[1]See, for example, Hensley (1976) and Congressional Budget Office (1977).

passengers in the cycled many-to-one service option. Passengers had to use the feeder option in order to make all but very short trips on the paratransit service. In the "Mill Town" scenario with cycled (e.g., scheduled) many-to-one service and coordinated transfers, 32 percent of paratransit passengers transferred to or from line haul service. In the many-to-many scenario, without coordinated transfers (which served many fewer passengers in total), only 11 percent of the passengers were feeder passengers. However, a large number of transfers is not necessarily a positive achievement; as seen in "College Town," the many-to-many service, which did not require transfers, resulted in higher overall ridership. Coordinated transfers are most appropriate in large areas, where short feeder trips can tie in to much longer line haul trips.

11. Would the Introduction of IP Have a Significant Impact On the Taxi Industry?

Most of the publicly operated IP scenarios considered resulted in a decrease of taxi revenues of around 10 percent, and (because of diseconomies of scale) a decrease in profits of 30-40 percent.[1] Clearly, this is a significant impact on an industry which is only marginally viable at this time. The extent of the impact will vary from company to company within a given setting, and the overall impact will depend on the local state of the industry. For example, in "Mid-American City," where the taxi industry was very weak in the base case, the profit from the exclusive-ride taxi service was projected to decrease by over 70 percent.

One obvious way to deal with this problem is to contract with the taxi industry to operate all, or portions, of the paratransit system. The analyses suggested that this would more than offset the loss of exclusive-ride taxi revenue, in most cases, while at the same time reducing the cost of the IP service.[2] However, it

[1] Note that the impact on profit might be very different in fleets with lease drivers. It was assumed that all drivers in each setting are commission drivers.

[2] The existence of possible economies of scale resulting from the operation of both exclusive-ride taxi and IP service was not considered in the analysis.

may not always be possible to contract with a private operator. For example, a taxi operator may not be the appropriate provider of route deviation or other "hybrid" fixed route/demand-responsive systems. Also, in cases where some fixed route service is curtailed, labor provisions (e.g., Section 13(c)) of the UMTAct of 1964) may make it impossible to provide paratransit service other than with unionized transit labor.[1]

If contracts with the private taxi sector are to be instituted, a number of factors must be considered. First, there is the potential that drivers will not be of the same quality or reliability as public sector labor, because of the lower prevailing wage rates and general characteristics of some individuals attracted to the taxi industry. This may be viewed as a particular problem when providing services for the elderly and handicapped. If a concerted attempt is made to hire more reliable drivers, the wage rates may be forced up. Second, in cases of integrated services, it may be more difficult to achieve coordinated transfers between fixed route and paratransit service if different groups of employees are involved.

The terms of the contracts are important to both parties. The private sector must be ensured of a return sufficient enough to make their participation worthwhile. The public sector, for its part, should be provided with the ability to receive a part of any system economies wh ch may be achieved. Some mechanism offering incentives to operators to maximize productivity while at the same time allowing the public sector to benefit from increased productivities is required.

12. Are There Low-Cost Methods of Increasing Mobility Through the Use of Exclusive Ride Taxi Service?

Because of their limited productivities, exclusive-ride taxi generally cannot be provided as inexpensively as shared-ride

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[1] Other potential institional problems exist as well. For a more complete discussion of how the institutional environment impacts the use of the taxi industry as paratransit providers, the reader is directed to: Multisystems, Inc. (1978) Taxis, the Public and Paratransit: A Coordination Primer. Draft Final Report prepared for the International Taxicab Association.

services. However, some low cost options may sometimes be possible. For example, in areas where there is an undersupply of taxi vehicles, the public sector may be able to encourage the taxi industry to expand service. If financing of vehicles is a problem, the public sector may wish to offer low cost loans. If the taxi industry feels that there is not enough demand to justify new vehicles, a capital subsidy may be considered to help reduce total costs and allow the industry to achieve any possible economies of scale through expansion. In some instances, however, taxi fleet expansion may not be possible in an area; in others, it may be possible but will have only marginal impacts. In any case, the net cost to the public sector for subsidizing exclusive-ride taxi service will be fairly low.

User-side subsidies for the general public represent an extremely expensive alternative. The cost can be reduced if the subsidies are targeted for just marginal trips (e.g., for expanded feeder service in one area). Nevertheless, the cost per passenger will remain higher than the costs for a comparable shared-ride service. A user-side subsidy for the elderly and handicapped, however, could prove to be significantly less expensive (on a per passenger basis) than a separate paratransit service established just for those groups.

13. In What Areas Are IP Services Most Likely to Be Implemented?

Urban areas with population under 500,000 may be more likely to institute large scale IP systems because of lower wage levels, less severe institutional constraints, and less extensive existing fixed-route service. However, in larger urban areas, IP may be viewed as the best way to equitably serve suburban areas. It should be noted that the decision to implement IP must be made on the local level, based on local objectives, conditions, and institutional arrangements, and an understanding of the potential range of IP impacts.

14. Will the Impacts of IP Change Considerably by the Year 2000?

The results suggest that the impacts of IP in the year 2000 will be very similar to those predicted for 1980, given present demographic projections. Even in the case where auto operating costs are projected to increase by 40 percent (in 1977 dollars) and total auto ownership decline, the overall impacts of IP are not significantly different. Continued high auto ownership, even under the reduced auto ownership scenario, and the limited capacity of paratransit service are factors which will inhibit IP from having significantly different impacts from those projected for 1980.

15. What Areas of IP Service Require Additional Research?

This study has focussed on a wide range of issues related to integrated paratransit service. Many issues are still not resolved. Among the areas touched upon by this study that seem to warrant further research are the following, which clearly do not represent a non-exhaustive list:

a. The relationship between social service agency services and IP and the way in which IP may allow such agencies to increase their primary service.

b. The impacts of paratransit services designed exclusively for the elderly and handicapped.

c. The factors that influence travel by youth.

d. The potential economies offered by paratransit service during evening hours.

e. The long-term growth potential of a vanpool service and the factors that influence vanpool market penetration.

f. The impact on ridership of requiring advanced requests for paratransit service.

g. The impact of unreliability on ridership and the ways of measuring, projecting, and reducing unreliability.

h. The potential impacts of AVM, passenger information systems, and other technological devices not considered in the study.

i. The impact of different local sources of subsidy on IP implementation strategies.

j. The actual effect of paratransit implementation on automobile ownership.

Perspective

A variety of results and conclusions were summarized on the previous pages. The sensitivity of these results to errors in data and forecasting was explored (see Volume 6), and it is clear that there are uncertainties about the outputs. While the uncertainties limit the confidence one can place in some of the individual results, in the absence of any uniform error bias (i.e., the errors are not in a single direction only), the overall conclusions should be quite reasonable. Basically, the study has indicated that IP systems may be beneficial, if designed carefully. The study has compared different services and service characteristics and drawn some conclusions regarding what might be preferable under different conditions. The study did not, nor did it attempt to, answer all possible questions about IP service. Instead, it pointed to the desirability of continuing research, experimentation, and demonstration.

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Appendix A

Glossary of Terms Used in This Report

Case Study	- As used in this study, reference to study of an actual IP system
Central City	- The principal city of a standard metropolitan statistical area (SMSA)
Cluster Analysis	- A computer-based tool for clustering together "objects" which are similar along a set of pre-specified characteristics
Chauffeur Trips	- Automobile trips taken for the sole purpose of serving a passenger
Checkpoint Many-to-Many Service	- Service in which a patron is transported from a prespecified checkpoint nearest to his origin to a prespecified checkpoint near his/her destination anywhere within the specified service area
Checkpoint Route Deviation Service	- A transportation service in which the vehicle travels along a prespecified route except to pick up or drop off passengers upon request at prespecified checkpoints not along the route
Consumer Surplus	- The difference between what each individual consumer is willing to pay for a good or service and that which he/she actually does pay. See Section 2.2 of the Technical Appendices (Volume 6) for a more detailed description.
Coverage	
Spatial	- The percent of the population which is eligible for the transportation service and lives within a specified distance from a point at which a patron may board the transit service
Temporal	- The hours the transportation service is in operation
Cycled Many-to-One Service	- A demand-responsive transportation service in which vehicles are scheduled to arrive and depart from a specified location at fixed times

Demand Responsive Transportation (DRT)	- A family of transportation services in which vehicles in some manner respond to the demands of passengers
Doorstep Many-to-Many Service	- A demand-responsive transportation service in which passengers can travel from any point in a service area to any other point in the service area
Exclusive-Ride Taxi	- Conventional taxi service in which only one request for service may be served by a vehicle at a time
Feeder Service	- A transportation service designed primarily to transport passengers to a point where they can catch some other linehaul service
Impact-Incidence Matrix	- A method of displaying costs and benefits such that impacts are disaggregated among the different groups which accrue them
Induced Trip	- A trip which, prior to a transportatio[n] service being provided, would not have been made by the individual
Integrated Paratransit (IP)	- Transit service in which flexible paratransit services are integrated with conventional fixed-route transit services through designed transfers and/or services which fulfill special needs
New Transit Trip	- A trip which wouldnot have been taken <u>on the transit service</u> prior to the implementation of a new transit service. This includes trips which would have been made on other modes (diverted trips) and trips which would not have been made at all (induced trips)
Opportunity Cost	- A non-monetary impact resulting from the use of scarce resources. This impact is given an economic value by determining the cost of obtaining the necessary resources
Paratransit	- The family of transportation services between exclusive-ride automobile (including taxi) and conventional fixed-route transit

Route Deviation Service	- A demand-responsive transportation system where vehicles follow a pre-specified route, but are free to deviate from the route to pick up or drop off passengers
Scenario	- As used in this study, this term refers to a hypothetical IP system designed for an actual urban area (setting)
Setting	- As used in this study, refers to an actual urban area selected as a site for the analysis of alternative IP scenarios
Shared-Ride Taxi	- Doorstep many-to-many service using small vehicles operated by a taxi company
Standard Metropolitan Statistical Area	- Census definition of metropolitan areas with 50,000 or more persons
Transportation Handicapped (TH)	- The group of individuals who are restricted from using conventional transit services as a result of physical, mental, or emotional impairment
Urban Area	- The portion of a standard metropolitan statistical area considered to be urbanized
User-Side Subsidy	- Direct subsidy to individuals using a transportation system, rather than subsidization of the transportation supplier
Vanpool	- A paratransit service in which a single individual consistently drives a van in which other passengers regularly travel between their homes and work

Appendix B
Report of New Technology

A diligent review of the work performed under this contract has revealed that no new innovation, discovery, or invention of a patentable nature was made. However, this report contains a number of improvements to state-of-the-art demand-responsive transportation demand and supply modelling. These improvements include increased capabilities of the existing FORCAST computer software which enables external modelling of a greater variety of transit services, as well as the inclusion of previously unmodelled demand. The improved reporting capability of the model allowed disaggregation and market segmentation of the results from the paratransit demand models. The market segmentation has been expanded to include elderly, non-elderly, auto ownership levels, and trip purpose (work, non-work).

New formulations of previously existing models resulted in improved new supply models for doorstep route deviation, exclusive-ride taxi, and checkpoint many-to-many services.