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Authors
Homburger, Wolfgang S.
Carroll, J. Douglas, Jr.
Einsweiler, Robert C.
et al.

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Urban Mass Transit Planning

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PREFACE AND ACKNOWLEDGMENTS

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A set of course notes was written for that offering and reproduced in limited quantity. Presented herein is an expansion and revision of the original notes, intended to provide background material, particularly for use in graduate courses and extension conferences.

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THE AUTHORS

J. Douglas Carroll, Jr.,	Executive Director, Tri-State Transportation Commission, New York, N. Y.
Robert C. Einsweiler,	Director of Planning, Twin Cities Metropolitan Planning Commission, St. Paul, Minn.
Martin J. Fertal,*	Highway Planning Engineer, Bureau of Public Roads, U. S. Department of Transportation, Washington, D.C.
Frank W. Herring,	Director, Extension Programs in Transportation, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
Wolfgang S. Homburger,	Associate Research Engineer, Institute of Transportation and Traffic Engineering, University of California, Berkeley, Calif.
Donald C. Hyde,	Associated Consultant, Parsons, Brinckerhoff, Quade & Douglas, New York, N. Y. Formerly General Manager, Cleveland Transit System, Cleveland, Ohio.
Michael C. Kleiber,	Associate Librarian, Institute of Transportation and Traffic Engineering, University of California, Berkeley, Calif.
Michael Lash,	Chief, National Highway Planning Division, Bureau of Public Roads, U. S. Department of Transportation, Washington, D.C.
Louis J. Pignataro,	Professor of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
Ali F. Sevin,	Highway Planning Engineer, Bureau of Public Roads, U. S. Department of Transportation, Washington, D.C.

*Mr. Fertal has since joined the Service Bureau Corporation, Pittsburgh, Pa.

CONTENTS

1. THE URBAN TRANSPORTATION PROBLEM: DEFINING THE CENTRAL ISSUES

J. DOUGLAS CARROLL, JR.

I would like to describe "The Urban Transportation Problem" as I see it, and list some of the major issues of Urban Mass Transportation. I intend to identify eleven issues, though they tend to lap one another. There are baskets of issues and subissues; the problem is to decide how to strain them out and to give each one a title and an identity.

First, as background for my selection I will attempt this through five assertions, each with brief supporting arguments. I want to establish a particular view or philosophy of urban transportation.

Fundamentals of the Problem

1. The urban resident is like an animal and unlike a vegetable in that he must move in in order to live. Motion is an essential ingredient in urban regions. This is self-evident, and yet it is a crucial fact to grasp in defining more effective ways for transportation to serve urban dwellers. The average urban resident presently reports making two trips per day (that is, one-way trips that require some means of transport). For example, in the New York region, there are about 30 million one-way journeys a day by a means of transport other than walking.

2. People receive rewards for traveling. In general, this is also self-evident for without a reward there would be no reason to travel. Further, rewards obtained are always greater than the cost of the trip (and cost is here used in its most general sense to cover all expenditures: cash, effort, time, etc.) for otherwise the trip would not be made. This suggests, however, that a rise in real income will generally be followed by an increased tendency to travel. In other words, formerly marginal trips which were not made because the cost exceeded the potential reward can now be made because of the increase in income. It is even quite likely that travel capability increases productivity--i.e., the more and the easier one can travel at a particular cost or within a given unit of time, the more productive he will probably be. If we assume that everyone uses what time and spare energy he has productively, it becomes clear that increasing one's ability to get to places should expand his productivity. And so, I argue that real transport improvements tend to bring about a rise in real income in urban regions, and, if one could measure this, it would be a figure of merit whereby competing improvements could be assessed.

3. Transportation in urban places has improved over time. There is a great deal of contention about this assertion. I have seen a number of "then and now" pictures with captions stating that it takes just as long or longer to traverse Central London or to cross Manhattan today as it did 40 or 50 years ago. Or timetables that prove the New Haven Railroad had better schedules 50 years ago than it does today. Nevertheless, I am convinced that transportation in urban places has improved steadily over time. By improvement I mean greater average speed and greater flexibility with more options of places to go. On the average, the sheer fact that people travel more today and still spend the same portion of their disposable income--13% to 14%--on travel, lends support to the argument that transportation has improved.

4. Transportation must continue to enlarge and to offer improved performance. Urban places have consistently grown more rapidly than the national population. We expect future population to continue to concentrate in urban places. To make this possible, and for the society to maintain steady gains in productivity, in livability, and in providing greater choices, good and steadily improving transportation is a necessary condition. Urban transportation presently suffers from capacity limits. It is congested. This urban congestion is in contrast to inter-city transportation which has a notorious excess of capacity. Roads, railroads, even the airlanes between cities, have the capability to handle much greater amounts of travel. But the minute the traveler hits an urban area, speeds drop, congestion appears, and the cost of providing a virtually congestion-free route is often prohibitive. This means that today, urban residents must bear the cost of congestion in urban areas because of the impossible costs of a congestion-free system. And it is my belief that we will never have peak-hour travel fully free and unimpeded, because we could not afford the off-peak idle capacity (and idle capital) that unimpeded travel would necessitate. (Parenthetically, I have been surprised at how insistent even the smallest hamlet is that it has a problem of traffic congestion--perhaps it is axiomatic that no urban place should have the problem solved.)

Thus, a part of the future improvements needed will be to expand capacity to meet growing demands and to make gains by relieving some congestion. At the same time that quantity is expanded, the quality of urban transportation must improve. While relief of congestion is one kind of quality, there are many others--environment, visual impact, for example. But all can be identified in measures of price, comfort, or safety. In sum, future improvements must do more than keep pace with growing population: they must provide a much higher quality than we have at present.

5. Mass transit is really part of an urban system of transportation. It is not possible to extract mass transit and look at it in any isolated fashion. Not only does mass transit compete with other modes of transport--it also, in some degree, depends upon the other modes for its ability to serve. Along with the word "system" that is so popular today, we have the term "interface"--where one subsystem touches another. This could be the parking lot, the airport, or the subway station: a junction or interface where a traveler changes mode. The success of any element of an urban transportation system depends in large measure on how well it fits with other elements, including the deployment of urban activities and land uses that are served. New interfaces occur between land use and transport. Mass transit must fit well with the entire urban system. The performance of the mass transit subsystem should be measured in the terms of the output of a greater system, by the beneficial effect on the daily life of all members of an urban population, not by how well the mass transit system works within itself.

Now for the issues.

The Central Issues

Issue No. 1. What portion of the total task should be allotted to mass transportation (the bus, train and subway) as we proceed into the future? To what extent can mass transit meet the growing and changing urban transportation needs?

Part of our problem here is structural: where will things be placed in an urban area? Part of it may be consumer oriented: how well can various modes meet consumer requirements for a presumably more affluent society? Part of the problem may be answered only in the technical world where hardware can be invented which we don't yet have--hardware which will gradually improve the performance of these systems. So our first issue leads to a whole series of subsidiary issues.

Issue No. 2. Should new or different elements or modes be devised or invented? Certainly, innovation is a problem in a variety of ways. It is a problem because many of our public transportation systems have not the financial or even the manpower vitality to keep renewing themselves. It becomes very difficult to support new development on a declining volume of business. There are institutional problems because of finance. There are institutional problems in the supplier end of the business where manufacturers can turn to defense or other activities with a much greater reward.

Apart from this question, I think that there is a subsidiary one of how innovation could be introduced. Who takes the gambles, where is the new blood, what does one do to take a fresh look at the task of moving people through a thick urban area? I have always had a pet notion that the missing link is a system that could move a pedestrian at about eight miles an hour and serve both young men and old ladies with bundles. This could provide effective enlargement of the tributary area around mass transit stations so that a fixed system of subways or rails could be more readily adapted to new locational demands. The Department of Housing and Urban Development has provided funds to test new ideas, but not too many have showed up. The Department of Commerce, under the Northeast Corridor project, has begun to experiment with ways to promote new items of hardware or design. However, it seems likely that the most effective way to concentrate public effort and attention on new types of transport is for the Russians to come up with a new means. Seen as a system, it is certainly possible to think of new elements that can get a person from door to desk and back. Also, on this question, we should ponder about manpower. What about training in schools? How can capable and active people be attracted to this problem area? Where is the money coming from? What is the role of government?

Issue No. 3. Should public policy direct investment into new designs, and should it support development of new hardware and promote new modes? Should public funds take on the risks of trying new ideas?

These are difficult questions. Innovation is particularly difficult to promote if you recognize the massive investment in what already is in place and the glacial difficulty of starting something new. The supplier industry is conservative in providing new mass transit equipment, and the entire automotive industry and all of its related facilities has a tremendous investment in things as they are and would certainly want to move slowly towards new and different ways of doing things. If public funds were applied to R & D work, there are very knotty problems of public-private rights--issues of copyright, of ownership, of investment. Yet, this remains a very real problem that I think will have to be faced in the future. It certainly does not appear that new risk capital is coming out of the transit industry, and there seems every reason to believe that it is just as reasonable an enterprise for government to promote invention of ways to haul people through urban areas as to get people to the moon. Should public funds support risky development to much greater degree? I think this is a difficult issue.

Issue No. 4. What criterion of performance is wanted for evaluation of an urban system and particularly the mass transit portion of it?

I say criterion instead of criteria because each of us has his own list of criteria. We want transport to be swifter, safer, cheaper, quieter. There are many ways in which we want to improve a transit system and a transportation system, but we cannot go in all directions at the same time. If we improve safety, we obviously are going to increase cost--if we raise speed, we will increase cost--thus, you cannot have the cheapest and the swiftest system. We often hear that our purpose is to provide the greatest good for the greatest number, or the best system at the least cost. But, the greatest good may very well not be possible when you deal with the greatest number. There is a need for definition of the single superlative or the single criterion. Different values must be balanced. Thus, we must find a criterion whereby we can evaluate the options which lie in front of us, and it must be accepted and clear. Frankly, I can't say what it should be. Whatever the criterion, it must allow for trading in different values--for example, is unit gain in safety worth a sacrifice in speed or an increased cost in investment? Or, how much are we concerned with improvements in comfort or convenience versus a reduction in user charges?

Issue No. 5. What will future requirements look like and what will be the preferred investment policy to meet these requirements?

I have argued that these requirements may very well exist somewhat independently of the system as it exists or may evolve; that is, the deployment of people across the urban space, the amount of development in the central business district, the location of places of work, all present a set of requirements which a transport system must meet. This is, in part, the way things go because we seldom have enough funds to build our transport systems well ahead of land development. Thus, land development, in large measure, grows from what is. That means moving from what we have today towards what we will have to provide in the future, and it is quite clear that it is unreal to scrap what you have and design a wholly new system for a distant point 25 years from today. The restraints of actual planning require change in what is here today towards what would be a preferred system for the future. Let me illustrate this issue or problem with a case from the New York Area.

Let us say that in the future there will be more and more people who live on Long Island and who will want to go downtown to work. The World Trade Center and other places will increase the number of job opportunities located "downtown." One could solve this problem by allowing the Long Island Rail Road train to go over the city subway tracks and terminate in downtown Manhattan, or, you can imagine running a subway train out over the Long Island Rail Road, or you could build a new tunnel. Now clearly, if you tried to build a new tunnel, you would have to provide the improvement in one giant step, since you could not deliver anyone downtown until the tunnel was built and connected. Or you could proceed in an interim fashion--providing some joint service and causing both subways and the railroad to readjust schedules and services. This approach would mean slower and more incremental improvements.

Or, take the Christie Street subway which was planned 23 years ago and is just growing to completion today. When it was planned, additional expense was incurred to allow the positioning of a fully grade separated highway across lower Manhattan over the subway. Now, if that highway were never built, the added costs incurred would prove to have been unnecessary. The same is true if the highway were not built in that location. These are just cases, but if you extend them to an urban system, the whole strategy of investment in time and in certain places in the right sequences appears to me to be a very real issue and one that has to be increasingly clarified. Certainly, the payoff for making the right investment at the right time is a very crucial point.

Issue No. 6. What are the values of high-density living and working places? What are the virtues of particular configurations of land use?

Again, we must dispose of the common notion of planning for the average urban resident. Of course there are many different preferences for living environments, so it is obvious we shall have to supply a variety of types. This will affect the various types of density, as well as other elements. Density is a significant factor affecting the utility of transit investments. But we will not design or emphasize high-density living and working patterns simply to support transit. It seems much more likely that the variations in density will depend upon the rewards to the inhabitants of structures. Thus, more must be known about the effect of densities on livability and workability of land uses.

A crucial issue in virtually every city in the country is the proportion and number of employees that are going to be working in the central business district. For the most part, while these work densities have remained high, they have not increased, and so CBD's have tended to house a smaller portion of metropolitan labor force. This in turn has affected the portion of workers traveling by public transit.

Comparable observations can be made about residential densities. They too have been falling. For the future, evidence of increased satisfaction and performance must be found in more dense settlement patterns if the advantages of public transportation are to be exploited.

Related to this is the whole question of the values associated with different configurations of urban settlement. What is the value of an extremely dense and concentrated urban settlement surrounded by a lightly used ring of hinterland as opposed to a more dispersed urban settlement pattern? What is the advantage of building one large park versus a lot of small parks? (If you continue with the notion of smaller and smaller parks, you may come to backyards and so to single family dwellings.) We can certainly conceive of a variety of possible ways of housing people and their work places and different patterns of settling them over the land. The issue, I think, is to define rewards to the inhabitants and to the community at large for these various configurations since they will, in large measure, determine what the transport system of the future should be.

Issue No. 7. Money--where will it come from--and who pays?

Views range from the traditional one that the user pays for full costs to the view that he should ride free. And those proposing full cost argue whether peak-hour irregular users pay most and off-peak users least. Clearly, if the objective of pricing is to insure the most profitable or efficient use of resources, full costs paid by the user is the superior strategy, whereas, if maximum use of facilities is desired, free travel will be the best device.

If any charge less than full cost is assessed to the user, the problem of finding the difference will be the issue. Where should the money come from? Is this a region-wide or city responsibility? Is it a benefit to be paid for by property tax, or should it be paid from some other source? Of particular concern for the future will be the average city's fiscal ability to support transit costs. Cities--once the sources of the nation's wealth to be taxed to support the poorer agricultural regions--are fast becoming problem centers with severe demands for services, but with older and weaker tax bases. Clearly, there must be regional and/or federal support if needed additional funds to maintain high quality transit services in the cities cannot be raised locally.

Issue No. 8. Should responsibility be governmental or private, and if governmental at what levels?

Urban mass transit services have been moving steadily out of private into public ownership. Even a commuter railroad has recently been acquired by a public authority. For the future, what is the prospect of private enterprise in the mass transit business? Are there ways in which incentive management can be combined with public ownership? And, assuming public ownership or responsibility, should it be an authority armed with revenue bonding power, or a direct governmental function?

Above all, we should be more and more ready to find ways to establish regional or state participation in establishing transit management; direction for this has the virtue of bringing transit management and planning into better balance with highway, airport and other transport programs.

Issue No. 9. When does the "public interest" warrant disciplinary action to enforce a particular pattern of modal use? When should public authority dictate a change in emphasis on mode used? What is the effect of limitation on parking in downtown areas?

In New York we have proposals to introduce tolls on all bridges leading to Manhattan in order to reduce the number of people driving. We have even heard proposals to close bridges and tunnels at some point each day with a sign marked "sorry--Manhattan is full."

In some ways, the question is academic, for government is already taking an important hand in influencing modal use--by subsidy, by private-versus-public parking, and in other ways. The real issue is to define that point at which the public interest requires action on the part of our governmental authorities to further alter the "rules of the game." And this is a very significant issue, and one where we have got to be quite clear as to the result wanted and the way in which it is brought about as a consequence of a particular action or policy. In short, the issue will be to obtain desired changes in uses without generating unexpected side effects. This will require full understanding of the complex urban system and its short and long term reaction to a particular new policy.

Issue No. 10. How can we best exploit technology?

Unquestionably, there will be rapid gains in automating some aspects of transport. For mass transit we can foresee automatic train control, fare collection, and scheduling right now. Increased system control will follow. The possibility of comparable changes in highways, toll charges, traffic control and vehicle control will make the highway system more nearly like the transit system and will increase the chances for managerial decisions on the proper blending of the two systems. The issue will be to bring the ability to manage and control the urban systems along with the potential for increased automation.

Issue No. 11. With automation in view, what needs to be done to assure fair and equitable treatment of labor?

Along with the owner-operator and the traveling public, the people whose job is to provide transport have a very real interest in the direction and character of change. The issue raised here is one of keeping the equities of labor in balance with those of the other two parties: the riding public and the management. Certainly, changes in automation cannot be adopted and workers displaced without compensation or protection of the worker. And, equally certain, it is unrealistic to forego useful improvements simply because they may displace workers.

These are real issues that will persist into the future. New means will have to be found to avoid strike threats and wage freezes. New means will have to be devised to fairly share productivity gains promptly and to insure against undue hardship when skills are no longer required.

Summary

We have an assortment of weapons in our arsenal of means for moving people around: tubes, shanks' mare, railways, subways, buses, autos, helicopters, boats, and so on. This entire arsenal of travel machinery is specialized both as to different situations in different urban areas and as to different portions of a rather complex population. Over time, the usage of the several weapons or modes has been changing. Whether this is due to finance, public policy, customer preference, or changing urban settlement patterns can be debated. The fact is, however, that the more individualized forms of transport are gaining while mass or group public travel is declining.

Mass transportation is like a wholesale operation. Although travelers need not start at the same origin and end at the same destination, they must assemble themselves in time and in space and in sufficient quantities to justify specialized equipment, operators, and bulk treatment. If, on the other hand, travelers prefer to travel at their own convenience between their own points at their own time, group patterns atomize to those of individuals or very small groups, and travel approaches a retail operation. Because of the wide difference of people, the wide difference of timing, the increasing dispersion of places to go, we have a changing balance between the wholesale and retail types of transportation. Thus, any notion of dealing with the average urban resident or the average mode of travel is out. The problem at hand is to bring the right weapons to bear to meet these requirements at the right time with full attention to changing demands of the future.

2. URBAN GROWTH TRENDS

MICHAEL LASH

Introduction

There has always existed a close relationship between available transportation and both the geographical location and the internal growth pattern of cities. Since the primary function of cities is exchange--exchange of commodities, services, and ideas--the available transportation mode has always determined the points at which such exchange could be carried out economically.

But while the predominant mode of transportation between a settlement and the world outside determined its geographical location, it was the transportation mode for internal circulation that determined the size and shape of the city itself.

In either case, the relationship was never entirely a one-sided one. The needs of commerce and human welfare themselves created the motivation for innovations in transportation. Thus the two forces worked one on the other through time, steadily expanding the flexibility and economy of available transportation.

With each improvement came new dimensions of freedom for man to influence the location of a city, its opportunities for growth, and its internal development pattern. Today we enjoy a wide variety of transportation modes to choose from. No longer entirely dependent on natural features such as rivers and the sea for economical transportation, we can create both external and internal arteries of transport virtually anywhere we desire--and quickly. As a consequence, man's control over the location of cities and their physical internal structure is greater than ever before. Today's urban transportation issues then revolve around the following two inter-related questions:

1. What combination and arrangement of transportation facilities are required to best serve the economic and social needs of our urban populations; and
2. What combination and arrangement of transportation facilities should be provided to influence the physical growth of our urban areas in patterns that are most beneficial to our society?

This chapter explores several facets of these two issues. It identifies trends of growth in several elements of urban activity having particular relevance to transportation service. These trends need to be understood and correctly interpreted in order to assess the economic and social demands that we would attempt to satisfy through the tranportation systems that are planned for an area.

The chapter also explores, in a limited way to be sure, some of the key issues that relate to the future of our central cities and their central business districts. The future role of the central city in a metropolitan complex is a matter of lively debate today. The transportation planner can hardly remain aloof from this discourse since the fate of the central city is not only a matter for him to take account of in his planning, but also may well be the result of his own efforts. Certainly the question of improving mass transit is a pivotal issue in planning transportation for the central city. Whether or not to invest public funds to revitalize public transportation in our cities may hinge largely on the question of what we would have our central cities become.

Influence of Mass Transit and the Automobile on the Shape and Size of Cities

In reviewing the influence of internal transporation on the physical size and configuration of cities, it is easy to see the relationship. During our early history American cities were limited in size to the horse-and-buggy mode of transport. Most people walked everywhere--to work, store, church and school. Industries remained small, partially because they could draw workers from only a limited radius.

With the gradual appearance of mass transportation, beginning with horse-drawn cars, people were able to travel faster and further with less effort. This helped factories to grow larger, being now able to draw workers from much longer distances. The business section of cities grew also, and began showing signs of increasing specialization. With faster transportation, owners, clerks and customers could live at some distance and still get back and forth in the same time.

As cities expanded, improvements in public transportation followed in rapid succession. With the electric street car, people were carried at a speed twice as fast as walking. As trolley lines were extended outward, new residential areas rapidly developed around them. Businesses and factories did the same. Thus cities took on star-like patterns of growth.

By 1910 nearly 90 percent of people in cities rode to work and most other places on street cars. But about this time the automobile began to appear on city streets, bringing with it another rise in the speed of travel. Whereas in 1890 people could live three miles from the heart of a city and get downtown in 30-45 minutes, by 1920 and using the automobile they could make the same trip in 10-15 minutes. People could now live even further out and still get downtown in the same time.

With more and better automobiles, suburban communities grew, and of course are still growing. In addition, more and more retail stores, industries, warehouses and similar activities have been locating in the suburbs.

Although certainly the automobile contributed importantly to making decentralization possible, there were other powerful forces working in the same direction. Electricity for example broke the central city's monopoly as a source of power. No longer was it necessary for a manufacturing plant to be located next to a steam generating plant; electrical power could be carried swiftly and inexpensively virtually anywhere.

Similarly, the telephone eliminated the necessity for people to be physically close for instantaneous communication, weakening one of the prime motivations for businessmen to locate close together. The radio and telephone added to this. Whereas in an earlier day news about the outside world and about local happenings came first to the telegraph and newspaper offices downtown and filtered out to outlying areas only slowly, use of the air waves made access to the news independent of location.

These technological changes made locating in the suburbs relatively easy for both industry and housing. Moreover, housing in the suburbs was given impetus by rising family incomes, particularly since 1945. In the last 20 years family incomes have more than doubled, and a good share of that increased purchasing power went to buy private housing in the suburbs.

> The outward movement of the well-off is nothing new; what is new is the spread of wealth to far more numerous classes who can afford what Susannah's husband provided for her in Babylon and great senators took for themselves in ancient Rome--a suburban home in a garden . . . such environments reflect a universal natural desire that man indulges whenever he becomes prosperous and free.
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> Osborn, Frederic J. "The Conqueror City," Town & County Planning, April 1961, p. 141

Residential Population - Trends of Change in the Central City and in the Suburbs

The forces described above, both technologic and economic, are reflected in observable trends of urban development. The decade 1950-1960 is a good one to study because plentiful census data are available. And trends during that period appear to be continuing.

One thing the 1950-1960 census figures show is that the population of central cities grew hardly at all, while the population of the remaining parts of the metropolitan areas grew substantially. For example, in the 10-year period mentioned, the central cities of the 212 metropolitan areas of the country increased 1.5 percent in residential population within their 1950 boundaries. But the fringe areas increased by 48.6 percent.

The population in our largest central cities not only failed to evidence growth, but on the contrary showed a predominant trend toward losing population. Of the sixteen American cities with populations of more than 600,000, eleven lost in population and only five gained (Table 2.1). The biggest gainers were the newer western cities. Most of the older cities from New York to San Francisco were on the wane.

TABLE 2.1 - POPULATION CHANGES IN 16 U. S. CITIES AND SMSA'S
1950 - 1960

Metropolitan Area	Central City Population 1960	Change in Central City Population, 1950-1960		Change in SMSA Pop. 1950-1960
	Thousands	Thousands	Percent	Percent
New York	7,782	- 110	- 1.4	+ 11.9
Chicago	3,550	- 71	- 1.9	+ 20.1
Los Angeles	2,479	+ 509	+27.1	+ 54.4
Philadelphia	2,003	- 69	- 3.3	+ 18.3
Detroit	1,670	- 180	- 9.7	+ 24.7
Baltimore	939	- 11	- 1.1	+ 22.9
Houston	938	+ 342	+57.4	+ 54.1
Cleveland	876	- 38	- 4.2	+ 22.6
Washington	764	- 38	- 4.8	+ 36.7
St. Louis	750	- 108	-12.5	+ 19.8
Milwaukee	741	+ 104	+16.3	+ 24.8
San Francisco	740	- 50	- 4.5	+ 24.2
Boston	697	- 105	-13.0	+ 7.4
Dallas	680	+ 246	+56.4	+ 45.7
New Orleans	628	+ 58	+10.0	+ 26.7
Pittsburgh	606	- 74	-10.7	+ 8.7

In summary, it is roughly accurate to say that one-third of the American population is within the central cities of metropolitan areas, and this segment is increasing at the rate of 1 percent per year, almost entirely by annexation.* Another third is in the metropolitan fringes, and here the rate of increase is 4 percent per year. The remaining third of the population is in the rest of the country, mainly rural areas and small towns, and this segment also is increasing at the rate of about 1 percent per year. (Ref. 13, page 20)

*Figures showing a fairly high population growth for some central cities can sometimes be misleading. That is, the apparent growth might well be due to annexation of additional developed land rather than through population added within the original city boundaries. For example, Phoenix, Arizona is sometimes shown as having increased its population from 107,000 to 439,000 in the time between 1950 to 1960. But the entire increase came through annexation; within its 1950 limits, Phoenix actually lost 46 people.

The recent trends in the population growth of central cities and suburbs is hardly anything to be very surprised about. When the land in central cities is fully built up, new growth can hardly go anywhere but to the outlying undeveloped land. But even so, the 1960 census figures came as a shock to the officials and chambers of commerce of many core cities.

The meaning of these population figures to transportation planners is that future urban population growth will not take place through increasingly higher residential densities in the central cities, but rather will occur almost entirely in the outlying suburbs. Also, that we can expect all cities to reach a saturation level in their populations contained within fixed boundaries; and as a consequence of which, cities will also reach a ceiling in the amount of travel generated by residents. Moreover, there is strong evidence that in most of the large central cities this saturation level has already been reached.

Socio-Economic Composition of the Residential Population - Trends of Change

The figures on changes in numbers of people living in central cities tell only half the story. The other half is that even while the number of people living in many of our cities remains relatively static, the composition of that population is changing. The trend is toward the increasing domination of the old cities by the disadvantaged, the low-income and minority families who have no other choice in the current housing market.

For example, the New York City Health Department estimated that between 1960 and 1964, a half-million white persons left New York City and were, in effect, replaced by 400,000 Negroes and Puerto Ricans.* In the central cities of the 12 largest metropolitan areas, the percentage of the non-white population changed from an average of 7.6 percent in 1930 to an average of 21.4 percent in 1960, and is still increasing rapidly.

The sharp difference in the socioeconomic status of central city and suburban residents is based largely on the experience of the larger metropolitan complexes. Employing 1960 census data for 200 urbanized areas, Leo Schnore, a sociologist, compared core cities and their suburban rings on the basis of these variables: income, education, and occupation. (Ref. 4, page 90)

His findings show that although no city of more than 500,000 exceeds its suburbs on any of the three variables, a clear reversal of this pattern takes place as one moves down the size range. In the 53 smallest urbanized areas, those of 50,000 to 100,000, the socio-economic status of the central cities on the average tended to be about the same as the suburban ring.

> The same study found that age of the area (measured by the number of decades that have passed since the central city first reached 50,000 inhabitants) is an important determinant of city-suburban differentials. The common conclusion that high-status persons live in the suburbs tends to be true of urbanized areas having very old core cities, but it is progressively less often true of the newer urban strongholds.
> (Ref. 4, p. 92)

Trends in Density of Housing and Choice of House Type

About 80 percent of trips in an urban area either begin or end at home. For this reason, where people live is a key element in establishing an area's travel patterns. But equally important is a study of density of housing; that is, the number of housing units occupying a unity of land area. Residential density determines the density of residential trip generation, a key variable determining the feasibility of transit service to a particular sector.

A key question is whether future housing will continue to be low-density single family housing or whether future trends will swing to higher-density apartment living. There has been a considerable amount of comment in the popular literature in recent years suggesting a massive disillusionment with suburban living and a growing trend toward apartment living in the city. There is no evidence, however, that this is actually occurring.

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*Source: Editorial, New York Times, May 8, 1966.

At present about 69 percent of the people who live in metropolitan areas live in single-family houses.

Single family house	69%
Two-four family house.	16%
Row house	3%
Apartments.	12%

The popular preference for housing type is still strong for a private single-family house. This was clearly reflected in a 1965 survey by the Survey Research Center of the University of Michigan. A cross-section of residents in metropolitan areas were asked: "If you could do as you please, would you prefer an apartment or a single-family house?" The results, shown in Table 2.2, indicate that 83 percent of the people would choose the single-family home. (Ref. 8)

TABLE 2.2 - PREFERRED TYPE OF HOUSING BY POPULATION OF AREA

Preference	Percent of Respondents Expressing Preference in:			
	All Areas	Metropolitan Areas with Populations of:		
		Under 350,000	350,000 to 1,499,999	1,500,000 and over
Single family house	83	77	89	83
Apartment	14	20	7	16
No preference	3	3	4	1
Total	100	100	100	100
No. of respondents	744	271	272	201

These results are corroborated by a similar but independently made survey in the St. Paul - Minneapolis, Minnesota metropolitan area conducted in 1963-64. Based on intensive home-interviews of 4,600 residents, the survey found that 85 percent of residents prefer a single-family home, 5 percent favor duplexes, and most of the other 10 percent favor various sizes of apartments.

The conclusion is clear: the present strong popular preference for single-family housing will continue into the foreseeable future. And indications are that this trend will continue unimpeded by any yearning to live close to the city center. For the same University of Michigan survey shows that the public is largely indifferent to the attractions of the city center as a place near which to live. The replies to the following two questions show this:

Q. "Some people like the excitement of living close to the center of things in a big city where something is always going on, but others don't like all the hustle and bustle. How do you feel about this?"

Tabulation of Answers:

Like the excitement of living close to center	15%
Indifferent or ambivalent	8%
Don't like the hustle and bustle	77%

Another question in the same survey asked:

Q. "If you could do as you please, would you like to live closer to the center of (name of metropolitan area) or further from the center of (name of metropolitan area) or just where you are?"

A.

Closer to the center of the city	9%
Just where we are	66%
Further from the center of the city	25%

The strong preference for living in the suburbs as shown by observable trends and by the results of polls may, of course, simply reflect decisions based on present conditions rather than enduring value choices. Few families who do have a choice will want to bring up their children in an increasingly ghettoized city, with its crime and other social problems, even if they hate suburbia. But if the city were characterized by a low crime rate, by superior schools, by fine city homes suitable for children, by numerous parks and leisure time facilities, then the attraction to city living might well change radically. But this is all highly speculative since evidence is meager that such extraordinary change can come about within the foreseeable future.

Employment Levels - Trends of Change in the Central City and in the Suburbs

Next to residences, the second major generators of trips are places of work. About 40 percent of all trips either begin or end at a place of work. Thus, the existing spatial distribution of employment centers as well as trends of change in job locations are key determinants of an area's travel patterns. What are these trends?

Data reflecting trends of change in the location of jobs in Central Business Districts, in central cities, and in the suburbs are limited. But the data available indicate that the number of jobs in large American cities has leveled off, and that rapid growth of jobs is taking place in the suburbs.

As for changes in employment levels in Cental Business Districts (CBD) specifically, the fragmentary data available fail to suggest any trend toward increasing CBD employment levels. The following 13-point summary of available evidence on CBD activity levels is from The Urban Transportation Problem by Meyer, Kain, & Wohl (pages 35-37):

1. In Detroit, the number of persons leaving the CBD during the evening peak hour by all modes of travel (including walking) averaged between 78,000 and 81,000 in the years 1944-1950, but was down to 73,000 in 1953.

2. In Dallas, despite a more than 40 percent increase per decade in total SMSA population from 1940 to 1960, the number of people leaving the CBD during the evening peak hours increased only 14 percent between 1946 and 1958.

3. In Los Angeles, the number of people leaving the CBD during the evening peak hour has remained stable at about 125,000 since 1941, even though SMSA population has been increasing over 50 percent each decade.

4. In Philadelphia, SMSA population has been increasing about 15 percent each decade since 1940, but the CBD's share of total jobs in the SMSA dropped from 41 percent in 1950 to 39 percent in 1956; the number of daily person-trips to the CBD has declined from 471,000 in 1947 to 373,000 in 1960, with most of the drop being concentrated in shopping and social-recreational trips. Even the daily work-trips decreased, however, dropping from 260,000 to 220,000. The peak-hour travel to the CBD remained reasonably stable from 1947 to 1960, falling only 3 percent over those years; by contrast, travel to the CBD

during the hour preceding the peak decrease 21 percent and that during the hour following the peak decreased some 27 percent.

5. In Houston, the number of persons entering the CBD between 7:00 a.m. and 6:00 p.m. declined from 324,000 in March and June of 1953 to 272,000 in July of 1960. During the same period, the maximum number leaving the CBD during the peak hour declined from just over 60,000 to 52,000.

6. The San Francisco - Oakland SMSA's population rose 50 percent between 1940 and 1950, and 24 percent between 1950 and 1960, but the number of persons leaving the San Francisco CBD during the evening peak increased only 10 percent between 1947 and 1959.

7. In Minneapolis, there has been a steady decline from about 110,000 people a day entering the CBD in 1947 to about 93,000 in 1960.

8. Washington, D.C., though an office and government town and therefore less likely to be sensitive to private economic forces and changes in manufacturing technology, had only a 2 percent increase in CBD employment between 1948 and 1955; population increased more than 30 percent in the SMSA during the same period.

9. The total number of trips to Tucson's CBD decreased from 41,500 in 1948 to 36,144 in 1960; automobile-driver trips increased from 22,280 to 23,192; bus passenger trips declined from 8250 to 3245; and other passenger trips decreased from 10,970 to 9707.

10. In Phoenix in 1947, 53,358 trips a day were made to the CBD from other parts of the area, and an additional 16,161 vehicle-person trips per day were made having both origin and destination within the CBD. By 1957 total trips to the CBD had decreased 33 percent to 35,606 and intra-CBD trips had decreased 65 percent to 5,666.

11. New York City has seen a 10 percent decline in the daily number of people entering downtown Manhattan (south of 61st Street) between 1948 and 1956, even though there was a 5 percent increase in the number entering during the morning rush hours; between 1950 and 1958, Manhattan lost some 200,000 jobs, while during the same period the outer boroughs gained 168,111 jobs, or 15.1 percent. The New York decline represents a change in trends evident prior to this period; between 1940 and 1948, the number of persons entering lower Manhattan increased by 15 percent.

12. A decline of CBD entrants in New York after 1948 is also supported by Francis Bello, who points out, "Despite a spectacular office building boom in Manhattan, the number of workers decreased 2 percent from 1950 to 1955." He notes that the occupants of new Manhattan office buildings make up the headquarters staffs of national corporations, which use larger amounts of space per worker. He concludes that, "While difficult to document, it appears that the worker population has increased little, if any, in the downtown districts of most big cities."

13. For Chicago, the number of persons leaving the CBD during the evening peak hour by all modes of travel (including walking) was 225,600 in 1950 and 223,600 in 1961.

But while employment levels show signs of having reached stability in the larger central cities, within these levels there is a flux in the nature of that employment. While some employers are moving out from the central city to suburban locations, others who have a stronger need to be in the central city are replacing them.

1. Manufacturing, Retailing, Household Services, and Wholesaling seem to be moving out.

2. Moving in are Financing, Business Services, and Central Office Administration (e.g. banks, law offices, advertising agencies, consulting firms, government agencies).

Another way of expressing this is that in the central cities the total number of blue collar jobs in declining while the number of white collar jobs is increasing rapidly, and within this shift is a high-rate of increase in the high-salaried managerial jobs.

One consequence of the evolving pattern of the distribution of residence and jobs in the metropolis is for high-salaried workers in the central city to live in the suburbs, while the low-salaried people who live in the central city increasingly have their places of work in the suburbs

Retail Sales - Trends of Change in the Central City and in the Suburbs

An indication of the number of shopping trips made to an area is the total volume of retail sales in that area. For that reason, the next element of urban change examined here is retail sales.

The Bureau of the Census provides excellent statistics showing changes in retail sales levels in the CBD, in the central city, and in the suburbs. These show that sales are declining in the CBD's, leveling off or growing moderately in the central cities, and growing rapidly in the suburbs. An illustration of this is the data from 11 randomly selected cities showing changes in retail sales from 1958 to 1963 (Table 2.3).

TABLE 2.3 - CHANGE IN RETAIL SALES IN SELECTED METROPOLITAN AREAS (1958-1963)

Metropolitan Area	SMSA Population (1960, millions)	Percent Change in Retail Sales in:		
		CBD	Central City	SMSA
San Francisco-Oakland	2.8	+ 3%	+13%	+27%
Boston	2.6	- 4	- 9	+13
St. Louis	2.1	-23	-13	+12
Washington, D.C.	2.0	- 1	+ 3	+30
Cleveland	1.8	-20	-15	+12
Minneapolis-St. Paul	1.5	-15	- 4	+16
Atlanta	1.0	- 4	+19	+33
San Diego	1.0	-38	+ 5	+19
Portland, Oregon	0.8	-20	+ 7	+20
Hartford, Conn.	0.5	- 7	-12	+19
Salt Lake City	0.4	- 3	+13	+29

NOTE: Above retail sales data are originally from Bureau of Census reports, but have been reduced by 5% to account roughly for the change in the consumer price index between 1958 and 1963.

The Central City and the CBD on Trial

Summarizing the trends of change examined above for the central city and the CBD we have the following:

--Decline in residential population in the large central cities, small rates of growth in moderate-sized cities.

--Continued public preference for single-family housing in the outlying suburbs; no change of tide evident for middle and high income families to return to apartment living in the city.

--But as middle and upper income families leave, they are replaced by low income, non-white families who are a growing proportion of the central city population.

--The number of jobs is not increasing in most of the larger central cities or in their CBD's. But the composition of that work force is changing--more white-collar, higher-income employees and fewer blue-collar workers, particularly in the CBD's.

--The daytime population of the central city is getting richer while the nighttime population is getting poorer.

--Declining retail sales in the CBD, moderate growth in the city as a whole.

--Net effect on travel: most of the larger cities have reached a point of stability in the number of trips generated. Future increases in travel will take place almost entirely between points in the suburbs where population, jobs, retail sales, and average family income are all on the upgrade.

Most of these trends spell trouble for the central city. They point to growing obsolescence, lower land values, a smaller tax intake, and growing expenses for welfare, police, and physical renewal. But the reduced number of trips likely to begin and end in the central city will work to reduce street congestion. But of course the problem is that reduced travel to the central city also means reduced economic activity. And less economic activity means a decreasing tax income to finance increasing costs.

Does all this spell doom for the central city? Opinion on this is mixed. Most planners and other students of the problem, however, are far from willing to give up the city as a lost cause. The prevailing opinion is that the central city and the CBD still have formidable natural strengths and an important role to play in the modern metropolis.

In the center of the large central cities there is every reason to expect vitality. The CBD is still the prime location for the following activities, most of which will continue to expand in the Nation:

--government offices,

--offices for confrontation industries,

--service industries that seek the economies which concentration offers,

--specialty stores,

--cultural and entertainment industries.

Vernon views the future potential for growth of both the CBD and the rest of the central city as follows:

> This activity aside, one sees only a growing obsolescence in the rest of the central city beyond its central business district. There is nothing in view calculated to interrupt the cycle so far evident in the old cities. When middle income structures reach an advanced stage of obsolescence, they will be converted to intensive low-income use. The ancient slums will be partially abandoned as they have been in the past, for the newer ones; populations will thin out in the former and rise in the latter, in a wave which moves gradually outward to the edges of the city and into the older portions of the suburban towns.
>
> The outward movement of people will be matched by an outward movement of jobs. Retail trade will follow the populations. Manufacturing and wholesaling establishments will continue to respond to obsolescence by looking for new quarters and by renting in structures in the suburban industrial areas where obsolescence is less advanced. The movement of jobs will reinforce the movement of residences.
>
> Beyond the central business district, therefore, but within the confines of the central city, there is likely to be a long-run decline in the intensive use of space as sites for jobs and homes. Will such space be converted to other uses? It is difficult to detect any actual or incipient private demand for city space which is of a magnitude calculated to replace such prior uses. Modern factory space is ruled out by the high costs of recapturing the site; new multi-story lofts face a poor market, since they will be competing with obsolescent factories vacated by their prior owners; office space, however greatly it expands, can scarcely be expected to fill more than a minuscule area, largely concentrated toward the city center; high-income renters may fill a little more space, but not much.
>
> This leaves two possibilities: that middle-income families may decide to return to the cities in great numbers; or that subsidized governmental intervention, such as low-income housing or open-space projects, may be expanded to such levels as to

constitute a significant space-using force. The first possibility would fly in the face of deep-seated historical trends, based on powerful sociological forces. The latter demands a scale of intervention much larger than any which heretofore has been contemplated.

from The Changing Economic Functions of the Central Cities, by R. Vernon. (In Ref. 4, p. 61-62.)

Planning the Future Central City

The whole future of cities is increasingly under debate. This is a question that should concern the transportation planner as well as the city planner. The likely future density and spatial organization of the central city is a key variable influencing the configuration and make-up of the needed future transportation system in a metropolitan area. Depending on whether one assumes the city can retain its high density of land use development or will continue to lose economic activity to the suburbs, will hang the question of the feasibility of an improved mass transit system, or of the desirable orientation and size of the highway network. Thus the urban transportation planner can hardly remain aloof from this crucial question.

The overwhelming bulk of evidence makes the outward movement of population and economic activity and the concomitant reduction of densities of development in central cities seem inexorable. Searching economic studies suggest that local governmental actions tend to follow the economic pattern rather than to lead it. Governmental innovations that complement the decisions of the market place are likely to succeed; others are not.*

Even so, there is an impressive array of observers that believes the tide of movement out of the central city can be checked and reversed by improved mass transit, renewal of the older urban areas, and various other remedial measures.

Conflicting views on the efficacy of public policy in shaping and directing patterns of urban settlement give rise to a wide variety of views on the likely future of our central cities and the CBD.

One school of thought, probably subscribed to by most city planners, holds that the preservation of a densely developed central city with a strong CBD is essential to a wholesome and vibrant metropolitan community. As they see it, the CBD epitomizes the essence of the metropolis--mutual accessibility. It provides the most favorable environment for the growth of commerce, management, professions, culture, fine arts, and education. In addition, a densely developed CBD provides a certain richness of experience and vitality of living through the wide range of choice it allows in stores, restaurants, theatres, specialty shops, and in a variety of other activities.

But another school is skeptical about the likely survival of the central city in its highly dense traditional form. Catherine Bauer Wurster explains this point of view as follows: (Ref. 14)

Only a limited segment of business and political interests have favored the old cities, however, while the great push of market forces has been on the other side. And now even the intellectuals are increasingly divided. The latest word from urban theorists representing various disciplines--Kenneth Boulding, Scott Greer, Melvin Webber, for example--is that anything resembling the traditional city is probably on the way out. Increasing dispersal is inevitable and even desirable. Communications technology destroys the "friction of space," opening up a wider choice of locations. There is no necessity to live close together, or close to work, shops, amusements. Old-fashioned centers are not needed. Communication, the original reason for cities, is less and less tied to local geography.

Finding himself in agreement with Boulding, Greer and Webber on this point, E. A. Gutkind, Research Professor of Urban Studies at the University of Pennsylvania and author

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*Odrian, Charles R. "Metropology: Folklore and Field Research," Public Administration Review, Summer 1961, page 155.

of "The Twilight of Cities," argues that urban planning should have as one of its aims the facilitation of deconcentration of central cities.

> There is only one solution. Cities must be decongested internally and decentralized externally. Both are interdependent, and both lead to the only way out of the present chaos--that is, to regional planning on a large scale, creating a new pattern of settlement and industry over vast areas.
>
> E. A. Gutkind, in a letter to the New York Times, May 28, 1966.

There is still a third viewpoint on the question. This school, while recognizing the centrifugal economic and social forces at work, nevertheless places high value on the amenities provided by a central city and concludes in favor of its preservation. This view is typified in the following:

> Or take the more fundamental question of whether we really want or need cities at all. There is a strong case to be made that we don't. The productive work of society, under modern technology, is more centrifugal than centripetal; we don't have to do much of it in or near a city any more. And it is quite obvious that a large majority of people who are prosperous enough to have a choice choose a suburban rather than an urban way of living. In that sense, people don't want cities. And yet the vision of a decentralized suburban society is rather appalling. Civilization carries the idea of the city in the very word. What kind of civilization could we have without urban centers of excellence? Where would we go for a really good lawyer or surgeon, to see really good acting, or to put through a really large loan?
>
> From Editorial in International Science and Technology, July 1965, page 17.

The debate over the future of the central city will no doubt continue for many years. It is confusing to many who are faced today with decisions where an assumption about the future density and form of the central city is an essential element influencing the choices available. Certainly this is the problem faced by urban transportation planners.

The question is simply not a black and white matter. For the future of the central city will be determined not only by market forces but by public actions as well. While the compact multi-purpose city is no longer an economic and functional necessity as it was from pre-history until a few decades ago, there are still compelling arguments for its preservation. But whether it should be preserved at anything like its present level of compactness is a different matter. This issue can only be decided locally, depending on the type of city the people of the metropolitan area want.

It does seem clear, however, that the higher the future level of density decided on for a central city above a natural equilibrium level established by economic forces and the state of technology at a particular time, the more public expenditures will be required to support it. That is, high densities will require greater outlays for improvements in urban renewal, mass transit, highways, parking garages, and similar facilities than will lower densities. So the decision about the form and density of the central city seems to boil down to what the people of an area decide they want and on the public funds available to support that density.

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3. COMPONENTS OF URBAN TRAVEL

FRANK W. HERRING

Introduction

American cities have shared a common, and well publicized, experience with transportation matters during the past few decades. Severe declines in usage, and therefore in revenue, have beset the mass transportation systems, while private transportation, by automobile, has grown at such a rate that there are ever more pressing demands on highway construction programs. Corporate-owned mass transportation systems have been abandoned, have gone bankrupt, or have required public support to enable them to continue service; publicly-owned systems have required increasing levels of subsidy. Despite massive programs of highway investment, city streets and major arterials are clogged with travel during critical hours.

These basic facts are widely known. They have induced some drastic policy proposals intended to change materially the pattern of urban travel behavior. There have been proposals to ban the automobile from urban centers or to impose tolls at city-center gateways, to expand the service areas of mass transportation systems, to build new high-speed systems in cities not now provided with them, to seek out new technology that would provide super-speed service. Certainly, such efforts to improve the quality and utility of mass transportation needs warm support, in the interest of improving the livability of our cities. But they should not rely upon an assumption that the urban traveler is perverse or stupid, that he does not know what is in his best interest.

To understand the problems of urban transportation it is necessary to pick apart the statistical data that are most widely available and to examine urban travel behavior in terms of its significant components. Aggregate data can at times conceal more than they reveal.

Examples of the misconstructions that endanger interpretations of gross statistics are plentiful in urban studies. Consider the relatively simple field of population growth.

Gross data on population growth for metropolitan areas between 1950 and 1960 appear to indicate that almost all central cities (those of Texas excepted) declined in population, while outlying areas showed growth. The exceptional situation presented by Texas cities is explained by large-scale annexations that took place during the decade, enlarging the city data base. It could be concluded from these data that centrality of location was a distinguishing feature of population decline. Scrutiny of data on sub-areas reveals that there were many small outlying areas which declined and some close-in areas that grew. When other data are introduced, particularly data on date of settlement, it appears that age of settlement has been a more important factor in population decline than centrality of location.

Similarly, when data on urban travel data are studied in "fine grain," it is found that the aggregate can be broken down into meaningful components showing strikingly different behavior patterns. Some of these components strongly favor mass transportation, some the automobile. Some are growing in total travel volume, some are declining. Some have more impact on transportation planning than others.

Urban travel does not comprise a homogeneous mass of trips which can be represented by a simple magnitude. Trips are made for a multitude of purposes, at different times, from a multitude of origins to a multitude of destinations by travelers of many different types.

Weekend and Holiday Travel

Saturdays, Sundays and holidays account for about 30 percent of the hours of the year and for some purposes the travel that takes place during those hours may provide the controlling magnitudes for facility planning. Most trips are recreation oriented rather than occupation oriented and consequently the parks, beaches, sports centers, places of entertainment and homes of friends and relatives are prominent traffic generators. The CBD is low in generating strength. Trip destinations are widely dispersed over the entire urban region and there is no prominent traffic pattern.

As trip purposes are geared to personal satisfactions, Saturday, Sunday and holiday travel is typically family travel, including children, pets, bags, lunches, and other impedimenta. Trips by automobile have heavier vehicle loading than trips made on working days. Trips are occasional rather than repetitive. Travel times are at the traveler's convenience rather than responses to set schedules such as work-starting or work-quitting times.

The load curve is relatively steady. There are certain peaks of demand, however, such as those on Sunday nights for return-to-home trips. At times departure volumes on Friday afternoons, anticipating week-end activities, aggravate the usual afternoon rush-hour traffic. In some cases, as with travel arteries directly serving popular recreation centers, these peaks may present the controlling magnitudes for the transport capacities needed.

Understandably, in view of the factors of convenience and economy, travel in this category is heavily dominated by usage of the automobile. Mass transportation cannot compete successfully. Indeed, it is probable that a large proportion of the week-end and holiday trips now made by automobile are of the kind that just were not made at all in past years when the automobile and the supporting highway system did not exist. In this sense there has been no diversion at all from common carrier transportation to the automobile.

The volume and importance of this component of urban travel have increased greatly during recent decades, as we have had more leisure time, as we have become a more affluent society. The simple shift from a six-day to a five-day work week almost doubled the amount of opportunity for free-time travel. As leisure time increases in the future it is to be expected that Saturday, Sunday and holiday travel will continue to grow faster than population, and even faster than automobile registrations.

Off-hour Weekday Travel

Weekday travel during off hours, say from 10 a.m. to 4 p.m. and from 7 p.m. to 7 a.m., does not present magnitudes which are controlling on capacity requirements but it is highly important in contributing to the annual revenues of revenue producing facilities. For mass transportation it provides much needed revenue at minor incremental cost.

Off hours, assuming that three hours each should be allowed for the morning and afternoon peaks, account for three-fourths of the hours of the day, but the proportion of daily usage of transportation facilities is in all instances far less than three quarters. That proportion, however, varies widely among the various modes of travel. It is lowest for mass transportation, particularly in those urban areas of low population density, and moderate for automobile travel.

Trips are for a multitude of purposes, and a large share of them are for short distances. Journey-to-work travel does not play a major role. Consequently, origins and destinations are highly dispersed, with generation by stores and shopping centers, schools, hospitals and medical centers during the day-time hours, and with entertainment centers and friends' homes prominent during the evening hours. Travel in this category is mainly intra-regional. During the mid-day period the load is relatively steady; during the night hours the load falls off sharply after midnight.

In the outlying urban areas, those developed at low residential density, trips are almost all by automobile. In the central parts of the city mass transportation plays an important role, in the largest cities even all night long.

Peak-hour Weekday Travel

Weekday travel that takes place during the peak hours of travel is primarily journey-to-work travel but it comprises two distinct segments displaying quite different characteristics.

Travel to non-CBD Jobs. Long before manufacturing establishments, in response to technological forces, began to seek large open sites in outlying areas there were important job centers outside the Central Business District. There are many such employment facilities today, well within central city boundaries, surrounded by moderately dense residential areas. They include neighborhood commercial centers, hospitals, small factories, cultural centers and the like. In the aggregate they account for a sizable proportion of the total urban employment. In all probability most of their workers live not too far away and may represent a major share of the "walk to work" and "work at home" responses to journey-to-work surveys.

Of greater significance to today's transportation problems is the growing volume of employment in outlying centers, large manufacturing plants, regional shopping centers, and even executive office establishments that have chosen suburban locations. Its significance stems from the fact that it accounts for the lion's share of projected employment increase in the future.

A sizeable proportion of these workers live within the more central parts of the city and therefore travel outward when going to work and city-ward when returning home. Strong reliance is placed on the automobile, for many of the new job centers are not well served or are not served at all by mass transportation routes. Even though mass transportation lines typically radiate from the Central Business District, home origin and job destination are frequently not in the same radial corridor. Nevertheless mass transportation receives moderately strong usage, for many of these travelers are factory workers of relatively low income and cannot afford the more convenient service that the automobile could provide them.

Travel to CBD Jobs. This brings us to what is probably the most important component of urban travel, certainly the most important for mass transportation, travel during the peak periods to and from the Central Business District.

All but fractionally it is work travel and its magnitude is a reflection of the CBD strength as an employment center. CBD employment is relatively stable in most cities; in some it has even been declining. There are conflicting views of its future. There are some who look to downtown rebuilding and expect that downtown activity will be revitalized by vigorous planning programs, including programs of transportation improvement. The contrary view is that avoidance of further loss of strength is the most that can be hoped for reasonably. It may be said fairly that the future is in doubt.

In any event there is no question that the character of downtown employment has been changing. Manufacturing and other activities involving materials handling have sought suburban locations. Executive office activities have grown in importance and employment opportunities, and have in most instances displayed their growth in Central Business Districts. The two opposing trends have cancelled each other leaving a small positive balance in some CBD's and a small negative balance in others. But even when the total number of CBD jobs has remained the same there has been a marked change in the type of employees, a shift from blue collar to white collar. To an uncertain degree this also meant a shift to employees of a higher income level.

Mass transportation is the strongly dominant mode for this component of urban travel, the proportion varying from city to city, but reaching as high as 90 percent in the New York metropolitan region. This is the travel for which mass transportation lines were originally laid out, and they still perform much the same role they did in days past. Travel demand is sharply peaked, however, with high demand for two or three hours in the morning and an equal period in the evening. It is the base load, or off-hour load, which has declined for the common carriers.

The usage of mass transportation is quite dependent upon this journey-to-work travel to the CBD, and so its future is closely bound up with the future of CBD employment. From a revenue point of view the decline in the base load has been a serious blow for there has been no corresponding reduction in the costs of providing the service. Facilities requiring large capital investment, such as rail facilities, have been particularly vulnerable to this revenue loss.

Even though mass transportation dominates this segment of travel a surprising number of CBD-bound travelers who live at close-in points choose to drive automobiles to work. Of those using this form of transportation to New York's CBD some 65 percent live within New

York City and some 25 percent live in Manhattan. New York's CBD is relatively large but even so it is striking to find that about 5000 of those driving to work in it live in the CBD itself.

Insofar as past trends and present behavior, in both travel and urban growth, give an insight to the future, there is but a moderate prospect for growth in this important component of urban travel.

4. CHARACTERISTICS OF MASS TRANSIT SYSTEMS

WOLFGANG S. HOMBURGER

A. Definitions

1. Mass Transit - Service provided for the carriage of passengers and their incidental baggage on established routes and fixed schedules within cities and metropolitan areas, usually on a fare-paying basis. (The term is not applied to intercity transportation.)

2. Rapid Transit - Mass transit service on exclusive right-of-way operating without interference from other traffic or pedestrians, usually at speeds above 20 mph, with stops spaced one-third mile or more apart.

3. Local Transit - Mass transit service on city streets, subject to interference from other street traffic.

4. Commuter Railroads - Railroad systems which operate a form of rapid transit service in metropolitan areas over their facilities.

5. Short-haul Transit - Service over short distances (less than about two miles) intended to move passengers within congested areas such as central business districts, amusement parks, airports, etc., and to facilitate access to and from transit, parking, and other terminals.

6. Glossary of other transit terminology:

   Access Time - The time required to walk or drive from the origin of a trip to a transit stop, plus a waiting time based on the frequency of transit service; the walking or driving time from the transit stop to the destination. Includes miscellaneous delays encountered within transit terminals. (For auto trips, it is the time required to walk to or from parking places, and delays within parking facilities, if any.)

   Bus Lane - A street lane intended primarily for buses, either all day or during peak hours, but which other traffic may use under certain circumstances; i.e., to make right turns. If other traffic is physically prevented from using this lane, it is referred to as an exclusive bus lane, i.e., in a freeway median strip.

   Capacity - The maximum number of passengers that can be transported over a given section of a transit route in one direction during a given time period (usually one hour) under prevailing traffic conditions.

   Capital Costs - Nonrecurring costs required to construct transit systems, including costs of right-of-way, facilities, rolling stock, power distribution, and the associated financing charges, administrative and design costs.

   Express Service - A type of operation providing higher speed with fewer stops than generally exist on local transit lines, in order to traverse fairly long distances as rapidly as possible. May be on exclusive right-of-way (rapid transit) or in other traffic (buses on freeways, city arterials).

Feeder Service - Local transit service to pick up or deliver passengers in connection with a transfer at a rail rapid transit station or express bus stop or terminal.

Headway - The time interval between successive vehicles or trains moving along the same track or route in the same direction.

Line, Route - The course followed by scheduled transit vehicles as a part of the transit system.

Local Service - A type of operation involving frequent stops and consequent low speeds, the purpose of which is to deliver and pick up transit passengers as close to their destinations or origins as possible. May be on exclusive right-of-way (rapid transit with stations spaced at 1/2-mile intervals or less) or in other traffic (local transit lines).

Maximum Load Point - The point on a route where the total number of passengers carried is a maximum.

Network - The configuration of transit routes and stops which constitute the total system.

Operating Costs - Recurring costs incurred in operating transit systems, including wages and salaries, maintenance of facilities and equipment, fuel, supplies, employee benefits, insurance, taxes, and other administrative costs. Amortization of facilities and equipment, which is a recurring cost, is occasionally included, but more often stated separately.

Operating Revenue - The gross income from operation of the transit system, including fares, charter income, concessions, advertising, etc. Does not include interest from securities, non-recurring income from sale of capital assets, etc.

Terminal - The terminating point of transportation routes of one or more modes with transfer facilities and, often, amenities for passenger convenience. (This term is also used for intercity passenger transportation, and for freight transportation where freight storage space may be provided in lieu of passenger amenities.)

Train - Two or more transit vehicles physically connected and operated as a unit.

Transfer - The portion of a trip between two connecting transit routes, both of which are used for completion of the trip.

Trip - The one-way movement of one person between his origin and his destination, including the walk to and from the means of transportation.

B. Description of Systems

1. Local Mass Transit Systems. These are operated on city streets, expressways and freeways. Vehicles are subject to interference by other users of the streets, both vehicles and pedestrians.

    a. Bus Systems: Because of the low capital costs (no right-of-way or power distribution system need be provided), almost all local mass transit systems are now operated by diesel or propane buses. A bus system is flexible, permitting temporary or permanent change of routing at minimal expense. Special services and charter trips are easily made available. Local and express services can be operated on the same street, because vehicles can overtake each other.

    To reduce interference from other traffic somewhat, bus lanes have been established in some cities, e.g., Chicago, Atlanta, Baltimore, Nashville.

These lanes are reserved for exclusive use of buses except that, where the lane is along the curb, other traffic may enter it prior to making a right turn.

Access to the system is at bus stops, which can be easily relocated if necessary. Bus stops are generally at the curb, and permanent parking prohibitions are enacted to keep the stop zones free for buses. See Section D. 4 below for bus stop location and length.

b. Trolley Coaches: Because of the heavy investment required in, and maintenance of fixed electrical distribution system, and because of the lack of flexibility in routing and operations, this type of vehicle is disappearing in the U.S. and in some other countries. No new trolley buses have been built in the U.S. since 1956.

c. Streetcars: While right-of-way costs for streetcar routes on streets are usually very small., investment in fixed facilities and rolling stock is considerable, and flexibility of operation is poor. In very large cities (e.g., New York, London, Paris) which have extensive rapid transit networks, streetcars have disappeared, and in most small and medium size cities they have been replaced by buses. However, streetcar systems have the advantage of using larger vehicles than bus systems (higher capacity and lower labor cost per passenger), providing a smoother ride, and using electric propulsion, which permits underground operations without elaborate ventilation facilities. Therefore, some larger cities are retaining streetcar routes either to supplement rapid transit networks (Boston, Philadelphia, Cleveland, San Francisco) or in lieu of them (Brussels, Frankfurt). Where such systems are to be retained, they either are or are planned to be, underground in the downtown areas, on exclusive right-of-way above ground wherever feasible - often in medians of wide city streets - and on their present alignment in the street elsewhere. Coverage of outlying areas is better than with rapid transit systems because of the lower capital costs per mile.

2. Rapid Transit Systems: These systems have higher capacity and speed than local transit systems, because of using an exclusive right-of-way. The capital cost per mile of route is very high compared to local mass transit systems, and the route mileage which can be provided is therefore limited. As a result, most rapid transit systems must rely on feeder transit routes and the use of the private car as a feeder in outlying areas, and may need distribution transit routes in central business districts. The exception is the use of buses on exclusive freeway lanes; these buses can perform their own feeder and distribution service at either end of the trunk-line portion of their routes.

a. Right-of-way: By definition of the term "rapid transit," a separate right-of-way must be provided. This right-of-way may already be public property and may therefore cost nothing; the use of streets as right-of-way for elevated or underground facilities is common. For some underground routing only an easement under private property need be obtained; this occurs frequently in London where the combination of favorable soil conditions for deep tunneling and an irregular street system geometry make routing under private property the optimal solution in many cases. In other cases, right-of-way must be purchased outright. However, just as in the case of urban freeway facilities, the possibility exists for using this right-of-way for other purposes by leasing the air rights above a facility or the space below an elevated structure for other uses. For example, parking decks have been constructed above open-cut sections of the Yonge Street route in Toronto, and department stores have been built over, under and around rapid transit stations in Tokyo.

b. Roadway: The rapid transit facility which will carry the vehicles or trains can be built underground, at grade, or above ground. The decision depends on the comparison of combined right-of-way and construction costs, urban aesthetics and impact on the street network.

(1) Underground construction minimizes need for outright purchase of right-of-way, presents no aesthetic objections at the surface level (though, possibly, underground - public nuisance, crime), and has minimum adverse impact on the street system, since grade-separation is automatic. However, construction costs are by far the highest; at 1966 prices they range from $10 to $20 million per mile in downtown areas, plus probably $2 - $3 million per station.

(2) Elevated construction also requires little or no land acquisition, if located above city streets, and also makes grade separation simple. Older structures are unsightly, however, and even modern design will block some light and air from adjacent land. Where elevated profiles are used on specially acquired right-of-way, construction can be partially on fill (lower construction costs, but greater width of land needed and "barrier" effect on adjacent neighborhoods). If built on continuous structure, land below can be used for other purposes, or landscaped to reduce the adverse aesthetic impact. Construction costs are in the range of $2 - $5 million per mile, plus about $1/2 million per station.

(3) At grade construction is least expensive ($1-$3 million per mile, plus about $1/2 million per station) and can be attractively designed. However, land must be provided for the right-of-way, some cross streets closed off, and grade separations built for others.

(4) Use of freeway medians (Chicago, San Francisco) is an economic approach, and reduces disruption of neighborhoods. However it causes some difficulties in station layout, and makes these stations more remote from the actual origins/destinations of transit users; not only must users walk considerable distances within the freeway right-of-way, but also the freeway alignments will bypass high-density land uses which may deserve direct rapid transit service. Congestion may be caused on streets which feed both a freeway interchange and a rapid transit station.

The complete facility includes a suitable base or ballast, the running surfaces (track) of steel, wood or concrete, switches or other mechanisms to guide vehicles positively at junctions, signalling with visual indications and automatic fail-safe provisions to stop vehicles in case of operator error - or, alternately, completely automatic train control - and stations (see Section D. 4). In addition, provisions must be made for turning or reversing vehicles or trains at terminals and, perhaps, at some intermediate stops, and connecting the facility to storage and maintenance areas.

c. Vehicles and Tracks: Rapid transit vehicles (other than buses on exclusive right-of-way) include a variety of different forms, but they all have certain features in common: ability to operate separately (or in "married pairs") or as a part of a train; capacity to accept and discharge passengers rapidly through multiple doors, positive train control or complete automation, and electric propulsion. They also suffer from the inability to leave their specialized track to operate on city streets.

The rapid transit vehicle types may be classified by the wheel and track combinations used, and by their means of support or suspension.

(1) Type of wheel and track: Steel wheels on steel track is most common: advantage is the low power demand and cost required to overcome the low rolling friction while disadvantages are lower rates of acceleration and deceleration, restriction on the degree of gradient which can be

negotiated, and higher noise levels. Rubber tires on concrete or wood have a higher rolling friction; advantages and drawbacks are the reverse of those listed for steel-on-steel.

(2) Support or Suspension: Most transit vehicles are supported on two tracks for optimum balance and minimum cost of both track and vehicle wheel assembly. Support on a single rail ("Alweg" system - Seattle) requires a less light-obstructing structure when elevated, but a more imposing single rail which even when at grade requires substantial foundations; wheel assembly is complex because horizontal guide wheels are required in addition to vertical main wheels, and ride is rough (in Tokyo, maximum hoped-for speeds have not been possible because of this).

Suspended systems use either a single rail (the original monorail of Wuppertal) or a split beam with two tracks (SAFEGE system of France). Advantages are said to be higher speeds in curves and general superiority over supported systems, but this has yet to be proven. Disadvantages include problems of stability, and the added cost of structure, since the track can never be laid at grade, and, if above a street or freeway, must be 12 - 15 feet higher than a supported track would have to be.

(3) Examples of the various possible combinations include:
Steel-on-steel, supported, two rails: "Conventional" rapid transit.
Steel-on-steel, suspended, one rail: Wuppertal monorail
Rubber-on-wood, supported, two rails: Paris Metro, Montreal
(however, these also have auxiliary steel wheels and steel rails in case of tire failure and for switching)
Rubber-on-concrete, supported, two tracks: Westinghouse "Skyway"
Rubber-on-concrete, supported, one rail: "Alweg" monorail
Rubber-on-concrete, suspended, two tracks: "SAFEGE Monorail."

All single-rail systems, as well as the suspended duo-rail, still have not solved the problem of fast switching. Networks of these types have not been built with any switches except into storage and maintenance areas. This severely limits possible network and routing configurations.

For an analytic study of the technical and operational comparisons of various vehicle and track systems, see Reference 1.

- Buses on their exclusive right-of-way have in the past been limited to terminal approaches (New York, San Francisco) and - in a partial way by police control - to the Lincoln Tunnel in New York. A complete network of bus roadways was proposed for St. Louis (Ref. 2), but was never built, and has been proposed for an expressway in Chicago and for one reversible lane in the north-south freeway in Seattle. The principal advantages of such systems would be that the vehicles can leave exclusive right-of-way to provide their own feeder function in outlying areas, and that an extensive network could operate even in early stages of construction, which could be programmed over longer periods than other forms of rapid transit. The disadvantages include higher labor costs (smaller vehicles, probably not practically made up into trains), no positive vehicle control or automation at the present stage of technology, and the problem of downtown distribution. The latter would either have to be made on city streets (slow, congested), on elevated roads (aesthetically objectionable) or underground (ventilation problem or need for a power plant which can switch from diesel to electricity).

A summary of a thorough comparison of three rapid transit alternates for one set of transportation conditions is given in Appendix No. 1.

For more complete information, see Ref. 69 in Appendix 2.

3. Commuter Railroads: Commuter railroad systems have been declining in most U.S. cities, and have disappeared in some. This has generally been due to problems of route location and operations. Occasionally it has been possible to transfer a commuter railroad branch line to a rapid transit network with little capital cost, provided that freight service could be abandoned (e.g., Highland Branch, Boston; Rockaway Line, New York). The federal transit legislation of 1962 and 1964 provides subsidies for purchases of commuter equipment and experimental service improvements.

   a. Route Location: Railroad routes were generally located with intercity rather than intracity traffic in mind. Most routes terminate at only one downtown point, and this terminal is often located inconveniently to the destinations of commuters. Station spacing is longer than in most rapid transit systems; this increases trunk line speeds, but reduces accessibility, and makes feeder service by bus or private car essential. Except in rare cases, no parking areas for commuters are provided at suburban railroad stations.

   b. Operations: The large station spacing, long platforms, and cars of generous dimensions contribute to a transportation system with high speed, comfort, and capacity features. However, efficiency and safety are affected by possible interference from freight and intercity passenger operations, grade crossings with highways and other railroad tracks, and problems inherent in the layout of dead-end downtown terminals. In some foreign cities (e.g., Tokyo, Hamburg, Brussels, London) some of these difficulties are overcome by providing separate tracks for commuter trains, grade separations, and through, rather than dead-end terminals. In the U.S., exclusive commuter tracks are occasionally found, and there is a proposal to enhance the efficiency of two separate commuter operations in Philadelphia by linking their separate terminals and eliminating the need to reverse trains downtown.

   Economy of operation in the U.S. is decreased by the cost of large train crews required partly because of complex fare collection tasks, and partly by labor agreements or state "full-crew" laws.

4. Short-haul Transit and Distribution Systems: In many situations there is a demand to move large numbers of persons for distances of less than about two miles. Examples of such situations include:

   Connection between two large traffic generators.
   Connection between a large traffic generator and transit stations or parking facilities.
   Movement within large complexes, such as central business districts, airports, university campuses, and amusement parks.
   Movement within large parking facilities, or within large transit stations.

   Vertical transportation by elevator may be considered part of this type of transportation, but is not considered here. It should not be overlooked, however, as a complex, important, and fascinating transit problem.

   Passenger movement in the short-haul range can efficiently be carried out by special systems, which differ from other transit systems in that their maximum speed need not be high. The systems may be grouped as follows:

   a. Individual vehicle systems: These include special buses designed for frequent stops and low operating speeds, and tractor trains which can travel on pedestrian walks as well as on streets. These systems require little initial investment, but considerable operating (labor) cost; capacity can be adjusted to meet fluctuations in demand, and routing is flexible. Top speeds may be 25 mph, but average travel speed on the route is probably less than 10 mph for buses and about 5 mph for tractor trains.

b. Belt systems: Among these are included escalators for overcoming vertical as well as horizontal distances, pedestrian belts for alignments within 10% of horizontal, and belts and cables carrying individual vehicles (e.g., aerial cabins and gondolas, "carveyor"). Such systems require a greater initial investment, but lower operating costs; they have constant capacity regardless of demand, except for one type of gondola system; their locations and routes are fixed. Belts and escalators operate at 1.0-1.4 mph, because of safety considerations at the boarding and alighting points. The "carveyor" system is designed for 15 mph between stations, and 1.5 mph while passing through stations. Aerial tramways operate at up to 17 mph between stops. The suspended systems (aerial tramways) are, of course, especially suited for crossing topographical barriers, such as valleys or small bodies of water, and to overcome vertical differences in elevation in mountainous terrain.

5. Auxiliary Facilities: Any transit system requires certain auxiliary facilities for its operations. The most important among these are:

a. Vehicle Storage - garages for buses (including fueling and cleaning installations), yards for rail vehicles (including cleaning installations and consist make up layouts). These occupy considerable ground space. From an operations viewpoint, they would optimally be located in downtown areas, so that vehicles not needed between the morning and evening peak could be stored near the point where they are withdrawn from and later reinserted in the transit network. However, land costs make this usually impossible; storage areas are therefore located outside downtown areas, requiring considerable "deadhead" mileage to be operated by vehicles entering and leaving scheduled service.

b. Maintenance - garages for buses and shops for rail vehicles, including necessary machinery and tools. Also, shops for track maintenance equipment and crews in rapid transit systems. On occasion, such shops may even build new, specialized equipment which is not available from manufacturers.

c. Administrative - office space for supervisory and administrative personnel, locker rooms for operating personnel, facilities for processing fares collected on vehicles or at turnstiles.

C. Field Studies for Mass Transit Planning

Mass transit studies are designed to obtain data needed for analysis of the quality of transit service, extent of usage, problems of traffic flow, safety, and other operational problems. The most important studies are listed below. Transit studies are described in detail in Refs. 3 and 4.

1. Mass Transit Inventory: An inventory of mass transit service supplies essential background information for other transit studies and for the evaluation of the service provided. Data gathered includes a map showing the routes of all transit carriers in the study area, schedules indicating the frequency and hours of service on each route, as well as the trip times between various points on the system, a summary of the rolling stock used in providing the service showing its capacity, age, and condition, and the schedule of fares charged.

2. Origin-Destination Studies: These studies are conducted to determine the origins and destinations of transit patrons. The mass transit riding studies discussed in the next paragraph will not give any information about the portion of passengers' trips between actual origin and boarding stops or between alighting stops and final destination. The origin-destination information may be obtained as a part of a comprehensive study of the area. In a special study, a questionnaire may be handed to each boarding passenger on one or more routes with the request that he is to complete it and return it to the driver when alighting. Since this procedure may cause delays near the bus doors and inconvenience to passengers (those without

writing implements and those having to stand may not complete the questionnaires), return postcards are sometimes used. Passengers can then complete the card at a time convenient to them. A return of 30 to 50% of the cards issued may be expected.

3. Mass Transit Riding Studies: Mass transit riding studies provide data on passenger volumes, boarding and alighting, vehicle occupancy, and adherence to schedules. These studies are of concern primarily to the engineers of the transit company, since the data developed leads to improvement in the routing and scheduling of transit lines. City traffic engineers will need some of these data for the location of bus stops, consideration of turn prohibitions and establishment of one-way plans which favor transit vehicles (signal timing, exclusive bus lanes, etc.). Two types of studies are used to determine transit riding characteristics.

    a. Transit load checks (Ref. 3, pp. 67-69) are performed by observers stationed at one or more points along the transit routes being surveyed. Each observer records vehicle identification, time of arrival and/or departure, number of persons on board the vehicle when arriving, number of persons alighting, and number of persons boarding.

       Generally, the point is observed along the transit route where the number of passengers carried is known to be the greatest (maximum load point); additional locations along the route may be included to develop other data of interest. If two or more points along one route are studied simultaneously, the travel time of the transit vehicles between these points can be checked.

    b. Boarding and alighting checks (Ref. 3, pp. 69-74) are conducted by observers traveling on transit vehicles. Each observer records the number of persons boarding and alighting at each stop, the number of persons on board between stops, the time the vehicle passes certain time-check points en route, and, sometimes, the type of fare paid (cash, school tickets, transfers). On lightly traveled transit runs, the observer may be able to keep track of each passenger to relate his boarding stop to his alighting stop; however, he will find it impossible or difficult to do this when the vehicle is almost or completely full.

4. Transit Speed and Delay Studies (Ref. 3, pp. 74-77). These studies parallel similar studies for the entire vehicle stream. The data are obtained by observers riding on transit vehicles at various hours of the day. The time each vehicle passes a check point and the cause and duration of delays is recorded. In addition to the types of delays found in the vehicle speed and delay studies, the corresponding transit study will also show delays caused at bus stops by passengers alighting and boarding, delays at time check points if the vehicle has arrived ahead of schedule, and delays caused by crew changes, fare zone checks, and the like.

D. Capacity and Performance Capabilities

1. Passenger Capacity of Vehicles and Trains: Examples of the design capacity of some transit vehicles is given in Table 4.1. It should be noted that the capacity of a transit vehicle varies inversely with the degree of comfort. The same vehicle shell, equipped with few seats and much standing room, will have a larger capacity than when furnished with many seats and little or no room for standees. The degree of comfort to be provided may be in part a policy decision - made either by the operating agency or a regulatory body - but it is also a function of trip length. Passengers are unwilling to stand on long trips, but perhaps quite willing to do so on short ones. It is often observed that passengers will pass up a full vehicle on which they would have to stand to wait for one with available seats. (It can even be observed that they will pass up one where only uncomfortable seats in the back row are vacant.) Therefore, a technical capacity figure which includes more standees than are ever willing to stand will not be reached and cannot be used.

TABLE 4.1 - EXAMPLES OF TRANSIT VEHICLE AND TRAIN CAPACITIES

Type of Vehicle	Vehicle Dimensions and Capacity					Train Length and Capacity		
	Length (ft)	Width (ft)	Capacity*			No. of Vehicles	Length of Train (ft)	Total Capacity
			Seats	Standees	Total			
"Minibus" - short haul	19.5	7.7	18	12	30	-	-	-
Bus, urban transit, U.S.	30.0	8.0	36	19	55	-	-	-
	35.0	8.0	45	25	70	-	-	-
	40.0	8.5	53	32	85	-	-	-
Bus, articulated, Europe	54.1	8.2	48	124	172	-	-	-
Streetcar, "P.C.C.," U.S.	46.5	9.0	59	66	125	3	140	375
Streetcar, articulated, Europe	64.0	7.5	45	155	200	2	128	400
Rapid transit, IRT, New York	51.3	8.8	44	136	180	12	615	2,160
Rapid transit, IND-BMT, New York	60.5	10.0	50	170	220	10	605	2,220
Rapid transit, 2nd series, Toronto	74.6	10.3	84	221	305	8	597	2,440
Rapid transit, San Francisco	70.0	10.5	72	78**	150**	10	700	1,500**

*In any transit vehicle the total passenger capacity can be increased (and passenger comfort decreased) by removing seats and making more standing room available, and vice versa.

**System designed on one-seat-per-passenger basis. However, there would be room for standees if needed.

2. Vehicle Capacity of a Route: The route capacity of most transit systems is limited by the capacity of stops and stations. In addition, bus and streetcar surface routes must share available street capacity with automobile traffic.

   a. Bus routes: Bus stop capacity depends on the "service time" per vehicle at the stop. Service times may be calculated from loading and unloading times given in Table 4.2. The capacity of the first loading position is roughly 3,600/[2(service time)] buses per hour; additional loading positions at the same stop will handle fewer buses. Buses on exclusive lanes, where there are no stops in the running lanes, operate at flow rates of about 60% of the normal lane capacity; Ref. 5 indicates that a bus is equivalent to about 1.6 passenger cars in uninterrupted traffic streams.

   b. Streetcar routes: Streetcar stops have similar capacities for the first loading position. Because these types of vehicles cannot overtake each other, however, the capacity of additional loading positions is considerably less.

TABLE 4.2 - SERVICE TIME ON AND OFF BUSES - PER DOOR

	Seconds per passenger
UNLOADING	
Very little hand baggage or parcels - few transfers	1.5 - 2.5
Moderate amount of hand baggage or many transfers	2.5 - 4.0
Considerable baggage from racks (intercity runs)	4.0 - 6.0
LOADING	
Single coin or token fare	2.0 - 3.0
Odd-penny cash fare	3.0 - 4.0
Multiple zone fares: prepurchased tickets and registration on bus	4.0 - 6.0
Multiple zone fares: cash and registration on bus	6.0 - 8.0

Source: Ref. 6, p. 346.

   c. Rapid transit routes: Since trains arrive at stops not at random, as do buses and streetcars, but spaced by automatic signals, the capacity of a rapid transit track depends on the length of a cycle which includes service time in the busiest station, acceleration and deceleration characteristics, and minimum safe spacing between trains. Generally, minimum headway is 90 secs., and route capacity is 40 trains per hour.

   d. Escalators and belts: Observed capacity is 45-60 persons/minute/lane of 21-24 inches width; additional width is needed for balustrades which contain the handrails - roughly 10 inches per stationary handrail, 15 inches per moving rail. However, if it is the intention to have users walk on the belt or stair (so that the function of the facility is to add to the normal walking speed) somewhat lower capacities are to be expected.

   e. Aerial tramways: One type of tramway has two cabins, one of which leaves each terminal at the same time. This is common in sloping installations, where power costs are reduced by counterbalancing the two cabins. The

TABLE 4.3 - MAXIMUM OBSERVED MASS TRANSIT PASSENGER VOLUMES IN THE UNITED STATES AND CANADA

TYPE OF MASS TRANSIT OPERATION	LOCATION	VEHICLES OR TRAINS PER HOUR	TOTAL PSGRS.		PSGRS/VEH OR TRAIN Full hour	REMARKS
			Full Hour	15-20 min rate/hour		
Buses on City Streets	Hillside Ave., Queens, New York City	150	10,251	10,824	68	Several routes, separate sets of bus stops
Buses on Reserved Lanes	Main St., Rochester, N. Y.	93	4,982	-	54	Curb lane
	Washington Blvd., Chicago	66	3,235	3,600	49	Center lane and loading area in one-way street.
Buses on Exclusive Lanes	Ramp to PNYA Bus Terminal, New York City	511	23,187	28,556	45	Considerable gradient
	Bay Bridge, San Francisco	222*	9,187*	12,205*	41	Temporary lane (1962); not at capacity
Buses on Expressways, Bridges, etc.	Lincoln Tunnel, New York	480	21,600	22,860	45	Preferential right of way
	Bay Bridge, San Francisco	269*	10,693*	13,880*	40	No preferential right of way
	Lake Shore Drive, Chicago	99	5,595	6,350	57	No preferential right of way
Rail Rapid Transit	IND Queens Line, New York	32	61,400	71,790	1,920	11-car trains, 60-ft cars
	IND 8th Ave. Express, N. Y.	30	62,030	69,570	2,070	10-car trains, 60-ft cars
	IRT Lex. Ave., New York	31	44,510	50,700	1,440	10-car trains, 51-ft cars
	Yonge St., Toronto	28	35,166	39,850	1,260	8-car trains, 60-ft cars

* Some intercity buses also used this facility, but are not included in totals.

Source: Ref. 7, except Bay Bridge data, which are from I.T.T.E. counts.

capacity of such a system is the capacity per cabin multiplied by the trips per hour possible. Another form of aerial tramway allows individual gondolas to be added to a continuously moving cable as loaded, subject to a minimum safe spacing, and to be detached from the cable at the unloading point. The capacity in this case is the passenger capacity per cabin multiplied by the number of cabins per hour (cable speed divided by safe spacing).

3. Total Passenger Capacity of a Transit Route: The capacity of a transit route is the product of the passenger capacity of individual vehicles or trains (para. D.1) and the vehicle capacity of the route (para. D.2). A few actually observed values of passengers handled, which can be used to check the results of such a multiplication are given in Table 4.3.

4. Characteristics of Transit Stops

   a. Bus stops: Bus stops are commonly provided at the sidewalk curb, so that passengers may have a safe waiting, boarding and alighting area. They are usually designated by distinctive signs, and by curb and/or pavement markings which indicate a prohibition for stopping or parking of other vehicles. Minimum desirable lengths of bus loading zones are given in Table 4.4. Whether a one-bus stop, two-bus stop, or even longer zone is required can be calculated from the estimated service time per bus and average headways.

   Bus stops may be located either in the approach to intersections ("near side"), in the exit from intersection ("far side"), or in mid-block locations. The optimum location depends on the turning movement patterns of buses and of other traffic, pedestrian patterns (including to and from stops on other routes), and the location of large traffic generators on abutting land. (Ref. 8)

   (1) Near side stops are preferred at locations where transit is more "critical" than automobile traffic and parking, at intersections where more traffic joins the street than turns off it, at intersections with one-way streets moving from right to left, and at locations where buses will make a right turn.

TABLE 4.4 - MINIMUM DESIRABLE LENGTHS FOR BUS CURB LOADING ZONES

Approx. Bus Length (ft)	Loading Zone Length (in ft)[a]					
	One-Bus Stop			Two-Bus Stop		
	Near Side[b]	Far Side[c]	Midblock	Near Side[b]	Far Side[c]	Midblock
25	90	65	125	120	90	150
30	95	70	130	130	100	160
35	100	75	135	140	110	170
40	105	80	140	150	120	180

a. Measured from extension of building or "stop" line, whichever is appropriate. Based on side of bus positioned 1 ft from curb; if bus is positioned as close as 6 ins. from curb, 20 ft should be added to near-side stops, 15 ft to far-side stops, 35 ft to midblock stops.

b. Add 15 ft where buses are required to make a right turn. If there is a heavy right-turn movement of other vehicles, lengths should be increased 30 ft.

c. Based on roadways 40 ft. wide which enable buses to leave loading zone without passing over centerline of street. Add 15 ft if roadway is 32 ft wide.

Source: American Transit Association

(2) Far side stops are preferred at locations where transit is less "critical" than other traffic or parking, where there is a heavy right and/or left turn movement off the street, at intersections with one-way streets moving from left to right, and where buses make left turns.

(3) Midblock stops are recommended where traffic or sight distance problems make stops near the intersection undesirable, or where large traffic generators are located between intersections (e.g., department stores). They should not be used where passengers wish to transfer to and from a route or an intersecting street, where parking is critical (more curb space needed), or where jaywalking would be especially dangerous.

(4) Bus stops at intersections have the additional advantage that they can be used by turning vehicles when not occupied by buses, thus increasing intersection capacity.

b. Freeway bus stops: Special bus stops within a freeway right-of-way are necessary only in special instances. Many bus routes use the freeway only as a fast connection between downtown and the outlying area to be served, and are not intended to furnish transit service to intermediate points along the freeway. However, where such routes make important connections with crosstown distributor routes - usually near the downtown perimeter - a stop may be necessary. Stops are also needed where a single trunk line route is planned for a freeway to serve adjacent land and all connecting crosstown or feeder routes. In outer suburban areas, where branching of bus routes is impractical, it is also necessary for the single bus line to stop at intervals along the freeway.

Where simple diamond interchanges exist, bus operators usually prefer to have buses leave the off-ramp, stop at the intersection of the cross street, and then reenter the freeway. This does not require passengers to walk excessive distances to reach the street, including negotiating the difference in elevation between freeway and street. At more complex interchanges, where leaving and reentering the freeway would cause excessive delays to the buses, stops are provided. Reference 9 gives several schematic layouts of such stops. Ref. 10 gives more details concerning the need for providing such stops.

c. Streetcar stops: Because streetcars usually occupy the center portion of city streets, stops are provided along the tracks with appropriate refuge islands for the protection of passengers.

d. Rapid Transit stations: Most rapid transit systems have stations spaced at intervals of about one-half mile (e.g., New York, the new network in Montreal); passengers reach these either on foot or via connecting surface transit routes. In some key locations, elaborate transfer facilities between rapid and local transit are constructed (e.g., Eglington Ave., Toronto). However, most stations at the street surface consist only of entrance and exit stairways or, perhaps, escalators. At the train level, loading platforms of up to about 500 feet are provided, either a single "island" platform to serve passengers boarding and alighting in either direction (minimizes operating and construction costs), or two platforms outside the pair of tracks (increases capacity by separating pedestrian traffic streams), or at very critical locations by a combination of the above - the central platform being used for alighting passengers in both directions, and the outside ones for boarding (maximizes capacity and minimizes time required for train stop).

Two recent rapid transit systems (Cleveland, San Francisco) are designed on the premise that at the outer end of trips passengers will generally arrive by automobile or feeder transit line, and not on foot. Outlying stations are therefore located 1 - 5 miles apart, not in the immediate area of major traffic generators but at points where automobile access can readily be provided. Stations include large parking areas, bus transfer arrangements, and "kiss-and-ride" loading areas where short-time waiting of cars is permitted. The cost per station of this type is naturally higher than that of a pedestrian-oriented one, but the number of stations being less the total cost may be about the same for either type of system.

e. Terminals: Terminals are elaborate transit stops, the meeting point of several routes and, often, different modes of transportation. They are located off-street, and are designed to handle not only the movement of transit vehicles or trains and the boarding and alighting passengers, but also transfer movements between routes and different modes. Where the total volume of transit users is very large, auxiliary facilities for the comfort and convenience of passengers are provided, including rest rooms, waiting halls, ticket and information counters, and eating and shopping concessions. Mass transit terminals include:

(1) Bus terminals - e.g., PNYA terminals in New York, Bay Bridge terminal in San Francisco.

(2) Rapid transit stations, where off-street transfer facilities are provided - e.g., Cleveland, Toronto.

(3) Commuter railroad terminals, usually combined with intercity passenger railroad terminals.

The design of such terminals must provide for adequate access for vehicles and pedestrians, loading and unloading areas, pedestrian passageways, stairs and escalators, and a system of clear guide signing. In some terminals (e.g., major rapid transit transfer stations in London) the layout of pedestrian passages is a complex of one-way tunnels, escalators, colored guide lights, and signs which requires careful planning and involves considerable costs.

5. Speed: The highest speeds occur on systems having an exclusive right-of-way, i.e., rapid transit. Actual speed depends on station spacing and capabilities of equipment. Where stations are about 0.5 miles apart, an overall speed (including stops) of about 20 mph is common. In the San Francisco system, with much larger station spacing, the overall speed is expected to be 45 mph, with equipment able to travel at a maximum speed of 80 mph. However, access time increases as fewer stations are provided, so that an increase in rapid transit speed does not necessarily reduce door-to-door travel times. Speeds of local bus service are usually about 10 mph overall - somewhat less in very crowded parts of a city and a little more in outlying areas. Express buses on city streets can average 15-20 mph; routes using substantial lengths of freeways will have overall speeds of 25 mph and more, while those going into outer suburbs can exceed 40 mph overall.

6. Convenience and Safety: The performance characteristics of a transit system of interest to the user include its convenience and safety. Primary aspects of convenience are reliability and comfort.

a. Reliability: Transit systems using an exclusive right-of-way have the best records of reliability and on-time performance. Since the transit operator has complete control over his right-of-way, he can assure maximum reliability by proper control systems and operating procedures. Proper maintenance schedules will minimize mechanical failures of vehicles and control systems. A standby power source in case of failure of the regular power supply is essential. Note the results of the major power failure of 1965 on the New York, Boston and Toronto transit systems.

Reliability of local transit systems depends in part on the traffic conditions of the streets which may cause some vehicles to be delayed. Once this happens, headways become irregular, and an overloaded vehicle will be closely followed by one or more almost empty ones. Field supervisors can issue orders to turn back a vehicle before its route terminal in order to fill a headway gap and even out the spacing of all vehicles on the route.

Reliability is also reflected in the number of breakdowns suffered by vehicles in a transit fleet. The breakdown rate increases with vehicle age and depends also on quality of maintenance.

b. Comfort: In transit service, comfort is primarily related to the number of seats available and the need for some passengers to stand, and secondarily to the smoothness of the ride, appearance of the vehicle interior, lighting, ventilation (especially air conditioning), and odors. The number of available seats can be increased only at higher operating costs; furnishing seats for most or all passengers at peak hours is extremely costly, because these seats - and the vehicle or train operators needed to "move" them - cannot be utilized during off-peak periods. The secondary comfort factors also are provided only at additional cost. However, in some cases, such as the provision of air conditioning, the extra cost is partly offset by extra revenues produced.

Comfort also enters into the design of stops and stations. At bus stops, benches are often furnished free of charge to the transit company by local advertisers. At stations, comfort is enhanced by aesthetically attractive entrances, passageways and waiting areas, by provision of escalators instead of stairs, and by the appurtenances mentioned above under "terminals." Again, these involve extra cost - both initial and operating - but are now often deemed essential for an adequate transit system.

c. Safety: The safest type of transit is that operating on its exlusive right-of-way, especially where automatic train control is provided. Most signal systems are designed to override operator action when an error is made. Accidents, which may still occur, can be caused by persons straying or jumping onto tracks, objects falling on the tracks on at-grade alignments, accidents caused by failure of a vehicle component, and on-board accidents caused by sudden starts or stops.

Bus operations are subject to all the hazards of automotive traffic streams. In addition to injuries and fatalities which may occur as the result of collisions, transit passengers are also liable to becoming victims of in-vehicle accidents, as when a vehicle makes an emergency stop throwing standees to the floor. The National Safety Council reported accident rates of 53.5 and 26.8 per 1,000,000 vehicle miles for city bus fleets and suburban bus fleets respectively. A more detailed analysis of types of transit accidents - for Canada, 1965 - is shown in Table 4.5. These statistics indicate for example, that more than one-half of all accidents to transit passengers involving injury or death are "on board" accidents, caused by sudded braking, accelerating, swerving or cornering.

7. Automation: Rapid transit systems, because of their exclusive right-of-way, lend themselves readily to automation of all vehicle movements. Research to develop the best control system has been carried out at the Diablo Test Track of the San Francisco system (BARTD), and results will be available to the transit industry upon completion of the analysis.

Rapid transit systems also feature a simpler access control than local transit systems; entrances and exits can easily be controlled by a number of turnstiles proportional to the number of stations in the system rather than to the number of vehicles in use. This has led to research into automating fare collection procedures, in order to make it possible for large rapid transit systems to charge fares which are proportional to the length of the trip rather than being the same for all trips. (The present universal fare in all U.S. and Canadian rapid transit systems exists not because it produces most revenues or is optimal from a policy viewpoint,

TABLE 4.5 - MASS-TRANSIT ACCIDENT STATISTICS FOR CANADA - 1965

Category	Motor Bus		Trolley Coach		Streetcar	
	Number	Rate*	Number	Rate*	Number	Rate*
Total Transportation Accidents	14,283	93.5	3,359	121.5	2,711	136.1
Collisions (with other vehicles, pedestrians, fixed objects)	11,849	77.5	2,554	92.4	2,396	120.3
Other transportation accidents	2,434	15.9	805	29.1	315	15.8
Total Persons Killed or Injured	3,500	22.9	645	23.3	902	45.3
Employees	214	1.4	40	1.4	34	1.7
Passengers	2,835	18.6	536	19.4	737	37.0
Persons in motor vehicles, pedestrians, others	451	3.0	69	2.5	131	6.6

Category	Persons Killed or Injured				
	Employees	Passengers	Pedestrians	Persons in motor vehicles and others	Total
Total Accidents	523	4,213	337	507	5,630
Collisions	53	401	384	248	1,086
Boarding (excluding door accidents)	19	419	---	---	438
Alighting (excluding door accidents)	20	621	---	---	641
Caught / struck by doors	---	470	---	---	470
Accidents on board	159	2,268	---	---	2,427
Other accidents	272	34	3	259	568

Source: Compiled from data in Ref. 11. *Per million revenue vehicle miles.

but because any other system would raise labor costs well beyond the additional revenues which might be derived.) It is expected that by 1969, when BARTD enters operation, zoned fares can be collected automatically. London, which has an elaborate scale of fares, is also interested in, and assisting the development of the necessary equipment.

Bus and streetcar systems do not lend themselves readily to automation, because of the conflicts with other motor vehicles and pedestrians. Some research into automatic guidance of buses has been conducted by General Motors with a view toward applications in freeway medians.

E. Transit Networks

1. Area Coverage: As a general axiom, a transit system is considered to serve an area of up to one-half mile from its stops (based on acceptable walking distances). Where feeding by private automobile is expected, the transit route may serve a much larger area - for example, a Cleveland study (Ref. 12) has shown that about 48% of those using parking lots at four rapid transit stations had origins of more than 3 airline miles away (21% more than 6 miles). However, "coverage" beyond a half mile of the station or of bus routes feeding to it is only for persons having a car or ride available, not for the entire population.

   From the operator's point of view, the denser the trip ends in an area, the more profitable or less unprofitable will a transit route be. Thus high-density residential and employment areas can support several bus routes or a rapid transit route, while low-density areas often cannot justify any transit service at all. However, the justification of routes, and the capacity to be provided, depends also on trip orientation - the linking of origins and destinations. Thus, a high-density industrial complex or airport may be served by mass transit only with difficulty, since the locations of the other ends of the trips to/from these generators may be scattered all over the metropolitan area, and no high-density "corridor" exists along which a substantial part of the total users may wish to move.

2. Stops or Station Spacing: As has already been mentioned, the spacing of stops or stations directly affects the overall speed of the transit system. An increase in overall speed is of great benefit to the transit operator, since he can use his equipment more effectively - more revenue trips in the peak periods when the demand for equipment is high. For the user, higher overall speeds are of benefit if the total door-to-door travel time is reduced thereby. However, fewer stops require longer access times for most users, and this may cancel or even outweight the gain in travel time on the transit system itself.

   a. Bus stops: Bus stops are generally located at every cross street, except where street spacing is less than about 400 feet. Since buses do not have to stop at every designated point, but only when passengers wish to board or alight, the addition of stops in outlying areas does not increase travel time of buses as much as added stops in downtown areas. The added time is related to the maximum speed which the bus can reach before it must decelerate again. Time at each stop varies with the number of passengers wishing to board and alight (Table 4.2 above), and to some extent with signal timing along the streets. If a bus stop is eliminated to accelerate service, the passengers previously using this stop will instead appear at an adjacent stop, lengthening the service time there.

   b. Trolley coach and streetcar stops: Because trolley coaches and streetcars cannot overtake each other, stops in streets used by more than one route are critical. Lightly used stops should be eliminated, so that a trolley coach or streetcar picking up a passenger does not hold up the following vehicle which does not need to stop at all.

c. Rapid transit stations: Theoretical analysis of the optimum spacing of stations has been done only for specific cities in the past, but some research is presently being conducted. The type of result that will be sought is shown in Fig. 4.1 by V. R. Vuchic (Ref. 13).

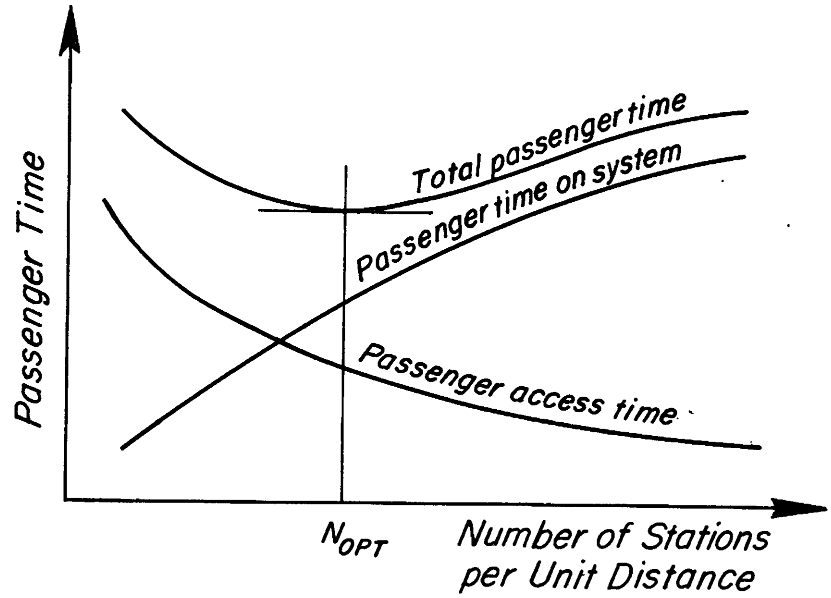

Fig. 4.1 - Passenger travel time as a function of the station spacing along a route.

Rail systems sometimes employ the "skip stop" operation to accelerate service, usually in peak periods only. Half the trains along a route do not stop at one group of stations, the other half bypass some others. All trains make the most important stops. The only inconvenience is to passengers who wish to travel from a station in "Group A" to one in "Group B"; they are required to transfer to a station where all trains stop.

3. Routing: A network is composed of a series of routes designed to join origins and destinations by the most expeditious alignment. Since it is impossible to link all areas of trip ends to all others, some passengers will have to transfer from one route to another, but this transferring is time consuming, inconvenient, and - where a new fare must be paid or a transfer charge is imposed - costly, and should therefore be minimized.

Note the analysis of this problem made in Frankfurt; Appendix No. 1, Table No. 1.

Routes are generally classified as radial, crosstown, and feeder. Radial routes radiate from the central business district (c.b.d.) and are the most important and financially most rewarding component of the network. Crosstown routes serve to connect several radial routes circumferentially outside the c.b.d. Feeder routes feed from the radial or crosstown routes into areas not otherwise served. Table 4.6 illustrates the financial results of these classes of routes, and underscores the problem of furnishing feeder service, especially when one agency operates the trunk lines and another is expected to offer the feeder service only.

Routes may be branched if the number of vehicles per hour on the trunk part of the route is sufficient to be divided among the branches with acceptable headways being maintained. Branching is easiest on bus routes and is freely done, even to the point of serving some branches with only two or three trips per day. On trolley coach,

TABLE 4.6 - REVENUES AND PASSENGERS PER MILE ON TRANSIT ROUTES, BY TYPE OF ROUTE (Fiscal Year 1965)

TYPE OF ROUTE	SAN FRANCISCO MUNI. RWY.		A. C. TRANSIT, OAKLAND*	
	Revenue per Mile	Psgrs per Mile	Revenue per Mile	Psgrs per Mile
Arterial	78.95¢	8.02	56.52¢	3.01
Crosstown	54.47¢	6.44	36.92¢	1.93
Feeder	34.54¢**	5.03**	29.89¢	1.76
System Average	74.38¢	7.66	50.29¢	2.70

Source: Ref. 14.

*East Bay System only
**Includes two shoppers' shuttle routes

streetcar and rapid transit routes, branching involves the provision of necessary fixed facilities. Because of the switching problem, branching on monorail systems is believed to be unfeasible at present.

Where demand along a route is very heavy and a substantial proportion of the riders travel long distances, express service is established. Such routes will serve all stops or stations in outlying areas and in the c.b.d., but will bypass some or all intermediate stops. The advantages have been mentioned in para. E.2 above. Bus express routes may either travel on the same streets as the local buses, move to a faster street in the express portion of the route, or make use of a freeway. In rapid transit a third, reversible track is needed to operate express service, and, in very high-density corridors, a pair of express tracks.

4. Special Services and Charters: Transit systems often provide special services to meet special needs: "Shoppers' shuttles," school buses, off-route service to athletic, cultural and other gatherings. Almost all this service is provided by bus, because the inflexibility of other types of systems prevents good utilization. The special service must be planned separately, integrated with normal schedules in such a way as to minimize the need for additional equipment and manpower, and carefully supervised because of special traffic and routing problems often involved.

   Charter service is a profitable sideline for bus operators. The charter rates are set to guarantee a profit, even in publicly-owned systems, and most charter work utilizes equipment and men available between peaks or on weekends.

F. Transit Operating Problems

1. Labor: The cost of manpower represents from 60% to 80% of all the operating costs of a transit system. Table 4.7 gives a breakdown of operating costs to illustrate this. One principal cause of high labor costs results from the daily and weekly traffic patterns on transit systems. In order to accommodate the peak demands - even at comfort levels well below the off-peak average - a transit system must staff a fleet of vehicles many of which will not be needed at any other time during the day or on weekends. However, under the standard labor contract it is impossible to employ operators for, say, three hours in the morning peak and three hours in the evening, and pay them wages for six hours worked. Instead, it is required that

TABLE 4.7 - OPERATING COSTS PER VEHICLE MILE, SAN FRANCISCO
Fiscal Year 1965

Cost Item	Streetcars		Trolley Coaches		Motor Buses	
	Cost/Mile	% of Total	Cost/Mile	% of Total	Cost/Mile	% of Total
Operators' Wages	38.76¢	33.72	45.56¢	43.58	38.36¢	41.19
Supervision, Maintenance, etc.	10.65¢	9.26	13.22¢	12.65	12.83¢	13.77
Salaries (office clerks, general), claims personnel, fringe benefits	15.76¢	13.71	18.02¢	17.24	14.98¢	16.09
Subtotal: Personnel expenses	65.17¢	56.69	76.80¢	73.47	66.17¢	71.05
Equipment	15.25¢	13.27	6.98¢	6.68	11.45¢	12.29
Way and Structures	11.02¢	9.59	2.89¢	2.76	0.71¢	0.76
Power or Fuel	7.54¢	6.56	7.45¢	7.13	4.81¢	5.16
Depreciation, Interest, Rent	8.41¢	7.31	4.37¢	4.18	4.82¢	5.18
Provision for Accidents	7.57¢	6.58	6.04¢	5.78	4.82¢	5.18
Total: Operating Costs	114.96¢	100.00	104.52¢	100.00	93.12¢	100.00

Source: Ref. 14

operators be paid for 8 hours of work, that these 8 hours of work (or not working) be paid within a span of 10 clock hours, and that additional time be at overtime rates. A typical tour of duty might be from 6:30 to 9:30 a.m. and from 4:00 to 7:00 p.m. (6 hours of actual work); but the actual span of 12 1/2 hours from start to end would require 8 hours of straight time for the first 10 hours plus 2 1/2 hours of overtime.

Since wages vary somewhat with hours worked and somewhat with the total number of operators required for the peak, the total operating costs are quite sensitive to average speed of the transit system, especially when expressed on a dollars-per-mile basis. (The vehicle mileage operated reflects both on the total capacity offered and the quality of service (coverage, frequency). Dollars-per-mile are therefore a valid scale on which to analyze costs of furnishing a system.) To illustrate the effect of speed on costs, Fig. 4.2 was developed from data in Ref. 14.

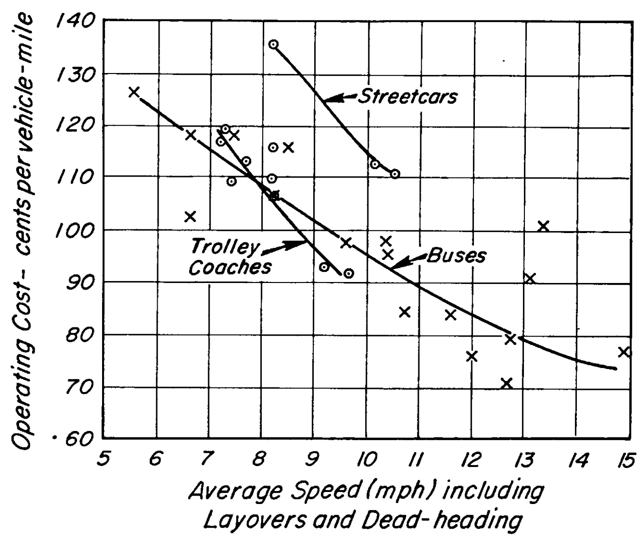

Fig. 4.2 - Transit operating cost related to speed of route (San Francisco).

One of the most important and intricate tasks in a transit system is the preparation of schedules and work assignments in such a way that the minimum number of total operators are assigned to staff all trips within the limitations of the union labor contract. A start has been made in programming this task for computers; if successful, it might result in substantial operating cost reductions in very large systems, where human limitations presently make the finding of the optimum schedules impossible. See Ref. 15.

2. Equipment: Characteristics of equipment have been described above. The maximum number of vehicles needed again depends on the peak demand; in addition about 5% additional vehicles are on hand as replacements for those vehicles unavailable because of major maintenance.

Although the amount of cost is less, the same problem of non-utilization in the off peak arises with equipment as with operators. Table 4.8 illustrates the point that many vehicles needed for peak service are not used at other hours. In the illustration given, even fewer vehicles could be used in the midday period; however, it is the policy of the San Francisco transit system to furnish a higher quality service at these hours than absolutely necessary, since the operators have to be paid in any case. Fig. 4.3 shows similar conditions for Cleveland.

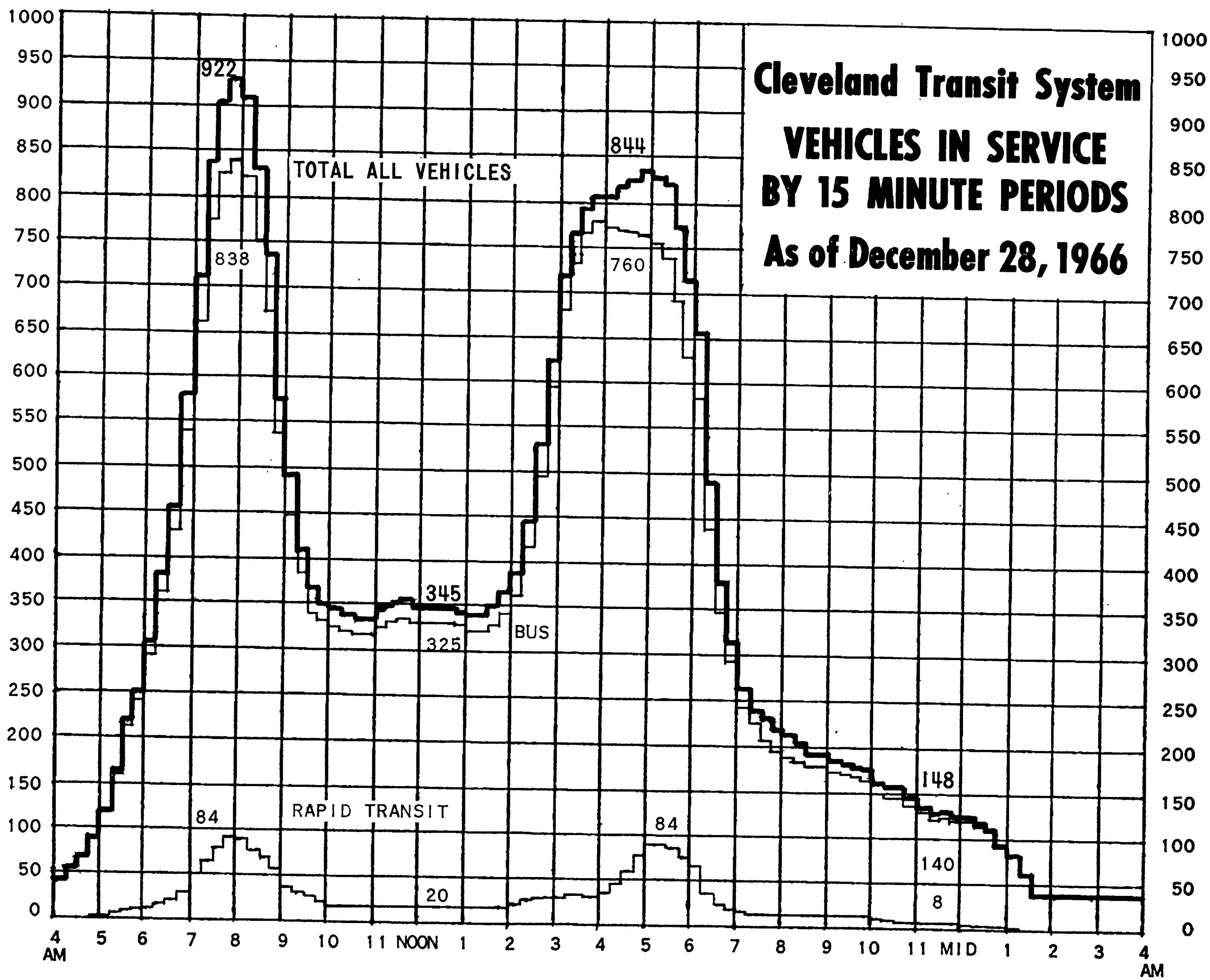

Fig. 4.3 - Transit equipment requirements, Cleveland, 1966.

TABLE 4.8 - TRANSIT EQUIPMENT REQUIREMENTS,
SAN FRANCISCO, 1966
(Weekday figures for school day)

Time	Cable Cars	Street-Cars	Trolley Coaches	Buses	Total
Weekday					
Morning Peak	16	100	271	441	828
Noon Base Period	18	67	197	247	529*
Afternoon Peak	26	94	292	425	837
Evening	13	29	88	111	241
"Owl"	0	3	2	20	25
Saturday - afternoon	21	42	122	147	332
Sunday - afternoon	17	26	81	112	236
Available Vehicles	39	105	332	514	990

*Some of these vehicles not required by traffic demand, but operated to utilize personnel who would be paid in any case, and thus provide more frequent mid-day service.

3. Other Operating Problems:

   a. Maintenance: To maintain vehicles in running condition, regular maintenance must be performed, and a spare parts inventory kept on hand. Emergency towing and road-call equipment must also be available.

   b. Supervision: Field inspectors and supervisors are needed to check on the on-time performance of vehicles or trains, to order changes as needed when vehicles run very late because of congestion or unforeseen delays, and to make emergency decisions.

   c. Accidents and claims: A sizeable staff of claims investigators is required by transit systems to investigate accidents and the claims arising therefrom.

   d. Schedule Making: The importance of careful scheduling to optimize the use of manpower and equipment has already been referred to. In addition, schedules must reflect the public demand, which must be checked by traffic counts at regular intervals. Special services must be integrated into the normal schedules.

   e. Fare collection and processing: Most transit systems now collect fares in locked fare boxes on road vehicles and at turnstiles on rapid transit systems. Operators and/or station agents are issued money for change making, plus stocks of tickets and transfer slips. In some systems, an open fare box is still used. The operator is issued less cash at the beginning of his tour of duty, because he can reuse cash from the fare box to make change. However, accounting at the end of his work day is much more cumbersome, and a union contract will often require that the operator be paid additional time for this accounting.

   Because of the difficulty of checking, fare structures which vary with trip distance have not been used in the United States to any great extent. In large cities, a rough zone system is used, and passengers crossing a zone boundary must pay an extra fare. However, this usually involves a time-consuming check of all passengers in a vehicle at the zone boundaries, or an intricate system of tickets.

As mentioned above, automation of fare collection at turnstiles is now being developed, to make graded fares feasible. It is also possible that a turnstile system might be designed for the interior of buses, so that distance-related fares could be charged on these vehicles.

f. Police: Very large transit systems must provide their own police force. Special problems are robberies of fare boxes and operators' cash and of change booths in rapid transit stations, and crimes committed in transit stations, especially in underground passages and on platforms during periods of low traffic volumes. The use of two-way radios on buses and trains is increasing.

g. General administration: Besides the usual administrative tasks, this involves extensive public relations activities - advertising, information on routes and schedules - training of operators, and long-range planning for new facilities, equipment, and services.

4. Traffic Engineering Impact on Transit Operations: Local transit systems operate on city streets, and are therefore affected by the manner in which these streets are operated. The importance of overall speed and avoiding delay to a transit operation is illustrated in Figure 4.2 above. To the extent that all traffic on a street moves smoothly, the transit vehicles will also be able to do so. Some traffic engineering measures which directly affect transit operations are mentioned here.

a. Bus stops: Establishment of stops of adequate length at the best location; enforcement of parking prohibition in stops.

b. Reserved lanes: Where traffic demands, prohibition of all curb parking and assignment of the curb lane to transit vehicles only; or establishment of a reserved lane in the center of a one-way street.

c. Signal timing: On some downtown streets, the importance of transit service may outweigh that of automobile and truck traffic. In these cases, traffic signals may be timed to favor transit vehicles by carefully analysing the average speed, including stops, of transit vehicles and designing the signal time-space diagrams for this speed.

d. Turn prohibitions: Prohibitions against making a left or right turn are often used by traffic engineers at critical intersections. However, this might require rerouting of a transit route with additional mileage and time involved. It is quite common, therefore, to except transit vehicles from such turn prohibitions.

e. One-way streets: Design of one-way street system must include consideration of transit routes. Establishment of a one-way street will probably accelerate transit speeds, but one of the two directions will have to be shifted to another street. This may move stops away from the traffic generators providing much of the transit patronage, and may increase mileage and travel time. Short-distance riders in downtown areas may be lost to the transit system altogether if, because of a one-way system, they have to walk almost as much to and from the relocated stop as to the destination itself. Example: one-way Avenues in Manhattan.

f. Terminals: Where transit systems use large terminals, it will, of course, be to their interest to have the optimum traffic engineering controls and operations on the streets giving access to these terminals.

G. Ownership and Policy Problems

1. Ownership and Regulation: All transit systems which include rapid transit in North America (and probably all over the world) are publicly owned. The heavy investment required for fixed facilities cannot be recovered by revenues and private capital is

therefore not interested in such ventures. In some cities, the transit system, either within the city government or in an independent municipal authority, is responsible for meeting operating costs from revenues; capital costs are furnished by the municipality and, since 1965, by federal grants. Examples are Chicago, Boston, and Toronto. In New York, some additional subsidies for transit police are made. In Philadelphia the operator is a private concern (negotiations for public purchase are in progress), but facilities are provided by the city. For Cleveland, see Chapter 10.

Local transit systems have also tended to go into public ownership. Profits on such systems are still possible, but are quite small, and do not therefore attract capital for new rolling stock and improvement of the systems. The largest U.S. privately-owned systems are in Washington, D.C., Houston, Texas, suburban systems in New Jersey and Connecticut, Twin Cities, Kansas City, and Honolulu. Such systems are subject to control by a public agency as regards level of fares and services. They must receive a certificate of necessity to prevent unnecessary duplication and competition, must operate unprofitable portions of the network and at unprofitable times (nights, weekends) if deemed in the public interest, and must keep complete accounts on which applications for fare increases are judged. The regulatory authorities have not always acted in the public interest, however, and their common policy to stave off fare increases as long as possible has probably contributed to the trend toward public ownership.

2. Financial Resources: The principal financial resource of a transit system is revenue produced by fares. Some additional income is derived from advertising on vehicles and in stations, concessions in stations and terminals, charter operations, and interest on cash investments and deposits. Municipal systems may, as a matter of policy, be given general tax proceeds as additional income in order to keep fares at a level desired by the policy makers. These subsidies, as mentioned above, may be for capital cost items only, or they may be for the operating budget. Federal grants to mass transit systems have become available under recent legislation. Such subsidies are on a matching basis (one federal dollar per one local dollar, or per 50 local cents if in conformance with an approved urban transportation planning process). The total federal monies available in fiscal 1966 and 1967 are $150 million per year, and no more than one eighth of each annual appropriation may be allocated to any one state. Private transit companies are not eligible to receive these subsidies. Funds may be used for capital improvements. There are also funds available for research, development and demonstration projects - see Chapter 7.

   In some instances, state funds have been made available for mass transit systems. Massachusetts has a subsidy program of this type. In California, state toll bridge revenues have been made available for construction of a portion of the San Francisco BARTD system; see Chapter 9.

3. Taxes: Private transit companies are often liable for all income, real estate, property, excise and sales taxes; this may represent a substantial part of the non-personnel costs of the system. Public transit agencies generally are exempt from these taxes except for sales taxes and, in some states, excise taxes on fuel. To aid both private and public transit agencies, some states have exempted them from fuel taxes in recent years.

4. Future Policy: It appears safe to assume that within another decade all transit systems in the U.S. will be publicly owned, that federal aid for transit will become a permanent program and will, perhaps, increase in size, that local tax proceeds will be used for all capital expenditures in most systems and for operating costs in some, and that transit services will tend to be analyzed and justified on the basis of their contribution to the total urban transportation network rather than as a separate account which has to be balanced on its own merits.

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5. COMPREHENSIVE TRANSPORTATION PLANNING

WOLFGANG S. HOMBURGER

NOTE: This chapter is a brief summary of the objectives and framework of comprehensive transportation planning, and is intended as an introduction to the chapter on "Estimating Transit Usage (Modal Split)."

A. Definition. Comprehensive transportation planning is the study of present transportation patterns in relation to present population, economy, and land use of an area; the estimation of future transportation patterns related to prediction of future population, economy, and land use; the design of alternate transportation networks and facilities; the evaluation of the alternates; and the selection of a transportation plan with proposals for its implementation, scheduling, and financing.

B. Objectives of Transportation Planning. Any form of planning has two objectives: (1) to enable policy-makers to reach long-range decisions by selecting from alternatives offered; and (2) to enable executives to implement the chosen plan by determining the appropriate procedures and priorities. Comprehensive transportation planning is aimed at these objectives.

Planning may be carried out on different scales: statewide or multistate studies (e.g., the Northeast Corridor Project), regional studies (typical metropolitan transportation studies), or local studies encompassing a single county, city, or neighborhood.

The policy-makers, for whom plans are prepared, must weight the often divergent or opposed interests of the community for which they plan. In transportation planning for highways and mass transit, there are at least three viewpoints which must be considered - those of:

1. The user of the service being planned; e.g., highway users (private, trucking, shippers), mass transit passengers, etc.
2. The operator of the system; e.g., highway departments, transit companies, etc.
3. Society generally.

It is obvious that the interests of these groups often fail to coincide. For example, users of transportation systems wish to have maximum service at minimum user charges; operators wish to minimize operating costs (reducing the quality of service if this is necessary) and capital costs; society as a whole, while hoping for the maximum benefits to both user and operator, also considers impacts outside the transportation system, such as the problems of aesthetics, noise, air pollution, land values and welfare, the optimization of which may require high user charges or high operating and capital costs, or both.

In judging among the alternatives, certain "values" are used by which one plan is eventually adjudged as better than the others. Some of these "values" are quantifiable, either in money or some other measure; others are less tangible, although economists often assign cash equivalents to them based on the prices offered in exchange for them. The final decision attempts to "optimize" the sum of the various values, maximizing benefits and minimizing costs; the equivalents between dollars, minutes, beauty, silence, fresh air, and other factors are determined subjectively by the political process operating in the minds of the decision makers. Six of the principal values considered in transportation planning are:

1. Economic performance - direct monetary benefits and costs.
2. Total time required by users to travel through the system - a measure of the level of service offered. "Time is money," but the equation is not as simple as some economists would like it to be.
3. Comfort and convenience - another measure of the level of service.
4. Safety.
5. Aesthetics - appearance of the system both to the user and to the community as a whole.
6. Public welfare - certain non-monetary benefits valued by the community, such as transportation service to reduce unemployment, support cultural or athletic events, or raise the general standard of urban living.

Adopting a plan which is never implemented is no better than having no plan at all. Any good plan must therefore include a program of implementation, scheduling and financing. Provisions should be made for reviewing the plan at regular intervals so that it may be amended when events run counter to the predictions on which the plan is based. A plan which changes with the faintest political breezes provides no guide for the long-range development of an area. A rigid plan constricts overall development and makes it impossible to take advantage of major political, social, or technological developments.

C. The Urban Transportation Planning Process. Since most of the funds for urban transportation studies come from the federal government, the standards set forth by the U.S. Bureau of Public Roads (Ref. 1) define the basic framework for such studies. The Federal-aid Highway Act of 1962 first required that, as a condition for receiving any federal aid after July 1, 1965 for highway projects in urban areas of over 50,000 population, such projects must be based on a "continuing comprehensive transportation planning process carried on cooperatively by States and local communities" (Ref. 2). Federal legislation enacted since 1964 for financial aid to mass transit also requires such a planning process if the federal contribution is to be two-thirds of the total project costs. In the absence of such a planning effort, federal mass transit aid is limited to one-half total costs.

1. The above-quoted phrase of the Federal-aid Highway Act of 1962 includes the "Three C's" of urban transportation planning:
   a. Continuity: After completion of an initial plan, the planning process must be continued to update inventories, forecasts, and the plan itself.
   b. Comprehensiveness: To be considered comprehensive, the planning process must include all the elements listed in paragraph 2 below, and must cover the entire area which is expected to be urbanized within the forecast period.
   c. Cooperation: Evidence must be furnished that cooperation with and by all local governments is assured by means of written agreements.
2. Elements of an urban transportation study, as required by the Bureau of Public Roads (Ref. 1), include:
   a. Economic factors affecting development.
      (1) Employment data
      (2) Per capita income
      (3) Income-consumption patterns
      (4) Car ownership per capita or per household
      (5) Inventory of pertinent forecasts for the region, the study area, or any of its subunits.

b. Population Studies

c. Land use inventory and forecasts

d. Inventory of transportation facilities.

   (1) Physical features
   (2) Operational characteristics - volumes, travel times, safety, etc.
   (3) Functional classification

e. Travel patterns (See Section D below).

f. Terminal and transfer facilities.

   (1) Parking inventory, usage and demand studies
   (2) Truck loading and terminal facilities

g. Traffic engineering features - control devices and measures

h. Zoning ordinances, subdivision regulations, building codes, etc.
   (1) Inventory of existing laws
   (2) Identification of deficiencies

i. Financial resources.

j. Social and community - value factors, such as preservation of open space, parks and recreational facilities, preservation of historical sites and buildings, environmental amenities, growth potential.

D. Travel patterns: The analysis and forecasting of travel patterns is of most concern in this introduction to the estimation of mass transit usage. It also is the most complex, time-consuming and expensive portion of the transportation planning study. A schematic representation of this process is shown in Fig. 5.1. The procedure may be broken down into the following four components:

1. Inventories: An inventory of existing land use, social, and transportation data is the first essential.

   a. Land Use data include the type and intensity of land use. The "Standard Land Use Coding Manual"(Ref. 3) provides a system of classifying and coding these data. They are obtained by means of aerial photography and field surveys.

   b. Travel Characteristics are obtained through expanded versions of origin-destination surveys. In addition to the standard data (Ref. 4), information on certain land use, economic and population data may also be collected at the same time.

   c. Transportation Facilities data include physical inventories and inventories of the usage of such facilities. The usage data are needed in the calibration stage which follows.

   d. Economic Activity and Population data are obtained from standard sources, such as the Bureau of the Census, and can be supplemented and updated to some extent by expansion of the Travel Characteristics inventory.

2. Analysis of Existing Conditions and Calibration of Forecasting Techniques. The study area is subdivided into zones and much of the analysis is done using the zone as the basic unit. The rationales of the travel forecasting techniques, however much they may vary in detail, all follow a similar pattern:

   a. It is assumed that land use and the economic activity and population thereon cause trips to be made. This phenomenon is called "trip generation." The analysis concerns itself with finding mathematical ways to calculate the number of trip ends in any zone from that zone's land use, economic, and population characteristics.

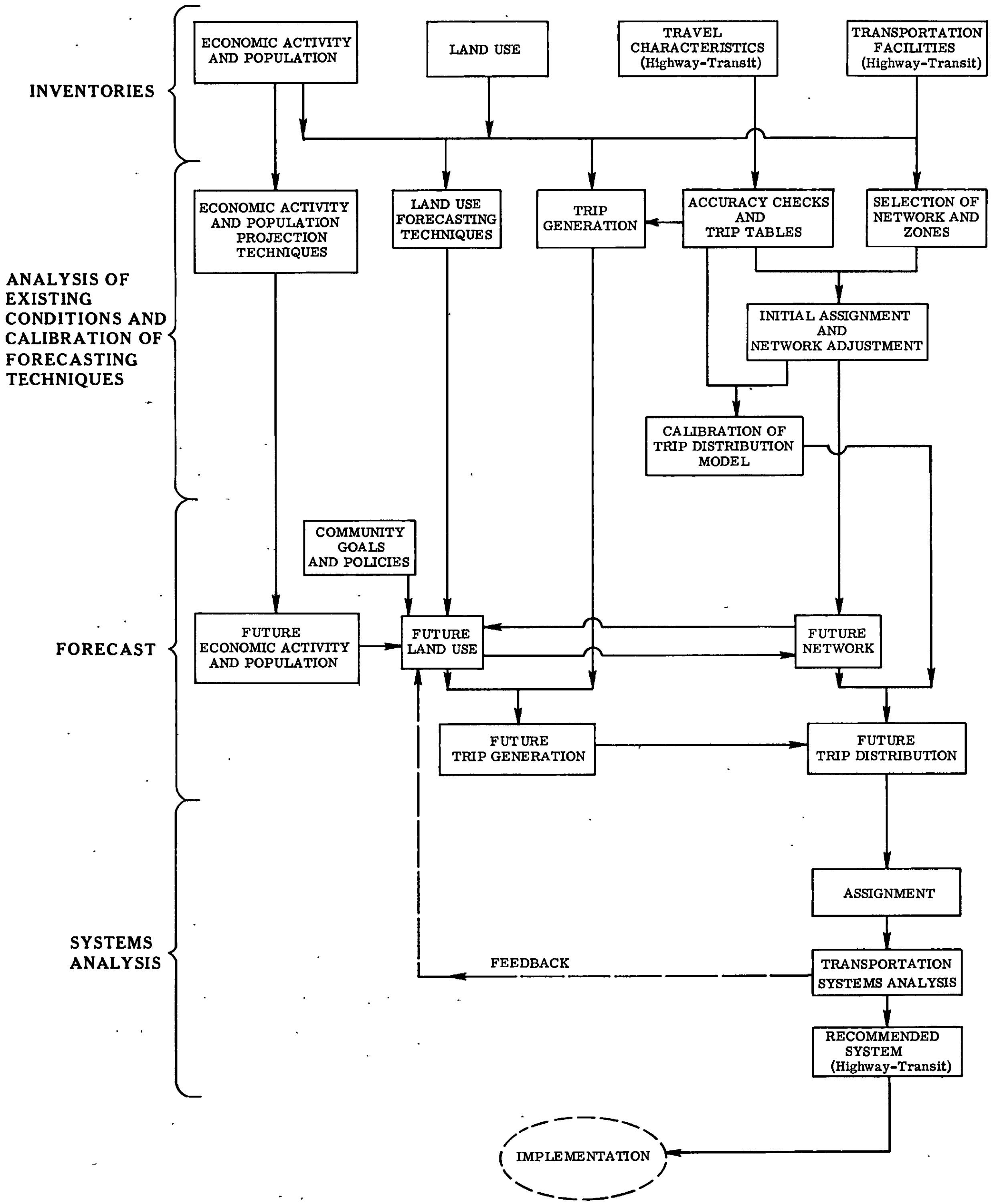

Fig. 5.1 - Urban travel forecasting process.

b. Each trip has two ends, an origin and a destination. Another portion of the analysis then concerns itself with describing the geographic pattern of the other ends of all trips starting from each zone. This procedure is called "trip distribution."

c. When it is known how many trips are made between any pair of zones, another stage of the analysis requires that the route chosen be determined. This is called "trip assignment."

d. At some stage in the chain of analysis which leads from trip generation to trip assignment, the proportion of all trips which will take each of the several travel modes available must be calculated. This procedure, called "modal split," is discussed in detail in the next chapter.

   (1) In some analyses, the trips generated by each zone are split among available modes before a geographic distribution of the other ends of these trips has been made. Fig. 6.3a in the next chapter is a generalized diagram of this procedure, which is called a "trip end modal split model."

   (2) Alternatively, some analysts first distribute trips geographically, and then split the travel between each pair of zones among the alternate modes. This procedure, depicted in Fig. 6.3b, is called a "trip interchange modal split model."

   (3) A third possibility is to combine modal split with assignment to specific routes. While this has been used in some intercity traffic studies, no applications in urban studies of such a procedure has been attempted.

e. Calibration is the process of validating mathematical representations of present travel patterns. Hopefully, these representations or "models" will not merely happen to give the correct answers, but will have within themselves an explanation for the travel phenomena which they are describing. The principal need for the inventories made before is in the calibration process.

3. Forecast. Even the best mathematical representations or models cannot be used to forecast future conditions without some thought. Good models allow for the insertion of parameters describing many future economic, population, and land use conditions, and will calculate the travel patterns resulting from such parameters. However, if the planning period is more than a few years - as it almost always is - the forecaster must use his own judgment to evaluate the effect of possible developments extraneous to the models, such as major technological breakthroughs, major changes in urban living patterns and communications, and changes in the way people will allocate their resources.

4. System Analysis. The forecasted travel patterns must be "loaded" on the alternate transportation plans being considered, and the performance of each plan must be evaluated in line with objectives such as those discussed in Section B above. Since the forecasting stage required preliminary assumptions about the future transportation network to be made, such assumptions must now be checked and, if found at fault, must be altered in a feedback process. Also, anticipating the problems of implementation, the way in which each alternate plan can be staged, and its performance during such stages (at, say, 5-year intervals) should be studied. Based on a combination of ultimate performance and performance during the long period of implementation, one of the alternates can be selected for recommendation to the policy-makers.

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6. ESTIMATING TRANSIT USAGE (MODAL SPLIT)

MARTIN J. FERTAL

ALI F. SEVIN

The design of a transportation system to serve tomorrow's travel demand is largely dependent, in terms of total capacity needed, upon a forecast of total travel demand. However, the portions of total capacity that should be provided by public transit and by highways in order to most efficiently serve the future demand is dependent upon a forecast of travel demand by mode: i.e., demand for public transit and demand for highways. In order to make this forecast, it is necessary to isolate and quantify those factors tripmakers consider important when choosing a mode. Procedures to accomplish this division of total travel demand into modes have been developed and are called "modal split models."

The Bureau of Public Roads has documented nine of these modal-split procedures currently in use, and subsequently organized a series of seminars in 17 cities throughout the country to acquaint the urban planners with "modal split." In an attempt to develop a better understanding of the factors involved in tripmakers' modal choice decisions, the authors asked the following questions of approximately 650 people at these seminars:

How did you get to work this morning?

Why did you choose transit/auto in preference to auto/transit?

In response to these questions, those persons truly having a choice of mode most frequently mentioned factors that can best be described as characteristics of the transportation system. Some were quantitative in nature such as travel time, travel cost, parking cost, availability of transit service, etc. Many, however, were of a qualitative nature; e.g., comfort, convenience, flexibility, dislike of driving, desire for privacy, etc.

The questions were asked in reference to work trips since prior research indicated that tripmakers respond to a given level of transit service at a higher rate when making a work trip than when making any other type of trip. In other words, transit usage also varies with the characteristics of the trip.

The fact that tripmaker response to a given level of transit service varies with the characteristics of the trip, trip purpose being one such characteristic, is illustrated by Fig. 6.1 which depicts the relationship between the response to a given level of transit service for work and nonwork purposes in Buffalo, New York.

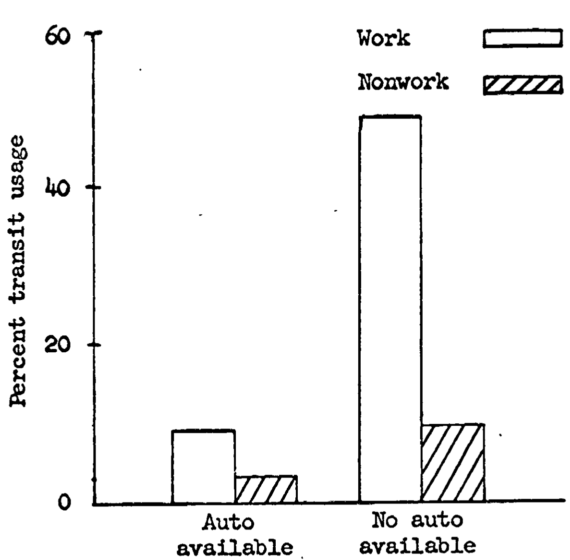


Fig. 6.1 -- Percent transit usage for work and nonwork purposes with and without an auto available (Source: Niagara Frontier Transportation Study)

Intuition dictates that such a relationship should exist since the work trip (the longest of all internal trips) is the most repetitive trip made. Because of its repetitive nature, one familiarization with a transit schedule suffices for as long as the tripmaker's residence and place of employment remain fixed. Furthermore, the work trip is usually made during peak travel periods when public transit is providing maximum service. In addition, a great number of work trips are oriented toward the central city where the parking supply is limited and, consequently, parking rates are high.

The responses received from the personnel attending the seminars are recognized to comprise a biased sample since the participants were not representative of the average tripmaker. In general, responses were received from people considerably higher on the income scale than the average person. This greater affluence, which translates itself into higher automobile ownership, was apparent in that not one person said he does not own an automobile, a characteristic of the tripmaker that has been found to be highly correlated with transit usage. To illustrate this point, consider the relationships shown in Fig. 6.2 between auto ownership and transit usage in Buffalo, N.Y., and San Juan, Puerto Rico. Although these areas are widely separated both geographically and economically, they are nevertheless similar in terms of response to transit service by "0," "1," and "2+" car owning families.

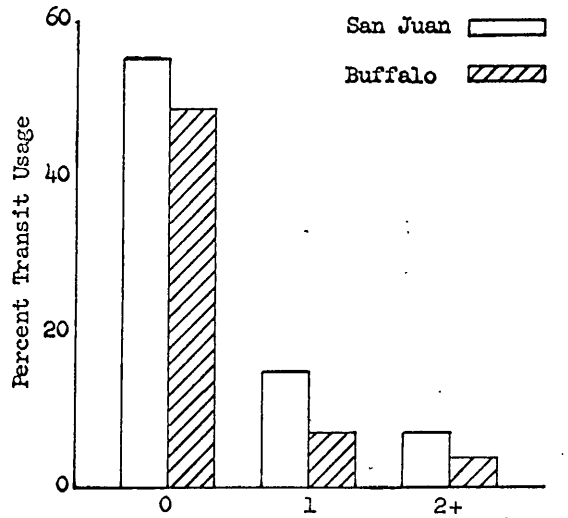
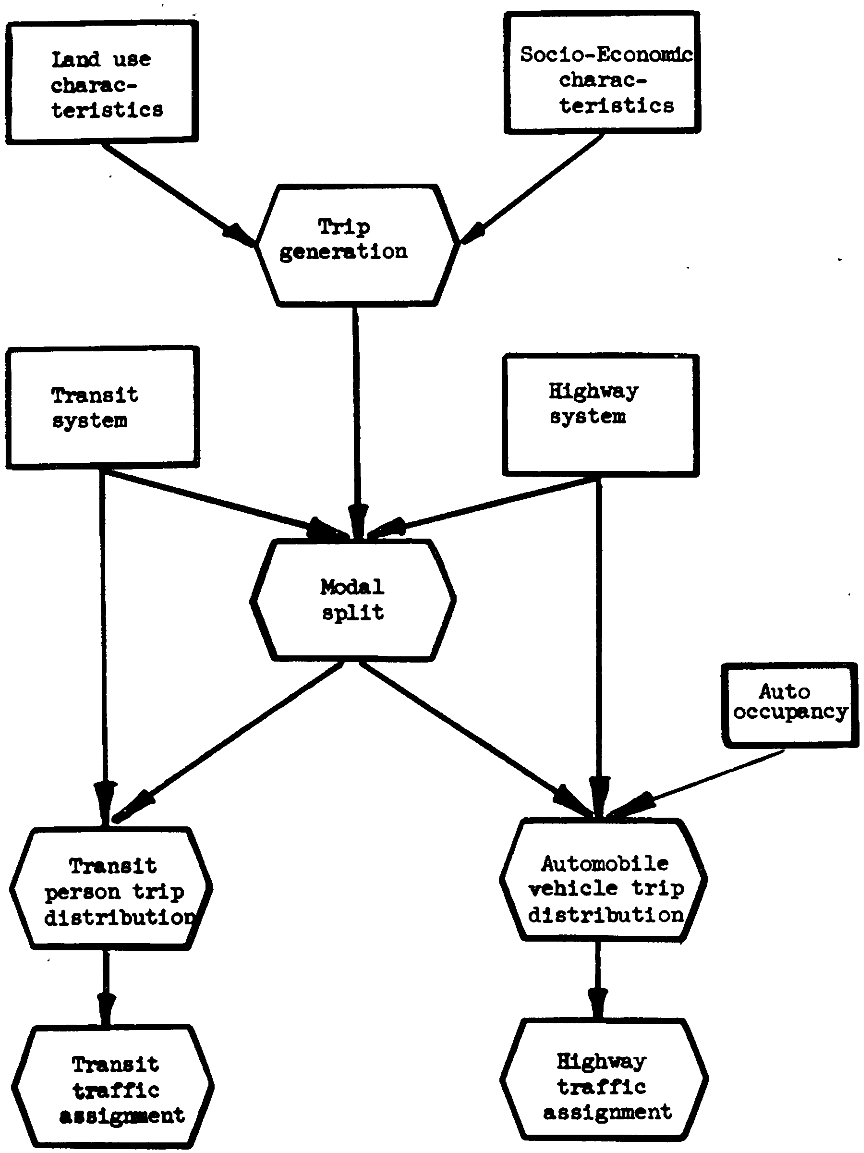


Fig. 6.2 -- Percent transit usage related to autos/dwelling unit. (Source: Transportation Study Data)

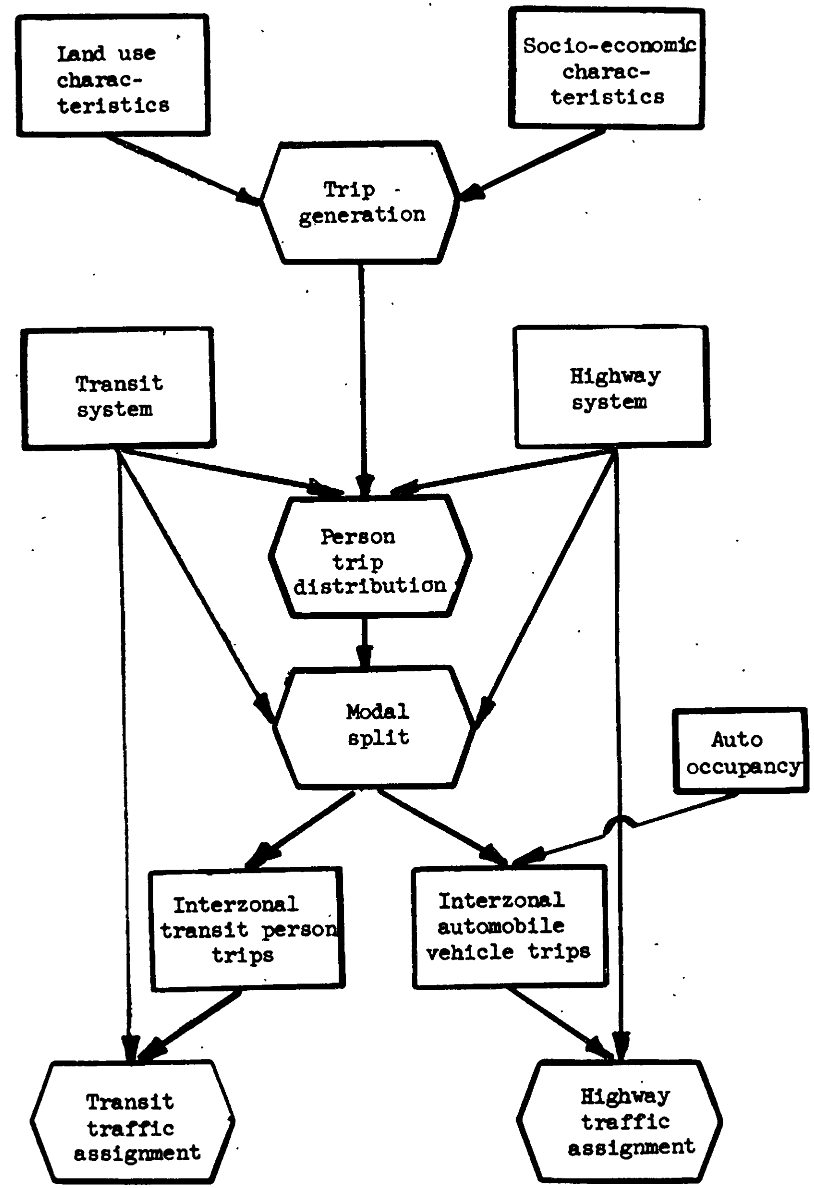
TABLE 6.1 -- CHARACTERISTICS OF GOLDEN TRIANGLE, SCHOOL, AND OTHER 1958 TRANSIT TRIPS

Characteristic	Transit Trips		
	To or From the Golden Triangle	To or From School	All Others
Trips by Mode			
Bus or Streetcar	151,964	152,507	163,609
Railroad	3,599	52	2,019
Total	155,563	152,559	165,628
Average Trip Length (airline miles)	4.2	1.8	2.9
Per Cent of Trips			
During 7-9 a.m. peak	24	46	17
During 4-6 p.m. peak	30	5	22
Between home and work	63	..	64
By licensed drivers	48	9	32
From car-owning households	69	91	53
With choice of driving	27	4	13

SOURCE: Pittsburgh Area Transportation Study
Volume I, November 1961, chapter V
Volume II, February 1963, chapters IV and V.



a. Trip-end modal-split model.



b. Trip-interchange modal-split model.

Fig. 6.3 — Generalized diagrams of modal-split models.

As previously mentioned, not one of the 650 or so people polled indicated that they did not own an automobile; however, several did indicate that at the time the trip was to be made, an automobile was not available. The significance of the difference between auto ownership and auto availability can perhaps best be illustrated by reference to Table 6. 1 which shows that of all transit trips to and from the Golden Triange in Pittsburgh, Pennsylvania, 69 percent were made by people coming from car owning households. However, only 48 percent of all transit riders were licensed drivers and only 27 percent had a choice of driving. In other words, 21 percent of transit users came from car-owning families, were able to drive, but did not have an auto available. Only 27 percent of all transit riders were truly "choice" riders; the remaining 73 percent were termed "captive transit riders"; i.e., they could not drive or did not have an auto available at the time the trip was to be made.

Thus far, it has been shown that transit usage varies with and is dependent upon the characteristics of the trip, the tripmaker, and the transportation system. A model to estimate transit usage should, therefore, contain measures of each characteristic mentioned.

The models that have been developed can be classified as either trip end or trip interchange modal split models. The distinction is dependent upon where in the transportation planning process the split is made. This distinction has been defined in Chapter 5, and is further illustrated by Fig. 6. 3.

a. An initial step in the transportation planning process is the generation of total person trip ends (origins and destinations) by traffic analysis zones. If the trip ends are, at this point, split into automobile and transit trips, and then distributed between zones separately for each mode, the model is termed a TRIP-END MODAL SPLIT MODEL (Fig. 6. 3a).

b. If, on the other hand, trip ends are first distributed between zones, and then the interchanges are split into automobile and transit segments, the model is defined as a TRIP-INTERCHANGE MODAL SPLIT MODEL (Fig. 6. 3b).

Trip-end Models

Transportation planning as it is known today got its start in the mid-fifties. It was at that time that the need for a procedure to estimate future transit usage was first recognized to be an integral part of the transportation planning process and procedures (mostly trip end) were developed to make the necessary estimates. The early procedures, although coarse by today's standards, were nevertheless a significant improvement over the then existing "modal split model," the transit diversion curve (see Fig. 6. 4).* The major advantages of the early trip end efforts over the diversion curve were (1) the procedures were capable of estimating transit usage areawide, a refinement made possible by advances in computer technology and the vast amount of data obtained in urban transportation studies, and (2) the procedures recognized that transit usage varies with tripmaker and trip characteristics. A typical example of the work done at this time is shown in Fig. 6. 5, a stratification of transit trips by trip purpose and the development of relationships between each purpose group and factors such as auto ownership and net residential density.

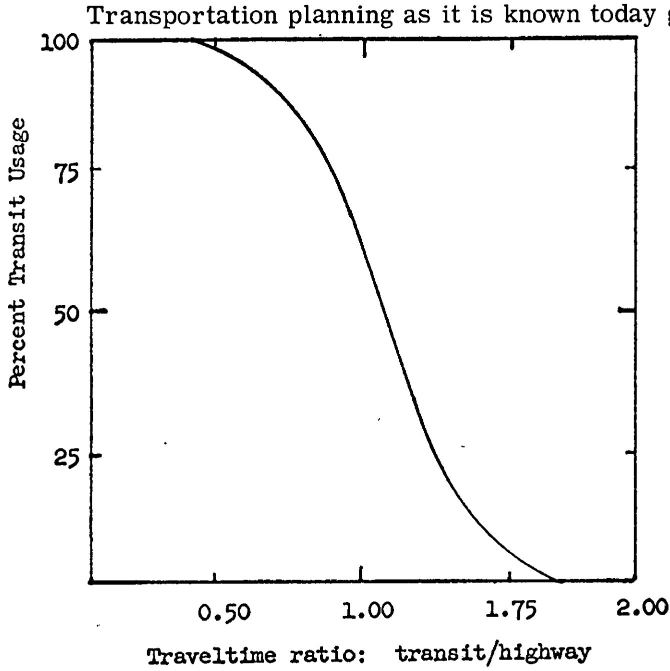


Fig. 6. 4 -- Transit Diversion Curve. (Source: Transportation Usage Study, Cook County Highway Department.)

*The diversion curve is a form of the trip interchange model.

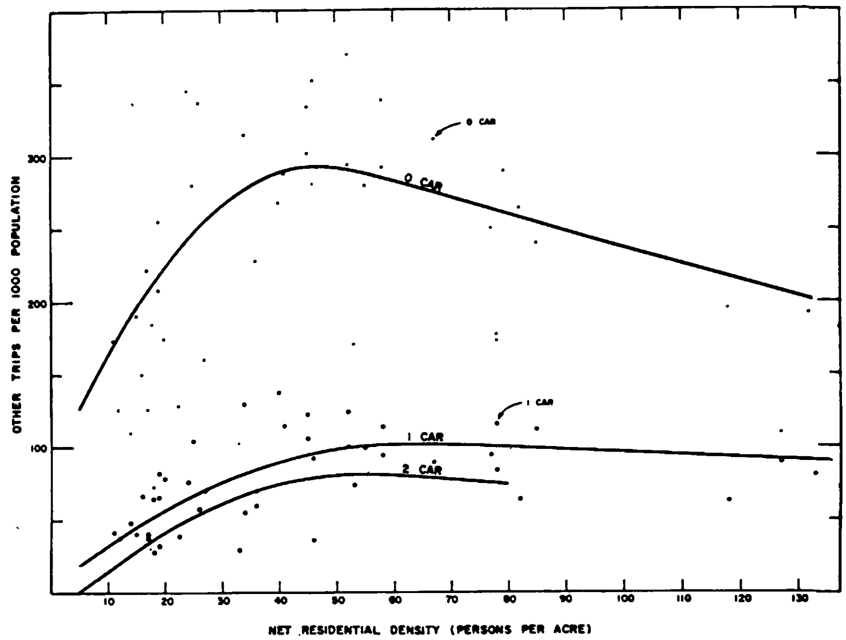


Fig. 6.5 -- Other transit trips by car ownership and net residential density - Pittsburgh, Pennsylvania. (Source: Schwartz, Arthur, Forecasting Transit Use, Highway Research Board Bulletin No. 297, 1961.)

Later, the necessity of including some measure of the transportation system in the procedures was recognized as an absolute necessity and the more recent trip end models have done this through (in most cases) the accessibility index. This index measures the ease by which activity within a planning area can be reached from a particular zone on a specific transportation system. Mathematically, the index can be expressed as follows:

$$Q_i = \sum_{j=1}^{n} (A_j F_{ij})$$

Where:

Q_i = accessibility index for zone i to all other zones (auto or transit)

A_j = attractions in zone j*

$F_{ij} = \dfrac{1}{(\text{door-to-door traveltime})^b}$ = traveltime friction factor (a measure of impedance) for travel from zone i to zone j on the particular transportation system being considered

b = an exponent which varies with trip purpose and traveltime range

n = number of zones

*In reference to the gravity model, home-based trips (one end at home) are always "produced" by the zone of residence of the tripmaker whether the trip begins or ends in that zone. Home-based trips are always "attracted" at the nonresidential end of the trip. Nonhome-based trips are always "produced" by the zone of origin and "attracted" by the zone of destination.

Door-to-door traveltime for the highway network includes:

1. Walk time at the origin
2. Unpark time at the origin
3. Driving time
4. Park time at the destination
5. Walk time at the destination

Door-to-door traveltime for the transit network includes:

1. Walk time at the origin
2. Wait time at the origin
3. Time spent in transit vehicle
4. Transfer time between transit vehicles (where applicable)
5. Walk time at the destination

From the above equation, it can be seen that the greater the traveltime from zone i to zone j, the smaller the friction factor and consequently the lower the accessibility index. This index is derived from the gravity model distribution formula in which it is the denominator:

$$T_{ij} = \frac{P_i \, F_{ij} \, A_j}{\sum_{j=1}^{n} \left(F_{ij} \, A_j \right)}$$

Where: T_{ij} = number of trips between zone i and zone j (auto or transit)

P_i = number of productions in zone i

and the other variables are as previously defined. Relative travel service provided by the two modes is measured by the ratio of the highway accessibility index to the transit accessibility index and is called the "accessibility ratio."

To illustrate how the accessibility ratio is computed, refer to Fig. 6.6, in which it is desired to compute the accessibility ratio for zone i, the zone of interest. The door-to-door traveltimes via the highway network (t_h) and via the transit network (t_t) are as shown. Assume that "b" is constant and equal to 2.0. The accessibility indices and the accessibility ratio are then computed as shown in the figure. The value of the accessibility ratio in this example - 0.58 - indicates that it is easier to reach all attractions (say employment which is a measure of attractions for work trips) within the area from the zone of interest via the highway network.

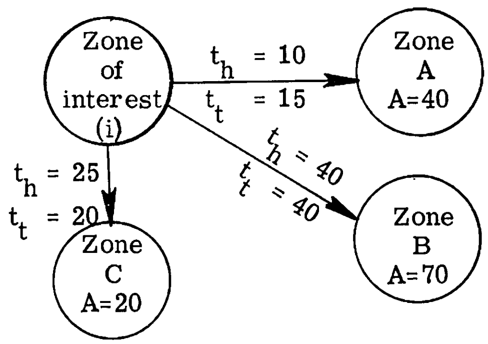
The relationship between the accessibility ratio and transit usage has been used by a number of studies to estimate the probable increase in transit patronage that can be expected with an increase in transit service. The Erie transportation study, for example, developed the relationship shown in Fig. 6.7.

As can be noted, an increase in transit service, as reflected by the accessibility ratio, is related to an increase in transit usage.

A point that should be made in reference to this relationship is that it does not incorporate any characteristics of the tripmaker. In other words, the relationship assumes that all tripmakers, regardless of economic or car ownership status, respond to a given level of transit service at the same rate. In this context, the relationship is similar to the transit diversion curve shown in Fig. 6.4.

The Puget Sound Regional Transportation Study (Seattle, Washington) carried the modal split procedure one step further to include in the primary estimating relationship a characteristic of the trip, the tripmaker and the transportation system.* This was accomplished

*The primary relationships were later modified on the basis of residential density, car ownership, and income.



To zone	Time (minutes)		Time (minutes)^2		Attraction (A)	$\frac{A}{t_h^2}$	$\frac{A}{t_t^2}$
	Highway (t_h)	Transit (t_t)	Highway $(t_h)^2$	Transit $(t_t)^2$			
A	10	15	100	225	40	0.40	0.18
B	40	40	1,600	1,600	70	0.04	0.04
C	25	20	625	400	20	0.03	0.05
Σ						0.47	0.27

Accessibility ratio: transit/highway $= \sum \frac{A}{t_t^2} \Big/ \sum \frac{A}{t_h^2} = \frac{0.27}{0.47} = 0.58$

Fig. 6.6 - Hypothetical example illustrating the computation of the accessibility ratio

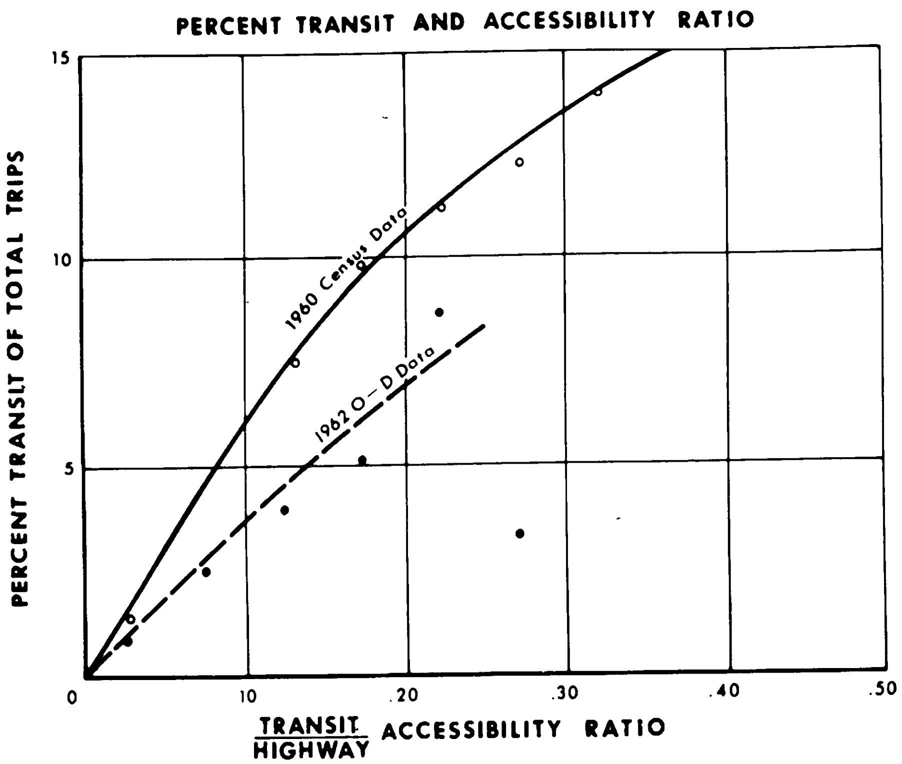


Fig. 6.7 - Relationship between percent transit usage for work trips and accessibility ratio - Erie, Pennsylvania. (Source: Alan M. Voorhees and Associates, Inc., Modal Split Model, Erie Area Transporation Study, (Staff Report No. 3) September 4, 1963.)

by stratifying trips into four trip purposes and three income groupings and relating each stratum through the accessibility ratio to the percent of trips on transit.* As can be seen in Fig. 6.8, which shows two of the four purpose relationships developed, there is a significant difference between the response to a given level of transit service by people in different income ranges.

The preceding discussion has attempted to demonstrate that transit usage varies with the characteristics of the trip, tripmaker, and transportation system. It has also attempted, in general terms, to illustrate how the various characteristics have been incorporated into the estimating procedures. It is recognized that the preceding discussion of the trip end procedure and the discussion of the trip interchange procedure that follows do not answer all of the more subtle questions that the very interested reader will have. These answers are available, however, in another publication.**

Trip Interchange Models

A refinement of the all inclusive diversion curve technique is provided by the Washington, D.C., procedure. Although the primary variable is the traveltime ratio, the procedure makes use of stratifications which reflect characteristics of the tripmaker and the trip as well as a cost variable which measures another dimension of the transportation system. As in the case of the customary diversion curve, the traveltime ratio is plotted on the x axis with percent transit usage plotted along the y axis. Separate curves are shown for stratifications of the other variables. Detailed descriptions of all the variables are given below.

1. Traveltime ratio.--The ratio of door-to-door traveltime by public transit divided by the door-to-door traveltime by private auto. The traveltimes include all components of walk, wait, travel, and transfer times for the transit trip and travel, park, and walk times for the auto trip.

The use of the absolute difference in traveltime between modes instead of the time ratio is sometimes advocated. This approach was rejected during the development of the Washington model. The rationale was that a time difference of say 5 minutes would be expected to have a different effect on a 10-minute trip than it would on a 40-minute trip. Yet stratification by time differences would show equal responses for both.

It should be noted here that the use of traveltime ratios can be criticized similarly but from the opposite point of view. Two identical ratios can actually hide sizable absolute differences in traveltime. Furthermore, it can be argued that one does not really think in terms of traveltime ratios but rather in terms of minutes saved when comparing two modes of travel. But more on this during the discussion of the San Juan and Buffalo procedures.

2. Relative travel cost.--This variable is defined as the ratio of the out-of-pocket travel cost via transit to the travel cost via auto. It is expressed as follows:

$$\text{Travel cost ratio} = \frac{X_1}{(X_2 + X_3 + 0.5X_4)/X_5}$$

Where:

X_1 = transit fare

X_2 = cost of gasoline

X_3 = cost of oil change and lubrication

X_4 = parking cost at destination

X_5 = average car occupancy

---

*The trip purpose stratifications used were home based work, shop, social-recreation, and miscellaneous. The income groups chosen were (1) low income, under $4,500 per year, (2) medium income, $4,500 to $5,999 per year, and (3) high income, $6,000 per year and above.

**Modal Split - Documentation of Nine Methods for Estimating Transit Usage, by Martin J. Fertal, Edward Weiner, Arthur J. Balek, and Ali F. Sevin, available through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 70 cents each.

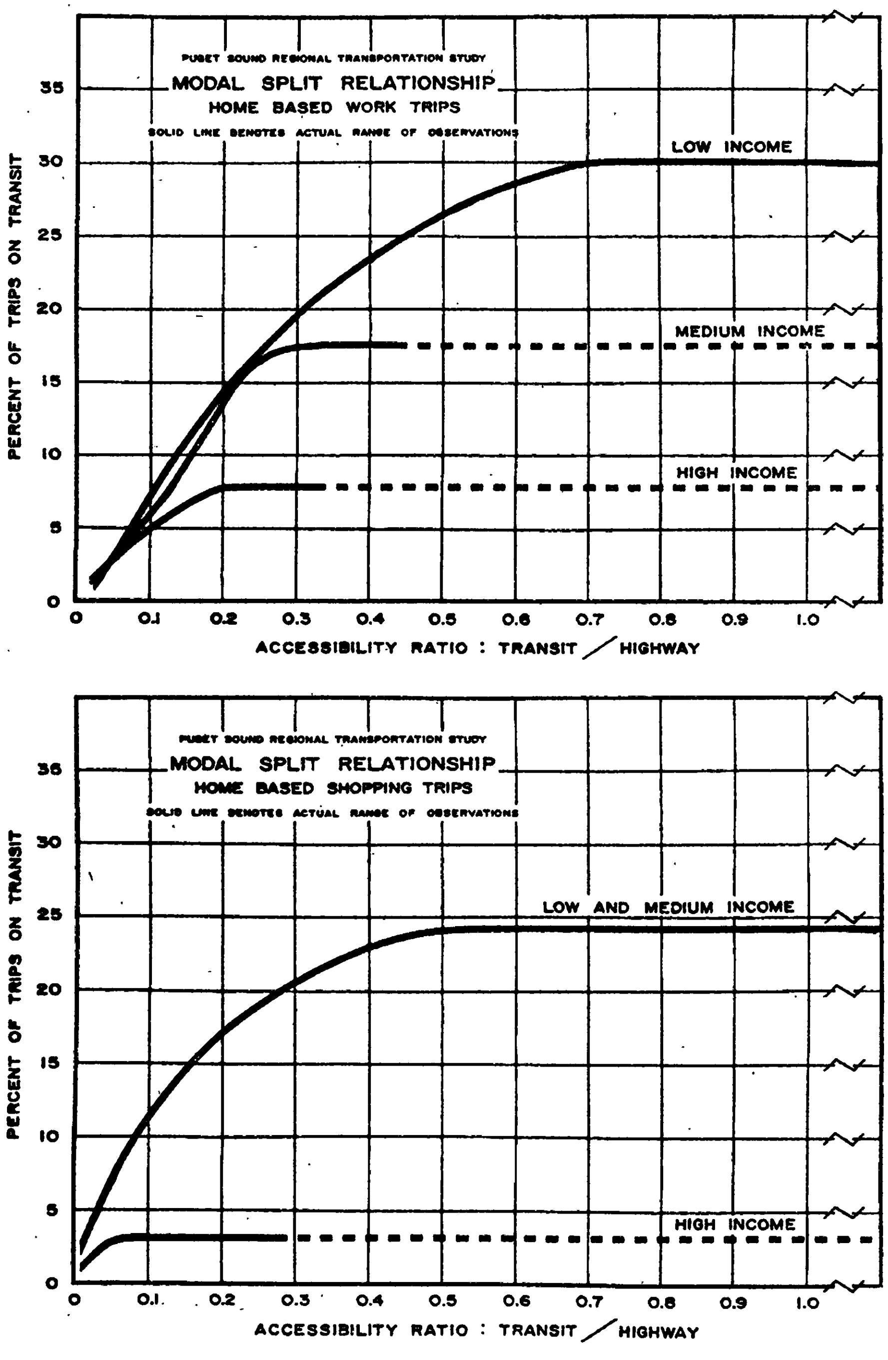


Fig. 6.8 - Modal split relationships, home-based work and shopping trips. (Source: Basmayciyan, H., and Schmidt, J. W., Development and Application of a Modal Split Model for the Puget Sound Region, (Staff Report No. 12) Puget Sound Regional Transportation Study, May 1964, Seattle, Washington.)

The cost of gasoline, oil change and lubrication, and parking are the only costs used in developing total cost via auto. This is based on the assumption that they are the only costs considered by a tripmaker. The parking cost used is one-half of the all day parking travel cost for this a.m. peak hour model. For nonwork trips to the CBD zones, the parking cost is assumed to be one-half of the half day parking fee. Furthermore, this travel cost by auto is divided by an average car occupancy factor to reflect the cost per person.

3. Economic status of tripmaker.--Use of the automobile mode depends on one's ability to purchase and maintain an automobile. The median family income is, therefore, used as a variable.

4. Relative travel service.--Many factors make up the level of service for each mode of travel. Included are environment within the vehicle, appearance of the travel vehicle, comfort, smoothness of ride, availability of seats, convenience of transferring, flexibility of arrival and departure times, etc. Since these factors are difficult to quantify, the Washington procedure attempts to approximate the service level by a factor called excess traveltime. It is defined as the time spent outside the vehicle during a trip - walking, waiting, and transfer time for transit - and parking delay and walking time from parking place to destination for autos. It can be expressed as follows:

$$\text{Travel service ratio} = \frac{X_6 + X_7 + X_8 + X_9}{X_{10} + X_{11}}$$

Where:
- X_6 = transfer time between transit vehicle
- X_7 = time spent waiting for transit vehicle
- X_8 = walking time to transit vehicle
- X_9 = walking time from transit vehicle
- X_{10} = parking delay at destination
- X_{11} = walking time from parking place to destination

This variable provides a separate measure of the annoyance portions of the auto and transit trips. Since these same time portions are included in the total traveltime ratio, the procedure has been criticized for double counting. It does, however, provide the capability to account for changes in annoying portions of trips even while the total traveltime might remain constant.

In the development of diversion curves, the data were stratified into the following cost ratio, economic status, and service ratio groups separately for work and nonwork purposes.

Stratification Levels for Cost Ratio (CR),
Economic Status (EC), and Service Ratio (L)

CR_1 = 0.0 to 0.5
CR_2 = 0.5 to 1.0
CR_3 = 1.0 to 1.5
CR_4 = 1.5 & over

EC_1 = \$ 0 to \$3,100 per annum
EC_2 = \$3,100 to \$4,700 per annum
EC_3 = \$4,700 to \$6,200 per annum
EC_4 = \$6,200 to \$7,500 per annum
EC_5 = \$7,500 per annum and over

L_1 = 0.0 to 1.5
L_2 = 1.5 to 3.5
L_3 = 3.5 to 5.5
L_4 = 5.5 & over

NOTE: Traveltime ratio is plotted as a continuous variable on the horizontal axis of each group.

This produced 80 diversion curves for each trip purpose for a total of 160 curves. The curves are displayed in Fig. 6.9 and Fig. 6.10 together with plots of similar data from Philadelphia and Toronto where available to provide a comparison base.

Another approach to the division of zone-to-zone person trips into the auto and transit modes is the regression analysis exemplified by the Twin Cities procedure. The general framework of the model is indicated by the following formulation:

$$T_{i-j} = F(S_{i-j}, PC_i, AC_j)$$

Where: T_{i-j} = transit passenger trips from i to j as a percentage of person trips.

S_{i-j} = relative level of transit and highway service between i and j.

PC_i = characteristics of persons making trips as measured at the production end.

AC_j = characteristics of the environment at the attraction end of the trip.

This form is suitable for multiple regression analysis and the final equations were derived for Twin Cities by successive regression runs with the following variables.

Zone-to-zone variable

S $$X_1 = \frac{\text{Transit riding time i-j + walk and wait time at i + walk time at j + transfer time}}{\text{Driving time i-j + terminal time at i + terminal time at j}}$$

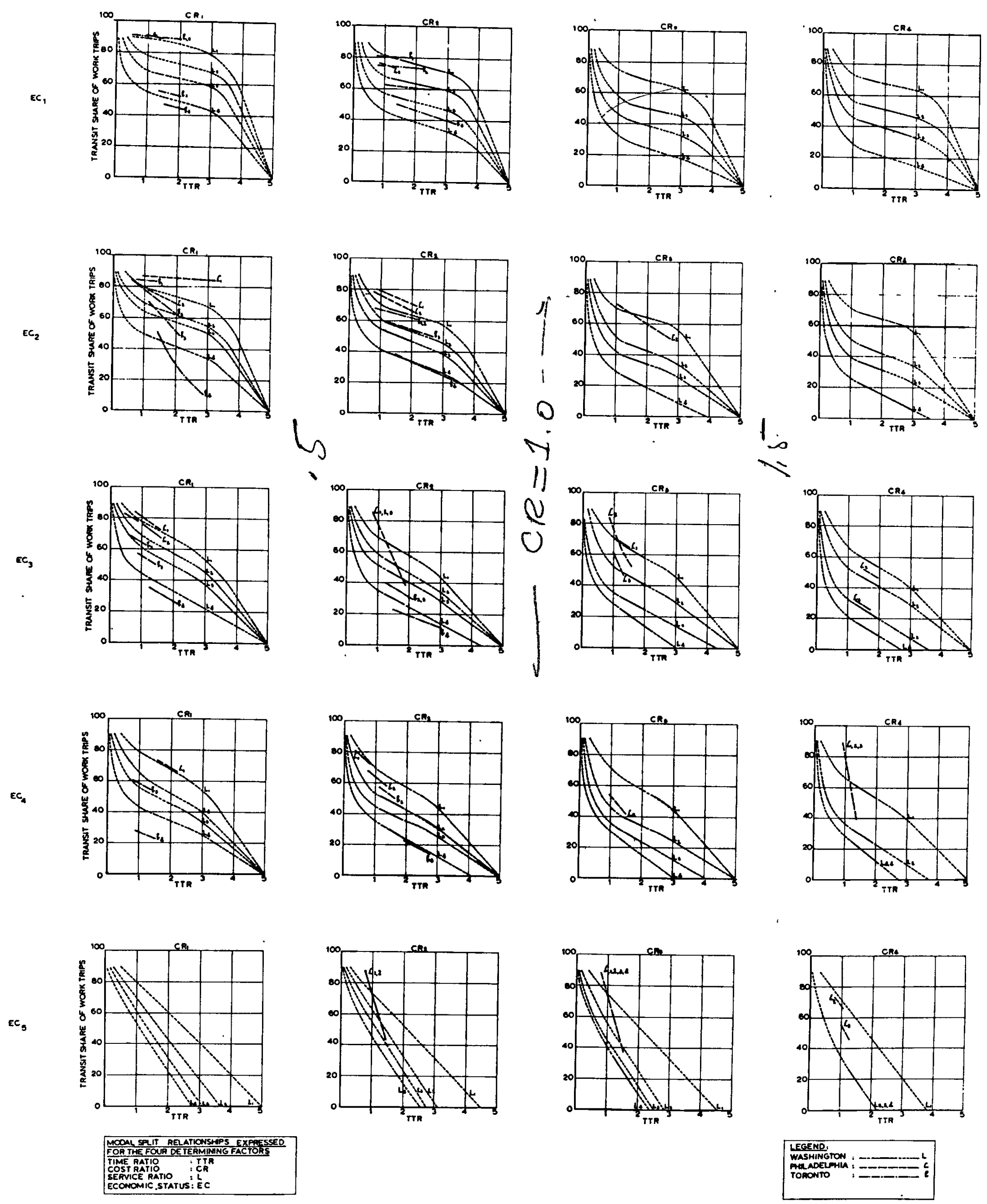


Fig. 6.9 - Work Trip Modal Split Relationships.

(Source: Report to the President, November 1, 1962, Appendix, volume III; Traffic Forecasting, volume IV; A Model for Estimating Travel Mode Usage, National Capital Transportation Agency, January 9, 1962.)

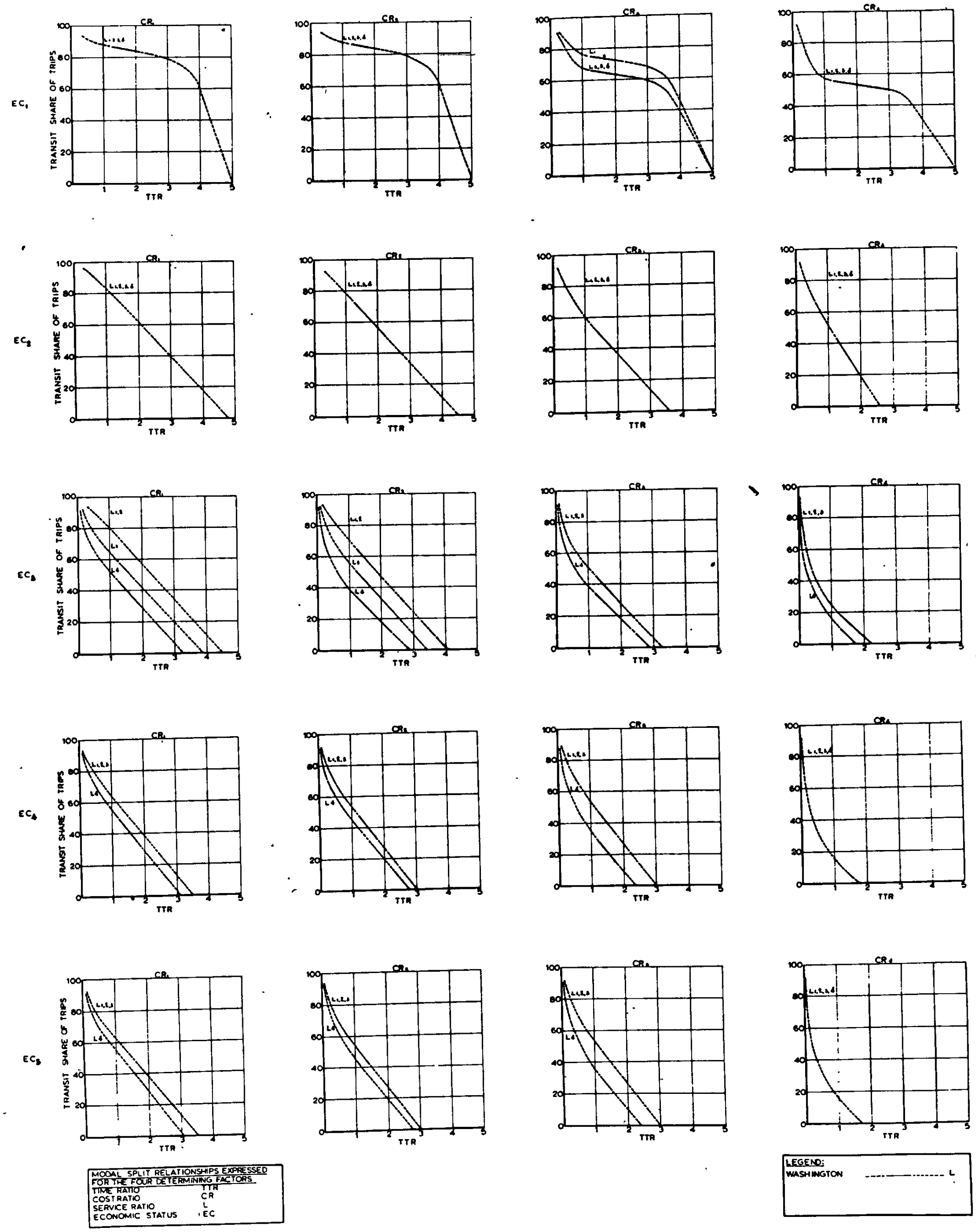


Fig. 6.10 - Nonwork, Nonschool Trip Modal Split Relationships.

(Source: Report to the President, November 1, 1962, Appendix, volume III; Traffic Forecasting, volume IV; A Model for Estimating Travel Mode Usage, National Capital Transportation Agency, January 9, 1962.)

Production-end variable

X_2 = median family and unrelated individual income in dollars

X_3 = housing units per net residential acre

X_4 = cars per housing unit

X_5 = accessibility to employment (ratio of transit to highway)

Attraction-end variable

X_6 = 9-hour parking cost (average hourly rate for 9-hour parking, in dollars)

X_7 = 3-hour parking cost (average hourly rate for 3-hour parking, in dollars)

X_8 = employment per gross acre

X_9 = accessibility to population (ratio of transit to highway)

The nature of some of the variables such as income, employment density, and residential density is self-explanatory. The accessibility variables are measures of each district's relative proximity by bus to all employment or to all population expressed as a ratio of each district's relative proximity by auto to all employment or to all population.

The downtown parking cost variables averaged \$.05 to \$.10 for 3-hour parking and slightly less for 9-hour parking. The highest average hourly rates were \$.15 and \$.12 for 3-hour and 9-hour parking, respectively.

It was found that observations with at least 250 trips provided a stable input and what appeared to be an unbiased sample. All district-to-district movements with less than 250 trips were therefore excluded. The final equations derived for the prediction of transit passenger work trips and transit passenger "other" trips on a district-to-district basis are shown below.

T_{i-j} = (percentage of work trips by transit) = 41.4 - 12.1 ln (traveltime ratio) - 4.4 ln (income) + 8.0 ln (residential density) + 1.3 ln (employment density) + 365.5 (9-hour parking cost)

T_{i-j} = (percentage of "other" trips by transit) = 29.0 - 3.6 ln (traveltime ratio) - 3.2 ln (income) + 2.4 ln (residential density) + 285.2 (3-hour parking cost)

Multiple correlation coefficients of 0.80 for the work trip equation and 0.79 for the "other" trip equation were obtained. These levels were judged satisfactory considering that some of the variation can be attributed to the observed values obtained at the 5 percent sampling rate. The equations are shown in graphic form in Fig. 6.11. The percentage of trips expected to be made by transit can be determined for selected values of each variable by adding the constant of the equation; i.e., 41.4 for "work" trips and 29.0 for "other" trips to the percentage increments from the vertical axis. Thus, the Twin Cities procedure emerges as a cumulative diversion curve method.

Yet another twist of the old diversion curve idea is presented in the San Juan method. While traditional diversion curves use traveltime ratios to reflect the relative attractiveness of the two modes, the San Juan curves are based on different variables for different auto ownership levels. Three distinct levels of automobile ownership, "0," "1," and multi-automobile families, are used. Accessibility, cost, and time differences are considered in the modal split analysis. Of course, the two major trip purposes, work and nonwork, are treated separately.

It is shown that propensity to use transit among the "0" car group is closely related to the accessibilities offered on the transit system. The variable used to reflect transit accessibilities is called the accessibility index. This index differs from the conventional accessibility

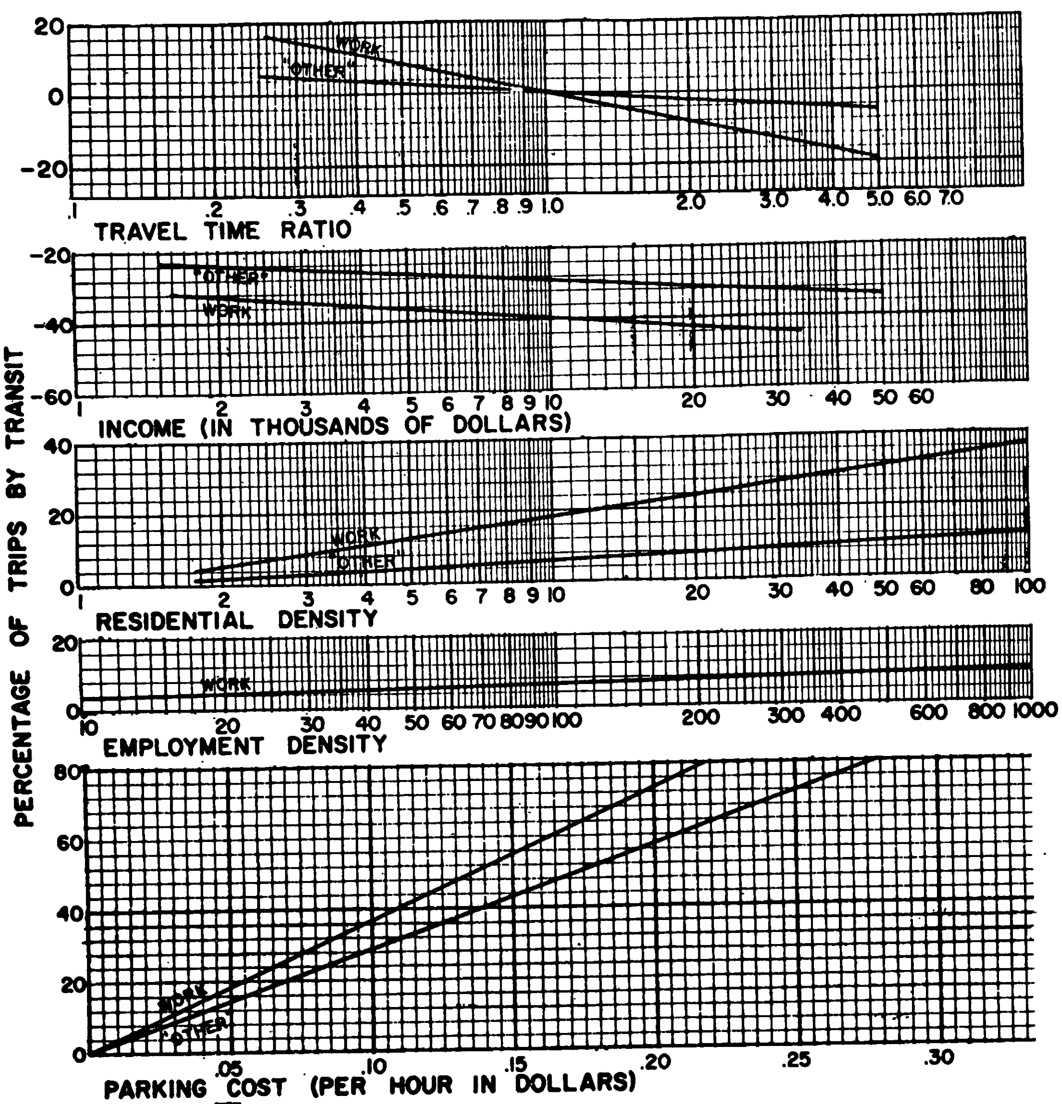


Fig. 6.11 - Percentage of Work and "Other" Trips by Transit Related to the Variables Used in the Model. (Source: Forbord, R. J., Twin Cities Modal Split Model, Minnesota Highway Department, January 1966.)

index defined earlier as the denominator of the gravity model trip distribution formula. The transit accessibility index used for the San Juan modal split work is:

$$\text{Index} = \frac{1}{\sum_{j=1}^{n} t_{oj}} + \frac{1}{\sum_{j=1}^{n} t_{dj}}$$

Where: t_{oj} = minimum traveltime from the origin zone to zone j

t_{dj} = minimum traveltime from the destination zone to zone j

The traveltimes from the origin zone to all the other zones are summed. Then the traveltimes from the destination zone to all the other zones are summed. When the reciprocals of these two sums are added, the index is obtained for the two zones in question. This index is computed for each zone-to-zone movement and a relationship is obtained to determine percent transit usage for "0" car trips as shown in Fig. 6.12.

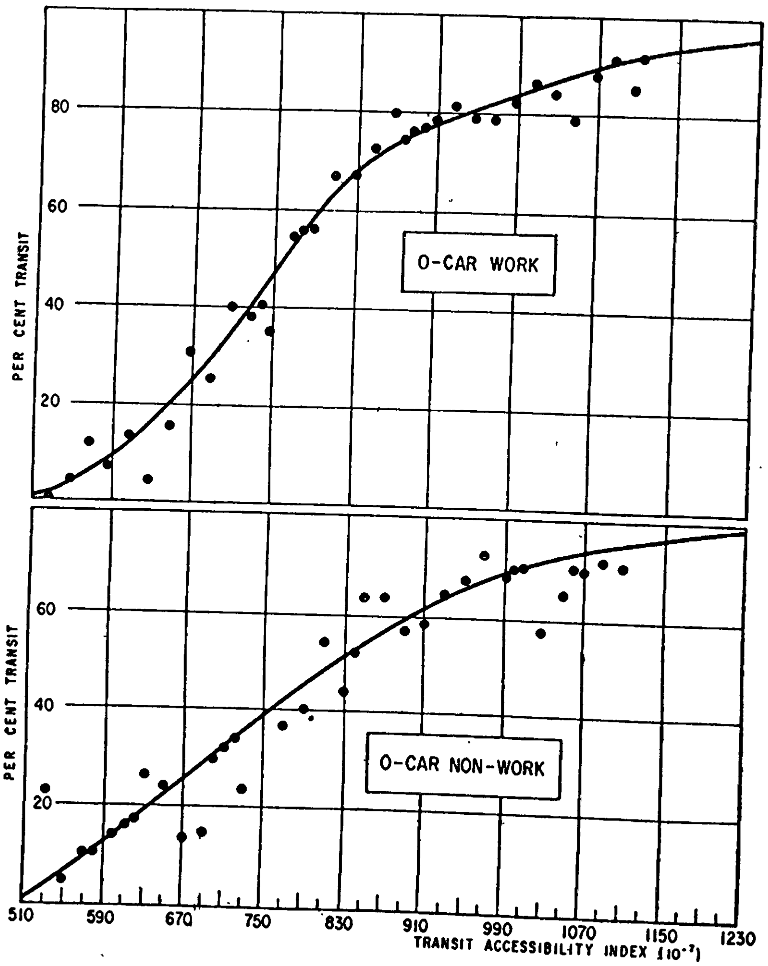


Fig. 6.12 - Transit Accessibility Modal Split. (Source: Travel Projections and Modal Split, San Juan Metropolitan Area Transportation Study, prepared for Commonwealth of Puerto Rico, Department of Public Works, Wilbur Smith and Associates and Padilla and Gracia, February 1966.)

Transit usage among the "1" car group is related to the difference in the cost (transit minus auto) of travel for each zone-to-zone movement as shown in Fig. 6.13. The "2" car group is shown to be sufficiently responsive to traveltime to permit the development of the modal split curve of Fig. 6.14 based on the difference in traveltime between the two modes. It should be noted that this study deals with absolute differences of travel costs and traveltimes. This is consistent with the premise that one does not think in terms of ratios but rather in terms of cents or minutes while contemplating alternatives in travel. Yet, the procedure is vulnerable because it shows the same transit usage for say a 5-minute time difference on a 40-minute trip as it does for a 5-minute difference on a 10-minute trip. The reader will remember a similar difficulty of using time ratios discussed with the Washington procedure.

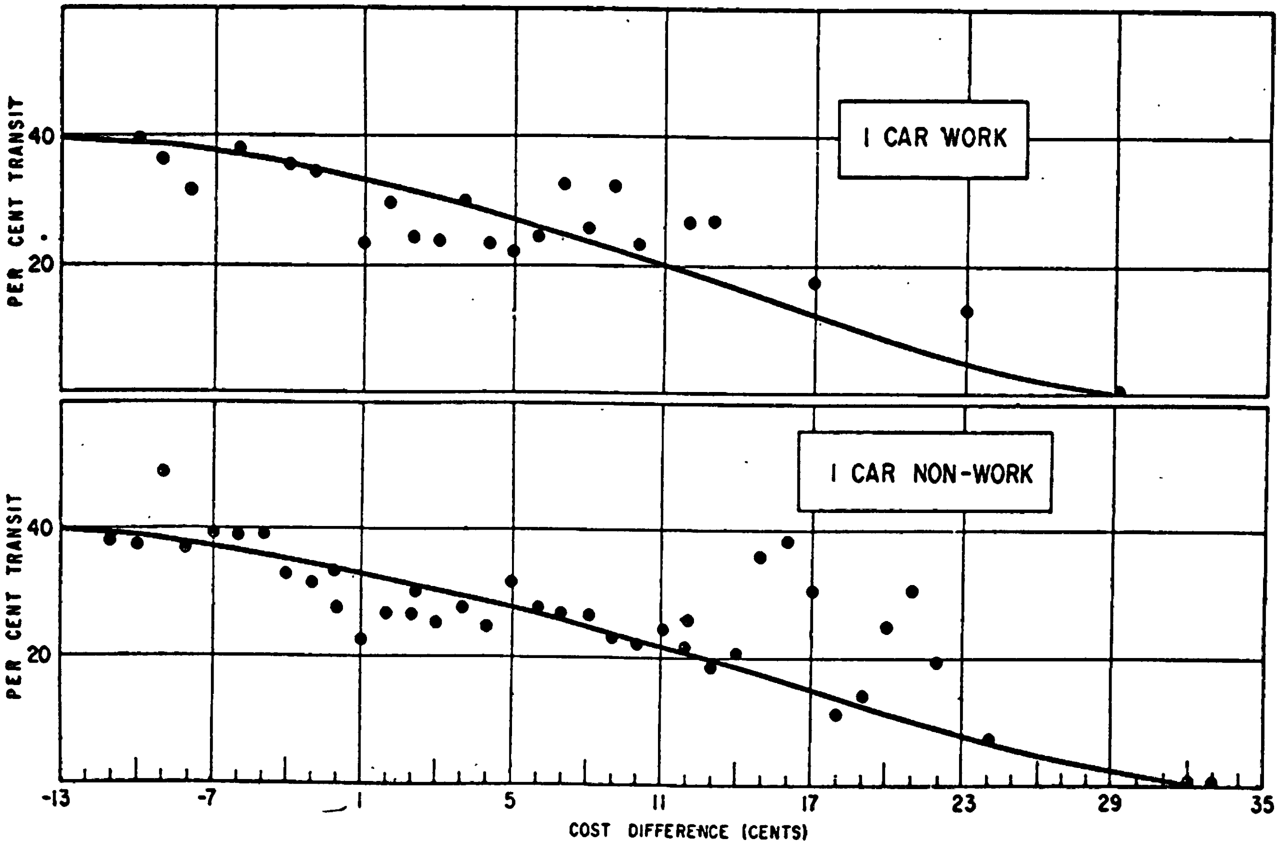


Fig. 6.13 - Cost Modal Split. (Source: Travel Projections and Modal Split, San Juan Metropolitan Area Transportation Study, prepared for Commonwealth of Puerto Rico, Department of Public Works, Wilbur Smith and Associates and Padilla and Gracia, February 1966.)

The Buffalo approach avoids this difficulty nicely by using the traveltime ratio as the prime measure of relative attractiveness but stratifying the user response into trip length categories. Thus, it is possible to measure varying degrees of transit usage for a given time ratio depending upon trip length.

The Buffalo procedure also recognizes that the availability or lack of an automobile would be an important factor to a prospective tripmaker in how he viewed the choice between taking transit or using an auto. Thus, Buffalo introduces the notion of auto availability to the modal split language. Household auto ownership, by itself, is not considered to be a direct measure of auto availability. It is argued that the auto, if driven to work, may be unavailable to other members of the family during the day. This new notion, auto availability, is treated in the following general way.

All trips made by households not possessing an automobile are placed in a "no-auto-available" class. The trips of households owning two or more vehicles are all classed as "auto-available" trips. For households that own one automobile, if the auto is used for work,

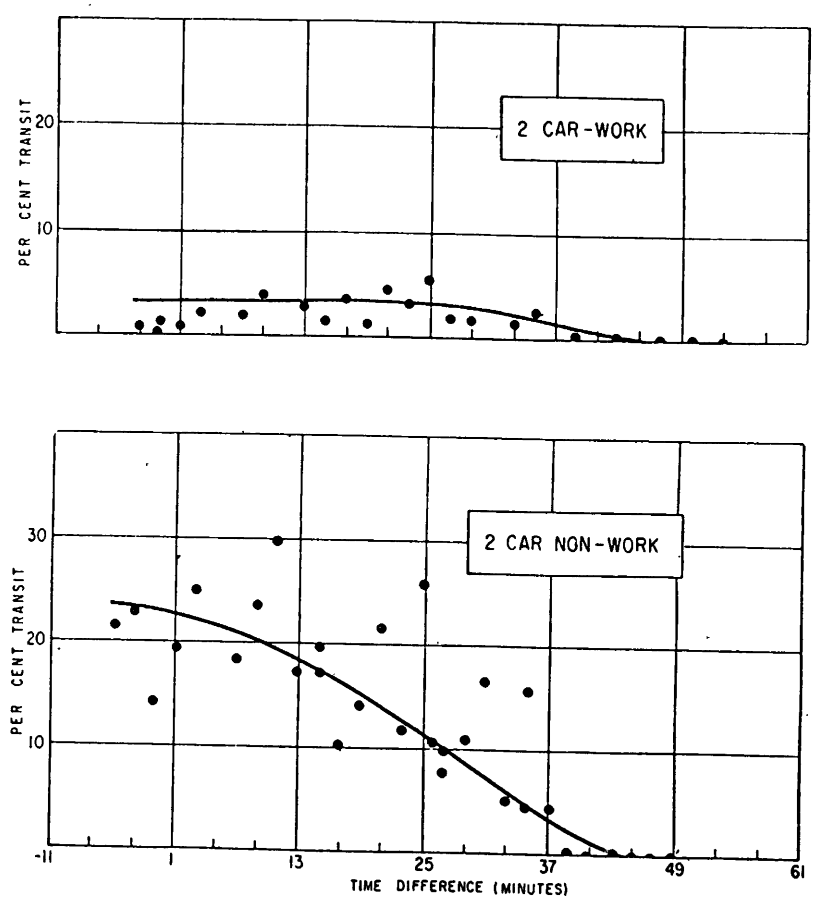


Fig. 6.14 - Time Modal Split. (Source: Travel Projections and Modal Split, San Juan Metropolitan Area Transportation Study, prepared for Commonwealth of Puerto Rico, Department of Public Works, Wilbur Smith and Associates and Padilla and Gracia, February 1966.)

the nonwork trips fall in the no-auto-available class. The nonwork trips are further classified by the proportion that occur during work hours (8 a.m. to 5 p.m.) and those that occur later. The latter trips, by one-auto households, are classed as auto-available trips.

The dichotomy of auto availability and the inevitable two-purpose breakdown prompts the four classifications shown below.

1. Work - auto available
2. Work - no auto available
3. Nonwork - auto available
4. Nonwork - no auto available

Within each trip class, the choice between alternative modes, for any one trip, would depend largely on the quality of service provided by one mode relative to the other. Thus, traveltime ratios are developed and user responses are recorded for each trip class by trip length.

Parking costs for auto trips are introduced as time penalties at the rate of 2 cents equalling 1 minute or $1.20 per hour. If tests of transit patronage with an increased fare were desired, the proposed cash increase would be converted similarly at 2 cents for 1 minute and the times added to total traveltime via transit. Otherwise, all the other traveltimes includes the customary walk, wait, travel, and transfer components of the transit trip and the travel, park, and walk components of the auto trip.

The values of transit usage, traveltime ratio, and trip length can be arranged three dimensionally to form a "response surface," as shown in Fig. 6.15. In order to achieve a traveltime ratio of 1.0 or better, performance of the transit system must equal or excel that of the highway system. Typically, this requires off-street operation. At present, transit service in Buffalo is provided almost entirely by a bus system operating on city streets and the response surfaces derived from the Buffalo survey data were inadequate for testing potential patronage of rapid transit. Therefore, they were extrapolated on the basis of transit usage for comparable traveltime ratios obtained from the Chicago data which include rail rapid transit and commuter train trips.

The Problem of Trip Distribution

So far, this summary of trip interchange modal split models has covered the factors which were found to be influential in modal choice and has described the relationships developed in four cities. To apply these relationships and determine future levels of transit ridership, one needs a future zone-to-zone person trip matrix. The trip distribution models

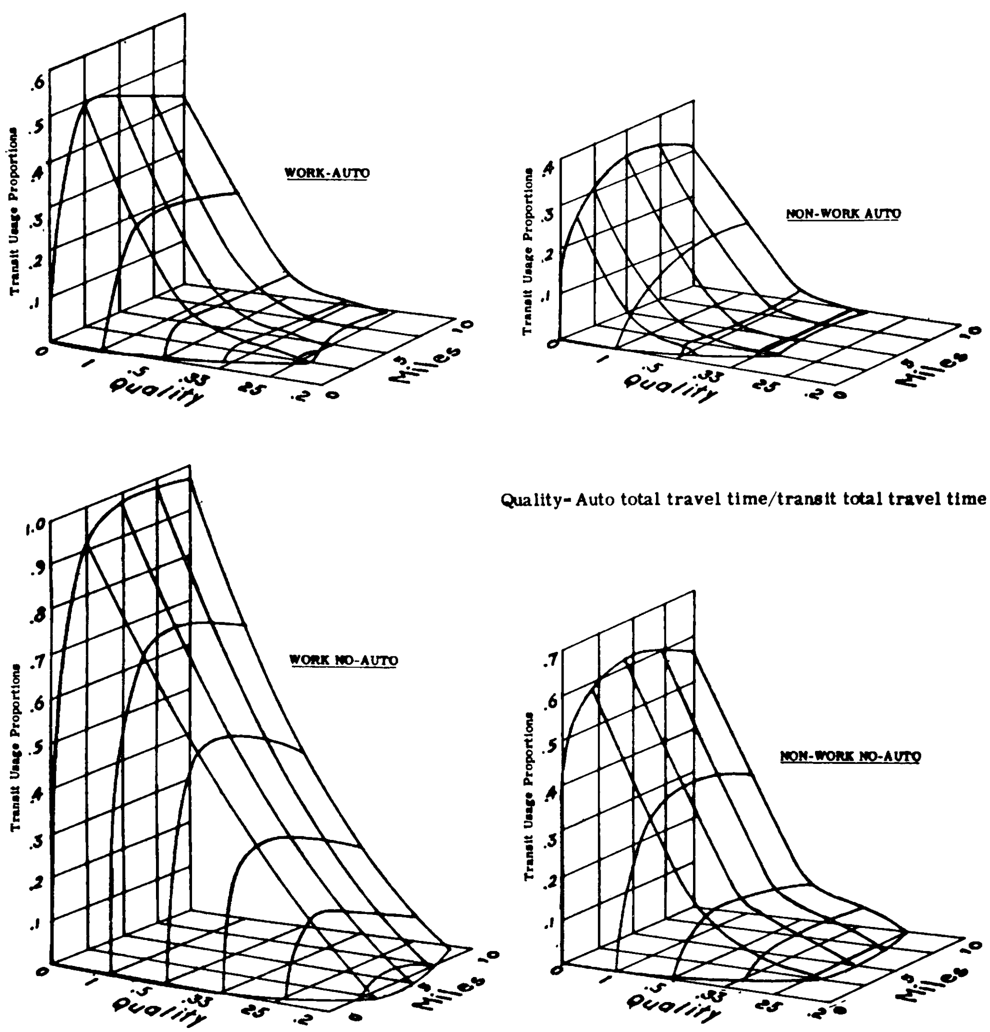


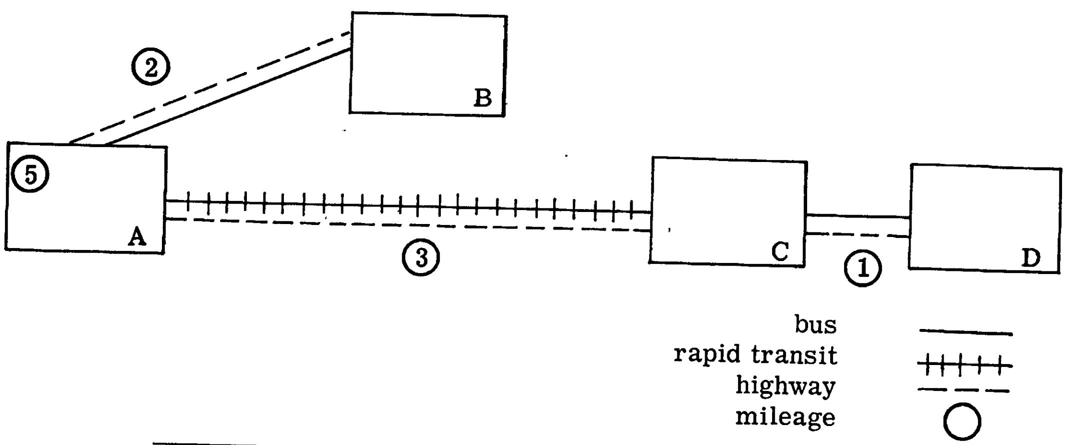
Fig. 6.15 - Transit response surfaces. (Source: Unpublished writings developed by the Niagara Frontier Transportation Study.)

generally assume that trip interchange volumes will vary according to accessibility. For example, two zones, once poorly connected by arterial streets but now joined by a freeway, would be expected to interchange more trips. Both the gravity and opportunity trip distribution models are capable of dealing with just such a condition of changing accessibilities due to changes in the transportation system. The use of highway systems in the distribution model would be reasonable if one wished to distribute only vehicle trips. If, on the other hand, the purpose is to distribute future trips by persons using both the private and public transportation modes in their future activities, one should consider accessibilities offered not only by the highway system but also by the transit system.

The Washington, D.C., and the Twin Cities procedures, on the assumption that highway networks adequately approximate total accessibilities, used only the highway networks in distributing person trips. The San Juan and Buffalo procedures, on the other hand, recognized the problem of varying accessibilites and attempted to deal with it. The San Juan procedure distributes all person trips generated by "0" car dwelling units using the transit network and all trips generated by car owning dwelling units using the highway network. There is a distinction between the calibration procedures used for "0" car and "1" car dwelling unit trips. But this level of technical detail is beyond our scope here.

The Buffalo procedure consists of a weighted average between two separate distributions of total person trips, one using the transit network and the other using the highway network. The process suggests that the final zonal interchange volume between any two zones can be bounded by estimates of zonal interchanges which result from forcing all person trips to use each mode exclusively.

The logic can be illustrated by the following, somewhat simplified, example of an area having four zones. Trip interchanges, calculated using the opportunity model, are shown in Fig. 6.16. In this example, the transit network favors zone C over zone B as compared



Trips from zone A to zone	Estimated interchanges by transit only[1]	Estimated interchanges by auto only[1]
A	330	330
B	150	220
C	220	150
D	100	100
Total	800	800

[1] by opportunity model

Fig. 6.16 - Four Zone Illustrations. (Source: Unpublished writings developed by the Niagara Frontier Transportation Study.)

with the highway network. Therefore, the A to C interchange is higher under the all-transit assumption than it is under the all-auto assumption (220 versus 150). The opposite is obtained for the A-B interchange. Zones A and D have the same relative accessibility by both networks and, therefore, their zonal interchange volumes are identical.

Having established limiting estimates of trips between zones and also a basis for modal split proportions, it is now possible to make the final zone-to-zone estimates by mode as illustrated below. For this purpose, work trips only are used with the volumes estimated in the example in Fig. 6.16. To make these calculations, it is necessary to first complete the modal split estimates as described earlier.

1. Given a table of modal split proportions for work trips obtained as shown previously:

Zone-to-zone pair	Transit modal-split proportion	Auto modal-split proportion
A-A	.40	.60
A-B	.54	.46
A-C	.67	.33
A-D	.62	.38

2. Multiply the modal split proportions by the respective zone-to-zone interchanges shown in Fig. 6.16, sum the products by zone pair.

Zone to-zone pair	All trips by transit	Transit propor-tion	All trips by auto	Auto pro-por-tion	Estimated trip inter-change
A-A	330	.40	330	.60	330
A-B	150	.54	220	.46	182
A-C	220	.67	150	.33	197
A-D	100	.62	100	.38	100
Total	800	--	800	--	809

3. Normalize final zonal interchange (to reduce 809 to 800) and apply the modal split proportions developed previously to the now final zonal interchanges.

Zone-to zone interchange	Normalized zonal interchanges	Transit trip interchanges	Auto trip interchanges
A-A	326	130	196
A-B	180	97	83
A-C	195	130	65
A-D	99	61	38
Total	800	418	382

This procedure can be criticized because of its rigidity in limiting the total interchange between any two zones to either the all transit or the all auto case. It is probable that a pair of zones connected by good transit service and a good freeway link with improved overall accessibility would interchange even a greater number of trips than either the all auto or the all transit case. But, such is the state of the art at the present.

Auto Occupancy

After the modal split, the person trips assigned to the transit mode can be used directly for transit planning. The highway planner, though, needs vehicles to plan the highway facilities. It is necessary, therefore, to convert the person trips allocated to the auto mode into vehicles. While most studies have assumed the observed auto occupancy rates by trip purpose to remain constant and used them for the target year conditions, the Twin Cities procedure attempted to relate auto occupancy to other variables and developed the following equations:

$$\text{Work trip auto occupancy} = \left[1.411 - 0.202 \times 10^{-4} \text{ (income)}\right] \left[0.972 + 5.878 \times 10^{-4} \text{ (employment density)}\right]$$

$$\text{"Other" trip auto occupancy} = 1.75 - 0.16 \times 10^{-4} \text{ (income)}$$

As Table 6.2 indicates, auto occupancy rates for work trips reach an absolute minimum of 1.0 when income reaches $20,000 and employment densities are low. This is reasonable for instances where work trips are going from high income areas, where automobiles are in ample supply to low employment density areas, where parking is ample, and where chances of pairing common destinations are at a minimum. And, conversely, the occupancy rates increase to 1.57 even for the $20,000 income group with high employment densities at the attraction end which produce high parking costs and car pooling opportunities.

TABLE 6.2 - PREDICTED WORK TRIP AUTO OCCUPANCY

Income at production end	Employment density at attraction end					
	1	10	50	100	500	1,000
$20,000	1.00	1.00	1.01	1.04	1.27	1.57
$15,000	1.08	1.08	1.11	1.14	1.40	1.73
$10,000	1.18	1.18	1.21	1.21	1.53	1.89
$ 8,000	1.22	1.22	1.25	1.29	1.58	1.95
$ 5,000	1.27	1.28	1.31	1.35	1.66	2.04
$ 2,000	1.33	1.34	1.37	1.41	1.74	2.14

Source: Forbord, R. J., Twin Cities Modal Split Model, Minnesota Highway Department, January 1966.

Discussion

This chapter has described how estimates of future transit can be made using two major types of models - trip end and trip interchange. Within each type, fairly significant variations were observable in terms of method and variables used between the applications in different cities.

Ideally, this analysis would contain a complete and itemized presentation of the comparative advantages and disadvantages of each type. Unfortunately, this is presently impossible because the models have not as yet been tested one against the other.

In the interim, however, it seems desirable to present some of the opinions currently held by transportation planners concerning the existing modal split models.

Critics of today's models suggest that they all have a built-in bias because they are based on existing levels of service and, consequently, favor the automobile. They reason that transit usage rates will, therefore, be on the low side if substantially improved transit service is provided and contend that this possibility should be considered very carefully in view of recent developments favorable to the mass transit segment.

Supporters of today's models have argued that the preceding comment might be a weakness of those models that do not include some measure of the transportation system but, even then, only if a significant change takes place in the transit system and the highway system remains at today's level of service. This, they say, is unlikely and furthermore there may even be a greater potential for a worsening of transit's present competitive position.

In reference to the specific procedures, advocates of the trip end models feel that the capability of making separate highway and transit distributions is very desirable because of the variation in auto and transit trip lengths. They, therefore, consider the distribution of total person trips a weakness of the trip interchange model. Furthermore, they feel that the number of splits that are necessary in the trip interchange models, which increase as the square of the number of zones used, is also a disadvantage of the procedure.

On the other hand, advocates of the trip interchange procedure contend that a disadvantage of the trip end models is that transportation system characteristics are input as average area-wide values and cannot therefore be brought to bear on a particular zone-to-zone combination as precisely as in the trip interchange models.

Great strides have been made in the past few years in the development of methods to estimate the proportion of forecasted travel demand that should be allocated to the alternative modes of transportation. However, differences of opinion do exist concerning the existing modal split models. This suggests that additional research is still very much in order.

In that context, the thoughts on mass transportation research expressed in a joint report to the President on urban transportation by the Bureau of Public Roads and the Housing and Home Finance Agency dated March 8, 1962, are still quite applicable. The following excerpt from this report emphasizes the importance of reliable modal split models.

> "Outstanding among the many studies which need to be made of the economics of urban transportation are questions of why groups of people choose different means of urban travel under various conditions and how their choices would be affected by changes in the quality and cost of different kinds of private and public transportation what might be made available. Planning and investment decisions for highways and mass transportation are profoundly affected by what people believe about the answers to these questions. But there is little systematic knowledge on which to base these beliefs."

All of the existing modal split procedures are attempts at explaining quantitatively the rationale of modal choice. Even the most sophisticated ones which are responsive to changes in the transportation systems and the tripmaker as well as the trip itself derive their quantitative measures from observed behavior. They are no more than a reflection of today's transportation consumer reaction to today's transportation system for today's trip purposes. The quantities which these models produce are valid only under quantitative changes within today's qualitative bounds. For example, if the quality of service is varied such as the addition of hostesses on public transportation facilities or electronic guidance of private vehicles, the responses of users would surely be different. To account for such changes, a predictive model must include attitudinal variables imported from the fields of psychology and sociology. This is equally true for current models for land use forecasting, trip generation, trip distribution, and traffic assignment which constitute the battery of analytical tools in the urban planners shop. All of these models are heavily rooted in the quantitative observations of human behavior under existing conditions. They are not geared for the behavioral inputs which, though seeming far fetched at the present time, may spell the difference between success and failure of a new innovation in transportation. Take a driverless bus for instance. While such a vehicle can be extremely efficient, ridership estimates based on efficiency alone may be misleading. Human response to the impersonal, somewhat eerie operation of such a system must surely be looked into before a commitment is made to build it.

But, such is the present state of the art in the transportation planning process. It is hoped that additional talent from the fields of psychology and sociology can be successfully incorporated into the technology which up to now has been the domain of the engineer and the mathematician, the planner, and the economist.

7. SUMMARY OF RESULTS FROM HHFA/HUD MASS TRANSIT DEMONSTRATION STUDIES

LOUIS J. PIGNATARO

A. Introduction

The Housing Act of 1961 initiated a program which provides federal financial assistance in testing and demonstrating new ideas and new methods for improving mass transportation systems and service. Section 303 of this Act authorized the expenditure of not more than $25 million for mass transportation demonstration projects.

Additional support was provided by the Urban Mass Transportation Act of 1964 to undertake research, development, and demonstration projects in all phases of urban mass transportation. Section 6 of this Act authorized financial assistance for these projects in the amounts of $10 million for fiscal year 1965, $20 million for fiscal year 1966, and $30 million for fiscal year 1967. An amendment to the Act, approved September 8, 1966, authorized amounts of $40 million for fiscal year 1968 and $50 million for fiscal year 1969.

The financial assistance provided by both Acts is presently administered by the Department of Housing and Urban Development, and only public agencies are eligible for grant funds. However, private transportation companies may participate in projects through contractual arrangements with a public agency. Eligible public agencies include states; municipalities and other political subdivisions of states; public agencies and instrumentalities of one or more states, or of one or more municipalities or other political subdivisions of states; and public corporations, boards, and commissions established under state law.

Demonstration grants for new projects cannot exceed two-thirds of that part of the cost of the project which cannot be reasonably financed from revenues, and this cost has been termed the net project cost. For demonstration projects approved through June 30, 1966, the federal government has contributed approximately $39 million of the net project costs. (Ref. 1).

B. Criteria for Evaluation

A demonstration project proposal must meet certain criteria before a grant is awarded. Criteria for the evaluation of demonstration grant proposals are as follows: (Ref. 2)

1. Specific Objective - The project must have a well-defined objective which will add to existing knowledge or techniques of mass transportation and which, if successful, will contribute to the improvement of mass transportation in relation to total urban transportation.

2. Applicability - The knowledge or improved techniques expected from the project must be useful in solving important problems of urban transportation in other areas, rather than being limited to unique or highly specialized problems in a particular locality.

3. Conformity with Community Planning - Consideration will be given to the extent of existing comprehensive transportation planning in the demonstration area and the contribution of the demonstration in carrying out such planning as well as the probability that the demonstration project will fit into future long-range community development plans in areas where plans are not complete.

4. Practical Benefits - Ordinarily a demonstration project should be so planned that, if successful, it will continue as a useful feature of the community's transportation system.

5. Estimated Cost and Non-Federal Contributions - The scope and cost of the proposed project will be weighed in relation to the anticipated value of the results and to the total funds available for the program. The extent of the non-federal contribution to the project will also be taken into consideration.

6. Professional and Technical Capacity - The applicant must have the legal, professional and technical capacity to carry out the proposed project effectively, or must have specific plans and arrangements to obtain such capacity in the event the project is approved.

7. Geographic and Subject - Matter Diversification - Each proposed project will be considered in the light of the contribution it could make to a total demonstration program covering as many aspects of mass transportation in as many geographic areas as possible.

The established criteria provide for conservative approaches to experimental projects which could result to be simply variations of existing knowledge or techniques. Much more imaginative, intensive and highly experimental projects may not receive as favorable consideration under the existing criteria. The desire to distribute available funds over many projects may negate the possibility of developing truly significant innovations of mass transportation.

C. Approved Demonstration Grants

Demonstration grants have been awarded for a variety of projects, and the "Directory of Mass Transportation Demonstration Projects" (Ref. 1) briefly describes the projects approved through June 30, 1966. Final reports are available for about 30% of the projects listed in the Directory. However, even when the results of all demonstration projects have been analyzed, there will remain many unanswered questions about urban mass transport problems.

The results obtained from completed projects as well as available information from other projects are summarized in the following sections. In an attempt to categorize the various demonstration projects some difficulty was encountered because the scope of some experiments was sufficiently broad to overlap more than one category. For example, the Massachusetts project partly belongs in the fourth of the following categories and partly in the fifth. However, the categories are normally broad enough to minimize this problem. The following categories have been selected to subdivide the projects, and are discussed in the succeeding sections.

Coordination of Transit Systems

Design and Improvements of Transit Systems for Suburban Communities

Effects of Improved Transit Service and Fare Schedules on Ridership in Cities

Effects of Methods Utilized to Improve Rail Commuter Patronage

Effects of Using Small Buses

Equipment and System Developments

Public Awareness of Transit Services

Transit Administration Problems

D. Coordination of Transit Systems

1. Chicago Transit Authority - Skokie Swift Project (Refs. 3 and 4)

The demonstration grant was awarded to rehabilitate 5 miles of an abandoned interurban railroad right-of-way and operate a rapid transit line for a 2 year period which began in April 1964. Estimated project cost and completion are $523,825 and October 1966, respectively. The purpose of the project is to determine the effectiveness and economic feasibility of linking the fast-growing, medium-density suburban area of Skokie (about 68,000 population) with the Howard station, of the Chicago rapid transit system, located on the Chicago north city limit. Over this link, a high-speed, non-stop rapid transit operates, utilizing electric cars operated by one person, which is coordinated with a suburban bus service to provide bus-train connections in Skokie and with the CTA network of bus and rapid transit lines. In addition, a parking lot at the Skokie terminal can presently accommodate 522 all-day parkers. The parking fee is 25¢, and a 45¢ fare is charged which includes transfer privileges to any part of the CTA system. Trains operate from 6:00 AM to 11:00 PM with a headway of 2 1/2 to 7 1/2 minutes during peak periods and 15 minutes during off-peak periods on weekdays, and the average travel time is 6 1/2 minutes for the 5 mile run.

The experiment has thus far proven to be a resounding success as indicated by the following preliminary results:

a. By the end of 1965, weekday patronage averaged over 7,000 which is almost 5 times the predicted traffic.

b. Average travel time for all patrons has decreased 15 minutes when compared to their former mode. The greatest decrease in travel time was experienced by those who had previously used bus or other rapid transit.

c. The system is definitely self-supporting. For the last quarterly period of 1965, the project was returning a net income of almost $12,000 per month (Ref. 4).

d. Over 95% of the users transfer to the CTA subway system (Ref. 5).

e. About 25% of the patrons are new mass transit riders and 7% did not make a similar trip before the inauguration of the service. Therefore, about 18% was diverted from using private vehicles (Ref. 5).

In evaluating the significance of the results obtained, it is necessary to give full cognizance to the fact that the transit line is strategically located, serving a travel corridor. Nevertheless, it does reaffirm passenger support of a quality transit service.

Before and after the initiation of the rapid transit service, the CTA has operated a parallel bus line. In spite of improvements in service and extension of the bus line, the competition of the trains has resulted in a decrease of about 17% of bus patronage (Ref. 6).

2. <u>City of New York-Queens-Long Island Corridor Study</u>

A comprehensive study was initiated during the latter part of 1963 which is focused on the complex problem of how to maximize the utilization of existing facilities to accommodate peak hour overloading of rapid transit lines linking Queens and Long Island with Manhattan. Estimated project cost and completion were originally $4,778,000 and Dec. 1967, respectively. However, certain difficulties arose which precluded complete fulfillment of the project. As a consequence, the project will be officially terminated on June 30, 1967, and a final report will be prepared describing all work accomplished to date.

The broad-based objectives of the project originally included demonstration of the following: (Ref. 7)

a. The ability of existing suburban and urban rail transit systems to provide additional train service capacity during critical peak hour periods by means of operational changes, other than construction of new line capacity.

b. The ability of high-quality, medium-cost transit service to attract peak hour riders from low-cost transit service or private automobiles by means of modifications in fare structure, increased speed and frequency of service, and improved station facilities.

c. The ability of closer coordination among various transportation modes and facilities to increase the utilization of these facilities and to improve the efficiency of overall transportation by such methods as feeder bus service connecting with rail facilities in residential areas, and improved terminal, parking and transfer facilities along high-density transit arteries.

d. The ability of strategically located new transportation links to substantially increase the effective carrying capacity of existing transportation facilities and networks by providing short connections between existing lines, facilities to eliminate existing transportation system bottlenecks or access to high-density terminal areas.

e. The ability of study and engineering techniques to evaluate accurately the potential capacity of existing facilities and to integrate these evaluations into comprehensive transportation planning programs.

f. The ability to develop the administrative and operational methods necessary to achieve the desired physical improvements.

Portions of the project for which reports have been issued include the following:

a. An inventory of parking facilities on the Long Island Railroad within Nassau and Suffolk Counties which will be used to: (Ref. 8)

   (1) Determine the impact of parking facilities on the L.I.R.R. usage.

   (2) Conduct studies concerned with possible diversion of commuter traffic.

   (3) Explore possible institution of park-and-ride demonstration project.

b. The results of establishing a shuttle bus service between the Hunters Point Ave. L.I.R.R. station in Queens and Manhattan's east side (Ref. 9 and 10). The combined effect of phenomenal growth of office space along Manhattan's east side and the residential location of a significant number of employees of these offices into Nassau and Suffolk Counties created a serious problem of overloading a rapid transit line which was already operating at capacity. In an attempt to relieve this peak period bottleneck, the shuttle bus service was initiated in Feb. 1965. Buses operate during the morning and evening peak periods of weekdays. The bus service has proven to be successful in that it resulted in average diversion of 25.5% of passengers from the over burdened rapid transit line during the morning peak period for the first 6 months of service. The travel time via either route was practically the same, and the fares were the same.

Other portions of the project which are of vital importance to the Queens-Long Island transit corridor include the following:

a. Capacity study of the L.I.R.R. including track capacity and utilization, train speeds, availability of equipment, storage and maintenace problems, time table design, electric power supply, signal system, and other facets of rail operation.

b. Computer simulation of L.I.R.R. operation, taking into account train speeds, station stops, track assignments, number of cars per train, etc. It will serve as a means of testing various alternatives for increasing capacity, including major capital improvements.

c. Mathematical model of traffic patterns involving all modes of transportation.

d. Computer simulation of the operation of the 4-track Queens IND subway line to determine the feasibility of operating 3 tracks (2 express, 1 local) Manhattan-bound during the morning peak and Queens-bound during the evening peak.

3. Alameda-Contra Costa Transit and San Francisco Municipal Railway Projects

The demonstration grant was awarded for the purpose of determining how the services of three independent public transit agencies could be correlated to reflect an area wide coordinated transit operation, particularly with respect to the operation of feeder service with convenient transfer facilities to and from rapid transit stations. The impetus for this study was the many questions which were generated regarding the effect of the creation of the Bay Area Rapid Transit District on the existing two local public transit agencies. Estimated project cost is $792, 500. The final report is being prepared.

The project will consist of seven work items as follows:

a. Formulate methods and techniques for determining the fullest practical development of coordinated services between any combination of rapid transit and local surface transit systems.

b. Development of requisite modernization schemes for existing systems.

c. Development of plans for determining the most efficient methods for the transferring of passengers and for handling fares.

d. Development of cost and revenue analysis to determine the economic results of coordinating services.

e. Determining the required fare structure to cover costs of single and combination rides, including any alternates.

f. Determination of methods for evaluation of effects of coordination program on existing transit system.

g. Methods and techniques for promoting use of coordinated transit systems.

Recently, a quarter million transit riders in the Bay Area were involved in a survey of their riding habits. General results of this survey can be stated as follows:

a. The San Francisco central business district may be a more powerful magnet transit-wise for employment than for shopping and other personal activities among East Bay residents.

b. Transit usage among trans-bay riders demonstrates the capacity of fast and convenient transit service to attract commuters traveling considerable distances even when they have an option of using an automobile.

c. The time advantages of auto travel over bus usage are lessened in peak periods, while travel cost differences are increased, making bus usage more attractive to the regular trans-bay commuter than to the occasional shopper.

d. To the extent that a coordinated system will improve the speed, comfort, and convenience of transit riding, more automobile drivers can be influenced to switch to transit.

E. Design and Improvements of Transit Systems for Suburban Communities

1. City of Chesapeake, Va. - Express Bus Service for a Developing Community

The demonstration grant was awarded for the purpose of determining whether new residents of a suburban community will use public, rather than private, transportation for work trips to the central city if frequent, low-cost, express bus service is available. A 2 year demonstration period was started in Sept. 1965 (Ref. 11). Estimated project cost and completion are $361,899 and Feb. 1968, respectively.

The effect on riding patterns and volumes are to be determined by establishing all-day express bus service between the Civic Center in Chesapeake and downtown Norfolk. Prior to the demonstration, bus service consisted of 8 round trips per day, Monday through Saturday, and the total number inbound passengers averaged about 120 per day. The improved service, over the 13.9 mile route, provides for 27 round trips per day operating with a headway of 35 minutes, Monday through Saturday, and 12 round trips with a 70 minute headway on Sunday. There are 3 intermediate stops between terminal points; fares range from 20¢ to 45¢, and the travel time is about 35 minutes.

During the first 6 months of the demonstration period weekday patronage has more than doubled that which was previously experienced, although little new residential development has taken place.

The results of 3 weekday on-bus inbound passenger surveys revealed the following characteristics: (Ref. 12)

a. Approximately 60% of passengers were female, and about 95% were over 16 years of age.

b. Approximately 60% of passengers indicated trade worker or domestic as their occupation.

c. Approximate 90% of passengers walk to the bus stop.

d. About 66% of passenger indicated work for the trip purpose.

e. About 56% of passengers indicated they rode the bus on a daily basis.

f. About 50% of passengers indicated they did not own an automobile.

g. About 20% of passengers indicated they lived in the area less than a year and, therefore, may be classed as newcomers to the area. As the demonstration program continues, a more significant test will result if there is a substantial increase in the number of new residents.

2. Memphis Transit Authority--Bus Service Experiments (Ref. 13).

A study of providing bus service for suburban communities was undertaken during the period from March 1963 through Aug. 1964. The purpose of the study was to determine the effects upon transit ridership of establishing full-scale mass transit bus service in the early stages of the development of various types of suburban areas in comparison with the effects observed when such service is deferred until the major part of the development has taken place. The project cost was $353,788, and the final report has been released.

The experiment was conducted in three areas of new development. One consisted of commercial and industrial development as well as moderate priced residences; the second was a residential area consisting of low-cost housing; the third was a residential area consisting of high-priced housing.

The important findings from the study were as follows:

a. It took only 4 to 6 weeks after initiating transit service to evaluate the effectiveness of a particular route.

b. The greatest potential for patronage was in the area of low-cost housing, where most of the riders will be residents of the area, and in the areas of medium to higher priced housing, where most of the riders will be domestics and others who are not residents of the area.

c. In the suburban industrial area where ample parking was available, bus patronage by employees was practically nil.

As a supplemental part of the program, the Memphis Transit Authority prepared a comprehensive report of its development, covering the period since it assumed responsibility for the operation of facilities of a privately owned company. This report is useful as a guide to other communities that are engaged in improving and strengthening their mass transportation facilities by considering public ownership.

3. Village of Skokie, Ill. -- Bus System Design for a Suburban Community

The demonstration grant was awarded for the purpose of determining the need for and the means of providing an improved local suburban bus mass transportation system, which must be capable of serving the medium-density, high-growth suburban area of Skokie, and must be coordinated with the Chicago transportation system. The funds originally provided for a two year demonstration period for the proposed system, but the project was amended in August, 1966 to provide funds totaling $855,000 until December 1968. However, by decision of the Village of Skokie Board of Trustees, the project was abandoned on January 23, 1967.

The first phase of the project was devoted to an analytical investigation of daily travel patterns to serve as a basis for recommending locations and operations of bus routes to satisfy travel desires (Ref. 14). Standard planning techniques were utilized. The area was subdivided into zones and trip generation characteristics and modes of travel were determined for each zone, and interzonal travel patterns were established. Desire lines were prepared showing the generalized orientation of daily travel, and the desire line maps were used to locate routes to fit travel needs. Final assignment of transit trips was based on existing transit usage as well as an estimated increase in usage due to improvements, such as fare structure, frequency of service, and extension of transit lines into sections not served by the existing system.

The second phase of the project, devoted to study of actual operation of bus routes which were established in the first phase, has been eliminated.

4. Metropolitan Transit Authority of Maryland--Suburban Express Bus Service to Downtown

A one year demonstration of an express bus route connecting a suburban town center and its surrounding low density, high income areas with the central downtown shopping, recreational, and employment sectors is being conducted (Ref. 15). The purpose of the demonstration is to test the economic feasibility and practical desirability of providing such a service with modern air-conditioned equipment, operating over controlled-access freeways and capable of maintaining speeds comparable to the private automobile. Estimated project cost is $80,025, and August, 1967 is the target completion date.

The experimental service is in the Baltimore area. The "Metro Flyer" starts its 15 mile route from the Towson Plaza shopping center parking lot, collects passengers along two miles of local streets, enters the Baltimore Beltway, and proceeds to downtown Baltimore via the Beltway and the Jones Falls Expressway. Downtown distribution is provided to various sections of the central business district. Return trips follow essentially the same route.

Park-and-ride facilities are provided at Towson Plaza; parking is also available along the local portion of the route as well. Twelve daily runs are made Monday through Friday between 7:10 AM and 5:20 PM from Towson Plaza, and between 7:45 AM and 5:52 PM from downtown Baltimore. Headways range from 30 minutes during peak hours to two hours during base periods. Running time ranges from 30 to 35 minutes; peak hour speeds average 26 mph and off-peak speeds are 30.4 mph; expressway speeds vary from 50 to 60 mph. The one-way fare is 50 cents--no commutation, school, transfer, or round trip reduced rates are offered.

Results achieved to date are as follows: (Refs. 16 and 17)

a. During the first eight weeks, average daily riding increased 84% from 169 to 311. Peak riding averaged over 60% of total passengers.

b. Subsequent riding pushed the average peak riding percentage to over 70%, with 19% base and 11% reverse riding.

c. Base and reverse riding has generally been disappointing.

d. Five week daily passenger averages for the third quarter increased 16% (to 448) from the first quarter figure of 385.

e. Work trips accounted for 88% of the total.

f. Analysis of prior travel mode indicated 36% auto, 42% other bus, 13% who did not make the trip at all, and 9% car pool.

g. Over 88% of inbound riders walk to their final destination while 9% use a car; the corresponding figures for outbound trips are 71% and 24%, respectively.

h. 62% of the passengers used the service every day and 24% most every day.

i. 80% of new transit riders are choice riders, while 46% of all Metro Flyer passengers are new, choice riders.

j. Revenues have increased to the point where they are almost covering operating costs.

The true test of this program will be whether this type of service is sufficiently attractive and accessible to stimulate increased choice patronage from areas not particularly oriented to transit use.

The results of this program are expected to have considerable bearing on future planning policies as they relate to rapid transit versus express bus potential in certain important corridors of a given area.

During the fourth and final quarter, two passenger surveys are planned, and additional peak service is contemplated. Future plans for Flyer operations beyond the demonstration project are being formulated (Ref. 17).

5. Bi-State Development Agency--Express Bus Service (Ref. 18)

A comprehensive study of express and crosstown bus operations has been completed in the St. Louis Metropolitan Area. The purpose of the study was to determine the criteria which influence the patronage of express bus operations, and to test the feasibility of a cross-county bus route serving commercial centers which are developing outside the central city area. The one-year demonstration project resulted in a cost of $536, 631.

The project involved establishment and operation of (a) seven new express bus routes between suburban residential areas and the central business district, and (b) cross-county local service between two traffic generators. The demonstration service and data program were designed to determine and document the various factors which influence ridership on the experimental lines.

With respect to the express routes, operation consisted of a 4 to 6 mile pickup zone, an intermediate express zone to the CBD, and a local downtown zone. The outlying cross-county local route provided connections between populous areas formerly only accessible in a roundabout way involving one or more transfers.

Express routes were operated Monday-Friday with varied service on each route. Crosstown service operated Monday-Saturday with 15 min. peak and 20 min. base headways (every 20 min. all day Saturday). Fares were 25 cents local, 35 cents express, and 5 cents per zone.

A summary of principal conclusions and criteria follows:

a. Radial Express Service

(1) The public was generally willing to pay a 10 cent premium for the direct route and faster service.

(2) Important factors affecting patronage are relative ease of access from the passenger's residence to the bus stop, presence or absence of competitive bus service, and extent of outlying employment.

(3) 70% of express riders live within 1/4 mile of the route, with 35% to 40% living within the first block on either side of the route.

(4) 85% to 90% of express riders walk to the bus, 5% to 10% use an auto, and 2% or less use public transportation.

(5) An average of 11.7% of express riders were transfer passengers. The system average was 30% for all routes and 12% for express routes.

(6) 25% of clerical, professional, and executive residents worked downtown, while only 10% of industrial or construction workers were so located.

(7) Of suburban service area residents working downtown, express service can expect to attract 15% to 20%.

(8) 10% of all trips are shopping trips.

(9) Radial express service may reasonably expect to attract between 15% and 20% of downtown shoppers from their respective service areas.

b. Crosstown Local Service

(1) About one-fourth of the 570 daily riders were new riders.

(2) 35% to 40% of riders live within the 1/4 mile service area, and only about 50% within 15 blocks of it.

(3) 50% to 60% of crosstown riders are employed on or near the route, 30% to 35% in other suburbs, and about 10% within the principal city but outside the CBD.

(4) 15% to 20% of all trips are shopping trips.

Five of the seven express routes were continued after completion of the trial period. It was necessary to eliminate only one route and to modify one other. The crosstown route was also continued without alteration.

F. Effects of Improved Transit Service and Fare Schedules on Ridership in Cities

1. Detroit, Michigan--Grand River Bus Route Study (Ref. 19)

A study of the Grand River transit line was undertaken during the months of April, May and June of 1962, to determine the extent to which patronage is affected by the frequency of service offered on weekdays, Saturdays, and Sundays, and to measure the effect of improved transit service on other traffic. The project cost was $295,454, and the final report has been released.

The bus route is about 14 miles long, and it connects the CBD with the northwestern part of the city and some suburbs. The demonstration period lasted for 8 weeks, and throughout this period the level of service was increased from 50% to 70%. Changes which occurred during the demonstration period were compared with figures for a base period of 3 weeks prior to the start of the experiment. An intensive publicity campaign was carried out during the study to acquaint the public with the experiment.

The pertinent results of the studies were as follows:

a. Farebox revenues increased progressively from 0.43% the first week to 8.6% during the eighth week. Revenue from Sunday operations increased more than any other day. The average weekly increase in revenue was 3.8% which was realized with a 56% average increase in equipment mileage.

b. Based on adjusted sample counts of passengers, average daily patronage increased about 12.2%, or approximately 3,100 riders.

c. In general, scheduled headways ranged from 2 minutes at peak periods to a maximum of 15 minutes on weekends as compared to former headways of 3 1/2 to 20 minutes.

d. The additional buses required for the increase in the level of service did not adversely affect traffic flow. Traffic volume counts and speed studies revealed that the buses did not interfere with the flow of other vehicular traffic to any appreciable extent.

e. Based on interviews of a statistically representative sample of bus riders, it was found that only about 6.4% of the increase in patronage could be classified as new bus riders. Increase in patronage was substantially due to existing riders making more trips and diversion of passengers from other bus lines.

The following comments appear to be in order after reviewing the results of the studies:

a. The 8 week demonstration period was entirely too short to obtain any conclusive results.

b. The study revealed that carefully selected increases in service are much more likely to be productive than overall increase in level of service throughout the week.

c. Since only about 6.4% of the increase in patronage was new riders, it could be concluded that more buses do not encourage people to use the public transit system.

d. Under the most favorable analysis of costs, it does not appear that the increased service can be justified. The cost of the experiment was approximately $295,500, and the total revenue increase for the 8 week period amounted to about $11,200. With an average daily increase of patronage of 3,100 riders, the bus line was subsidized at a rate of $\frac{295,500-11,200}{3,100 \times 56} = \$1.6$ per new passenger per day.

2. <u>Bi-State Development Agency (Mo. - Ill., St. Louis Metropolitan Area) Monthly Pass Study (Ref. 20)</u>

A study was undertaken to analyze the use of and the effect on riding of two experimental $12 monthly bus passes which were introduced in Oct. 1963. The passes provided for an unlimited number of rides for the month, and the report covers the sale of these passes for the months of Oct. 1963 through Nov. 1964. The project cost was $14,433, and the final report has been released.

Two basic surveys were conducted. The first was a return postcard survey in which a postcard was given to every purchaser of a pass for the month of July 1964. The second consisted of 2,000 personal interviews of passengers which were conducted on buses.

The principal findings from these two surveys were as follows:

a. The sale of the $12 monthly pass increased with reasonable consistency over the 14 month period. Approximately a 79% increase in the number of passes sold was experienced.

b. About 33% of the approximate 9,300 post cards were returned, and an analysis of the returns indicated that 12.5% of the pass purchasers had not been regular transit riders prior to the introduction of the monthly pass. The on-bus interviews revealed a similar increase for the pass users.

c. Because of different transfer charges, the break-even point for a $12 monthly pass user varied from 34 to 48 rides per month depending on the characteristics of the transit trips.

d. The postcard survey showed an overall average of 53.6 rides per month for pass users, and the on-bus interviews indicated an average of 50.2 rides per month. About 60% of the pass users made 48 or more trips per month.

e. About 95% of the passes were used by riders whose primary trip purpose was for work.

f. The postcard survey indicated that about 64% of the trips made on the monthly passes involved a transfer ride as compared to the average system transfer ratio of about 24%.

g. The on-bus interviews revealed that the primary reasons why cash fare patrons were not purchasing monthly passes were that they were not regular riders, or the price of the pass was too high, or it was too much money to spend at one time.

3. <u>University of Illinois - Contractual Fare Bus Service and Other Improvements in Peoria and Decatur</u>.

A study was undertaken to determine if some novel bus service improvements could ease the continued decline in ridership being experienced by medium-sized cities of 50,000 to 250,000 population. The ideas being tested include: door-to-door subscription commuter service, zone fares based on distance traveled, and improved off-peak service. The Peoria project was awarded in June 1964, and the Decatur project began in April 1965. Estimated total project cost is $329,470, and the final report is in preparation.

A most interesting experiment is the one involving door-to-door service, designated Premium Special Service (Ref. 21). The service involves subscriber-commuter runs to specific work destinations from a given residential zone in the morning and return at night. Commuters contact the bus company indicating a desire to use the service, their homes and places of work are plotted on a map, and when there are enough subscribers who can be readily reached by one bus at both ends of the trip, a new service is introduced. Commuters pay a monthly rate starting at $9.25 for 3-1/2 air-line miles of travel plus 75¢ for each additional mile. They are picked up within 1/2 block of their homes and expressed to their place of work.

In Decatur, the services were dropped after five months due to a prolonged industrial strike. However, after one year of operation of Premium Special Service in Peoria, the results obtained were very promising. As of March 1966, 542 passengers were being serviced with 10 buses on 21 routes. The principal findings were as follows:

a. Fare revenues cover variable costs as well as contributing to existing fixed costs of the system.

b. 72% of passengers used to travel by automobile; 43% drove their own vehicle.

c. Each Premium bus has taken an average of 27 automobiles out of morning and evening peak period traffic flows.

d. Premium buses operate at an average of 16 mph as compared to 11 mph for normal buses.

e. 40% of the passengers ride for a lower cost than previously; 52% ride for the same cost as before.

f. 68% of the passengers leave for work in the morning later than before or at the same time.

Upon completion of the project, Peoria City Lines took over the operation and retained 17 of the 21 routes. Many of the consumer-servicing and quality-control aspects were eliminated and fares were raised, resulting in a 21% patronage loss. Most of the original project procedures were subsequently reinstated, and an increase in riders has once more appeared.

Shoppers Off-Peak Routes (Ref. 22)

This phase did not involve any new experiments in terms of general bus operation, but produced confirmation of what to expect when introducing similar service in small, middle and lower income areas which had no previous service.

Headways of 20 to 60 minutes were tried with little effect on revenue. Beyond hourly service, a critical level was reached at which revenue dropped significantly. In no case were these services able to earn more than 25% of operating cost. Teen-age riding proved to be significant, since revenue doubled during school holidays.

In Peoria, the company continued the project suburban regular route, but the Decatur routes were dropped, although an existing regular route was extended slightly and some of the school services developed were continued by rescheduled existing bus operations.

Automatic Zone Fare Collection

Zone fares were experimented with on the three poorest routes of Decatur's nine regular route system. This phase operated for only two months and no significant ridership change developed, although some important data were collected on passenger-handling times for various fare-payment arrangements.

The existing fare structure consisted of a small inner zone of 20 cents, with travel out of and into this zone costing 25 cents. The selected routes were made into four zones. Travel in any one zone was 10 cents, with an additional five cents per zone up to a maximum of 25 cents. To obtain a transfer, a 25 cent fare had to be paid, and boarding transfers were accepted for travel without an additional fare (Ref. 22).

The equipment used is the first attempt at onboard automatic fare collection. It is called "Illimatic" and consists of two machines: a zone-token dispenser at the entry door (rear) and a payment machine at the exit door (front). Upon leaving the bus, the passenger inserts his coded token into the payment machine which calculates the fare and displays the amount on an illuminated indicator. The machine accepts coins and makes change if required. The driver changes a zone selector switch as the bus proceeds from zone to zone, and he can also operate a flip-switch for either a child or a transfer rider. With each payment machine, a record of fares demanded, amount of cash paid, and amount of pre-paid tickets (if used) can be maintained on counters for accounting purposes. A statistical data analyzer has been designed to plug into the machine to record origin and destination of individual passengers (Ref. 23).

The experiment showed the feasibility of the equipment, and also areas of potential improvement. Of significant interest is that in the test environment the equipment demanded no increase in route schedule time.

4. Massachusetts--Bus and Rail Service and Fare Studies (Ref. 24).

A comprehensive series of interrelated service improvement and fare reduction experiments were undertaken throughout Boston and other large metropolitan centers in Massachusetts during the period from Dec. 1962 through March 1964. The purpose of the project was to provide data upon which predictions can be based as to the effects of various service and fare changes, alone or in combination on transit ridership. Participating facilities included the Boston and Maine Railroad, the New Haven Railroad, and several bus companies. The project cost was $5.4 million, and the final report has been released.

The major findings of the experiments were as follows:

a. The decline in public transportation ridership is not inevitable; it can be reversed.

b. Frequency of service is a more important factor than lower fares in increasing passenger volume on public transportation.

c. Selected, incremental improvements in frequency can be self-sustaining.

d. It is possible to develop a model whereby the costs of alternative rail service levels can be accurately evaluated.

The significant results of the experiments conducted on the rail commuter lines were as follows:

a. Additional passengers were attracted to railroad suburban service during both peak and off-peak hours.

b. Frequency of service is a more important factor than lower fares in both retaining present passengers and attracting additional passengers to railroad suburban service.

c. Increases in commuter fares, when accompanied by a continuation of a high level of frequency of service, do not necessarily result in decreases in patronage.

The most comprehensive investigation was made on the Boston and Maine Railroad, and the experiment consisted of three phases.

a. First Phase

  (1) Increase of toal weekly service by 77%. Weekday service was expanded by 92%, with peak-hour service increasing by 82% and off-peak service by 96%.

  (2) Average, overall fare reduction of 28%.

b. Second Phase

  (1) Continue service levels established for first phase.

  (2) Eliminate fare reduction established for first phase for commutation tickets.

  (3) Introduction of low off-peak fare.

c. Third Phase

  (1) Readjustment of service in accordance with the results obtained from the first two phases.

  (2) Continuation of second phase fare structure.

During the seven months the first phase was in operation, patronage increased about 26% (about 770, 500 additional passengers were carried) and passenger revenue increased by $21, 000 as compared with a comparable period of the preceding year. The cost of the additional service, however, approximated $700, 000 which resulted in a subsidy of about $0.88 per new commuter per day.

During the five months the second phase was in operation, patronage increased about 37% (about 790, 000 additional passengers were carried) and passenger revenue increased by $284, 000 as compared with a comparable period for the preceding year. The increased revenues were more than adequate to cover the fare reductions. However, they contributed only about 57% of the incremental service costs which approximated $500, 000. Significantly, the overall results for the second phase indicated a 36% increase in revenue passengers on a yearly basis on weekdays and a 54% increase on weekends.

During the three months the third phase was in operation, patronage increased about 44% (about 504, 000 additional passengers were carried) and passenger revenue increased by $221, 000 as compared with a comparable period for the preceding year. The additional revenue was more than enough to offset the cost of the experiment.

A detailed analysis of rail costs resulted in the development of a model to predict the costs that would be incurred to provide different levels of service. It was found that system semi-fixed costs, which constitute more than 1/3 of total railroad expenses, do not vary directly with volume and, therefore, produce a cost curve which rises rather sharply and then levels off. As a result, incremental costs at higher service levels are limited primarily to variable costs and do not rise in proportion to volume. For example, the 77% increase in service required only 20% increase in all cost. In addition, it was found that since a large proportion of total costs are not directly assignable to individual lines (41%), it makes local community support of commuter service difficult to establish on an equitable basis.

A variety of experiments conducted with private bus companies produced the following results:

a. Selected service improvements from suburban communities to the CBD of a major urban regional center can be self-sustaining.

b. The cost of improved service from suburban communities to the CBD of smaller urban areas greatly exceeds the incremental fare box revenues.

c. Feeder bus service from densely populated urban areas to rapid transit stations was found to be economically feasible, however, feeder services from low-density suburban communities to railroad stations were not economically feasible.

d. Carefully selected local service improvements in smaller urban areas can be self-sustaining.

e. Special service during peak hours to industrial plants, which have free and available parking for employees, was found not to be self-sustaining.

f. Off-peak fare reductions by themselves did not generate sufficient new patronage to offset reductions in revenue.

g. The greater proportion of costs vary almost directly with miles operated, with only a minor portion of total costs being fixed costs.

Experiments with the Metropolitan Transit Authority produced the following findings:

a. Increases in frequency in local service completely within the downtown district of Boston were self-sustaining.

b. Increased off-peak suburban bus feeder service through a low-density residential area to a rapid transit terminal produced no appreciable increase in patronage.

c. In the central city of a major urban region, as distance from the city center increases, circumferential bus service becomes more attractive to a larger number of people.

d. The combination of providing low cost parking at drive-in theaters on the fringes of Boston and express bus service to the core of the city and rapid transit facilities produced no appreciable ridership.

e. Reduction of parking fees from 35¢ to 10¢ at rapid transit stations resulted in substantial increases in transit patronage, and the increased revenues more than offset the loss in parking revenue.

5. <u>State of California (Los Angeles)--Relationship of Transit Availability to Job Opportunity</u>

This demonstration study was approved for the purpose of determining and testing the relationship between a public transportation system and job and other opportunities of low income groups (Ref. 25). A two-year experimental bus service will be operated in the South Central and East Los Angeles areas, which have been characterized as disadvantaged areas where lack of adequate transportation handicaps many of the area's residents in seeking and holding jobs, attending school, shopping, and fulfilling other needs. Estimated completion is September, 1968, and estimated cost is $2,700,000. This project is unique in that it is the only one to date whose cost is being fully covered by Federal funds.

The demonstration consists of three phases:

Phase I - A 24-month operational test of the validity of the assumption that increased public transportation service can substantially improve employment opportunities for the residents of a disadvantaged area. A 13 mile east-west bus route has been established between the Watts area and an industrial area near Los Angeles International Airport.

Phase II - Studies of the public transportation needs of the entire project area, the adequacy of existing transit services in terms of those needs, and how existing services can be restructured or supplemented to eliminate specifically identified deficiencies.

Phase III - A limited number of operational tests of the conclusions reached during Phase II studies.

The service operates daily, including Saturdays, Sundays, and holidays, between 5 AM and 12.56 AM, and charges zone fares. Monday through Friday headways are 15 min. peak, 20 min. offpeak, and 30 min. at night. Headways are a uniform 30 min. on Saturday and 60 min. on Sundays and holidays. Schedule speeds range from 15.5 to 17.2 pmh, while midday and peak running times vary from 46 to 51 minutes for the entire route length.

Present results are as follows (Refs. 25 and 26):

a. Daily patronage has increased from an initial 720 to a stable 1900.

b. Two-thirds of all trips are either work or work-seeking trips.

c. Over half of all passengers are males, as opposed to 40% male riders on the Transit District's entire system.

d. 60% of the passengers had not previously made their trip by bus.

Phase II studies have pointed out the following deficiencies in the public transit system:

a. Absence of a satisfactory grid system with north-south and east-west crosstown lines.

b. Absence of transfer privileges in many cases.

G. Effects of Methods Utilized to Improve Rail Commuter Patronage

1. Philadelphia, Penn.--Southeastern Pennsylvania Transportation Compact (SEPACT) Studies

The Philadelphia area has received three interrelated demonstration grants which will help to provide for a unified approach to the transportation problems in the area.

SEPACT I (Ref. 27)

A three year study of three of the region's electrified commuter lines, the Pennsylvania Railroad's Levittown line and the Reading's Lansdale and Hatboro lines, began in Nov. 1962. The purpose of the study was to determine whether increased and improved schedules, reduced fares and other improvements would increase rail patronage. The improvements included providing new or expanded station parking facilities and experimenting with bus-train transfers at certain stations. The project cost was $4.7 million, and the final report has been released.

The major finding from the project was that the decline in rail commuter patronage can be dramatically reversed if improved service, attractively priced is provided. For example, percentage increases in passenger volumes, based on the pre-demonstration period of 1962, on the Levittown line were 49%, 98%, and 143%, respectively for the years 1963, 1964 and 1965. During the period of the demonstration the total increase in passenger volume was about 1,700,000, and the Pennsylvania Railroad received approximately $1,600,000 in subsidies. The percentage increases in passenger volumes on the Reading Railroad lines were 24%, 37%, and 46% respectively for the years 1963, 1964, and 1965. During this period the total increase in passenger volume was about 3,900,000, and the railroad received about $2,700,000 in subsidies. Therefore the railroads were subsidized at a rate of $\frac{4,300,000}{5,600,000}$ = $0.77 per new passenger.

Despite the success of this project, both railroads continue to report a heavy commuter deficit. The Reading Company's situation is acute. Even if passenger volume increases are sustained and the demonstration subsidy continued, the commuter deficit may bankrupt the company. To provide a better insight for a permanent solution to this complex problem, the SEPACT III Demonstration Grant will provide funds to continue Reading service while basic facts are determined that, hopefully, will lead to long range programs to integrate both the Readining and Pennsy commuter services into a viable regional public transportation system.

SEPACT II (Ref. 28)

A 32 month study which began in Jan. 1965. The purpose of the study is to develop the most feasible model or models of operation of a commuter rail system for the Philadelphia metropolitan area, based primarily but not entirely on existing trackage. The project will involve studies of the factors affecting ridership and revenues, studies of cost of service and its underlying elements, and of the capital improvements required to make these models most effective. Estimated project cost and completion are $437,500 and June 1967, respectively.

The project will evaluate the findings from the three major study areas of Marketing, Engineering, and Cost and coordinate them to furnish the following information.

a. Order of magnitude, cost and benefit estimates to determine the economic feasibility of capital outlays required to achieve the facility, equipment and operating improvements suggested by research findings.

b. Findings affording a solid base upon which to determine future equipment needs and operating method decisions.

c. Nature of the future market to be served, its relationship to regional transportation needs as a whole.

d. Design of a regional commuter service rail operation pruned to the most efficient level in terms of operating costs and methods, equipment, capital requirements, relation of fare box revenues to outlays required.

SEPACT III

An 18 month study which began in April 1965. The purpose of the study is to attempt to find answers to the critical problems of how to reduce railroad commuter losses while maintaining adequate public service. SEPACT III and SEPACT II studies will supplement each other. Estimated project cost and completion are $4.7 million and Dec. 1966, respectively.

The experiment will develop and test techniques for revitalizing the Reading commuter operation while maintaining adequate public service. It will concentrate on three principal areas:

a. Obtain information on all cost factors involving passenger operations in order to determine the minimum financial requirements needed to continue the service and to provide a basis on which to ascertain future public commitments.

b. Study Reading's management of passenger operations to determine its adequacy and to make recommendations for any necessary improvements.

c. Conduct operational tests involving train equipment and crew utilization in order to obtain maximum efficiency and economy.

During the experiment, controlled tests will be conducted at various intervals to determine the effect on patronage of service frequency, fare changes, service convenience (including new equipment), and advertising.

2. Tri-State Transportation Commission (N.Y. - N.J. - Conn.) Studies

The Tri-State Transportation Commission has received six demonstration grants dealing with various aspects of commuter rail service.

The first grant provided funds to establish a new commuter station on the Pennsylvania Railroad and 300-car free parking lot about 1 1/2 miles from the downtown New Brunswick, N.J. station (Ref. 29). The 18 month demonstration period began in Oct. 1963 and ended in April 1965, and the operation of the facility will be continued by the railroad. The purpose of the project was to determine the effects of the auxiliary park-and-ride rail commuter station on commuter patronage and distribution. Estimated project cost is $256,185, and the final report is in preparation.

Throughout the demonstration period, average weekday patronage at the new commuter station has increased by as much as 123%, and the number of cars parked has increased by 157%. It was assumed that most passengers at the new station would be diverted from the downtown station, but this was not true since traffic at the downtown station has increased. Since downtown scheduled service is about twice that for the new station and there is a charge for downtown parking, the addition of the auxiliary station in the rapidly growing suburban area appears to be completely justified. To determine more fully the reasons for greater use of the downtown station a sample survey of passengers boarding trains at both stations was conducted and the results of the survey will be included in the final report.

The second grant provided funds for the purpose of testing and evaluating newly developed automatic railroad ticket encoding and cancellation equipment under operating conditions in railroad stations (Ref. 30). The demonstration period was 12 months, and actual operation of the experimental equipment began in July 1964, at the Kew Gardens and Forest Hills Stations of the Long Island Railroad. The project cost was $228,418, and the final report has been released.

The system provided for the insertion of a magnetically encoded ticket into a sensing device and upon validation, one ride was canceled and the turnstile was released. The equipment that was installed was only part of a complete system. Fully automated station fare collection is a system of validating and collecting passenger fares in advance of boarding trains as well as an effort to speed ticket sales and passenger flow, eliminating loss of revenue on crowded trains, providing essential traffic data to improve scheduling of trains and to adjust the number of cars to fit passenger needs, and lowering passenger handling and accounting costs.

Such sophisticated systems are being experimented with by the London Transport Board and by the San Francisco Bay Area Rapid Transit District.

The L.I.R.R. experiment was considered to be successful to the extent that it demonstrated the capability of the equipment to perform the work for which it was designed. Capacity data, recorded at the test site, indicated that the turnstile equipment was capable of passing people at the rate of 30 per minute maximum and at a rate of 18 to 22 per minute for design average capacity.

In its appraisal of the experiment, the L.I.R.R. submitted a comprehensive critique which contained a number of mechanical and functional mishaps it had experienced in operating the equipment.

The third grant provided funds to study the effects of more rapid operation of rail commuter service, more frequent service, improved station parking facilities, and coordinated feeder bus service to express rail stations (Ref. 31). The project began in July, 1964, and it is being conducted on the Harlem Division, between Brewster and Grand Central Stations, of the New York Central Railroad.

The experiment proposed to speed up and improve service by converting some rush hour local trains to express service and establishing hourly express service during off-peak periods, reducing running time by rearranging stops on locals, expanding parking facilities to provide more spaces at lots adjacent to express stations, and making contractual arrangements with local bus operators to provide coordinated bus-rail service at express stations. The project does not provide for any fare reductions. Estimated project cost and completion are $1.9 million and April, 1967, respectively.

Based on progress reports, the principal findings of the study to date are as follows (Refs. 31 and 32):

a. During the first 4 months of the demonstration, the revised schedules of operation resulted in peak period time savings of as much as 13 minutes between Brewster and Grand Central. Off-peak period time savings ranged from 27 minutes to 1 minute. Patronage gains during the first 6 months of 1966 averaged almost 14,000 rides per month more than the same 6 months in 1965, and more than 20,000 monthly rides above the first half-year of 1964 prior to project operation. These gains are both peak and off-peak, with off-peak increases accounting for about 49% of the total.

b. Complaints of non-express station patrons resulted in the Public Service Commission ordering the railroad to change schedules which restored most pre-project peak period service and increased off-peak service at local stations. The effect of this order was to readjust the experimental aspect of limited stop service during peak periods so severely as to eliminate this as a further phase of the project.

c. Ticket sales during the first 10 months of the project as compared with the same 10 months of the previous year indicated a 1.1% increase in commutation travel and a 11.9% increase in other travel.

d. Parking lot surveys reveal a well established trend away from the local stations to the express stations.

e. The test of a coordinated bus-rail service proved unsuccessful because it did not attract sufficient patrons and difficulty was encountered in coordinating a line bus service with a railroad service at an intermediate point on the bus route.

The fourth project was begun in September of 1963 to determine whether coordination between a feeder bus service and the main line of a rail route in a suburban area could attract substantial journey-to-work and off-peak traffic when several alternatives were available (Ref. 33). The project was concluded in June of 1965 at a total expense of $148,740, and the final report has been released.

Project location was Rockland County, a low density, rapidly developing suburban area, located about 35 air miles from Manhattan's central business district. Connections by mass transportation to the CBD are poor, but auto access is good. The experiment involved an increase in feeder bus service from four rush-hour round trips daily to 24 round trips per day during peak and off-peak hours. Reductions were found necessary during the course of the experiment until service was confined to five round trips during each morning and evening rush period. The bus ran from New City in Rockland County along a 16.5 mile route across the Tappan Zee Bridge to the New York Central Railroad station in Tarrytown. Local and express buses made the run in 44 and 36 minutes, respectively. Fares between Rockland points and Tarrytown ranged from 25 cents to 50 cents, with multi-ride books available. During the project, fares were raised five cents, except within individual zones, while multiple rides increased about 4 1/2 cents.

Principal findings of the data analysis were:

a. A feeder bus service in a low density suburban area, providing fast, frequent and accessible service coordinated with rail service to a major employment center, will attract substantial traffic.

b. This traffic will, however, be work-trip oriented, and will be unbalanced in the peak direction during morning and evening rush periods.

c. The location of a core terminal which provides convenient access to places of employment will exert an affirmative influence on the passenger's choice of route when several alternatives are available.

d. It is doubtful if a feeder bus service will attract an appreciable volume of off-peak traffic.

e. Unbalanced peak-hour flow and under-utilization of off-peak capacity places the cost burden on the peak hour rider. Cheaper alternatives will undoubtedly be more attractive to these commuters.

f. A feeder bus service, essentially short haul, must find substantial off-peak use or be subsidized if reasonably priced peak hour shuttle service is to be provided.

Some specific statistics of interest follow:

a. Daily two-way patronage figures rose from about 222 during the initial week of the test to a high of 467 in September, 1964. Adverse service modifications curtailed this figure to 257 riders by June, 1965.

b. 72% of all riders rode during the peak periods before the fare increase. After the increase the figure rose to 81%.

c. Altogether, 169,491 passengers were carried at an average deficit of 63 cents a rider.

d. The short haul pattern of riding that characterized much of the patronage using the service contributed significantly to the deficit. Average revenue per passenger was only 32.5 cents. Expense per passenger was lowered from $1.04 to 67 cents, but the average deficit per ride could never be brought below 32 cents.

e. While travel time via the project bus and New York Central Railroad to downtown New York City was 5 to 20 minutes faster than alternative public means, it cost between 25 and 50 cents more to use.

f. The service was attractive to users for a variety of reasons, including nearness to homes, relief from traffic congestion and parking expense, speed, and convenience of access to Manhattan's east side.

g. Although a considerable number of auto drivers were diverted to the service, many persons from the area continued to drive because (1) it took more time by bus, (2) schedules were inconvenient if a trip or part of it was made in off-peak hours, (3) the route was too far from their home to walk, and (4) the convenience of using their own car was more attractive.

Upon the withdrawal of public support on June 25, 1965, all service on the project route ceased. The operator could not be persuaded to continue even the level of service that had existed at the inception of the experiment.

The fifth grant provided funds to define the means, techniques, and arrangements that can help convert a bankrupt rail commuter service into a modern, efficient, viable transportation artery (Ref. 34). The demonstration period is 12 months, with an optional extension for an additional 6 months, and the study began in July 1965. This project is quite different from other mass transportation demonstrations in that it does not emphasize experimentation with fares, schedules, or other operational matters. Estimated project cost and completion date are $4.5 million and June 1966, respectively.

The project is devoted to the plight of the New Haven Railroad which has been in serious financial difficulty since 1957. The grant has made it possible for the states of New York and Connecticut to devote the necessary time and collect information required to achieve a stable, long-term arrangement for the New Haven Railroad to continue and improve commuter service. To achieve this, the demonstration project is divided into four major phases:

a. Continuation of existing passenger service, including maintenance of equipment.

b. Full review and weighing of public policy problems that must be solved in establishing a pattern for the support of the service.

c. A series of studies to define the costs, revenues, nature of operations, and technical features of the new service.

d. Actual implementation of a stable, long-term arrangement.

The first phase is an essential step to the execution of the project because if service were curtailed or abandoned during the period of the project it would cause substantial rider uncertainty.

The second phase can prove to be of great value in other cases and in other urban areas by the lessons being learned in interstate cooperation and the new problems of local-bi-state-federal relationships with an interstate suburban railroad.

The sixth and most recently approved demonstration project of the Tri-State Transportation Commission is a study to determine whether the gas turbine is economical and desirable for use as a power source in commuter rail service. Approval for the test was granted in January, 1966 and expected completion is July, 1967. Estimated cost is $1,386,609 (Ref. 1).

An existing lightweight Budd Company car body has been equipped with two gas turbine power units, torque-converter transmissions, and new coupled-axle trucks. A 20-mile stretch of Long Island Railroad trackage within Nassau and Suffolk Counties, from Bethpage to Ronkonkoma, has been upgraded for the test operations at speeds up to 75 miles per hour. A test schedule has been designed to simulate actual service conditions, but without passengers.

The gas turbine operation will test out its potential as a power source having the moderate-cost feature of the diesel with a power output comparable to the high-cost electrification system which more efficiently meets the demands of frequent start-stop urban rail service.

H. Effects of Using Small Buses

1. District of Columbia--Minibus Project (Ref. 35)

A one year study was undertaken, commencing in Nov. 1963, to determine whether small buses, designed specially for circulation within the CBD, operating on a fixed route and a frequent schedule, could attract enough riders to facilitate the movement of people, reduce traffic congestion, and stimulate business activity. The project cost was $239,300, and the final report has been released.

The project was divided into two phases. The first phase was devoted to the selection of an appropriate vehicle. The Minibus was chosen which has a capacity of 30 passengers, 18 seated and 12 standing. During the second phase, a full scale test was conducted utilizing sufficient Minibuses to provide for a headway of 2 1/2 minutes over a 1.86 mile route which connected all the downtown department stores and coincided with the area of highest pedestrian density in the CBD. The fare was set at 5¢.

The principal findings from the experiment were as follows:

a. The Minibus was used primarily by shoppers, and the number of shoppers entering the CBD increased.

b. During the demonstration period over 1,850,000 passengers were carried.

c. The general impression of persons familiar with Minibus was overwhelmingly favorable primarily because of the time saved and 5¢ fare.

d. The majority of Minibus passengers reported that the service enabled them to get to more stores and do more shopping.

e. Traffic counts showed a 4% reduction in vehicular traffic volumes along the Minibus route. However, most of this reduction in volume was attributed to a decrease of 18% in the number of taxicabs.

f. The following factors appeared to contribute in a significant way to the success of the Minibus system:

   (1) An extended CBD with a dense pedestrian movement.

   (2) Specially designed vehicles with the main features of attractiveness, charm, wide windows and doors, and low floor height.

   (3) Extremely convenient and frequent service suggesting the instant availability of a moving sidewalk.

   (4) Low fares.

The complete success of the Minibus project can be measured by the retention of its service on a modified basis since the end of the demonstration period. Since the beginning of 1965, Minibus service was scheduled to operate with a 3 minute headway. This change together with others effected at the end of the experiment permit the Minibus system to be self-sustaining with the 5¢ fare. However, the fare has since been raised to 10 cents.

2. City of New Castle, Penn.--Bus System for a Small City

The demonstration grant was awarded for the purpose of determining whether the use of smaller, more maneuverable buses operating on schedules which reflect passenger demands with fares based on the intensity of these same demands can effectively provide efficient self-supporting service. A 3-year demonstration period was started in Sept. 1965 (Ref. 36). The urbanized area has a population of about 65,000 and a land area of 40 square miles. Estimated project cost and completion are $548,847 and Sept. 1968, respectively.

The scope of the project will involve the following studies:

a. The feasibility of utilizing 14- to 20-passenger buses (comparable to the Minibus). The assumption is that smaller buses, more directly related to the number of passengers and length of route, can operate more efficiently than standard buses in a small city.

b. Location and length of transit routes related to land use and residential density. The assumption is that the greater mobility of the small bus will permit the extension of service providing more convenience for patrons.

c. Scheduling in accordance with peak period demands of work and shopping trips. The assumption is that effective scheduling related to demand will result in economy of operation.

d. Transit fare experiments based on monthly passes, off-peak shopper rates, and rates related to distance traveled. The assumption is that special fare structures will encourage more patronage.

e. Provision of free off-street parking areas at outlying terminals of transit routes in an effort to increase patronage and reduce vehicular congestion within the CBD.

f. Provision of express lines from the CBD to outlying areas with transfer to local feeder lines serving various neighborhoods in an effort to increase patronage.

Numerous problems beset the initial period of the project, including late delivery of the first five Ford Cottrell buses, absence of a project director for the first five months, and a variety of mechanical problems with the buses, which included improper steering post location, discomfort due to excessive motor heat, excessive brake lining wear, rough riding quality and several other minor problems (Ref. 37). As a consequence, 10 Minibuses were purchased to achieve the fifteen required by the project. These were scheduled for delivery in late 1966 (Ref. 38).

Initial schedules call for Monday through Saturday service with a series of routes radiating outward from downtown New Castle and employing headways ranging from 15 minutes to 60 minutes. Fares are 20 cents for adults and 10 cents for children, with free transfer privileges.

A series of three surveys--passenger count, passenger interview, and neighborhood interview--revealed the following facts concerning convenience, scheduling, and rates as factors in bus usership (Ref. 39):

a. Housewives and students were the heaviest users in all six neighborhoods. These groups, along with industrial workers, appear to directly engender the total number of bus riders to rise or fall in each neighborhood.

b. Inconclusive evidence exists to indicate that neighborhoods with larger families tend to have more consistent riders than those with smaller families.

c. There appears to be a positive correlation between the number employed in the family and the number of bus riders.

d. Neighborhoods with low family incomes and many families without cars will use bus transportation if it is convenient.

e. In observing similar bus routes with all other variables being equal, those routes having a greater number of bus stops revealed greater passenger use. There seems, however, to be no correlation between the number of consistent riders and the convenience of bus services as provided by ample bus stops.

f. There were more complaints listed about poor scheduling than about stops being too far away from the rider's residence.

g. Generally, the last few outbound and the first few inbound stops on each route are heavy pickup points with stops in between being of lesser importance.

h. An average of 43.5% of all riders by route gave "convenience" as the reason for riding. The figure was over 65% for riders by neighborhood.

i. Shopping was the major reason for going downtown. Over 30% of all riders were housewives.

j. In neighborhoods farther from the center city a higher percentage would use the bus during bad weather.

k. Peak hours on Saturdays occur in mid-day and at night, signifying the use of the bus for shopping and entertainment.

l. Proper scheduling of bus services will affect patronage since there was a lower user ratio for neighborhoods having a high percentage of complaints about schedules.

m. A curious result concerning rates was that a significant number of people felt strongly that the bus fare was an important objection to the service, yet there was not a strong correlation between high complaint areas and low bus ridership areas. The conclusion is that although fares cause complaints, they do not significantly decrease ridership, even in low income areas.

n. Ride passes or rate bargains had little effect on the amount of ridership, and it is quite doubtful that the bargain rate had increased ridership or will do so in the future.

All evidence seems to spotlight the fact that the compact units cannot satisfactorily accommodate peak hour ridership volumes. Standard sized buses are especially useful for handling large volumes of riders for the short periods when they occur, and it is probable that a combination of the two bus sizes might best satisfy the transit demands of the area. This idea will be tried after delivery of three 30-passenger gasoline units.

The continuing operation of the project will consider the problem of the slack patronage interval between the two peak periods, and will attempt to make this interval less costly. In addition, a personalized, contractual, home-to-work express commuter service (similar to the demonstration project recently concluded in Peoria, Illinois) might be tried in the areas having concentrations of industrial workers. Plans to determine the feasibility of initiating this service are under preparation (Ref. 40).

I. Equipment and System Developments

1. Port of Oakland, Calif. --Test of Air Cushion Vehicle

The demonstration grant was awarded to study and test the new air cushion vehicle (ACV) and to determine the operating and economic feasibility and public acceptance of using these vehicles to provide convenient airport access and public transportation in metropolitan areas. ACV's appear to be particularly suitable for transportation over water and can also leave the water and travel over land. The vehicle skims the surface on a cushion of air created by a horizontally mounted fan which forces air downward and beneath the craft. Forward propulsion is achieved by a conventional airplane propeller.

The project was divided into two phases. The first phase consisted of the detailed planning and preparation for the second phase which consists of 12 months of vehicle operation in passenger service. The second phase started on Aug. 10, 1965 with the inauguration of scheduled service across San Francisco Bay between San Francisco and Oakland airports. Service to downtown San Francisco was started on Nov. 1, 1965 (Ref. 41). Estimated project cost is $1.2 million. The study has been completed and the final report is in preparation.

Preliminary operational results for 8 months of service are as follows: (Ref. 42)

a. 73.7% of the trips scheduled for the system were performed. Mechanical failure of the vehicle accounted for 7.5% of the scheduled trips, adverse weather conditions for 12.4%, and other reasons including cancellations due to no passengers for 6.4%.

b. Block speeds averaged approximately 38 mph. The block speed is determined by dividing the route distance by the time it takes from the instant the vehicle is brought to a hover when leaving one terminal to the instant it is brought to rest at the gate of the destination terminal.

c. Passenger enplanement load factor averaged 21%. The enplanement load factor is the percentage of the available seats which are filled. Average monthly enplanements were 680 passengers.

d. Public acceptance is being evaluated from the returns of passenger questionnaire cards which are given to each passenger boarding the ACV. The percentage of returned questionnaires was 24%, and 91% of the responses indicate that overall comfort was acceptable.

2. San Francisco Bay Area Rapid Transit District Studies

Voter approval of the 75-mile rail rapid transit system in Nov. 1962, has presented the Bay Area Rapid Transit District (BARTD) with a unique opportunity to undertake a test and development program designed to produce advanced concepts in rapid transit construction and operation.

An overall development program which will have broad national significance has been formulated and will involve an expenditure of about $28 million and include nine major projects as follows: (Ref. 43)

a. Sound and vibration reduction--The objective of this project is to increase attractiveness of mass transportation by minimizing or eliminating objectionable noise and vibration through application of modern techniques in the design of the transit vehicle, track and roadbed, and structures. A significant reduction in noise levels at trackside would make aerial and on-grade lines more acceptable particularly in residential areas.

b. Transit vehicle stability, wind resistance and buffeting--The objective of this project is to determine the effects of wind on the vehicle. A basis will be established for determining track gauge and tunnel dimensions to assure a stable, safe, smooth, comfortable ride under all foreseeable conditions by first using empirical relations and then checking by wind tunnel experiments.

c. Propulsion equipment and power supply--The objective of this project is to reduce costs and maintenance time through improved and more efficient propulsion and distribution systems.

d. Transit vehicle truck--The objective of this project is to manufacture and test an experimental truck which would incorporate all advanced truck and propulsion equipment features. The results of this project will establish the basic test data necessary for the proper design of a new and possibly radically different truck.

e. Development car--The objective is to provide a rolling laboratory for the final operational testing of sound control features, track and roadbed design, trucks, train control, and power consumption studies.

f. Train control--The object of this project is to design and test an advanced train control system which will permit increased track capacity over that possible with conventional signaling systems, optimize equipment utilization and power costs, and improve service through electronically controlled train movements. This is the first project that has been completed and the final report has been published (Ref. 44).

   Four Automatic Train Control (ATC) systems were tested on 4.4 miles of track using three laboratory cars having varying brake, propulsion, and truck systems.

   ATC comprises three sub-systems:

   (1) Train protection must effectively possess fail-safety, have a minimum impeding effect on operating practices, and be achieved with reliable techniques and equipment.

   (2) Line supervision must automatically obtain an operating efficiency which reasonably satisfies passenger traffic and operating conditions. In addition, this must be achieved with reliable techniques.

   (3) Automatic train operation must achieve consistent performance and is the very feature which enables the high quality operations intended for this rapid transit system. In addition, this function must be achieved within the limitations required by train protection and line supervision.

   To confirm the criteria of these sub-systems, four classifications of testing took place:

(1) A series of qualifier tests to examine the contractors' general operational ability and safety system.

(2) Standards tests during which data were gathered on repeatability of speed, distance profile, and accuracy of station stopping.

(3) Headway tests to produce the minimum possible headway as a function of the train protection portion of each contractor's system.

(4) Special features tests intended to allow each contractor to display the unique features claimed for his ATC system.

The amount of data was too small for conclusive quantitative analysis, but within this limitation indicated:

(1) That all ATC systems responded safely to their control and indication signals.

(2) That speed-distance profiles can be accurately repeated run after run.

(3) That deviation from any nominal speed can be regulated to within 2.2 mph, and that this deviation is not a function of the reference speed.

(4) That deviations in runtime on station-to-station runs of two to three minutes can be held to less than 20 seconds, with average deviations of about 5 seconds.

(5) That automatic station-stops can be made to an accuracy of plus or minus 12 inches. The accuracy figures for all systems ranged from 66% to 91% within 12 inches, with an average of about 78%.

(6) That trains can turnback (reverse direction) within six seconds.

(7) That results of headway tests were inconclusive, and therefore minimum headways could not be determined.

g. Test track--The objective is to provide track and related test and service facilities for demonstration testing of transit vehicle, track and roadbed, sound control features, trackside current collection equipment, propulsion equipment, and the train control system. It is also intended to investigate structural elements to determine dynamic loads, stresses, and deflections. The test track section will eventually become a portion of the revenue system. The test facility will consist of 4.4 miles of electrified double track with crossovers, simulated station stops, turning loops, and a small yard with shop facilities.

h. Fare collection--The purpose of this project is to develop the most modern and automated system possible for collection of fares varying with the distance traveled.

i. Subway construction methods--The purpose of this project is to investigate other than the conventional "cut and cover" method of subway construction. This method requires that construction be conducted from the street surface which interferes with the economic life of a community.

In June 1963, a four-year demonstration grant was approved to cover a portion of the cost for the first seven projects. Estimated project cost and completion are $10.5 million (including a supplemental grant approved in April, 1966) and June 1967, respectively. In Feb. 1965, another four-year demonstration grant was approved to help support the eighth project. Estimated project cost and completion are $1.7 million and May 1969, respectively. Detailed reports are being prepared dealing with all phases of the development program.

3. <u>N.Y.C. Transit Authority--Two-Way Radio System for Transit</u>

A two year study was undertaken, commencing in July 1964, to determine the feasibility of providing two-way radio communication systems on a portion of the New

York City Transit System and testing their effectiveness in increasing the use and reliability of the rapid transit service (Ref. 45). Estimated project cost is $750, 805. Completion was scheduled for December, 1966.

One of the two radio systems which was installed permits constant communication between all trains in the test section and a transportation central control, the other between transit police officers in the test section and transit police headquarters. Each train going through the test section carries a 9-pound plug-in mobile transmitter-receiver in the motorman's cab. Each transit patrolman assigned in the test section will carry a 35-ounce walkie-talkie set.

The Authority has established communication systems with every phase of its operation with the exception of crews on moving trains, and it is hoped that this demonstration will provide an economical technological solution to the problem of overcoming the dissipation of radio waves in subway tunnels.

The test section for the project is an 8-mile stretch of 4-track subway with 17 local and 6 express stations. Various data will be collected for the test section and a control section which has similar operating conditions. In addition to the comparison data for "before and after" conditions on the test section, comparisons with the control section will provide for further validation of the conclusions that may be made. The following observations will be made for both sections:

a. "On-time" performance of trains on entering and leaving the test and control sections.

b. Train delays in the test and control sections.

c. Number of trains and passengers from 8:00 PM to midnight on Wednesdays and Saturdays.

d. Turnstile registrations at stations in test and control sections from 8:00 PM to midnight.

e. Police coverage and time elapsed in response to calls for assistance.

f. Crime statistics in the test and control sections.

g. Analysis of different types of typical delays, their duration and possible effect of the radio communications on the duration of such delays.

Partial statistical comparisons between test and control sections indicate that the average elapsed time for the police communication center to contact field personnel has become almost negligible. Other statistics which demonstrate the value of the police two-way radio system involve the difference between the number of crimes reported and the number of arrests made. This difference was reduced by an average of over 50% (Ref. 46). Subsequent reports will contain additional statistics to provide a basis for the evaluation of the system's effectiveness.

Approximately one year elapsed before the two-way radio systems became operative, and numerous engineering problems were encountered in the design, production, and installation of new materials and radio assemblies to accommodate subway operating conditions (Refs. 47 and 48). A complete operating manual was prepared by the end of 1965 for the two-way radio system installed for communications with train crews (Ref. 49).

4. <u>Port Authority of Allegheny County, Penn.--Transitway Test Facility</u> (Ref. 50)

The demonstration grant was awarded for the purpose of testing a new type of "Sky-Bus" rapid transit system designed specifically to provide mass transportation service to meet the needs of medium density urban areas in the 1/2 to 2 million population range. Estimated project cost and completion are $5.0 million and Dec. 1965, respectively.

The test track was completed in Sept. 1965, and it was constructed in a recreational park to provide a maximum opportunity for controlling test conditions. The project roadway is an elevated concrete structure 9,340 ft. long, with station and turning loops at each end. Three fully automated vehicles operate on this roadway at speeds up to 50 mph, either singly or coupled together.

The vehicle resembles a bus and runs on four pairs of rubber tires. The roadway consists of two 22''-wide tracks of concrete. A steel I-beam is mounted between the two tracks and is used by guide wheels on the vehicle to steer each axle and firmly lock the vehicle to the roadway.

The system is completely computer controlled, and a two-way communication channel is provided between each vehicle and the central control. It appears that the system capital and operating costs are substantially less than those of conventional rapid transit systems. The chief factors in reducing these costs are minimum vehicle weight, light-weight roadway, and automatic control. The demonstration project is now in its final stages of engineering tests.

5. University of Washington--Seattle Monorail Study (Ref. 51)

A comprehensive appraisal of the operation of the 1.2-mile monorail, connecting downtown Seattle with the site of the Seattle Century 21 World's Fair, was undertaken during the period from April through October 1962. The purpose of the study was to provide information on the effectiveness of monorail as a metropolitan rapid transit facility. The project cost was $15,000, and the final report has been released.

The results of investigations dealing with structural characteristics, operating characteristics and public acceptance are as follows:

a. Structural Characteristics

(1) No discernible differential settlements of column footings or tilting of columns were observed after about 10 months of operation.

(2) Sufficient camber can be built in to provide for smoothness of train movement over the supports.

(3) No evidence of structural failure or distress was apparent.

(4) The net effect of the presence of monorail support columns on roadway capacity was the loss of one traffic lane.

b. Operating Characteristics

(1) Maximum acceleration was about 2.4 mph per sec.; maximum deceleration was about 3.3 mph per sec., and maximum observed speed was 53 mph.

(2) Some loss of traction was experienced when beamways were wet. Therefore, a maintenance problem exists where snow and ice conditions prevail.

(3) Comparative riding qualities of different types of vehicles indicated that the railroad train was superior to the monorail which was superior to a passenger car or bus.

(4) Noise levels inside and outside of monorail cars was found to be within the same range as other vehicles.

(5) Seattle Transit System accident claim expense for a 10-year period has been about 2.95% of gross earnings or about 14 times the rate for the Seattle monorail operation.

c. Public Acceptance

(1) Monorail riders were greatly impressed by its speed, smoothness and quiet operation, although their comments may have been somewhat influenced by the carnival spirit of the Fair.

(2) In general, property owners were critical of the monorail because they felt the monorail would cause a decrease in property values.

(3) The large majority of business proprietors favored continued operation of the monorail because they felt that it brought a new look to the avenue which would attract new business.

Based on the results of the study there does not appear to be sufficient evidence that the monorail is in any way superior to conventional trains.

6. City of Los Angeles (Dept. of Airports)--Skylounge Ground-Air Feasibility Study

A nine-month study, which was scheduled for completion in March 1967, was conducted for the purpose of determining the feasibility and practicability of (1) designing and constructing a new high-speed mass rapid transportation system, and (2) operating the system for ultimate application to the growing problem of transporting passengers and baggage between a major airline terminal and its metropolitan centers. Cost of the project was estimated at $735,175 (Ref. 52).

The system studied was the "Skylounge" concept, utilizing a rapidly-detachable passenger/baggage "pod" that is joined alternately to a flying-crane-type helicopter and to a tractor-trailer combination, to provide rapid transportation between point of origin for air travel and the immediate emplaning area.

Analyses were made to delineate system design and operational characteristics, construction and operating costs, and coordination with other local transportation systems. Criteria and specifications were developed for selection of helicopter sites and the definition of routes, fare structure, service schedules, facilities, maintenance, and personnel requirements.

J. Public Awareness of Transit Services.

1. Washington Metropolitan Area Transit Commission (D.C.-Md.-Va.)- Information Aids for Transit Riders (Ref. 53)

The demonstration grant was awarded for the purpose of determining what types of informational aids and devices may be effective for informing the public of the services offered by public transit systems. The aids having the greatest potential will be designed, put into use on selected routes, and their effectiveness measured by market analysis techniques. A 2-year demonstration period was started in July 1964. Estimated project cost and completion are $262,634 and June 1966, respectively.

The goals of the project are to find what can be done through better information to get additional people to try mass transit and to get riders to use mass transit more frequently and for additional purposes. Decisions to use mass transit primarily depend on the services mass transit provide that people want, but the role of information is to ensure that people are aware of the useful services that are offered.

Before appropriate information aids can be efficiently utilized it is necessary to determine how much the public knows, or does not know, about their transit system. What kinds of information are necessary? What color and sizes should be used? How should the new aids be implemented? After all this is done, will more aids be required? Will the aids that have been implemented be accepted by the public? Will a program of this type attract new riders and also cause existing riders to use mass transit more?

K. Transit Administration Problems

1. Kansas State University-Computer Scheduling of Bus Operation (Ref. 54)

A study was undertaken to demonstrate the feasibility of utilizing a digital computer to schedule both drivers and vehicles in bus transit operations. In order to illustrate the advantages of the computer program that was developed, the program was tested under operating conditions within four different public transit companies, the largest of which operated 2,000 runs per day while the smallest had about 150 runs per day. The project cost was $18,337, and the final report has been released.

The basic objectives were to show that the use of the computer would provide the capability for almost instantaneous rescheduling to maintain effective service and would result in less cost when compared to manual scheduling. The computer program realized both of these objectives. Not only did the machine scheduling cost less, but the total time required to produce a complete workable schedule was less than one day as compared to 6 or 7 days required for manual scheduling. The program also proved to be completely flexible in that it handled scheduling for the significantly different size companies with equal ease. Appropriate use and development of computer scheduling could undoubtedly result in more efficient and economic utilization of transit equipment and manpower.

2. West Virginia University--Computer Model for Bus Operations Improvement (Ref. 55)

A demonstration project, completed in September 1966, had as its purpose the development of a mathematical model for computer programming which would enable schedule-makers to optimize run-cutting for more effective and efficient transit operations. Expenses for the project totaled $25,950 and the final report has been released.

In the Kansas State University project just discussed, it was demonstrated that the process of run-cutting could be accelerated by programming the process for a computer. The present project is predicated on the belief that the scheduling operation itself can be improved by analyzing the time and cost interrelationship of the various calculations, and that a mathematical model can be developed for computer programming which will help produce optimum schedules consisting of some straight and some split runs.

The problem is formulated as an integer linear programming model. The measure of effectiveness of criterion of optimality is the minimization of additional pay time, which is the time in excess of regular work time not actually worked. It consists of guarantee time, overtime, and spread penalty. One program splits every block into a number of different pieces of work. A second program prepares a number of different schedules from which one can choose the minimum cost schedule.

A comparison was made between a transit company's manually developed schedule and the computer's optimum schedule for the same company (minimum cost). The results proved that the computer schedule is as economical as the manual schedule. However, the ease and rapidity with which the computer schedule was developed was most significant. It eliminated all arithmetic work required in the manual process along with the subjective judgment of the schedule maker required in the computerized version of the manual process. The model possesses validity and simplicity.

3. Rhode Island Public Transit Authority-Transit System Design for a State-Wide Authority (Ref. 56)

Rhode Island cities were confronted with a severe curtailment of transit operations early in 1964 because the privately owned transit company could not continue to survive with steadily declining patronage. The only alternative, to safeguard the public interest, was public ownership.

The study was undertaken to demonstrate the techniques involved in determining the public necessity for transit service within the framework of a state public transit authority statute. The project cost was $30,000, and the final report has been released. The study report provides the following information:

a. Financial requirements for present and prospective transit service over a five year period.

b. Available sources of revenue from fares, tax relief, operating economics, and prospective assistance from local, state, and federal funds.

c. The form of ownership and management required to satisfy the public interest.

The contents of the report will be of valuable assistance to other communities which find it necessary to assume public ownership of transit facilities.

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8. CASE STUDY: TWIN CITIES
MASS TRANSIT AS A FACTOR IN METROPOLITAN PLANNING

ROBERT C. EINSWEILER

If mass transit is to be effective, it must be analyzed and planned as an integral part of total metropolitan development. With this fact in mind, 13 Twin Cities metropolitan area agencies joined forces in 1962 under a "Joint Program for Land Use-Transportation Planning" to see what could be done. The major ideas these agencies used to give direction to their work are described in Part I while the findings and proposals relating to transit are in Part II. Because the techniques used were far from perfect, a brief discussion of research needs is found in Part III. Notes on the background of the community and on metropolitan planning, to explain the Twin Cities setting which influenced the work of the Joint Program, are appended in Parts IV and V.

I. MAJOR IDEAS OF THE JOINT PROGRAM

The Planner, the Elected Official, the Public

All too frequently, the planners and engineers working for agencies that design highways, transit systems, parks, and other public improvements think of their task as a technical one. But it is not. When a specific speed is assigned to a highway or transit link, public policy is involved. A decision to provide for higher speeds means more opportunities to the citizen within a given amount of time, but at a higher cost in tax dollars. Thus, the highway planner, the citizen, and the elected official all have an interest in such a decision.

It is easy to say that there is a relationship among the planner, the elected official, and the citizen. It is difficult to formally organize the relationship. The planners and engineers find it difficult to program breaks in their work when elected officials are reviewing and reacting to proposals. There are no metropolitan elected officials, and only recently have we had metropolitan organizations of local officials. There are few metropolitan organizations of citizens, and those that do exist are recent additions to the urban scene.

The Twin Cities area's Joint Program made a start by putting together professionals from a variety of agencies on its Coordinating Committee and Technical Advisory Committee. The chief elected officials of each unit of government in the metropolitan area (about 300) were brought together in an Elected Officials Review Committee, and business, labor, and other community interests in a Citizens Advisory Committee. While much was done, much more must be done in the future. The area needs an elected metropolitan council to make major public development decisions. It needs effective citizen participation in metropolitan affairs. And last, but certainly not least, it needs more professionals who see their role as advising on and carrying out development decisions--not making them.

Metropolitan vs. Local Interests

The two are generally thought of as being in conflict. And they are if we define "metropolitan" as the total community and "local" as the individual community as in the example of freeways. From the metropolitan viewpoint, freeways must be designed to serve metropolitan high-speed, long-trip movement and major concentrations of activity. But the individual community sees access to the freeway as an enticement to tax producing development. If extensive local access is provided, the metropolitan purpose is thwarted.

From the vantage point of the individual resident who benefits from both ease of travel on high speed metropolitan facilities and from easy access to the freeway, it is not metropolitan vs. local. It is not a question of either-or. It is a question of how much of each. As this fact is better understood by the average citizen, better development decisions are being made.

This leads to the Joint Program view that metropolitan facilities are those that local governments cannot provide but which metropolitan citizens desire and need.

Purpose of Planning to Guide Development Decisions

The statute that created the Twin Cities Metropolitan Planning Commission in 1957 stated that "The Commission shall make plans for the physical, social, and economic development of its metropolitan area with the general purpose of guiding and accomplishing a coordinated and harmonious development of the area." Too frequently the purpose of planning is viewed as making the plans rather than guiding development. Plans should be viewed as one of a number of tools to guide development decisions and to make rational decisions about how to use scarce resources--dollars, man-hours of skilled people, land, and others.

In this task of guiding development, we note weaknesses in two areas--in research technique and in the making of development decisions. The Joint Program set out to balance efforts to improve research techniques with attempts to improve the ways development decisions are made. Other outstanding studies, such as Penn-Jersey and Southeastern Wisconsin, have put emphasis on improving the research techniques. We adopted a position early in the program of using existing techniques developed by others rather than use scarce resource to perfect new ones ourselves. It was our belief that research techniques need be no more sophisticated than our ability to make decisions based on research. We held to this with one exception, and that is in modal split, in which a new model was developed. In all other aspects of research and analysis, we used the best available mathematical models. Our crude research procedures were perfection itself compared to existing procedures for making organized metropolitan-wide development decision.

The Metropolitan Plan

If a metropolitan plan is to be a tool in guiding development decisions, it must contain agreed-upon rules for day-to-day decisions. The new "policies plans" do this. But if the plan is to be accepted, it must project some image of where the community will be in the future if it follows the rules. This the map-oriented master plans or "blueprint plans" do. There is a third approach, "incrementalism," where components are added to urban systems to meet daily needs with no long-range view in mind.

Map-oriented plans gather dust and die. They do not show how to reach the desired future state, so public officials ignore them. And they show so precisely how pieces of land will be affected that citizen opposition occurs. The incrementalists do not step on individual toes because no long-range proposals are made. But they do solve current pressing problems so they are relied upon by public officials.

We need a better approach, a blending of the policies and blueprint approaches. The Joint Program plan, to avoid confusion with standard master plans and to emphasize its purpose, is titled the Metropolitan Development Guide. Its focus is on major metropolitan development--large centers of commerce, industry, and government; large open spaces; and the systems of transportation and utilities that shape and serve those developments. The guide envisions making the major decisions at the metropolitan or state level while leaving the remaining decisions to the local level. The guide contains maps but does not show how each parcel of land should be used.

Goals-Policies-Programs

The Metropolitan Development Guide contains three elements: goals, policies, and programs. Goals are seen as the ends toward which we strive. Policies are the settled courses of action toward the goals or the decision rules that will be applied in moving toward the goals. Programs are the allocation of resources by type, time, amount, and location in line with established policies to achieve the goals.

The goals-policies-programs approach arrives at decisions by going from the general to the specific and getting agreement at each stage. When we agree to goals or ends, we are dealing with statements in which the values of the individuals of the community generally will be consistent and agreement will be fairly easy to achieve.

When we go to the next step, policies, we find differing values. Differences arise in political philosophy and the extent to which decisions should be made in the interest of total society rather than the individual. Differences between the values of producer and consumer are revealed. These must be reckoned with, argued out, and resolved at this point.

When we get to programs, we are for the first time talking of specific pieces of land and specific dollars of investment. We have, by this point, achieved substantial agreement on the objectives of investments and the rules for making investments. We now have a firm enough base of agreement to take this last difficult step, the step at which the blueprint approach to planning has failed in the past. In the blueprint approach, there was no opportunity to discuss over-all goals or objectives or the rules by which those who make decisions should be bound. Each individual could look at a map and see exactly how his individual interests were going to be affected. He reacted to those individual interests first and to over-all considerations second.

The Joint Program approach may sound like the planning-programming-budgeting system (PPBS) advocated by the federal government. The purposes are identical--to ensure the most effective use of scarce resources in meeting stated goals or objectives. The methods have similarities except for one important element. The PPBS technique starts from stated goals or objectives. We had to go back one step and formulate goals or objectives--a difficult task.

Goals: What Are They?

Some say that goals conflict. We do not hold this view. We believe that goals are sufficiently general by nature that they should not conflict, but that conflict arises when one begins to allocate resources to achieve the goals. In other words, people agree that they want ease of movement throughout the metropolitan area. But the disagreement occurs when they allocate dollars for highways as opposed to transit or for transportation as opposed to parks or schools. This is not a conflict in goals; it is a conflict in how much weight a given goal should receive or how each goal should be pursued. It is this conflict in weighing the goals that must be settled by a community, not a professional, decision.

Some believe goals should be used as tools for a community debate. Others believe they should be prepared by the professionals to guide their own later actions. We believe that goals can only be adequately understood and integrated when they are extended in terms of policies and programs. When the pursuit of a goal is expressed in terms of dollars from the pocket or property rights or some other item close to the individual, he can adequately assess how strongly he feels about the goal. Therefore, the final goals of the Joint Program and of metropolitan planning in the Twin Cities area will not be established until we have gone all the way through the process to adopted programs.

Let us examine some goals from the Joint Program. There are two generalized transportation goals. One is "ease of movement throughout the Metropolitan Area." The second is "a variety of modes of travel to meet the different needs of different people and activities." Hardly anyone could quarrel with statements of this generality. Professionals will look at these goals statements and be dissatisfied because they are not sufficiently concrete to provide any limits on acceptable decisions.

These goals are general because they were developed and debated, by a variety of people, many of whom were thinking about metropolitan development decisions for the first time. It was more important in the process of making decisions to get agreement than it was to have a high degree of precision on the items themselves.

General as they are, the goals have specific implications. The first supports increased transportation expenditures while the second is the basis for transit. What we need now are more precise objectives which can be measured in resource terms--that is, an expression of ease of movement in speed or time. Many transportation studies are doing this. But they are not going into the same detail for all other quantifiable expenditures for parks, schools, welfare, and other items. So no decision can be made on whether the investment is proper, only whether it is possible. In addition, the less tangible side effects of meeting specific objectives receive short treatment.

We make no apologies for our general goals. They serve a purpose. The next step is measurable objectives, but when we move to this step it should be done as comprehensively as the work on goals.

Goals: Their Preparation

How do we arrive at goals for the region? We started by conducting an attitude survey. This was a one-hour interview of a 1 percent sample of the households in the region. It tried to pinpoint the degree of satisfaction with the environment, questions of how one identified the part of the area he lived in, how he spent his leisure time, how he felt development decisions were made and who made them, and similar questions. The purpose was two-fold: to get a better feeling for what people valued in their area and to gain some insight into how they felt decisions were made and what their channels of information were.

We also studied the origin and destination data of 1958 in reverse. "O & D" figures are collected and used by traffic engineers to forecast travel. We looked at the origin-destination patterns to gain an understanding of how people live in an urban area. And we developed mathematical models for residential development and various categories of employment. These assisted us in understanding how people behave and how they made decisions in the region.

The next step was to put some of this together and publish it as a Goals Report. With response to these items, we then constructed a number of alternatives for regional development. The alternatives illustrated what would happen if certain policies were pursued to the year 2000. They were discussed in a series of public meetings. Looking at all this material together, we get some notion of community values, and therefore, what goals might be reasonable for metropolitan development.

Policies: What Are They?

Policies are the rules we agree to abide by in taking action to reach goals or objectives. But the line between goals and policies or policies and programs is broken and fuzzy. Henry Fagin has eliminated the problem by putting all of them in a category he calls "decision rules," an apt term. We prefer to separate the goals and programs from everything in between. That in between--the policies--could well be called the decision rules.

Here are two examples from the Joint Program relating to highways: (1) "Emphasize the metropolitan interest when designing and building the metropolitan transportation system," (2) "Obtain the most effective use of existing facilities by using the best available technology to manage traffic and to prevent unacceptable congestion on streets and highways." Two examples of transit policies are: (1) "Encourage the development of a new form of rapid transit system more specifically tailored to the needs of the Twin Cities Area than are the present bus or rail rapid transit systems," (2) "Combine mass transit service with major new community developments and redevelopments."

Such policies, in a general way, tell how resources should be allocated. They tell generally how transportation systems should be built--not where, when, or how much, but how it should be done. Although general, the second highway policy is a commitment to spend highway funds on traffic management as well as on construction and maintenance. The first transit policy is a step toward a new form of transit. It permits further programmed expenditures on research and development.

Policies: Their Preparation

The method of developing the policies involved a number of stages. Like the goals work, it drew on the results of the attitude survey, the review of O & D and models. The staff then proposed policies to be tested in the alternatives. These proposals were then reviewed by national consultants in commercial development, industrial development, housing, transportation, government, and the like. Following revision to respond to these comments, the policies were then reviewed by groups of local experts. For example, the committee on housing included a builder, a developer, an architect, a lender, and a public health representative (who rules on installation of septic tanks). Following reviewal, the policies were integrated and used to code variables in the land development and transportation models, and the alternatives were built. Following the construction of these alternatives, discussions were held with a Citizens Advisory Committee and an Elected Officials Review Committee over a period of six months. Then a single set of policies for commercial, industrial, transportation, and other development was prepared for the final plan and published. It was then re-tested and revised.

We can show diagrammatically what kind of a system the pursuit of the transportation policies would produce in 20 years. When we say what it would produce, we are entering the area of resource allocation. When we illustrate what can be done by 1985 in building a highway system or a transit system, the illustration must be realistic and responsible in terms of the dollars spent on transportation vs. other uses. This is where the great public debates can really begin. How important is another five-miles-per-hour speed on a highway or transit system compared to possibly three of four more metropolitan parks or an improvement in the quality of educational service? It is in this context that decisions must be made by government on the allocation of scarce resources to transit.

Programs: What Are They?

Programs usually are thought of as capital programs and they generally are short-term--one to six years. But they should be backed up by longer-range, financially-feasible, costed systems.

Programs, as we use the term, cover the commitment of resources--people, dollars, and others--at specific places and times. At this time, we are working on physical facilities, so the programs are three-fold. Physical programs show where and what type of facilities will be built. Capital programs cover the dollar amounts to build the facilities. And financial programs show how the dollars are to be raised. In addition, the resources of agencies necessary to produce these programs must be included.

Programs: Their Preparation

Planning agencies do not have the power to make development decisions and coordinate activities. Therefore, programs for transportation will be developed by bringing together those public agencies that build highways, transit, parking ramps, and also private investors in these facilities and perhaps some of the users of these facilities.

Relationship of Transportation Planning to Land-use Planning

Which comes first, the land-use "chicken" or the transportation "egg"?*

The cliche is apt, for like chickens and eggs, the ways we use parcels of land and the transportation systems we build to connect them are each products of the other. And we can't plan adequately for one without considering the other.

In its simplest form, this relationship is shown in the accompanying cycle diagram (Fig. 8.1).** Being a continuous cycle, we can enter it at any point, but let us start at (1) land use. Whether the land is used for shopping, manufacturing, residences, or parks, the activities on the site generate (2) trips. These trips are depicted on planning maps by straight lines called "desire lines" that connect point of origin and point of destination. Desire lines are the basis for identifying (3) highway needs. Construction of a (4) highway or other transportation facility to meet these needs creates (5) accessibility. No site in any area is going to develop if people can't get to it, so through the provision of access you help create (6) land value.

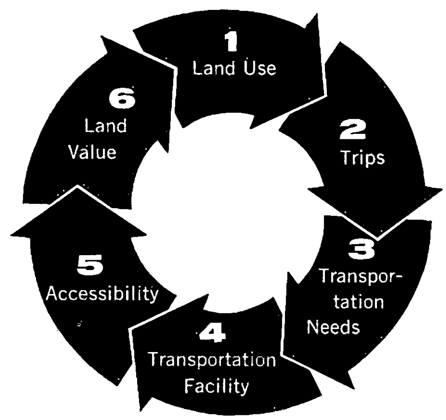

Fig. 8.1 -- Land use - transportation cycle diagram. (Source: "Transportation in the City," Architectural Forum, Oct. 1963, page 89.)

* The Joint Program. Metropolitan Balancing Act, Program Notes No. 1, March 1964.

** We could use the same basic diagram for other capital expenditures, such as sewers.

Land value in turn, completes the cycle by helping to determine (1) land use. For example, it is an exceptional person who can afford to build his home on the highest-value land in the city. Nor is this the likely spot for a marginal operation like a junk yard that can't afford a big capital investment. It is usually the site of the city's largest department store or a wealthy prestige office building. The name planners and land economists use for it is the "100-percent corner," the theoretical point of greatest activity. Thus, more trips are generated, the desire lines are drawn heavier, more highways are built to provide more accessibility and so on, perhaps until the cycle spirals out of balance.

If we accept this as an abstraction of how urban areas work, we can also see from a diagram how we can apply controls to make certain that the cycle does not spiral out of balance and to make certain that it does meet the needs of the region.

To keep the cycle in balance, we have traditionally used controls to manage the changes. Returning to the cycle diagram, we see that government regulates (1) land use by various means such as zoning and subdivision regulations. Highways are built with public funds. Thus, they are part of the (4) public capital investment which can be altered as needed. Land value (6), although affected by accessibility, is also affected by tax policies which can be altered as needed.

So policies affecting the land, expenditure of public funds, and the distribution of taxes offer three ways of managing development or change.

This gets us back to the planning process and shows us why it is important to agree on goals or objectives, that is, where we want to go and then to agree on policies concerning how we wish to get there.

Shape or Serve?

There is one other aspect of the diagram that we must cover, and that is the extent to which we will guide development, the extent to which we will use the controls noted above.

Traditionally, highways have been built to respond to forecasted needs derived from land use of the future. That is, the highway engineer has traditionally used only the right-hand side of the diagram. But if the construction of transportation facilities does affect land use, which is what the left side of the diagram says, can we afford to ignore this fact?

The Joint Program adopted the position that because of the rate of growth and change in the Twin Cities metropolitan region, we had to use all possible methods of control compatible with the communities' values. The Coordinating Committee of the Joint Program recommended that public capital investments be used to shape land use as well as to serve it. The community accepted this after considerable discussion.

It should be pointed out that there are many planners and engineers in the country today who contend that transportation facilities should not be used for such purposes while others indicate flaws in the old approach. It is our view that this is not a professional decision to make, but rather a decision for the community, because it involves the balancing of individual values against the values of the group and the benefits to be gained by the one at the cost or expense of the other. It is the role of the professional to show what can be done and to leave it to the community to decide which approach it favors.

We feel fortunate that our community has decided to use public capital investments to shape as well as to serve development. If we are to shape development, it is then mandatory that we agree on objectives for the development of the region before we make any of the public capital investments. It is no longer possible to just build highways, transit, or parks on an incremental basis. They must be designed to meet goals.

The ideas on the relationship of transportation planning and land use planning were incorporated in the forecasting procedures used in the Joint Program. The effect of land use on transportation can be seen by looking at the diagram of the forecasting process in Fig. 8.2.

The urban growth models provide the basis for traffic models. Policies enter into the Dwelling Unit Distribution Model in the two variables X_2 and X_3. In the development costs we start with such things as slope and soil quality and water table, which are not subject to policy. But added to that are the level of public services to be provided (such as sewer and water) and lot size or density, which can be controlled by development policies.

URBAN GROWTH MODELS				TRAFFIC MODELS		
"Basic" Employment Model	Population Model	Pop. Following Employment	Trip Production and Attraction	Trip Distribution	Modal Split	Trip Assignment
1) Manufacturing & Wholesale 2) Finance, Insurance, Real Estate 3) Trans, Comm. Utilities 4) Govt., State & Nat'l.	1) Dwelling Unit Distribution 2) Population per D. U.	1) Retail 2) Education, & Local Govt. 3) Service (Personal, Business, Professional) 4) Construction	1) Work 2) Shop 3) Social-Rec. 4) School 5) Non-Home Based Auto Driver 6) Light Truck 7) Heavy Truck 8) Misc.	Gravity		1) Transit 2) Highway

Dwelling Unit Distribution Model

$$X_1 = 1.2487390 + 0.093011140\ X_2 - 0.01427795\ X_3 + 0.023942100\ X_4$$

$$(R = 0.755)$$

Where:

X_1 = growth per capacity

X_2 = accessibility to base period total employment and basic employment change during the forecast period (end of period network)

X_3 = relative development costs (average = 100)

X_4 = Percent saturated at the beginning of the period

Fig. 8.2--Forecasting Process.

The reciprocal effect of transportation on land use can be seen in the variable X_2. The "accessibility to base period total employment" is derived from the gravity model, based on the network level of service--a policy decision. The network affected the distribution of basic employment, which in turn affected the distribution of population and of population following employment. The distribution was at three points in time, 1975, 1985, and 2000. So there was a crude recycling built in to the process. It is not a simulation of decisions as they would be made day-by-day, one-by-one; but it is much more accurate than a single forecast for the year 2000.

In addition to the limitation on the sophistication of procedures identified earlier, there were also limitations of funds. We had four alternatives to evaluate over three time periods, with nine major land-development models for each scheme. Every time period that was added multiplied the number of model runs by 36.

The important point here is that transit, highways, and land development have to be treated together. But there is no system perfected at this time that allows simultaneous interaction of the three. Therefore, you have to hold one constant and alter the others--hold land development constant and alter transportation or hold transportation constant and alter land development.

In this process, we laid out the network that seemed reasonable, used it to distribute land development and then to generate traffic on that network. The next step was to evaluate whether the resulting system that would have to be constructed was reasonable or not. If not, we had to go back and readjust land development. It is not acceptable to do as has been standard procedure in the past--to lay out a system to highways and transit to respond to demands for movement that are partly generated by the pattern of land development and partly by the quality of service put on the system itself. We must accept only those systems that are financially feasible and use those systems for whatever their effects will be on land development.

Relationship of Mass Transit to Auto Movement

Having looked at the relationship of transportation and land development, let us look at the relationship of one transportation mode to another--transit to auto. Members of the Joint Program hold two beliefs about the relationship of those two forms.

The first is that the mass transit systems and auto movement systems are converging. In the automobile, the transition is from a vehicle that initially traveled without any controls whatsoever; to the stage where a man had to run in front with a red flag; to a stage of traffic signs, traffic signals, one-way streets, no right turns, no parking, maximum speeds, minimum speeds, and other substantial controls. We are now reaching the point where systems are being tested that would give posted speeds timed to signal systems and that would control the access and egress from freeways to prevent congestion. The most visionary proposal would automate some facilities so that the man behind the wheel would no longer make all the decisions about how the vehicle will travel. At that point, the automobile's characteristics become quite similar to what is projected for transit.

The heyday of transit consisted of relatively large vehicles in mass movement. These trains and electric trolleys traveled on fixed routes. The next step in flexibility was the introduction of the bus, which had a fixed route on paper, but which physically could move around on other routes if permitted. Now we are discussing systems that extend this trend toward smaller vehicles and less fixed routes, and a trend toward a system in which the vehicle, rather than the individual, will transfer from one route to another. This begins to approach the door-to-door movement characteristics of the automobile and is only one step removed from the automated highway.

If we accept the convergence of these two modes and actually plan our policies to augment the trend, a more rational pattern of development can be established.

The second general belief is that systems of transit as well as highways have to be planned as evolutionary systems. It has long been common practice to establish a right-of-way for movement. We have Interstate highways on what once were foot paths, wagon trails, and U.S. roads. Similar things have occurred within cities where a town road later became a county or state route, a major arterial, an expressway, or a freeway.

But for some reason, when people build transit, they try to produce the ultimate in one blow. They want to build a rail transit system that will last for 40 years. The approach really should be to acquire rights-of-way that can be used for building an ever-improving transit system compatible with the ever-changing automobile system for the movement of the people in the region.

These general beliefs about the relationship of transit to auto movement and transportation to land development were incorporated in the modal-split model of the Joint Program. The equation shows the independent variables in the model.

$$T_{i-j} \text{ (Percentage of Work Trips by Transit)} = 41.4 - 12.1 \text{ Log}_n \text{ (Traveltime Ratio)} - 4.4 \text{ Log}_n \text{ (Income)} + 8.0 \text{ Log}_n \text{ (Residential Density)} + 1.3 \text{ Log}_n \text{ (Employment Density)} + 363.5 \text{ (9-hour Parking cost)}$$

T_{i-j} (Percentage of "Other" Trips by Transit) = 29.0 - 3.6 Log_n (Traveltime Ratio) - 3.2 Log_n (Income) + 2.4 Log_n (Residential Density) + 285.2 (3-hour Parking Cost)

Residential density and income reflect characteristics of the rider and his residence. Residential density really reflects the difficulty of parking, the likelihood that the people are either young couples without a great deal of money, elderly people, or multiple wage earners. The income reflects the dependency on transit.

The ratio of transit travel time to automobile travel time from origin to destination is a measure of the relative quality of service provided by the two competing systems.

At the other end of the trip, the employment density really reflects how high a level of transit service might be available, and the parking index reflects the difficulty or cost of parking. The parking factor used in forecasting is an index and not an actual cost. To use a dollar cost would require forecasting future income with some accuracy, forecasting the percentage of that income that would be spent on transportation, and then assessing whether the new parking cost would be a greater or lesser burden than the present situation. We short cut this process by just using the index of difficulty or burden, if you will, rather than by going through the cost figures.

II. JOINT PROGRAM FINDINGS AND PROPOSALS

The Use of Alternatives

The Joint Program's use of alternatives was quite different from the standard use of alternatives by professional engineers to arrive at a "best" solution. The engineer lays out several precise alternative schemes and then bases his evaluation of them on specific accepted criteria, such as cost-benefit analyses. The work is all done within his offices by the engineer.

Our purpose was to discover what individuals in the community value. We did this by obtaining responses to (1) the total pattern of development and (2) specific development policies. Four schemes were prepared, which seemed to bracket the range of choice. In each of these we asked the community to say which "direction" it preferred rather than which specific pattern.

For example, would they prefer to move strongly or slowly toward dispersion, as shown in the "Spread City" scheme, depending on the acceptability of the related development controls, tax policies, and transportation policies? The "Radial Corridors" scheme, building large concentrations in the downtowns, could have been made even stronger through tighter controls of the use and development of land. Therefore, in our meetings with the public, we asked not only which scheme they preferred but whether the scheme went far enough, too far, or not far enough in the general direction it represented.

Specific development policies were constructed to bracket the possibilities. In the four schemes, if we were to look at the size of centers of retailing and office employment, we find the smallest ones in "Spread City," next larger in "Present Trends," next larger in "Radial Corridors," and the largest suburban or outlying centers in the "Multiple Centers" scheme.

We noted that as one moved toward a large number of small centers, convenience increased and choice decreased at any given center. Conversely, as one moved toward a limited number of large centers, choice increased and convenience decreased. This was described as a "value couplet" in which each individual had to balance choice and convenience.

Obviously, no one was willing to choose either extreme convenience with no choice or a single center that would be very inconvenient but in which total choice would be available to the region. In fact, we found that neither the "Spread City" nor the "Multiple Centers" commercial pattern were acceptable. But we did find that choice was more important than convenience, suggesting that the centers should be relatively large. The upper limit on size was set by two factors: development controls and taxes. If the development controls had to be stringent to obtain large-size centers, they would be unacceptable. Also, if taxes are not redistributed to provide some benefits to the communities that otherwise might have had commercial development, the larger centers would not be acceptable. If these two points are taken into account, however, the public prefers choice to convenience and large centers to small ones.

The important point is that the planners and engineers must discover what the community values and not substitute their own personal preferences. To make a choice, individuals must be informed of the consequences of their choices.

The Four Schemes*

The four schemes are "Present Trends," "Spread City," "Radial Corridor," and "Multiple Centers." Each of the three alternatives to present trends contains a significant aspect of present development and builds upon it.

"Present Trends" reflects the many competing and sometimes conflicting forces at work in the urban area today. It also reflects a lack of strong development coordination at the metropolitan level.

The idea behind the scheme was to preserve present values and present ways of making decisions, not the present pattern. In so doing residential areas would continue to grow at low densities while the downtown areas became larger even though this compounds the transportation problem. Mass transit would be little improved--some freeway flyers added to the existing bus system. Open space would be limited. Public services would follow, not lead, development.

"Spread City" was designed around current decisions on the home. The scheme begins with the large-lot, single-family home and builds a rational scheme of non-residential development and public facilities around it. Mass transit is limited to local service in presently developed areas. Employment centers are small and distributed evenly across the region.

"Radial Corridors" was designed to produce the largest possible downtowns. High-speed rail or bus transit was used. Centers were organized as beads along the transport lines radiating from downtown. High-density housing was clustered around transit stops.

The "Multiple Center" scheme attempted to maintain as much employment in the two central business districts as possible while concentrating other employment into as large outlying centers as possible. Where "Radial Corridor" was concentration along lines, "Multiple Centers" was concentration around points. Transit was two-fold: local service into the centers and high-speed service connecting the centers.

Research Findings

Some of the conclusions we reached as a result of testing these schemes probably should not be listed as discoveries because they merely reinforce previous findings of others around the country.

There are two general conclusions. First, it requires major policy changes to produce minor development changes, and it requires major metropolitan development changes to produce minor metropolitan traffic changes. One problem with this conclusion is that it is derived from schemes and testing tools of admitted weakness.

If the conclusion is correct, the implication is that it really matters little to total travel on the metropolitan system what the metropolitan pattern of development may be. Therefore, we can choose the development pattern apart from its transportation implications and for reasons other than transportation.

The second general conclusion is that changes in the integration of transportation and land development at the local scale can produce significant differences in total travel. As a result, it was concluded that our initial position on the role and function of metropolitan planning was sound--that is, that we should create at the metropolitan level a framework or structure for the development of the region by controlling the size, location, and timing of major centers, major open spaces, and major transportation and utilities systems. Local governments can then respond by developing the details within this framework, with the framework designed to serve metropolitan needs or the needs of the community as a whole rather than the needs of individual parts. This led to policies that the metropolitan freeways should be designed for metropolitan travel and not for local travel or access to local land.

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* For a detailed description of the four schemes, see: The Joint Program. Goals for Development of the Twin Cities Metropolitan Area. Rept. No. 3, Nov. 1965, p. 7-15.

The second result of these findings is that, at the metropolitan level, we should develop standards and prototypes for local development, the detail which will actually produce the differences in total travel. The metropolitan structure will determine how people make use of regional opportunities. The control of standards of development at the local scale will determine the cost of taking advantage of local opportunities.

Here are some of the findings on transit. Mass transit as a percentage of total person-trips, is low under all schemes. With school trips excluded, trips by transit in "Present Trends" are 2.87 percent of total trips; "Spread City," 2.46 percent; "Radial Corridors," 4.35 percent; and "Multiple Centers," 4.65 percent. This is due to the great cross-haul traffic problem, which none of the transit schemes we tested are capable of handling. This led to a proposal to test new systems in which the vehicles could transfer and provide service approaching the door-to-door service of the automobile.

The second finding on transit is that mass transit ridership in any given corridor is too low for rail rapid transit as we know it today. The Twin Cities Area has two full circles in which transit service must be provided for its present 1.8 million people and the population of 4 million in the year 2000. A normal city has one full circle, and cities like Chicago have only slightly over half a circle of service. This means that each radial in the Twin Cities will not be carrying a great deal of traffic. The peak is less than 6,000 trips in the rush hour in the year 2000 on the most heavily trafficked route. Why not arbitrarily cut the number of radials and transfer the people to the remaining ones? The problem is that the slow-speed trip to the transit radials requires such high speeds on the radials that it is easier to take a slow bus on one of the expressways or freeways between the high-speed transit lines.

A third finding is that mass transit in the rush hour is important to the CBDs, whose size is dependent on it. In 1962, downtown Minneapolis employment was 86,000. By 2000, it would be 118,000 in "Present Trends"; 101,000 in "Spread City"; 139,000 in "Radial Corridors"; and 133,000 in "Multiple Centers." Table 8.1 shows that the number of automobile drivers changes little from one scheme to another and that the number of automobile passengers also is about constant. The major difference in the numbers of people coming to downtowns is in the transit work trips. This means that the size of downtown employment is directly correlated with the amount of transit service provided.

TABLE 8.1 - MINNEAPOLIS CENTRAL BUSINESS DISTRICT WORK TRIPS

Scheme	Number of Trips, by Mode of Travel		
	Auto Passenger	Auto Driver	Transit
Existing City (1958)	22,100	51,000	50,500 - 41%
"Present Trends"	27,500	93,600	64,200 - 34.6%
"Spread City"	25,700	89,800	51,000 - 30.5%
"Radial Corridors"	26,100	82,500	105,000 - 49.1%
"Multiple Centers"	25,000	83,400	97,100 - 47.2%

A fourth point is that mass transit is needed in all schemes tested. It is needed because of parking problems in the downtown area. It is needed to provide service for those who cannot provide their own automobiles. It is needed to relieve traffic congestion. And last, but certainly not least, it is needed to shape the pattern of development wanted by the community.

Community Response

In the meetings with the Citizens Advisory Committee and the Elected Officials Review Committee we found that the present transit system was rated as fair to poor and that most people wanted more and better transit. Half wanted more service to downtown and a third wanted more to other communities.

We then asked whether they would be willing to subsidize transit if necessary to provide a higher quality of service. The majority of the Citizens Advisory Committee and most of the E.O.R.C. members from communities over 10,000 population said yes.

When we asked whether transit should be used to serve existing development or to influence it, the Citizens Advisory Committee was overwhelmingly in support of using it to influence the pattern of development. In the Elected Officials Review Committee the same holds true in those areas which now have transit service but breaks off as you get to the smaller, outlying communities. And it reverses slightly in the fringe suburbs of 10,000 to 25,000 population.

Plan Proposals

The following are the specific policies that have been published in the Metropolitan Development Guide for transit in the region. We are in the process of testing these policies to see whether they adequately meet the needs of movement and development in the region.

Policy No. 4i--Acquire rights-of-way for mass transit use in accord with a metropolitan plan.

Policy No. 4j--Encourage the development of a new form of rapid transit system more specifically tailored to the needs of the Twin Cities Area than the present bus or rail rapid transit systems.

Policy No. 4k--Provide high-quality express and local mass transit service to the Minneapolis and Saint Paul downtowns and to the diversified centers.

Policy No. 4l--Combine mass transit service with major new community developments and redevelopments.*

Work on Transit

LEGISLATION--Members of the Joint Program worked with the Metropolitan Transit Commission and with state legislators in drafting a bill to create a metropolitan transit agency capable of carrying out the policies outlined above. The bill was passed by the 1967 Minnesota Legislature substantially as drafted.

PRESENT BUS SYSTEM--At this time (May 1967), a grant is being applied for that would provide funds to test simulated improvements in the existing transit system to provide a higher level of service from the facilities we now have. The transit act authorizes about $900,000 a year, which would finance the transit agency staff and provide funds for experimenting with improvements and service.

TECHNOLOGICALLY ADVANCED SYSTEM--Preparations are being made to enter into a contract for research on some prototype systems for the metropolitan area. The purpose would be to prepare a set of specifications for vehicle performance, level of service and other aspects of a transit system for the region. This would be coordinated with work being financed by the Department of Housing and Urban Development to identify the types of systems which will be needed and likely could be produced in the next five to 15 years. When these studies are completed, we would hope that our needs and the availability of equipment might match so that we could move into the design of a system. If not, we will have to test something that would be available and see how it would perform.

There are a number of factors to be considered. Is the increased level of service that would be required to attract ridership financially feasible? This parallels the questions of financial feasibility of the highway system. If we find that the new transit system is not financially feasible, we will have to try to tighten land development control policies so that a transit system of less flexibility and greater mass movement could operate effectively.

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* The Joint Program. Selecting Policies for Metropolitan Growth, Report No. 4, January 1967.

III. OTHER RESEARCH NEEDS

Values, Goals, and Urban Behavior

One of the most pressing needs is a better understanding of community and individual values and goals. Attitude survey techniques must be refined to give greater insight into why people make decisions as they do. As analytical and forecasting models become more decision-oriented, the values that support those decisions will be used to establish limits on the operation of variables within the equations.

For example, in traffic model work the questions asked are: "When is the trip length too long, when are trips per person too great, when is the parking index in the modal split model so high that too many are diverted to transit?" To answer these questions, we must have a better understanding of values. When we do, we can put the results directly into the models.

A second set of questions arises that cannot be directly responded to in the models. Hand adjustments to variables must be made on an iterative basis until satisfactory results are produced. In modal split work, when will congestion be so great that people go from auto to transit? Or looking at the two together, when will congestion going into the downtown be so great that the driver will go some place else and not go downtown?

A third set of questions is even more difficult to answer because it is concerned with how people in their own best interest should behave, not how they do behave. For example, when will congestion be so great that capital investment should go somewhere else?

All of these questions and many more require a better understanding of urban behavior, which in turn relies on better understanding of urban decision-making, which in turn relies on understanding what people value.

Land Development

Perhaps the most important item in all of metropolitan analysis is the effect of homogeneity vs. heterogeneity. This is far more important than what the pattern of development is. What we mean is the pattern of the people living in the development. For example, is the "Multiple Centers" community of possibly 250,000 a community in which a variety of jobs are available and a variety of income levels exist? If so, commuting could be relatively self-contained. If, on the other hand, only a narrow range of jobs were available and the income range was narrow, much commuting would occur unless the ranges were exactly matched. Even it they were matched, some commuting would occur to provide the services to the people commuting elsewhere. Therefore, it is not too important whether the scheme is "Spread City" or "Multiple Centers." But it is exceedingly important whether we have, at the metropolitan scale, a number of communities all of which have a range of incomes and employment opportunities or a number of totally different communities, each with its own income and employment pattern. While this is very important to know, we must note that none of the existing analytical tools are capable of taking it into account, even if we could identify it. This is probably our biggest analytical gap at this time.

Land Development Models

Use of linear regression equations, as we used them for distribution of development, implies that people in the future will respond to certain status variables, such as income, character of land, and accessibility, as they do today. And it also assumes that they will respond to factors controlled by policy, such as density, lot size, and other factors, as they do today. We know this is not the case. Much more advanced work than ours has been done on this already, and the movement is generally toward working on activity systems and time accounts--that is, getting directly toward the question of urban behavior, on what activities people spend their time, how much time, and at what part of the day. That means short-term decisions as far as travel is concerned. Then there are the long-term activity patterns, such as movement from one house to another as the life cycle progresses or as job opportunities change, the movement of industries from central areas to outlying areas, or the movement of shopping facilities from central areas to suburban centers.

A better understanding of how decisions are made will allow us to more accurately forecast development in the future and will lead us directly to the method of integrating policies into the forecasting process. Too much of the land development forecasting is still done as a direct projection of the physical development results of past decisions. We are moving toward the study of the decisions themselves, and therefore, the ability to forecast the effects of future decisions.

As mentioned earlier, we believe that it is vital at this time to work directly with those making decisions so that all the assumptions used can be realistic, at least in the short run.

Traffic Distribution and Analysis

There are two problems in traffic analysis that still require solution. The first is that while we now distribute employment in detail (eight different employment categories in our work), when we distribute the work trips there is only one. It is unlikely that the pattern of work trips to all of those places is the same. We know we are connecting high-income people to low-income jobs and vice versa. Use of "K" factors in the gravity model helps, but does not solve the problem. This is one point where the land development process in forecasting is more refined than the traffic.

The second need is to graft the strengths of the gravity procedure to the strengths of the opportunity procedure for trip distribution. Each of these schemes is calibrated to a phenomenon that is held constant. In the gravity model, the variable item is accessibility, and the item that remains the same is the response to travel time. In the opportunity model, the response to opportunities is calibrated, and the item that can vary is distance traveled. We have to put those together so that we can draw people out with a change in the pattern of opportunities and restrain them with a change in the necessity to travel.

Modal Split

Considerable headway on the major problem in modal split has been made since we did our model some years ago. It is a question of whether one splits before or after distribution and of whether one has a trip-origin or a trip-interchange model. What we really need is a model that can combine the two.

IV. BACKGROUND ON THE COMMUNITY

Physical Setting

1. Hub of the upper midwest--400 miles to Chicago; 450 miles to Kansas City; 850 miles to Denver; 1,650 miles to Seattle. No major city between. Hinterland--upper peninsula of Michigan, NW Wisconsin, Minnesota, northern Iowa, North and South Dakota, eastern Montana.

2. Present population--1.8 million; year 2000 estimate - 4,000,000. Fourteenth largest SMSA; one of most rapidly growing due in part to rapid shift from agriculture in a vast region. Net in-migration accounted for 30 percent of 1950-1960 growth.

3. Two cities that grew together. Minneapolis and Saint Paul central business districts, each with complete services, are ten miles apart. Minneapolis grew north and south from the falls of Saint Anthony, a grain milling and river crossing point. Saint Paul grew mostly to the west from the most northerly possible port on the Mississippi River. Street systems today do not mesh; dominant "grain" at right angles.

4. Development took place on flat sand plains now virtually used up. Growth moving to surrounding rolling or hilly terrain. No physical barrier to growth in any direction. Amenity of lakes (700 in metropolitan area), river valleys (three), and wooded areas strong drawing factor in recent development.

5. Two full circles of growth and transportation corridors compared to one circle for most cities and slightly over one-half circle for Chicago. Reduces traffic loads on individual radials.

6. Downtown concentrations of employment relatively small. In 1962 the two CBDs together had 22 percent of total employment; by 2000 down to 11-14 percent.

7. Metropolitan Planning Area--seven counties, 3,000 sq. m. Intensive study area--2,000 sq. m.

Economic Setting

1. Northwest edge of economic heartland. Very dependent on long-haul transportation--rail, truck, air.
2. Diversified, functionally stable economy. No large industry dominance. Limited heavy industry.
3. Skilled, well-educated labor force. At present a labor short area with jobs growing faster than employees.

Social Setting

1. Two separate "communities" with little crossing of the line between. Substantial K factors required in calibration of gravity model to reflect this social separation.
2. Traditional low income around cores with higher away from the center.
3. Most non-whites are Negro. Most Negroes live in the two central cities. Non-whites in 1960 = 1.8 percent of population of metropolitan area, about 4 percent of central city.
4. Most rapidly growing sectors of population are young and elderly, frequently transit "captives."

Political Setting

1. No focus on political power owing to two central cities. Two central cities = suburbs in population. Line-up of communities shifts by issue.
2. Area now has 319 units of government. Minnesota Municipal Commission, 3-man quasi-judicial body, rules on all changes in political boundaries.
3. State fairly well apportioned; metropolitan area is one-half of state population with 47 percent of representation in Legislature.
4. Traditionally weak executive, strong legislative function at all levels of government in state.
5. Professionals in government usually well regarded.
6. The metropolitan government issue. Community escaped the national rash of political science-inspired studies in the 1950s. Now digging in with a vengeance. Minnesota is home rule state; therefore, metropolitan government for 1/2 the people and 2/3 of earned income is not acceptable to State Legislature--passing too much power. If it is the state or metropolitan as only choice, many local governments prefer metropolitan. Law passed at 1967 session creates a metropolitan council to coordinate planning and development of metropolitan area. Coordination achieved in several ways: (1) review all local comprehensive plans, (2) review all applications for federal grants, (3) approve all plans of special districts--veto if contrary to metropolitan councilplan, (4) approve all federal or state grant requests for open space--deny if contrary to plan, (5) appoint council member to serve without vote on each special district in metropolitan area.

V. BACKGROUND ON METROPOLITAN PLANNING

Factors Creating Favorable Climate

1. Seat of state government--state departments in metropolitan area, know people socially as well as professionally; state legislators spend at least five months in metropolitan area every two years, learn problems.
2. State's major "stake"--1/2 of population, 2/3 of earned income, cannot be ignored.

3. Location of the state university--resource of trained people.

4. Metropolitan planning commission with its own taxing power, members representing all forms of government in the area, and a mandate to look "down" and solve problems that overlap local boundaries and look "up" as advisor to the Legislature on metropolitan problems. Will be superseded by metropolitan council about 1 August 1967.

Transportation Planning

1. 1958-1961: Highway Department undertook Twin City Area Transportation Study (TCATS); MPC, newly created, worked along on land use and transportation wherever resources permitted.

2. Volume 1 of study, survey findings was published. Volume 2, the plan, was not. The plan stirred up much local unrest because of extensive freeway-expressway system. Transit was not adequately treated. It was decided to join forces in Joint Program to see whether reductions in facilities could be brought about by shifts to transit or changes in land development pattern.

3. 1962-present: Joint Program. 13 agencies--Twin Cities Metropolitan Planning Commission, Minnesota Department of Highways, Minneapolis Planning Department, Minneapolis Engineering Department, Saint Paul Planning Board, Saint Paul Department of Public Works, Anoka County Highway Department, Carver County Highway Department, Dakota County Highway Department, Hennepin County Highway Department, Ramsey County Engineers Department, Scott County Highway Department, and Washington County Highway Department; budget of $2.3 million; first major metropolitan planning grant by HHFA in a joint HHFA-BPR venture; basis for changing some HHFA rules on working with public, etc.; no separate study staff, integration of efforts of existing agencies.

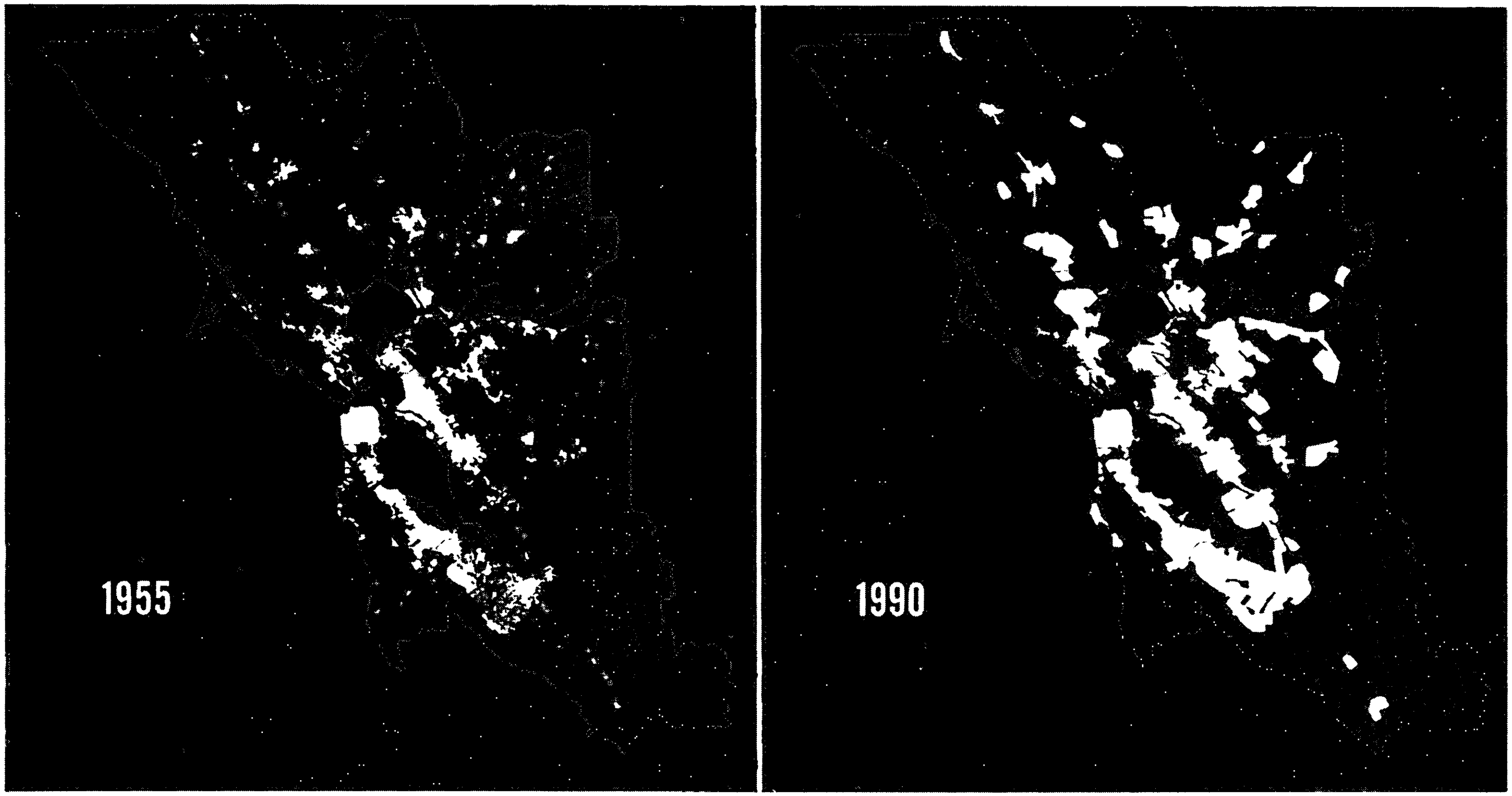

Fig. 9. 1 - Urbanization of the Bay Area.

9. CASE STUDY: SAN FRANCISCO BAY AREA RAPID TRANSIT PLANNING AND DEVELOPMENT

WOLFGANG S. HOMBURGER

A. Description of the Area

The San Francisco Bay Area, in transportation analysis, is usually defined as consisting of the nine counties bordering on the Bay. These counties include some 7,000 square miles. The population since 1930 and projected to 1980 is given in Table 9.1 (Ref. 1).

TABLE 9.1 - POPULATION OF THE SAN FRANCISCO BAY AREA, 1930 - 1980

YEAR	POPULATION IN THOUSANDS							
	San Francisco	Alameda	Contra Costa	BARTD Total	San Mateo	Santa Clara	Northern Counties	Bay Area Total
1930	634	475	79	1,188	77	145	168	1,578
1940	635	513	100	1,248	112	175	200	1,734
1950	775	740	299	1,814	236	291	340	2,681
1960	740	908	409	2,057	444	642	495	3,639
1970*	750	1,110	570	2,420	640	1,030	718	4,808
1980*	750	1,350	740	2,840	800	1,350	1,030	6,020

*Projections by Van Beuren Stanbery, March 1962. (Ref. 1)

It may be noted from the above that the central city, San Francisco, has reached a population saturation point and already in 1960 contained only 20% of the population of the Bay Area (and only 0.7% of its area). By 1980 its relative importance will have dropped further. Similarly, the counties served by BARTD* contained only 57% of the Bay Area's population in 1960 and this proportion is estimated to drop to 47% by 1980.

The land use and transportation patterns are determined almost entirely by the topography. The Bay and the major rivers entering it from the east are, of course, the major factor in the urban geography of the region. Steep ranges of hills along the spines of both peninsulas which face each other across the Golden Gate and parallel and a few miles east of the Bay have acted as barriers to development as well as green belts. In the east, the hills have been penetrated by railroad and highway tunnels for some time, and urbanization has moved outward. On the two peninsulas, however, the development has been largely on the Bay (east) side of the mountains. Thus, urban and transportation corridors can be identified in north-south locations along both sides of the Bay. The only area containing much flat land is in Santa Clara county at the south end of the Bay and beyond. This, largely orchard and other agricultural land, is rapidly being developed into a continuous urban area, sometimes referred to as the "Los Angeles of the Bay Area."

Because of the topographic limitations, the urban density of San Francisco is very high (16,900 persons/sq. mile), comparable to the densities of Philadelphia, Boston and Chicago. Other cities in the region have considerably lower densities, as shown in Table 9.2. This explains why rapid transit planning until 1952 was confined almost entirely to the city of San Francisco. The expansion to the regional scale was not so much because densities of other cities suggested rapid transit, but because the heavy traffic movements across the Bay called for an early solution.

Fig. 9.1 shows the extent of urbanization in 1955 and the projected areas of urbanization for 1990. Figs. 9.2 and 9.3 show the interurban automobile and transit traffic volumes measured in 1954.

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*BARTD - San Francisco Bay Area Rapid Transit District.

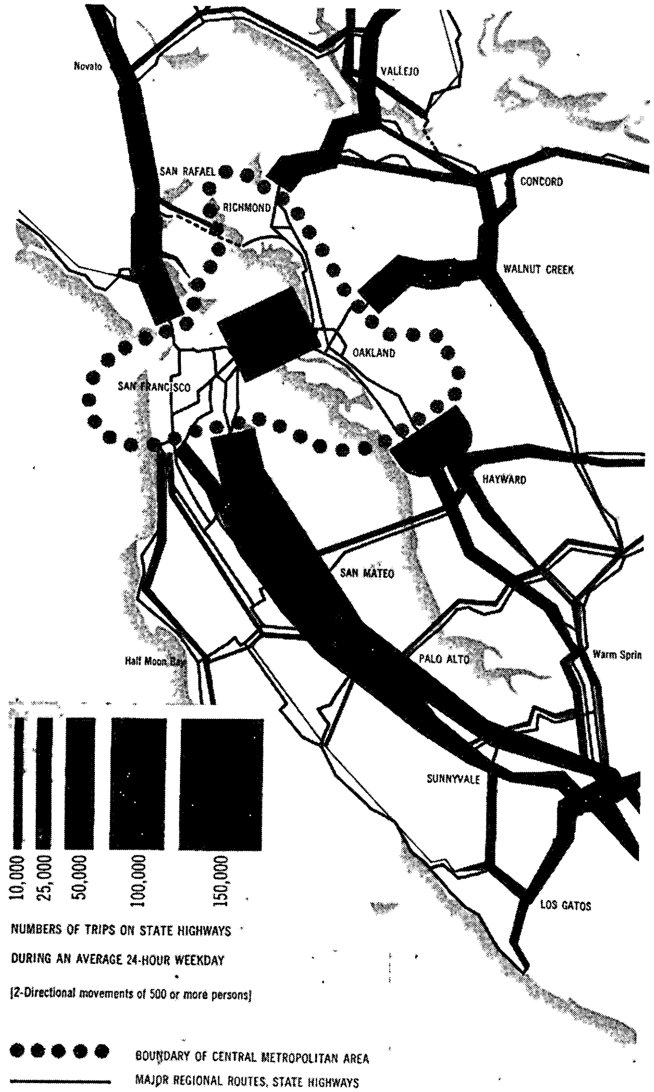

Fig. 9.2 - Generalized Automobile Traffic Flow, San Francisco Bay Area, 1954 (Ref. 1).

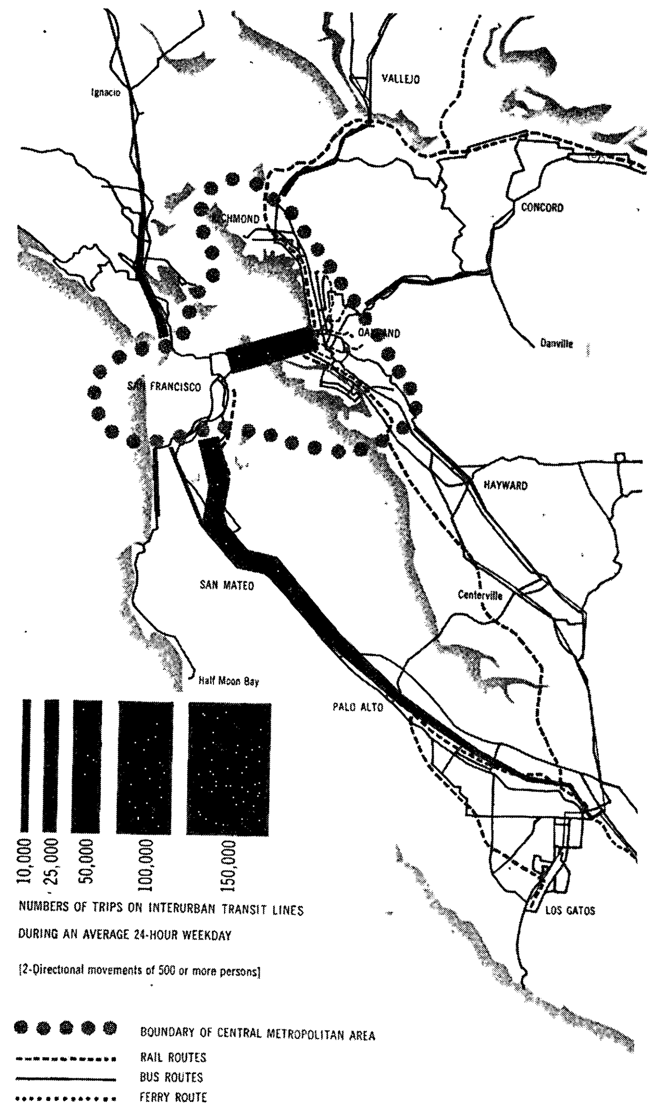

Fig. 9.3 - Generalized Transit Traffic Flow, San Francisco Bay Area, 1954 (Ref. 1).

TABLE 9.2 - POPULATION AND DENSITY OF BAY AREA CITIES SERVED BY THE BARTD SYSTEM

CITY	1965 POPULATION	AREA* sq. miles	PERSONS/SQ. MILE
San Francisco	755,700	44.76	16,887
Oakland	385,700	54.77	7,043
Berkeley	120,300	9.81	12,262
Hayward	83,856	30.75	2,728
Richmond	80,450	25.75	3,124
Fremont	75,700	99.00	765
San Leandro	69,600	12.31	5,654
Concord	64,522	13.78	4,682
Daly City	57,163	9.96	5,739
El Cerrito	26,800	4.30	6,232
Pleasant Hill	26,499	5.35	4,953
Union City	8,500	14.11	602

*Includes land and fresh water areas, but not salt water
Source: Ref. 2

B. Existing Mass Transit

1. San Francisco Municipal Railway

San Francisco is served by a mass transit system, the San Francisco Municipal Railway, whose service territory is almost exactly coterminous with the city limits. A small strip of San Mateo County at the south of San Francisco is entered by a few routes. No other transit companies operate local service in this area, but two jitney operations compete along major traffic corridors.

The Municipal Railway came into existence with approval of a bond issue in December 1909 (probably the oldest municipal transit system in the United States). Operations started in 1912 after construction of a new streetcar line, replacing a privately owned cable car line. During the ensuing 14 years, an extensive network of streetcars, partly competing with and partly supplementing the privately-owned Market Street Railway Co. was constructed. The "Muni" as it is known, pioneered bus routes in 1918 as feeder lines to the streetcars, and installed its first trolley coach route in 1941. In 1944, after approval of the voters, the Market Street Railway Co. was purchased and consolidated with the Municipal system. The Muni thereby inherited two cable car routes, and acquired two others in 1952 when the last private transit company within the city, the California Street Railroad, was purchased.

The Muni is unique in the U. S. in the variety of rolling stock in use and, unfortunately, in the antiquity of this. The causes are the hilly terrain and the extreme lack of executive powers granted to the city government by the people, who must be consulted at the polls on even minor decisions. Cable cars were invented in San Francisco because of its steep streets, and are retained, despite availability of modern buses, at the specific instructions of the citizens. In 1949, a consultant complained:

> "The spinning wheel, the oil lamp, the flatiron, the horse car, the Pony Express, all deserve recognition for the worthy part they performed in the progress of civilization ..... We have a sincere and deep sentiment for each of these ..... Surely no just person would insist on spinning wheels being used in our mills, if he had to wear the cloth, or oil lamps in our homes with the resulting inconvenience and eyestrain, nor would he wish to ride to and from work by horsecar or wait for mail to be delivered by the Pony Express. There is no more logical reason to preserve the cable cars in regular service." (Ref. 4, p. 179).

Nevertheless, and despite the fact that they cost $4.96 per vehicle mile to operate (vs. revenues of $2.73 per vehicle mile), they are a sacred institution, happily subsidized by the taxpayers and designated a National Historical Monument.

Streetcars remain for a different reason: in 1918 a 2.25-mile long streetcar tunnel was constructed under Twin Peaks to connect the western residential areas with the center of San Francisco, and in 1927 another tunnel, 1.2 miles,was opened for another route. Both of these offer much more direct alignment than any surface streets, and are not readily convertible to use by trolley coaches or motor vehicles. Four of the five remaining streetcar routes use one or the other of these tunnels. It was therefore decided to place the streetcar tracks underground immediately above the rapid transit routes along Market Street (Ref. 1). However, there has been one recommendation to convert two routes to full rapid transit and the others to feeder bus lines (Ref. 16).

Trolley coaches also owe their longevity to the hilly terrain, which they were able to negotiate much more easily than buses available in the post-World War II period.

The Muni has no capital funds available to it, except by appealing to the voters to approve bond issues, requiring a two-thirds affirmative vote. As a result, the management in the mid 1950's adopted a lease plan, under which a motor bus manufacturer leased buses to the city. The PCC streetcars were also obtained on lease (from St. Louis, where they were no longer needed) and, after some years, were purchased at a nominal sum. Cable cars and trolley coaches, as well as streetcars, are no longer being manufactured, and the Muni must make some difficult decisions in the near future regarding reequipping its fleet. Its current inventory includes the following (Ref. 5):

3 gasoline buses, 1939 (owned) -- two of them have more than 800,000 miles!
72 gas buses, 1948-49 (owned) -- average mileage 400,000.
449 diesel buses, 1955-60 (leased) -- average mileage 250,000.
360 trolley coaches, 1948-52 (owned) -- average mileage 375,000.
70 streetcars, 1946 (from St. Louis).
10 streetcars, 1948, and 25 streetcars, 1952, purchased new.
27 cable cars, 1893 (!) and 12 cable cars (1907), inherited.

For some other statistics of San Francisco's transit system see Tables 4.6 - 4.8 and Fig. 4.2 in Chapter 4.

A bond issue in the amount of $96.5 millions was submitted to the voters in November 1966, but failed to receive the required two-third vote of approval. This plus hoped-for federal grants would have provided funds to buy 660 buses, 150 trolley coaches and 75 rail cars, make minor extensions to the cable car routes, and extend the BARTD streetcar tunnel further west as a rapid transit line.

The city charter sets wage rates of transit employees automatically at the average of the two highest wages paid in large cities of the U. S. Thus, when New York transit employees received a substantial wage hike after the strike of January 1966, San Francisco wage rates rose automatically. This situation has virtually eliminated the possibility of transit strikes, but has proved costly, and has tended to raise wages in other parts of the Bay Area, where unions point to the San Francisco wage scale to back up their demands.

The city has made it a policy to provide a generous subsidy to the Muni, so that a 15¢ fare can be maintained. Partly as a result of this, patronage has remained constant at about 200 million passengers annually since 1955.

2. Alameda-Contra Costa Transit District (A. C. Transit)

The history of the mass transit system in the urbanized area on the east side of San Francisco Bay is complex, involving in the first forty years of this century as many as three rail systems (see next section), extensive streetcar lines and a large system of ferries. The private system which finally emerged and which, after 1941, became virtually the sole operator serving the area between the Bay and the first range of hills from Richmond to Hayward, had its beginnings in real estate promotions; in 1893 one F. M. "Borax" Smith (the nickname indicated the source of his wealth) began buying up streetcar lines, many of which had sprung up in the East Bay, and coordinating them with his real estate syndicate.

Within eight years he had acquired all operating routes, and had built a number of extensions into his land holdings to make them more attractive to potential purchasers. By 1903 he had built a 3-mile long pier into the Bay and begun ferry operations in direct competition with the until then unchallenged Southern Pacific. (Both Key and Southern Pacific Railroad ferries operated until 1939, when electrified tracks were opened on the lower deck of the San

Francisco-Oakland Bay Bridge, leading into an elevated 6-track terminal in San Francisco.)

Borax Smith eventually overextended himself and went bankrupt. After years of receivership, the transit system emerged as the Key System Transit Company in 1923, and became Key System Transit Lines when National City Lines obtained a controlling interest in 1946. The last local streetcar lines were converted to bus operation two years later, and the last transbay electric train routes in 1958. However, Key System made no attempt to improve or extend its service as the urban areas expanded for obvious financial reasons, and its public image was further severely damaged by a transit strike which shut down operations for 76 days in 1953.

The strike was the impetus for passage in the State legislature of an A. C. Transit District enabling act in 1955; the District was actually formed by vote of the people in 1956. In 1958 slightly over 50% of the voters approved a bond issue to purchase Key System; however, since a two-thirds majority was required, this issue had to be resubmitted the following year after the State Legislature had thoughtfully lowered the approval requirement to 50%. Again the "Yes" vote was somewhat over 50%, and the actual purchase and beginning of public ownership occurred in October 1960.

A. C. Transit, since 1960, has reequipped its bus fleet so that as of 1966 more than half its buses are less than 6 years old. It has inaugurated new express lines within the East Bay, new local lines both within the Key System territory and somewhat beyond it to the South. Transbay service has increased. As a result, patronage on A. C. Transit shows a constant, if slow, rate of growth: in 1965, 52.8 million passengers were carried, 13% above the number served in 1961, while bus mileage had increased about 7.5%. Financially, A. C. Transit follows a policy of holding fares approximately constant (though at a higher level than in San Francisco) and using tax proceeds as subsidy for capital costs of vehicles: in fiscal 1965-66, tax revenues of about $2.34 million were used toward costs of equipment renewal, bond interest, and retirement of principal, while operating revenues of about $14 million approximately balanced operating costs.

A. C. Transit's transbay operations, for which an interurban-sized fare of 50-70¢ is charged, is financially more successful than the East Bay operations, especially the more outlying and crosstown routes. There is some concern, therefore, about the financial results after BARTD commences transbay service. While BARTD assumes that A. C. Transit will immediately cease its transbay bus service, this is not assured where A. C.'s routes might compete successfully. In any case, A. C. Transit will suffer to some extent financially from BARTD's operations.

3. Commuter Railroads

Until the Golden Gate and Bay bridges were opened in 1937 and 1936 respectively, extensive railroad commuter service was provided from ferry slips in Oakland to East Bay cities and from Sausalito to Marin County towns north of the Golden Gate. In the East Bay, the Interurban Electric Railroad (a subsidiary of Southern Pacific) competed with Key System trains in the same general territory. Like the Key trains, they began operations across the Bay Bridge directly to the terminal in San Francisco in 1939, but the general increase in automobile use, and the attractiveness of the now available alternative of bus routes across the bridge proved too much, and service was abandoned in 1941. Key System took over the routes, including a few of them in its rail net and serving the remainder with buses. Of historical interest was the single route of the Sacramento Northern, which connected Oakland by a circuitous route and a tunnel with central Contra Costa County points, many of which will be served by BARTD's Concord route. This old route, which operated until 1940 -- the last year across the Bay Bridge -- contributed to the suburbanization of the area. After the abandonment of passenger service, Greyhound established a bus route, which will, in its turn, give way to rapid transit. The Marin routes of Northwestern Pacific also fell victim to progress; the Golden Gate Bridge furnished a faster route into San Francisco, against which the train-plus-ferry combination could not long compete. Service was abandoned before World War II, and Greyhound established commuter bus service here also.

On the land approach to San Francisco, Southern Pacific has had a commuter line for almost a century; this is the only rail commuter line west of the Chicago area still in service today. It is largely a peak-hour operation, with frequent trains at high speeds (45 mph average) during the rush hours. At other hours, and on weekends, the headways are irregular, often exceeding two hours. The route suffers from the inconvenient location of its San Francisco terminal, seven long blocks south of Market Street and a mile from the destination of most commuters. Even so, it is still used by some 10,000 persons on a typical weekday.

4. Greyhound Commuter Lines

Since the mid-1930's Greyhound Corp. has developed an extensive network of commuter bus lines into the suburbs beyond the areas served by the Muni and A. C. Transit. Some of the routes were established to replace abandoned rail services, such as those to Marin County and to the Concord area. The remainder, serving the peninsula south of San Francisco, are in competion with the Southern Pacific commuter service. This latter group of lines, however, suffers from the same problem as the rail service: the San Francisco Greyhound terminal, while fairly close to the Civic Center, is poorly located with respect to the many destinations in the financial district. The lines from the East Bay use both this terminal and the convenient Bay Bridge terminal, while from the North, rush hour service goes to both the main Greyhound terminal and to the Ferry Building.

If public statements are to be taken at face value, Greyhound would be happy to divest itself of commuter operations which it deems to be less profitable -- or perhaps a losing proposition -- than long-distance service. In the East Bay, their wish will be granted when BARTD begins to serve the areas now tapped by Greyhound lines. In Marin County a public transit district has been formed with the intention of acquiring Greyhound's commuter operations. And in San Mateo County, another public agency is considering the future of both Greyhound and the Southern Pacific.

5. Other Transit Service

Other transit service in the Bay Area is furnished in a number of ways:

a. Local mass transit in outlying suburbs is furnished by several private companies (e. g.: in San Jose, Palo Alto and San Mateo) and by at least one municipality (Santa Rosa). Another city (Vallejo) leases buses and shop facilities to a private operator. None of these is in the 3 counties served by BARTD.

b. A ferry has resumed one morning and evening run between Marin County and San Francisco for those who are willing to run the risk of delays in fog and discomfort in rough weather in exchange for a more adventuresome ride complete with coffee bar inbound and cocktail bar outbound.

c. A hovercraft was tested in service to and from Oakland Airport under a mass transit demonstration grant of the Federal Government. Results did not indicate that a revolution in mass transit technology is imminent.

d. Helicopter service to both San Francisco and Oakland airports from five outlying heliports is frequent, well patronzied, and evidently financially successful.

e. Limousine fleets operate sightseeing service throughout the area, and regular service to the two airports.

f. San Francisco's penchant for being a living transportation museum is also evidenced by the retention of jitneys, nine-passenger automobiles operating on fixed routes at frequent intervals and carrying passengers for fixed fares much in the manner of buses. These jitneys duplicate two of the Muni's more important bus routes, and skim the cream of the available traffic with resulting financial loss to the Muni. (It is believed that since the recent discontinuance of jitneys in St. Louis, this is the last such operation in the U. S.)

g. A bicycle rickshaw has been observed in service in Chinatown, and a double deck bus operates a shuttle service for tourists at Fisherman's Wharf.

C. Other Transportation Elements

1. Highways

The backbone of the highway system are state freeways and highways. The freeway net is entirely post-war, and provides service in all parts of the Bay Area. Development has already reached the stage where relief freeways paralleling some of the first-stage net at a distance of a few miles are being constructed. In San Francisco, the critical shortage of land, especially unattractive land, has made routing of freeways extremely difficult and led to "freeway revolts." City streets and country roads fall under some 100 different jurisdictions.

2. Toll Bridges

Because of the cost of bridging the Bay, all bridges built to date and any planned for the future are toll facilities. They are planned, built and operated by the California Toll Bridge Authority and the Division of Bay Toll Crossings, with the exception of the Golden Gate Bridge, which is owned and operated by a fiercely independent public agency. Toll bridge planning, therefore, has been done separately from freeway planning in the past, although some closer coordination should result from the comprehensive transportation planning process now required under the 1962 Federal Aid Highway Act.

The Bay Bridge is highly profitable; all its bonds have been retired, and tolls now help to defray the cost of building a replacement for the 40-year-old San Mateo-Hayward bridge some 20 miles to the south. The Bay Bridge originally included a pair of interurban railroad tracks, used by Key System from 1939 to 1958, and briefly by two commuter railroads. After conversion of all transbay commuter routes to buses, the rails were removed and replaced by additional roadway lanes. But, arguing that the new underwater tube of BARTD between San Francisco and Oakland is a replacement for the original interurban rails, the State Legislature has alloted $180 million in toll receipts partly as outright grant and partly as a repayable loan for this portion of the rapid transit project. Any future crossings which expect to be supported in part from the profits of the Bay Bridge (some $12 million per year), such as the long-argued "Southern Crossing" a few miles south of the Bay Bridge, must wait until the prior commitment to BARTD has been met.

The other toll bridges under State control are all self-sufficient, but are not presently a source of extra revenues for transportation purposes.

The Golden Gate Bridge deserves mention in the rapid transit context because the original BARTD plan called for a lower deck for rapid transit trains to be added, so that Marin County might have one route of the system. The directors of the Bridge and Highway District fought this suggestion strenuously. One reason may have been that such an addition (with BARTD funds) would make a second roadway deck (with Bridge funds) impossible, which would not only create congestion whenever the highway capacity of the bridge was reached, but would also assure the demise of the District and its Board of Directors in 1971, no new bonds being outstanding at that time. In any case, a group of consulting engineers ruled that the bridge would be unable to withstand the stresses of a two-track train deck and the live loads of the trains. Very soon thereafter they found that a four or five lane automobile deck would be possible, and, despite the unsolved problems of making corresponding additions to highway capacity at each end (the State's responsibility), the Bridge District appears determined to proceed with the second deck. BARTD, as will be mentioned below, lost interest in the Marin line at this time and did not try to dispute the Bridge District's actions.

3. Shipping and Air Terminals

These must be briefly mentioned because of recurring proposals to create a port authority which would take over all docks, airports, toll bridges, and -- possibly -- the rapid transit system. Consolidation of a welter of parallel agencies was, of course, one object, but a careful perusal of the legislation suggested that another was the application of Bay Bridge profits to harbors and airports.

4. Parking

The amount of transit patronage destined for central business districts depends to some extent on the availability of parking; little parking increases automobile times and costs and causes a shift in modal choice toward transit, and vice versa. Downtown San Francisco has a moderate amount of parking, furnished partly by private industry, and partly by a municipal parking authority. There appears to be no doubt, however, that some parts of the downtown area, especially the financial district, have a great shortage of off-street facilities. The situation is better in downtown Oakland, where considerable off-street parking has been provided by a joint effort of downtown business interests and merchants.

D. Rapid Transit Planning

1. Planning until 1952

It would take a large bookcase to hold all the reports on rapid transit for the San Francisco Bay Area. Plans have not only been oversized, but numerous. Only the more important ones can be mentioned here. The total period can be divided into four phases, the first of which, up to 1952, was typified by the fact that plans were concerned only with the city of San Francisco and, perhaps, a little area to the south. Only after 1952 was regional planning, involving the areas to the east and north of the Bay, begun.

Perhaps the first rapid transit proposal was made in the San Francisco Chronicle on July 15, 1900: the streetcars on Market Street should be placed underground. This suggestion has recurred in many plans since and has become a portion of the BARTD plan. Market Street, because of its width, location, and because of the pattern of tributary streets, has always been overcrowded, the major transit street in the city, and the obvious location for a high-capacity transit route. One of the first technical reports, prepared by the City Engineer in 1931 (Ref. 6), proposed about one mile of four-track and 1.7 miles of two-track subway for streetcars under Market Street and two diverging streets. Traffic on the four surface tracks was so heavy then that this subway was intended for only 60% of the traffic, and the remainder was to stay on the surface. The report proposed eventual extension and conversion to rapid transit trains, but no schedule for this was established. Cost was estimated at about $22 million.

In 1936 the Public Utilities Commission of the City of San Francisco*, to which jurisdiction over the Muni Railway had been transferred in 1932, proposed 8.5 miles of streetcar subway at a cost of $53 million (Ref. 7). The main axis was again Market Street -- and again there would still be considerable surface streetcar traffic. A new route proposed in a southerly direction is of special interest because it is closely followed by BARTD today. A third route would go due west in the Geary Boulevard corridor; this route also was in the BARTD plan for some time, but was dropped after the Marin route had been deleted. By this time the Bay Bridge with its interurban tracks was under construction, and the plan included a station under the Bridge rail terminal, but no direct track connections. During World War II an Army-Navy Board, charged with investigating the need for future crossing of the Bay first suggested a rail transit tube under the Bay; however, this was not in the context of a total transit plan.

In 1948 the rapid transit section of a total transportation plan for San Francisco (Ref. 8) proposed routes similar to the network of 1936. The chief difference was that the northernmost route to the west would be a tunnel for express buses and that extensive use of freeways by buses would be made. The other routes were still designed for initial streetcar operation and ultimate conversion to rapid transit. The cost estimate approached $90 million. A year later another version of this plan appeared (Ref. 4) for immediate use by rapid transit trains. A direct track connection to the Bay Bridge was shown as a "future extension." The cost climbed to almost $144 million. Several other reports or versions of this report appeared in quick succession.

The final report in the first stage of rapid transit planning (Ref. 9) was prepared at the request of the Mayor of San Francisco in response to persistent proposals and offers to build monorail systems. It analyzed the comparative merits and costs of monorail, elevated and subway rapid transit. The analysis was limited to the Market Street route, with streetcar equipment envisioned for both the elevated and subway route. The Twin Peaks Tunnel was to be used in any scheme, and the monorail was to be elevated, with three branches in the outer districts of the city. The total costs were estimated at $52.7 million for monorail, $49.5 million for subway, and $18.5 million for elevated. The monorail alternative was dismissed, but the choice between subway and elevated, or a combination of both, was left open.

2. The Rapid Transit Commission, 1952-1957

In 1949 the California Legislature passed legislation enabling the creation of a rapid transit district in the San Francisco Bay Area (Statutes 1949, Chap. 1239). While no district was ever formed, a commission was established under a 1951 amendment to this act (Stat. 1951, Chap. 1760). This commission undertook a series of technical, financial, and administrative studies. The major planning work was conducted in 1953-1955, resulting in the report "Regional

*Not to be confused with the Public Utilities Commission of the State of California which regulates private transportation and utility companies.

Rapid Transit" (Ref. 3). This plan differed from all previous efforts by studying and making proposals for the 9-county region bordering San Francisco Bay, rather than for the City of San Francisco alone. The recommendations included:

A "main-line" rapid transit system, with stations in outlying areas spaced 2-5 miles apart so that rolling stock with top speed capabilities of 70 mph could operate at overall speeds of 45 mph.

123 miles of routes, (Fig. 9.4), including a subaqueous tube under the Bay between San Francisco and Oakland. Altogether, 21 miles were to be underground, 31 miles at grade, 69 miles elevated (29 miles of this on private right-of-way, the rest over streets, freeways or railroads) and 2 miles on bridges. An alternative proposal included use of the interurban tracks across the Bay Bridge, and extensive elevated construction in San Francisco and Oakland, increasing total route length to 127 miles, and decreasing underground construction to 9 miles, mostly through hills.

Construction and equipment costs of $716.5 million for the "optimum" alternative involving more underground and sub-Bay construction, or of $586 for the "minimum" elevated version. Rolling stock and financing costs raised the total for the optimum plan to $873 million.

The routes included one from Palo Alto, just inside Santa Clara County, up the San Francisco peninsula, across or under the Bay to central Contra Costa County, another from south of Hayward in the East Bay north through Oakland to Richmond, and a third from downtown San Francisco along the northern waterfront and across the Golden Gate Bridge to Marin County. Thus five counties and a small corner of a sixth were to have direct transit service; to satisfy Santa Clara, "second stage" routes were shown from both Palo Alto and Hayward to San Jose, and for all outlying areas, including the three northern counties not involved in the first stage at all, liberal "third stage" lines were drawn on the map.

No attempt was made to analyze the economic benefits of this or any alternative system. The entire subject was dismissed in the report in a few brief paragraphs, summed up by the statement: "We do not doubt that the Bay Area citizens can afford a rapid transit; we question seriously whether they can afford not to have it." (Ref. 3, p. 3).

A report on financing (Ref. 10) investigated various sources of capital funds, since it was evident that fares would do not more than cover operating costs, costs of rolling stock and perhaps a small fraction of construction capital costs. Possible financial support from bridge tolls, taxes on real estate, a regional gasoline tax, a regional retail sales tax, and several others were studied. The final suggestion was for a real estate property tax, at a low rate over the entire nine counties and at a higher rate within the service district of the system to be built, plus a regional retail sales tax of not more than 1/2%. Additionally, bridge tolls were suggested if the transit system would postpone the need for a southern highway crossing of the Bay for some years.

The Rapid Transit Commission ceased its existence at the end of 1957, after the Legislature had established the San Francisco Bay Area Rapid Transit District (BARTD) within the five counties of San Francisco, San Mateo, Marin, Alameda, and Contra Costa. No vote of the people was required to make the district effective. Santa Clara was omitted at the request of officials from that county, and the plea by the Commission in its final report (Ref. 11) that Santa Clara give prompt consideration to annexation of BARTD went unheeded.

3. The BARTD, 1957-1962

The period of 1957-1962 saw the planning of the BARTD system, various stages of system shrinkage, and finally the successful submission of a bond issue to the voters which made construction of the system possible.

BARTD started with the Parsons, Brinckerhoff plan of 1956 and spent several years on detailed engineering and financial studies. The basic shape of the network was not altered, but some important changes in route alignment and extent took place. In San Francisco, the Marin County route was taken along the Geary Blvd. corridor (first recommended in 1936) to the Golden Gate Bridge; in north Oakland, a firm location of a future freeway permitted shifting from elevated design above city streets to at-grade alignment in the freeway median. All five routes were shortened somewhat at their outer terminals, so that by the summer of 1960 the mileage was

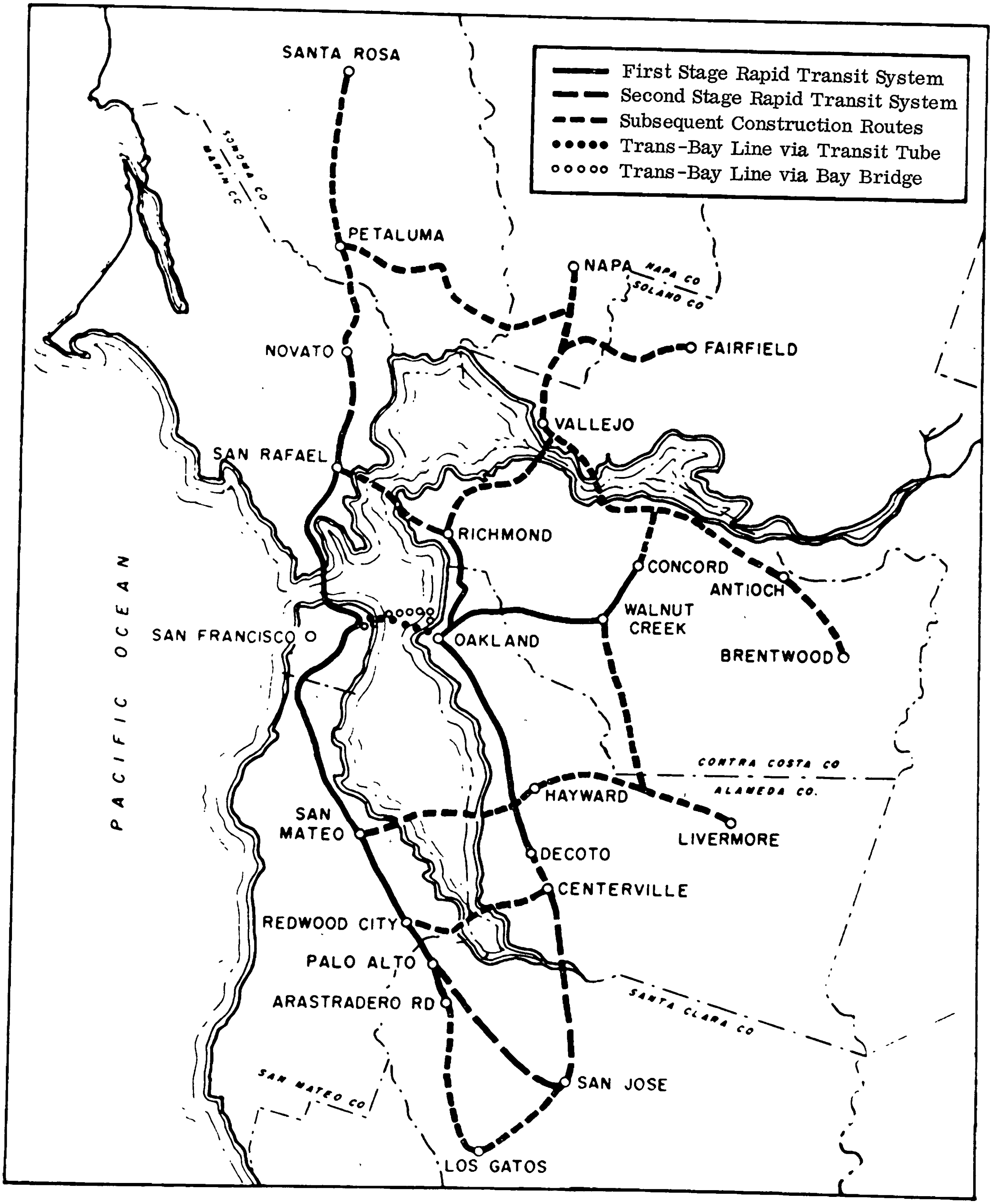

Fig. 9.4 - Rapid Transit Plan for the San Francisco Bay Area, Proposed 1956 (Ref. 11).

about 100 (compared to 121 in 1956). By 1961, four of the terminals were at their 1956 locations again, and the fifth had moved several miles south of Hayward into rapidly developing, but still agricultural territory. Mileage was up to 120 again. This plan was reported in Ref. 12.

At about this time BARTD collided with the Golden Gate Bridge and Highway District (see para. C.2 above), and found that it no longer had a convenient way to cross the Golden Gate. The Marin County line had been the least promising part of the network all along, because of the smaller population of that county and the higher construction costs in its mountainous terrain. It was unrealistic to think of constructing an underwater tube because of the enormous costs and engineering difficulties involved. (The subaqueous distance is less than across the Bay to Oakland, but the ocean floor is much deeper.) BARTD therefore began to look at a system without Marin County.

A four-county plan (Ref. 13) was prepared, with the Marin line replaced by one out Geary Boulevard to the northwest area of San Francisco. This plan was submitted as required by law, to the Boards of Supervisors of the remaining four counties for their approval. San Mateo County found good reason to be unhappy with the proposal: it already had fairly good commuter railroad service and freeway bus routes; the new BARTD route would replace this at high cost and with fewer stations; the industrial area in the northeast corner of the county would no longer be served as it is by the Southern Pacific; service to the south would terminate at the county line instead of at San Jose, thereby severing the connection between San Mateo residential cities and the electronic and aircraft industries of Santa Clara County; and -- perhaps most distasteful of all -- San Mateo's tax rate would rise while Santa Clara's would not, placing the latter county at an advantage in the competition to attract new industries. The Board of Supervisors therefore unanimously disapproved the plan in December 1961, informed BARTD that they were not interested in further proposals, and removed themselves from the district.

BARTD now decided that there was no hope for the remaining counties to support a Marin County line financially, and requested the Supervisors of that county to withdraw. This they were very reluctant to do; a cartoonist depicted the crestfallen suitor being told by Lady Bartd: "I love you -- but please GO!" After the Golden Gate Bridge directors discontinued all further feasibility studies of a rail deck -- and with unseemly haste began planning an automobile deck -- the inevitable was faced, and Marin withdrew from BARTD in May 1962. This time the suitor was shown calling after Lady Bartd, who was leaving on a rapid transit train: "I'll join you soon as I can."

Now there were three. A new plan had been prepared in early 1962 (Ref. 1) amputating the San Mateo line just beyond the city limits of San Francisco. The route along Geary Boulevard was also deleted and the streetcar subway above the BARTD tunnel on Market Street and beyond into the western part of San Francisco was substituted. Thus was the advice of a newspaper writer in 1900 heeded some 62 years later. Table 9.3 lists the most important versions of the BARTD plan for easy comparison.

TABLE 9.3 - BARTD RAPID TRANSIT SYSTEMS

	MILEAGE					
DATE	Total	Under-ground	Ele-vated	At Grade	Total Cost (Millions)	REMARKS
1956	123	21	71	31	$ 873	"Optimum" version of a 5-county plan.
June 1961	120	24	44	52	1,287	5-county plan. Route changes in San Francisco and Oakland since 1956.
Oct. 1961	103	20	40	43	1,145	4-county plan. Marin line deleted; Geary Blvd. line extended.
May 1962	75	20	31	24	991	3-county plan. San Mateo and Geary lines deleted; streetcar subway added. Officially adopted plan.
Dec. 1966	75	23	28	24	1,200 app.	Route in Berkeley underground. Cost raised by inflation and some embellishments.

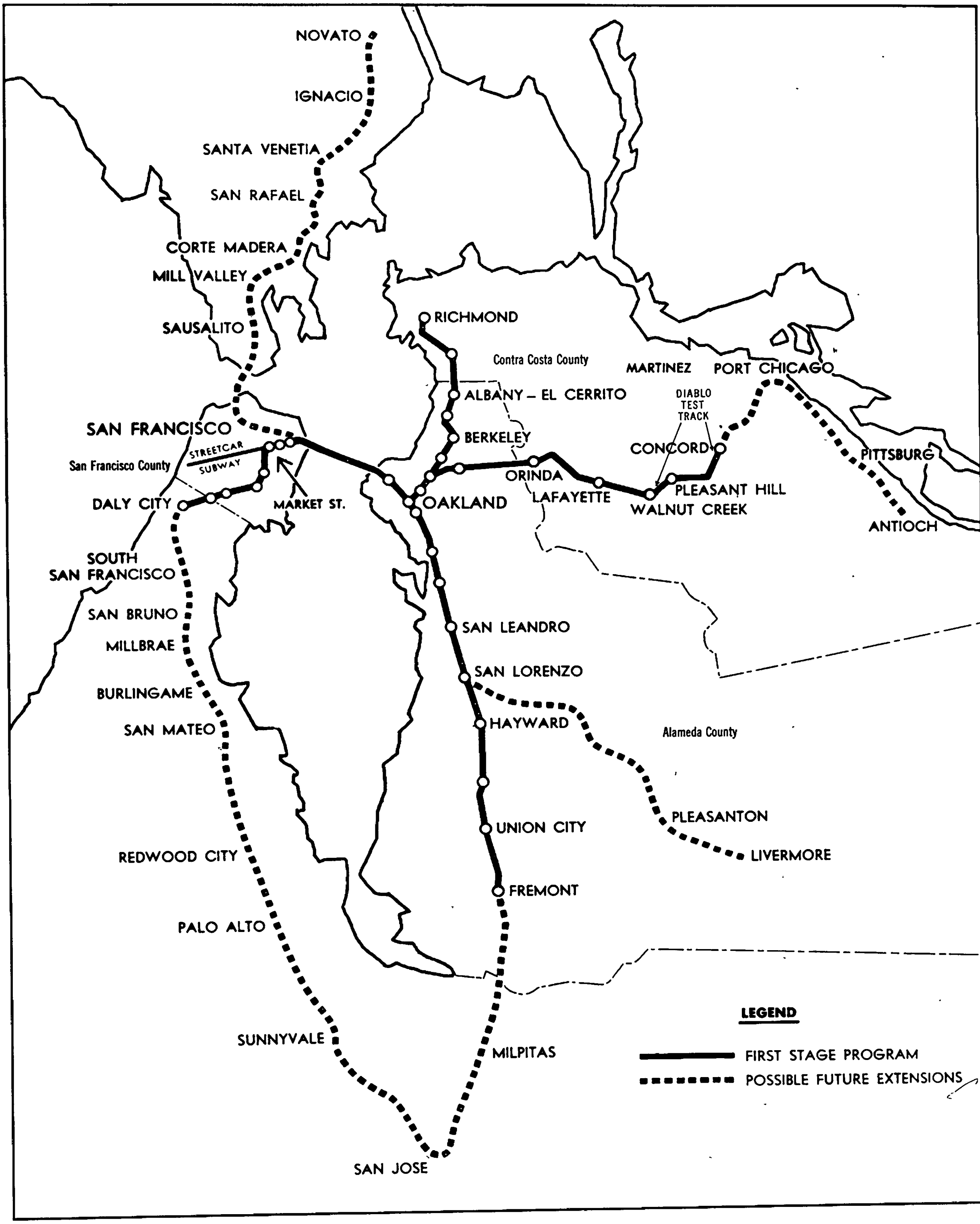

Fig. 9.5 — Rapid Transit Network adopted 1962 in the San Francisco Bay Area.

Rapid transit planners found themselves in route location conflicts only too familiar to freeway engineers. The public seemed to want rapid transit, but preferably underground, or in someone else's neighborhood. Cities worried about the loss of taxable real estate and the adverse effects of elevated alignments on property values. The following two examples illustrate the types of problems which had to be dealt with.

a. The city of Albany, population 18,000, with little industry except for a race track, much government-owned real estate paying no taxes, lies in the path of the Oakland-Richmond line. Fearful of losing some of the tax base left to it, the city strenuously opposed the alignment and the location of Albany station and its parking areas, proposing instead a route along the shore of the Bay. Immediately to the south, the city of Berkeley heatedly protested Albany's suggestion, because such a change would add to its loss of taxable real estate. The route was finally left in its original location, but the station was shifted north into neighboring El Cerrito. While this reduced the land to be acquired within Albany, it also decreased the usefulness of the system; Albanians will have to walk, drive or take a bus into an adjacent city before they can board a BARTD train.

b. In another conflict (which was not settled until 1964) BARTD had a change of mind. Its official plan, as approved by the voters, showed the Richmond station west of the downtown area. Further study indicated that a location along the Southern Pacific Railroad east of, and slightly further from downtown, would save in route length and cost, would lead to a preferable location for a yard and shop area, and would be a more logical point from which to build an extension in the future. BARTD therefore proposed this change to the city officials and found them almost evenly divided on the alternatives. Downtown interests wanted the station to remain where it had been planned, feeling that the new location would be of less benefit to them. Some city officials preferred the new alignment because BARTD would provide grade separations of several important arterials under the Southern Pacific at no cost to Richmond. After much debate and threats of lawsuits (which never materialized) the new location was finally approved by the city council, and the BARTD plan was amended accordingly.

In the summer of 1962 the plan was submitted to the Boards of Supervisors of the three counties. San Francisco and Alameda Counties gave their approval unanimously, but the Contra Costa Board provided a dramatic climax when two supervisors announced they were for the plan, two that they would oppose it, and one that he had not yet made up his mind. On the morning of the crucial vote, the mayors of San Francisco and Oakland and the president of BARTD's Board of Directors journeyed to the county seat to have breakfast with the undecided supervisor. Their persuasiveness prevailed, and that afternoon the necessary approval from all three counties had been obtained. A special bond election was called to coincide with the general election of November 1962.

The proposal before the voters was to approve the issuance of general obligation bonds in the amount of $792 million to construct a transit system of 75 miles. An additional $133 million was already allocated from Bay Bridge toll funds to cover the cost of the transbay tube and approaches. $66 million in revenue bonds were to be issued later for rolling stock acquisition. The system is shown in Fig. 9.5.

The impact of the proposed indebtedness on the debt structure of the area can best be described by the figure of all other oustanding obligations of the three counties, their cities, school districts and other districts at the time. This figure, in 1961, stood at $635 million gross, of which $224 million were self-supporting bond issues and $411 million net debt. The BARTD issue was therefore almost twice the sum of all other net debts of the governmental agencies in the district.

A citizen's committee supporting the proposal carried on a well-financed and efficient campaign, while opposition was scattered and only became extensive shortly before election day. The outcome of the vote showed 61.2% of the voters in favor of the bond issue. Since the State Legislature had lowered the initial 2/3 majority requirement of the district to 60% (Stat. 1961, Chap. 1622), the result was decisive, and the project became a reality.

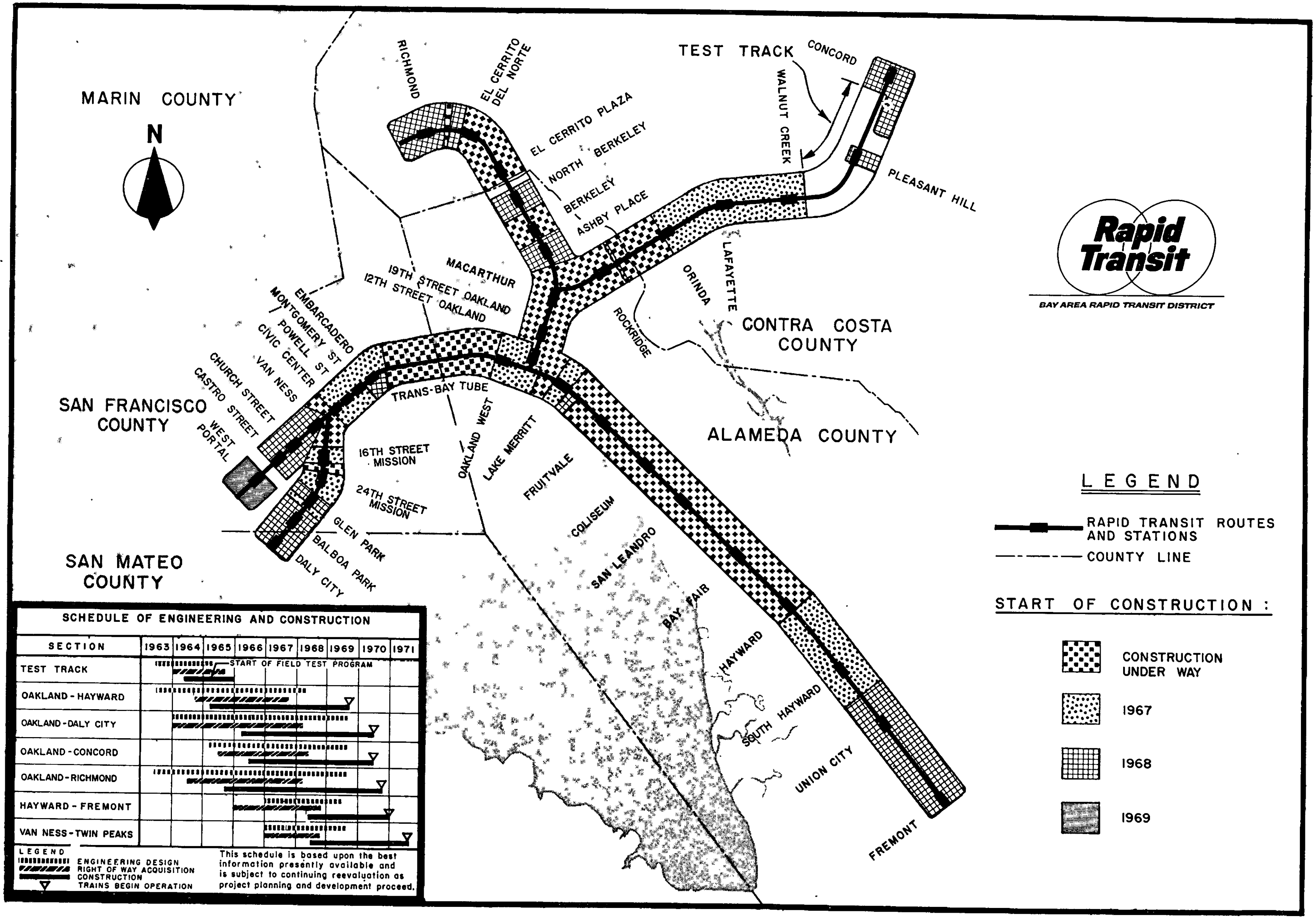

Fig. 9. 6 — Status of construction of rapid transit system in the San Francisco Bay Area, June, 1967.

4. The BARTD, 1962-1967

The first eight months after the election were wasted as a result of an unsuccessful taxpayers' suit challenging the legality of the district and of the election. (Attempts were made as recently as 1964 to gather enough signatures for an election to dissolve BARTD, also without success.) Detailed planning and design resumed in the summer of 1963, and ground was broken in the spring of 1964. The main events since then have been:

1964-65:	Construction of the first route segment for use as a test track.
1965-66:	Operation of the test track under federal mass transportation demonstration grants for research into components of rolling stock, fixed facilities, and automation (see Chapter 7).
Feb. 1965:	Start of the first major construction contract, the tunnel under the Berkeley Hills between Oakland and Orinda.
Apr. 1966:	Start of the largest construction contract, the transbay tube ($89.9 million).

As of June 30, 1967, about 44 miles of the system were completed or under contract at a cost of about $380 million. Except in the test track area, these costs are only for basic structure; contracts for stations, track, power distribution, etc., are still to be let. Fig. 9.6 shows the areas where construction is in progress.

Detail design has been a major effort, involving numerous engineering and architectural firms. Some confusion has inevitably arisen, and criticisms have been made on many points. Some local officials complained that they never got to talk to the same engineer twice about the same problem. Architects chafed under the restrictions put upon them by engineers, and engineers resented limits established by architects. A newspaper, having at that moment no freeways to battle against, attacked BARTD in an extensive series of articles for miscellaneous shortcomings in concept, design, and performance, and for the high fees being paid to the consulting engineers.

By early 1966 it became eivdent that the engineer's estimates of construction costs and inflation effects had been woefully inadequate. This was partly due to not fully explained additions made by the engineers after 1962, as for example a fourth track and longer mezzanines in downtown Oakland. In this instance, contractors' bids were so much above the available funds, that they had to be rejected, and a redesign had to be undertaken to revert to the original standards. BARTD also learned from this particular experience that, wherever possible, contracts should not be advertised in such large units ($50 million in this case) that only a few joint ventures of contractors could enter the bidding. This job was divided into four segments, which were bid at reasonable prices by a larger number of competing contractors.

Elsewhere, the City Council of Berkeley had some time before the 1962 election asked that the route through its city be entirely underground. BARTD had always shown only about 3/4 mile of route in the downtown area to be underground, including the central Berkeley station. The remainder of the route (2.75 more miles within the city) south and north of this tunnel, including two other stations, were indicated as being on aerial structure except at the transitions from underground to aerial. In the 1962 election campaign, the city council endorsed the bond issue anyway, but afterwards resumed its demands for complete burial of the line. BARTD pointed out the extra expense of this, especially if, should they grant Berkeley's request, other cities would insist on similar treatment. For some months the arguments revolved around the extra costs of underground versus aerial construction; the city employed consulting engineers who produced much lower estimates of the additional costs than BARTD's figures, and lengthy hearings with all the paraphenalia of a court trial took place.

The city and BARTD finally agreed that, first, BARTD would prepare alternate designs for underground and aerial construction of an additional 1,550 feet south of the originally planned tunnel portal, and 2,300 feet beyond the north portal, the City of Berkeley being required to pay the extra engineering design costs involved.

Next, alternate bids were requested and opened in July 1966. The City then called an election to ask the approval of the voters for any of three alternates: a) construction of the BARTD proposal; b) construction of the additional underground sections, known to cost an extra $3.6 millions, with city bonds to pay one-half of this amount and a federal grant promised for the other half; or c) commitment by the city to pay for underground construction of the entire line within the city limits at an extra cost of about $24 millions -- $20.5 millions of which to be local bonds and the remainder a federal grant. The voters by an overwhelming margin approved alternate c, and the creation of the necessary special service district to issue the local bonds. This decision requires additional redesign, and delays construction of this section of the system for an additional year.

Inflation and other additions to the system standards have raised to total project cost by from $100 to $250 million above the 1962 figure. Of this increase, $47 million have been made available by the State Legislature from toll bridge funds. The 1967 session of the California legislature considered several alternatives for raising some or all of the additional financing needed to complete the system. These included an increase in the in-lieu tax on motor vehicles in the three counties from 2 to 2-1/2% of assessed value, an increase of tolls on the San Francisco-Oakland Bay Bridge by 10¢, and imposition of the state sales tax on motor vehicle fuels. (Some of the bills were to be equally applicable to other transit systems in California.) However, none of the legislation passed for various political reasons. As a result, BARTD suggested that only 57 miles of the systems be built at this time, and that even on this portion some of the stations would have to be omitted. The deletions were carefully chosen to hurt all sections of the area somewhat, and thus to rally all local interests to the aid of BARTD in the next session of the State Legislature. However, the Board of Directors of BARTD then adopted a policy of continuing construction of the entire network until money runs out, even if this means that none of the system can be operated. Again, the hope is to force local support of the next attempt to obtain financing through state legislation.

Another source of additional revenue is further grants from the federal mass transportation program. One such grant, for $19.3 million, has already been awarded, but is for an addition to the system -- the construction of open plazas and new streets at two of the downtown San Francisco stations, and to lengthen the mezzanines at these stations. On the other hand, a request for federal aid to add a station near the foot of Market Street, where the Transbay Tube reaches San Francisco, has been denied. The omission of a station at this rather obvious location (adjacent to the huge Golden Gateway redevelopment project and to many existing office buildings) was probably because the State Legislature, in originally granting and loaning toll bridge funds to BARTD, specified that these could only be used on the transbay tube and its approaches to the <u>first</u> station on each side of the Bay. Not by accident, therefore, the first station on the San Francisco side was located 0.6 miles inland from the Bay front. Now that the Legislature has amended the law to specify that the funds can be used to a specifically named point, BARTD is no longer averse to having another station close to the Bay, especially if paid for by the federal and city governments.

Until the California Legislature acts on proposed aid to BARTD in 1968, and until the total federal-aid program for mass transportation in the next few years has been enacted by Congress and the amount likely to be available for the BARTD project is known, the final cost of this system cannot be estimated. It is likely, however, that it will be between $1,100 and $1,200 millions.

5. <u>Statistics of the BARTD System</u>

The following specific data on the rapid transit system now under construction were given in the official report to the Boards of Supervisors and the voters (Ref. 1).

a. <u>Basic concepts and standards</u>: Operating speeds of about 45 mph; equipment capable of top speeds of at least 70 mph. Service as frequently as every 90 seconds in peak hours to provide a capacity of 30,000 seated passengers per hour; off-peak service, except late a night, at least every 15 minutes. System must be safe, dependable, comfortable, penetrate major centers of business and commerce, have low external noise levels, be aesthetically acceptable.

b. <u>The rapid transit car</u>: The prototype car is 67 feet 3 inches long, 10 feet 5 inches wide, seats 76 passengers, has unloaded weight of 800 lbs per passenger, will be powered electrically, either by d.c. or a.c.

c. <u>Train control and automation</u>: Complete automation of all train movements. Automatic fare collection system, so that fares varying with length of trip can be readily administered; possibility of charge-account system.

d. <u>Stations</u>: Stations in suburban centers to have parking facilities and provisions for feeder buses. Downtown stations to have full-length mezzanines.

Station spacing averages 2 miles overall -- more in outlying areas, much less in downtown San Francisco and Oakland.

e. Construction Costs:

Tracks and Structures	$347,222,000
Stations	101,413,000
Yards and Shops	10,801,000
Electrification	49,514,000
Train Control	17,539,000
Utility Relocation	36,496,000
Engineering and Charges	56,297,000
Right of Way	74,818,000
Contingencies	69,411,000
Inflation	152,702,000
Total	$916,213,000
Pre-Operating Expense	7,000,000
Grand Total	$923,213,000

f. Rolling Stock Costs: Total of 450 cars at an average cost of nearly $160,000 are required, though some of these will not be needed until after 1972, when their cost can be financed from net revenues on the system. Thus, a revenue bond issue in the amount of $65,760,000 is planned to acquire about 410 cars.

g. Fares: Minimum 25¢ for up to eight miles (3.1¢ per mile at 8 miles); above this at a rate decreasing from 3.2¢ per mile at 8 miles to 2.25¢ per mile for the longest trips, plus an additional 10¢ for any trip crossing the Bay. Maximum fares for longest trips are $1.00 (Daly City-Fremont and Concord-Fremont); typical fares to downtown San Francisco are 25¢ (from Daly City), 35¢ (from downtown Oakland), 50¢ (from Berkeley and East Oakland), 65¢ (from Hayward, Richmond Lafayette), and 80¢ (from Concord). For trips within San Francisco these are 10¢ more than the Muni fare; for trips in the East Bay they are roughly the same or slightly lower than present fares, except that they are higher than the commute rates on Greyhound in Central Contra Costa County.

h. Patronage: Patronage was estimated at 72.7 million passengers in fiscal 1971-72 (the first year the system was to be fully opened) rising to 81.1 millions in fiscal 1980-81. This does not include passengers on San Francisco's streetcar routes.

i. Estimated Application of System Revenues: The following figures are for the first and tenth fiscal year in which the system was expected to be completed.

	Fiscal 1971-72 (add 000)	Fiscal 1980-81 (add 000)
Gross fare and concession revenues	$22,571	$25,788
Operating and maintenance expenses	12,589	14,074
Debt service for revenue bonds (for rolling stock)	3,462	6,612
Reimbursement to Toll Bridge Authority	3,420	3,420
Balance of Revenues	3,100	1,682

This balance will, in part, be applied for additional purchases of rolling stock and renewals and replacements of system components. If any money is still available, it will be applied to retiring the general obligation bonds, but this is not assumed to happen in the following figures.

j. Annual Costs to be Paid from Taxes: The entire capital costs of the system (except rolling stock and the transbay tube) are to be borne by real estate taxes. The following figures indicate the amounts involved in the first and tenth year of full operation.

	Fiscal 1971-72	Fiscal 1980-81
Total bond service (in thousands)	$38,590	$48,441
Estimated assessed value (millions)	5,452	6,842
Tax rate per $100 assessed value	67.3¢	70.8¢

Because of new real estate assessment procedures enacted into law by the State Legislature in 1966, the above figures for assessed value and tax rate may change. However, the actual dollars paid per market value of real estate is likely to remain the same.

For comparison, it may be noted that real estate tax rates in 1961/62 in the three counties averaged $8.76 per $100 assessed value. The BARTD tax burden will therefore represent something in the range of 5-7% of total real estate taxes in the 1970's, assuming a general rise in other local tax rates.

E. Some Current Problems

1. Final Design Decisions and Community Relations

Some problems of final design have taken several years for solution (see the discussion of the Berkeley alignment problem in para. D.4 above), and others have still not been finally solved. Two examples will suffice to indicate the type of problems still being dealt with as of the beginning of 1967.

a. "Bare necessities" or "frills"? At the outset, BARTD's policy had been to design a system which would compete with the automobile not only in speed but, to some extent, in comfort and aesthetic appeal. Architects have played a major -- if not always decisive -- role in the preparation of plans. (see Architectural Forum, June 1966) Some of the aesthetic embellishments envisioned include sunken plazas at major downtown San Francisco and Oakland stations, above-average station interiors, landscaping under aerial structures, and luxurious vehicles, including carpeting, air conditioning, and a detachable streamlined pod for the two end cars of a train (partly for aesthetic reasons, but also to reduce the number of train control units to two per train of any length rather than one or two per vehicle).

As so often happens, actual construction costs are turning out to be higher than estimates, and aesthetic "frills" were scrutinized as one possible economy. Some of these have been eliminated in, for example, reducing the length of station mezzanines in downtown Oakland after first construction bids were so high that they had to be rejected. For others, such as landscaping, federal aid has been obtained. Decisions are yet to be made on the amount of aesthetics which BARTD will be able to afford in its rolling stock.

The proposed redesign of two major stations in downtown San Francisco, replacing the proposed clear-span mezzanine areas with cheaper layouts which include rows of columns through these pedestrian areas, has met with strong opposition from the Board of Supervisors of San Francisco. This issue is particularly sensitive, since the Supervisors gave in to earlier demands that the subway in this area be placed as close to the street surface as possible for aesthetic reasons (openings to the sky) and to reduce stair and escalator lengths to a minimum. BARTD prefers a deeper alignment to minimize costs of relocating utilities, and won its point, but, in doing so, showed architectural drawings of the clear-span station mezzanines. At the beginning of 1967 the Supervisors "vetoed" any lesser design, but this veto has no legal force, and it is difficult to see how they could prevent BARTD from downgrading the design. On the other hand, BARTD is interested in maintaining good relations with all local governments, and especially with the largest one which will also be asked to cooperate with BARTD in its future Muni Railway operations. It is therefore possible that BARTD will look for a compromise solution within the very short time available to do so.

b. Community social values: A general community social value problem has been the lack of reimbursement for those displaced by BARTD to relocate. While land owners receive fair market value for their properties, they do not get relocation costs, nor do their residential or business tenants. After some threats of protest action, the State Legislature amended BARTD's enabling act to provide for relocation payments effective late 1966, but not retroactively for the two-thirds of the affected persons and businesses which had already been removed.

An example of a specific problem is in the City of Richmond. The older part of this city has always disliked the way in which two transcontinental railroads divide it into several pieces, including the "iron triangle" which includes the central business district. The railroads are either at grade with few grade crossings (each a major traffic bottleneck) or on fill, again with few opportunities to cross via underpass. BARTD's route into Richmond follows first one, then the other railroad, essentially at the same grade as already existing. However, BARTD early agreed to convert three grade crossings to grade separations of both its own and the railroad's tracks. The problem arising is that BARTD will have to fence its entire right of way, when at grade or on fill, to prevent pedestrian trespass and possible electrocution. Many persons now cross the railroads at will, trains being few. The new fence has, therefore, become a symbol of a new barrier to an already badly divided city. Many citizens demand that BARTD build an aerial structure instead of fill, so that the route can be crossed at any point. This would involve added costs, which the City of Richmond, unlike Berkeley in a different situation, has not indicated willingness to pay. The threat of a civil rights-type action by a citizen's group is an added factor in this unresolved dispute.

2. Integration of Local Transit:

BARTD's enabling legislation does not permit it to operate local transit routes. Its entire design, however, is based on coordination with feeder transit routes at outlying stations. The following is a partial list of the problems raised by this:

a. Where a local transit system exists (San Francisco Muni, A. C. Transit), will this feeder service be furnished? Note from Chapter 4 the problems of making feeder routes pay. In fact, will the Muni and A. C. Transit willingly give up routes which might compete with BARTD? In San Francisco, because of congested streets and freeways, Muni competition is unlikely; but some portions of the East Bay might as quickly be served by A. C. Transit directly to San Francisco, as by taking passengers to a connection with BARTD. -- Will there be any joint fares or transfer privileges between BARTD and the feeder system? If so, how will revenues be divided?

b. Where a local transit system does not exist -- as is the case at five important outlying stations on the Concord line and at two on the Fremont line -- who will provide such service? Would A. C. Transit be willing to expand its territory to engage in unprofitable feeder business? Would BARTD be willing and legally able to subsidize a feeder operator?

These are problems assigned to the "Northern California Transit Demonstration Project," (which covers no more of Northern California than BARTD and "demonstrates" nothing) to prepare recommendations for answering some of the questions raised above.

TABLE 9.4 - DECISION MAKERS ON TRANSPORTATION POLICY IN THE SAN FRANCISCO BAY AREA

Agency	Responsibilities for Urban Transportation Facilities
Federal Government	
Department of Transportation, Bureau of Public Roads	Federal-aid highway program.
Department of Housing and Urban Development	Federal-aid mass transit program; federal-aid for land use planning.
U. S. Army Corps of Engineers	Location of bridges across the Bay.
State Government	
Department of Public Works, Division of Highways	State highways, including freeways.
Department of Public Works, Division of Bay Toll Crossings	Toll bridges (design, construction, operations).
California Toll Bridge Authority	Toll bridges (policy).
Public Utilities Commission	Regulation of privately-owned transit systems.
Port of San Francisco	Streets adjacent to San Francisco docks.
Regional Agencies	
Association of Bay Area Governments (9 counties, voluntary membership)	Land use planning in comprehensive transportation planning process.
Bay Area Transportation Study Commission (9 counties)	Transportation planning in comprehensive transportation planning process.
Bay Conservation & Development Commission (9 counties)	Planning Bay shoreline, with veto power over most projects involving filling the Bay.
BARTD (3 counties)	Rapid transit.
A. C. Transit (portions of 2 counties)	Local mass transit.
Golden Gate Bridge & Highway District	Golden Gate Bridge.
Local Agencies	
Counties (8 in region)	Land use planning; highways in unincorporated areas.
City-and-County (San Francisco)	Land use planning; streets; mass transit*
Cities (about 90 in region)	Land use planning; streets. (Mass transit in Santa Rosa.)
West Bay Rapid Transit Authority	Transit planning in San Mateo County. Possible operations or merger.
Marin County Transit District	Transit planning in Marin County. Possible operations or merger.

*Through its semi-autonomous Public Utilities Commission.

3. Consolidation of Transit Agencies:

There are probably some optimists who hoped that the creation of BARTD might be the first step toward a single, regional transit agency. If so, their hopes are unlikely of realization. As mentioned earlier, the initial 6-county district envisaged by the Rapid Transit Commission emerged from the State Legislature as a 5-county district, and was reduced to 3 counties by the defection of San Mateo and the dismissal of Marin County. Both these counties have since formed transit districts of their own. There are also imposing difficulties in the way of amending BARTD's legislation so that it might take over the Muni and A. C. Transit. The Muni's financial and physical condition do not make it an attractive acquisition to the taxpayers of the East Bay counties. Its current subsidy is over $6 million annually; this could, of course, be reduced by a substantial fare raise, but this would make the new owners unpopular at the very start. Muni employees, enjoying the special wage arrangements under the city charter, would hardly wish to leave this shelter for more normal management-labor conditions.

A. C. Transit might, perhaps, be less difficult to merge into BARTD, but East Bay citizens would hardly agree to have their local transit system partially under control of San Francisco, when the present policies and management are eminently satisfactory to them.

4. Coordination with the Other Transportation Policy Makers.

This problem of the present and the indefinite future is best illustrated by a listing of governmental agencies responsible for decisions which affect transportation in the Bay Area (Table 9.4). If quasi-public agencies and citizen groups making recommendations on such policy were added, the list might well be twice as long.

However, coordination is essential and, in several instances, has been smooth and fruitful. One particularly happy example is the joint planning of BARTD and the California Division of Highways, which has made the joint use of right-of-way for both freeways and rapid transit possible in several portions of the system. Four different route segments are involved; each problem was of a different nature. The manner in which each was dealt with is described below. (Ref. 14)

a. BARTD alongside an existing freeway. In the southern section of San Francisco the BARTD route crosses under a recently completed interstate freeway and then parallels it for some 3.5 miles. An agreement is being worked out; it is expected that this will provide for BARTD to bear all costs of any necessary alterations or reconstruction of existing highway facilities, to pay the Division of Highways reasonable value for any right-of-way or easement and a negotiated sum representing BARTD's benefits and savings from the prior construction of the highway, to pay any increase in highway maintenance costs caused by BARTD's presence and to hold the highway agency harmless from any claims by reason of BARTD's use of the highway right-of-way.

b. BARTD in the center of an existing freeway. Between Orinda and Walnut Creek the BARTD alignment is in the median of an existing freeway for 6.5 miles. Portions of the freeway are 4 lanes, others 6 lanes wide; ultimate expansion to an 8-lane freeway throughout was envisioned, but not programmed for probably 10 years. An agreement here was negotiated which provides, among other items, payment by BARTD of all costs to move one existing roadway and place tracks in the widened median and a negotiated sum to cover BARTD's benefit from the prior existence of the highway. The cost of expanding the highway to 8 lanes will be borne by the Division of Highways eventually, but, because of lack of immediate funds, BARTD will pay this cost intially and will be reimbursed at a later date. The total cost of this work will be about $30 million; the Division of Highways estimates it will save $5 million by permitting BARTD to share its right-of-way and will have an expanded freeway several years earlier than planned. BARTD's savings over the alternative of finding another alignment must be even greater, but were not estimated.

c. BARTD and new freeway planned jointly. In north Oakland, the BARTD alignment is in the median of a new freeway for 3.5 miles through a densely developed urban area. Any alternate BARTD route would have had to include some tunneling and some aerial sections over streets; it is estimated that BARTD is saving anywhere up to $75 million by availing itself of the freeway right-of-way. The start of freeway construction was delayed 30 months because of the changes in design, but construction will be done in larger sections and will be completed almost on schedule. The agreement in this instance provided that BARTD pay the fee value of right-of-way occupied by its facilities plus a percentage of the cost of slope areas and clearance to the freeway fence, one-half of the costs of frontage roads, landscaping and fencing, a proportionate share of utility relocation and all of the construction attributable to BARTD only. BARTD also paid for lost engineering costs and for engineering done by the Division of Highways for BARTD. The total cost of this freeway-plus-transit section will be about $41 million (not including land), and the savings to the Division of Highways have been estimated at between $5 and $6 million.

d. BARTD parallel to a future freeway: Two sections of the route south of Hayward, totalling about 4.5 miles, parallel a future freeway, the alignment of which has been established, but plans for which are not yet complete. An agreement will be negotiated for BARTD to purchase and hold some of the common right-of-way (in lieu of paying severance damages) and to effect a railroad relocation necessary for both the transit and the freeway alignment. The State will later pay a share of the costs involved.

Altogether, about 18 miles of joint alignment are involved. In addition, four major transit stations will be located within the freeway median, and three immediately outside the freeway right-of-way. There will also be several points at which tracks cross one or both roadways of a freeway.

5. Civil Rights

BARTD is finding itself in the middle of a dispute, common in the U. S. today, between civil rights groups and construction labor unions who are alleged to discriminate against racial and national minorities in their admission to membership. In the Bay Area the focus of the protests is BARTD (although one may wonder why the much larger construction activities of the Division of Highways, for example, have escaped the attention of this movement). It was the announced intention of the protestors to halt construction of the BARTD system if their demands re union membership practices were not met. BARTD appears to be sincerely trying to settle the legitimate grievances involved, but, since it deals with contractors rather than unions, it is not clear what can be accomplished. It has been suggested that BARTD train members of minority groups in construction skills, but BARTD argues correctly that its legislative mandate does not include operation of trade schools.

6. General Criticisms

Some specific criticisms of BARTD have already been mentioned. More generally, there are a number of adverse viewpoints of the system being built which deserve mention.

a. The system is too costly. The enormity of the expenditure of over one billion dollars for just one component of the total transportation system, to ease peak hour problems while contributing little to off-peak transportation, is pointed out. Costs have not been fully justified in relation to benefits or alternate transportation solutions. No study has been made whether such a huge amount of the area's financial resources should be allocated to transportation at all, or whether other public programs need these monies more urgently. It is also felt that the vast new indebtedness will affect the credit ratings of the local governments, and that these will have more trouble gaining the voters' approval of future bond issues and will pay higher interest rates if they do.

b. The system will fail. These critics predict that the system will attract so little patronage in its automobile-oriented surroundings that it will neither solve any transportation problems nor have any salutary effect on land and use, and that, therefore, it is a waste of money at any price.

c. The system is no substitute for freeways. It is probable that some citizens of the Bay Area felt that a vote for BARTD was a vote against freeways (Ref. 15, p. 33). Critics state that the BARTD system will solve none of the freeway and bridge disputes which are current or temporarily dormant in the area. They are quite correct, but it must be pointed out that neither BARTD nor its engineers ever claimed that they would make the controversial automobile facilities unnecessary. They did estimate that another Bay crossing could be postponed for perhaps as much as a decade because of the amount of traffic which will be diverted to BARTD, and they said that, while all presently planned freeways would still be needed, some as yet unthought-of ones might not.

d. The system is obsolete. These critics, however, disagree on what constitutes current technology. Some advocate monorail; others automated freeway buses, helicopters or hovercraft, or individual transportation units such as the StaRRcar.

e. The system is for the rich. It is pointed out (correctly) that BARTD's network connects the c.b.d.'s of San Francisco and Oakland with suburban cities while passing through residential areas of the central cities at great speed with only few stops. Critics say that downtown employment for unskilled workers has almost disappeared, as manufacturing, wholesaling, and similar activities have decentralized, and that the suburbs served have housing only for middle and upper income families. Thus, the poor will receive no service either at the places where they might find work nor in their residential neighborhoods. It is also suggested that BARTD presents a new stimulus for a flight to the suburbs by those able to afford living there, turning the central cities more and more into ghettos of the poor.

There is considerable validity to this point of view, and the criticism was even more deserved when routes were proposed to serve the wealthy towns in San Mateo and Marin Counties. Even the streetcar routes within San Francisco, for which the improvements along Market Street are being made, radiate into well-to-do neighborhoods, and an earlier proposal to extend these routes into Chinatown and North Beach (Ref. 4), the areas of highest population density in the city, was never considered by BARTD. Where routes do pass through areas of lower-income housing, as in West and East Oakland, the station spacing is so great that few residents can use BARTD without an available car or a feeder bus (at additional fare?).

The causes for this are political. BARTD's legislative mandate reflects the forces which have been influential in the Bay Area (as they have in many metropolitan areas) for many years; the independent suburbs, always suspicious of the central cities and determined not to be controlled by them for fear of having to help solve their problems; the downtown interests, trying to maintain their economic status while their employees, clients and customers move ever further outward; perhaps even the land speculators and subdividers on the fringes of urbanization.

f. Also heard: The system is not responsible to the people; its directors should be elected, not appointed. The system does not meet the test of the market place; if it cannot be built entirely out of funds provided by the users, it should not be built at all.

7. General Praise

On the other hand, the BARTD project is considered by many as most praiseworthy undertaking.

a. The system is a technological breakthrough. Thanks to the federal-aid demonstration projects at the Test Track, the first thorough research into new developments of railroad hardware in several decades is being conducted, and BARTD will be the first beneficiary of it. The rest of the transit and railroad industry will gain from the results.

b. The system fits in the automobile age. It is the second system (after Cleveland's smaller one) to be designed to take advantage of the complimentary capabilities of rail transit and the automobile. Its trunk line speeds and standards of comfort are competitive with those of car travel.

c. The system will reduce urban sprawl. The high capacity of rail transportation will permit high densities of land use along its routes, rather than continuation of low density development in all directions. This comment is not accepted unanimously. Some disagree by doubting that the system will have as strong an influence on land development as other, older factors (primarily the highway system) do. Others ask why, if this were an objective, the BARTD lines extend into presently agricultural and orchard lands, presumably bringing urbanization with them?

d. The system will reduce highway congestion. There is little doubt that certain key links in the highway network will experience some reduction in peak hour trips, especially the Bay Bridge and its approaches. The extent of this reduction is yet to be measured.

e. The system will preserve downtown values. This is also yet to be determined. Neither San Francisco nor Oakland downtowns were suffering much in recent years. Even before BARTD was a positive fact, new skyscrapers were being built in both cities.

There is certainly no question that more than average imagination and daring has been shown in the conception of this project. The effects and impacts which the system will have on the metropolitan area when it is in operation will be carefully studied everywhere for guidance toward the solution of urban transportation problems.

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10. CASE STUDY: CLEVELAND
MASS TRANSIT PLANNING IN AN ACTIVE OPERATION

DONALD C. HYDE

A. Descriptive Background

1. Area Served

The Cleveland Transit System, owned by the city of Cleveland, is the dominant transit system serving Metropolitan Cleveland. In addition to serving the city, this system (also referred to as CTS) provides urban transportation to 39 nearby suburban communities, of which 29 are served in whole or substantially in whole and 10 in part.

The area served is located mostly in the northern half of Cuyahoga County and to a small extent in the northwest corner of Lake County. It covers approximately 140 square miles and has an estimated present (1967) population of approximately 1,637,000. As in other metropolitan areas, population growth in metropolitan Cleveland during the past two decades has been greater in suburban communities than in the City of Cleveland. Population growth by decades since 1910 and estimated growth in the future to 1980 are shown in Table 10.1. The figures from 1910 to 1960 are from the U. S. Bureau of Census, and the estimates for 1970 and 1980 were made by the staff of the Regional Planning Commission for Cuyahoga County.

TABLE 10.1 - POPULATION AND POPULATION INCREASE BY DECADE FOR CUYAHOGA COUNTY, CITY OF CLEVELAND, AND SUBURBAN COMMUNITIES FOR 1910-1980.

Year	Cuyahoga County Population	City of Cleveland		Suburban Communities	
		Population	% of Total	Population	% of Total
1910	637,425	560,663	88	76,762	12
1920	943,495	796,841	84	146,654	16
1930	1,201,455	900,429	75	301,026	25
1940	1,217,250	878,336	72	338,914	28
1950	1,389,532	914,808	66	474,724	34
1960	1,647,895	876,050	53	781,845	47
1970	1,875,000	850,000	45	1,025,000	55
1980	2,165,000	835,000	39	1,330,000	61

Metropolitan Cleveland spreads in a half circle along the south shore of Lake Erie, with the central business district near its center and close to the Lake. This is noted because it requires longer radial transit routes to serve a given population and density which radiates in a half circle from the c.b.d. than if the population were spread in all directions from the c.b.d.

The service area is divided by the Cuyahoga river and valley. All west side transit trips must cross this valley in getting to and from downtown, further adding mileage to the radial routes serving people living on the west side.

2. Physical Characteristics of the System

CTS has kept abreast of the growth in population and expansion of housing and industry in the suburban areas by yearly adding new lines and extending old ones. It operates 76 bus routes with 21 branches. For the year ending December 31, 1966, route and vehicle miles were:

	Route Miles	Vehicle Miles operated
Rapid transit	14.92	4,197,733
Motor coach	714.55	27,567,937
Subtotal	729.47	31,765,670
Chartered miles		659,172
Special mileage*	181.79	
Total	911.26	32,424,842

*Special bus service to schools and industrial plants.

Revenue vehicles at the end of 1966 numbered 1,023, consisting of 935 buses and 88 rapid transit cars. CTS took delivery of new buses every year from 1945 through 1965. Of the 935 buses, 427 are "new look" modern coaches made available to the industry in recent years. Sixty more new buses and 20 rapid transit cars are on order, with delivery scheduled before the fall of 1967.

Buses are housed and serviced at four operating garages, all of them new since CTS took over the system. A new maintenance building for rapid transit cars was opened when rapid transit was started in 1955. Bus maintenance facilities were moved into more modern efficient quarters in the late '40's. Another move planned in the very near future is to build a completely new modern overhaul garage and shops on property already purchased adjacent to the new $2.25 million storage and service garage opened on Woodhill Road in late 1966.

Eight automatic substations serve the rapid transit line. All of them are new since the advent of the rapid transit, with the last three of them put in service in 1965. Additional new substations will be built as a part of the project extending the rapid transit to the airport.

3. Ownership and Control of the System

In the early 1900's, Cleveland was a battleground for ownership and control of local transit lines. Tom L. Johnson, mayor of Cleveland 1901 - 1909 and principal owner of some of the transit lines in Cleveland, espoused municipal ownership as early as 1906, but at that time it was forbidden by Ohio law. After court proceedings, the several major systems were merged into one and the Cleveland transit war was brought to an end with the granting of the Tayler Franchise to The Cleveland Railway Company. This franchise became operative March 1, 1910.

History was made with the granting of the Tayler Franchise, named after Judge Robert W. Tayler. It was the first "service at cost" franchise in the industry. The theory was to give good service at cost; with "cost" covering operating and maintenance expenses, fixed charges which included taxes, interest on bonds and a return on capital, and a further provision for a return of capital during the last 15 years of the franchise if a renewal could not be worked out. A City Street Commissioner, appointed by the mayor, determined the amount of service to be operated by the company. His power rivaled that of the transit company president. An interest fund was the focal point from which the fare structure was determined. As this fund rose or fell, fares were reduced or increased according to a predetermined scale. Subsequently, other cities in Ohio adopted a service at cost franchise, patterned after the Tayler Franchise.

The transit industry generally suffered from the adverse economic conditions of the 1930's, and Cleveland was no exception. In order to continue payment of the 6 percent return to the stockholders, the company had requested City Council, month after month, to waive funds which should have been deposited in the Maintenance, Depreciation and Reserve Fund. The waiving of such funds led to a deterioration of the system. Interest in the purchase of the system by the City of Cleveland gained momentum.

The Cleveland Railway Company finally found itself unable to meet all fixed charges, including the 6 percent return to stockholders. It could not raise the money needed for new equipment to restore its operation to the fine system it had been in earlier years. Public interest in its local transit had always seemed strong in Cleveland. It became stronger as differences between the City Council, the Cleveland Railway Company, and the Street Railway Commissioner were often aired daily in the three local newspapers.

As dissatisfaction with the transit system grew, interest in public ownership grew proportionately. By 1941, offers had been made by the company to sell and by the city to buy. Finally, in November 1941 the proposal of the city to purchase the company was approved by the stockholders, with the stockholders to be paid $45.00 per share for their stock. Mortgage revenue bonds in the amount of $17,500,000 were sold by the city of Cleveland for the purchase and improvement of the system. A sum of $14,500,000 was allocated for the purchase of the properties, the remaining $3,000,000 being allocated for improvements.

The system was transferred to the City on April 28, 1942. On that date, the Cleveland Transit System was born. The City became the owner of the local transit system without having invested any of its own money -- and not even pledging a cent of its credit behind the bonds.

B. The Transit Board - Framework for Planning

1. Original 3-Man Board: Jan. 1943 - Dec. 1949

Initial operation of the Cleveland Transit System was under the Director of Public Utilities of the City of Cleveland. However, to improve the marketability of the bonds, the purchase ordinance of the city provided:

> "It is hereby declared to be the intention of the council to submit to the electors of the city of Cleveland, within one year from the date of the bonds, an amendment to the charter of the city of Cleveland placing the operation of the municipal transportation system under the management of a board or commission consisting of not more than five persons."

City Council adopted an ordinance creating an independent transit board, and at the November polls in 1942, Cleveland voters approved the necessary amendments to the City Charter. As a result of these actions, the framework for mass transit planning in Cleveland was built by (1) placing under the control of an independent board the responsibility for "the supervision, management and controls of its transportation facilities," and (2) the appointment to that board by the mayor of three men of vision, competence, and determination. These men accepted the appointments from the mayor because they saw an opportunity to improve their community through their leadership, guidance and approval of plans for bettering Cleveland's transit system.

Resourceful, imaginative management personnel are important to progressive mass transit planning. However, in a public operation, plans of management must be implemented by others. If it is within the financial resources of a transit system to move forward, approval of any proposed plan is necessary by the policy making Transit Board. Plans which call for change in a mass transit system seldom, if ever, please everyone. It sometimes takes a courageous Board to stand up to the nit-pickers and critics and to move ahead firmly to implement plans which are in the best interest of a community and the majority of its people, but are displeasing to a vocal minority.

This presumes that the Transit Board has the authority to implement plans. Sometimes the finest plans gather dust on a shelf because the Board "in control" lacks such powers.

The authority given to the CTS Transit Board by the city charter amendment of November 1942 had some limitations which could have (but did not) block transit improvements. On the premise that "He who controls the purse strings wields the power," City Council had the power because payment for any contract of CTS in excess of $25,000 had to be authorized by Council, and all new capital expenditures, regardless of amount, were first approved by Council. Likewise, rates of fare could be set by the board, but council could, by a two-thirds vote within forty days, veto the change. This situation existed from January 1943 to December 1949.

It is a tribute to the caliber of the original transit board members that every transit matter of importance requiring city council approval was approved by a majority of the council. The high respect held for the Chairman of the Board, who regularily attended city council meetings every Monday night, helped get through city council legislation which was necessary to carry out plans for a fast modernization of a run-down streetcar system.

2. Increased Authority of Transit Board

As described later, the Cleveland Transit System soon became actively engaged in planning the construction and financing of a rapid transit. Eventually a conditional commitment for financing was made by a federal agency, the Reconstruction Finance Corporation. One of the conditions precedent to borrowing money for building a rapid transit and making improvements to the surface system was an amendment to the charter of the city of Cleveland relative to the powers and authority of the Transit Board. In order to obtain money for transit improvements by issuing mortgage revenue bonds, which lacked the credit of the city behind them, it was necessary to strengthen the authority of the Board and lessen that of city council pertaining to transit matters. Briefly, the principal changes made were:

a. Membership of Board increased from 3 to 5.

b. Term of Board members increased from 3 years to 5 years.

c. Approval of city council no longer required for contracts or for capital expenditures.

d. City council to have no veto power over fare changes made by the Transit Board.

The Transit Board became almost autonomous in running the system. The only authority over transit matters remaining in city council were:

a. Confirming appointments made to the Board by the mayor.

b. The power to authorize the incurring or refunding of bonded indebtedness for transit system purposes.

c. Consent of city council is required for the board to dispose of the transit system as a whole.

Effective December 1, 1949, a 5-man Transit Board was appointed, which included the three members from the former board. Fortunately, the two additions to the board were men of stature in the community. They harmoniously worked with their associates from the former board in further guiding and approving plans for improvements of the system and development of a new rapid transit. Time formerly spent at council committee and regular meetings was better spent considering plans for the betterment of the transit system. Its larger membership gave a broader background of experience to the board which was an aid in making sound planning decisions.

C. Financial Planning - Capital Improvements

1. Accruals for Replacements and Modernization

The viewpoint of management at CTS has been that the system must be operated with a high degree of efficiency that will permit having enough money left over from fare box revenues for steady yearly capital replacements and improvements. Conversely, a regular yearly program of capital replacements is a contributing factor to an efficient operation. Not only should money be accrued for capital replacements, but it should be spent each year according to a planned program. Priorities for the spending of these capital funds were usually based upon savings in operating and maintenance expense to be realized per dollar spent, or the greatest number of riders to be benefited per dollar spent.

About 8 percent of gross revenue is acknowledged within the transit industry as an amount that should be available for depreciation or capital replacement of a bus system. The present indenture of mortgage for the bonds of CTS calls for an accrual in a Replacement Fund of 7 percent of revenues. This was adequate at the time of issuance of the bonds, because a part of the funds from the sale of the bonds was used for capital replacements and improvements to the surface system, as well as for the building of a new rapid transit. It is not adequate at the present time for keeping the system modern unless it is supplemented by borrowed funds or grants.

Accruals to the Replacement Funds of CTS from system revenues over the past 10 years have averaged $1,939,000 per year. This amount has been further increased by the allocation to the Replacement Fund of all proceeds from the sale of assets no longer needed for operation of the transit system. This has averaged nearly $200,000 per year, over the past 10 years. Interest earned on money in the fund also increases the annual accruals to the fund.

Since the sale of bonds to RFC in 1951, the Cleveland Transit System has not borrowed any money for the purchase of buses or replacement and modernization of any other capital facilities. The above mentioned indenture of mortgage requires that capital funds must be available before the Transit Board can authorize the expenditure of money for capital purposes. It imposes conditions too restrictive to permit borrowing. This has worked to the advantage of the riders of the system. Borrowing money to buy buses requires the payment of interest as well as repayment of the principal amount. All bus purchases and other capital replacements for more than the past fifteen years have been paid for with cash. In other words, all of the money that was spent for capital improvements went for the capital facilities and none to pay interest.

2. Incurring Debt for Capital Expenditures

The Cleveland Transit System has avoided borrowing money for normal capital replacements. Analysis of its financial history will show that CTS borrowed money only for:

a. Purchase of the system from the Cleveland Railway.
b. Accelerating its modernization program.
c. Expansion of the system by building a rapid transit.

The City of Cleveland purchased the transit system so that it might have better service. The Cleveland Railway Company had purchased relatively few vehicles in its last years, and many of its older vehicles were in deplorable condition. A normal annual replacement program would take much too long to bring the condition of the fleet up to what was expected by the public. A fast modernization of its passenger vehicles was brought about as soon as vehicles became available after World War II. CTS took delivery of more than 500 buses and trackless trolleys in the eight months between July 1947 and February 1948. Additional debt had to be incurred to finance such number of vehicles. The annual debt service, principal and interest payments, starting in 1947 ranged between two and two and one-half million dollars a year.

Management and the Transit Board had the bright outlook of being debt free before the end of 1952. However, rather than looking forward to 1952 as a time when the system would be relieved of the heavy load for debt service, thereby making the successful operation of the system easier, the Board and management were busily engaged in planning the building and financing of a new rapid transit system for the community. Money was borrowed again for the improvement of the system, this time to build a rapid transit. The annual debt service since 1952, resulting from this financing, has ranged from 1.5 to more than 1.8 million dollars.

D. Financial History

1. Financing for Purchase of the System

In April, 1942, $17,500,000 of 3-3/4% bonds were sold to purchase the transit system from The Cleveland Railway Company and to buy some new equipment. The bonds were to mature over 20 years.

The stockholders of the Cleveland Railway Company were paid $14,127,480. The balance of more than three million dollars was for the purchase of equipment. This was during the war, and new equipment was not available. The prudent thing to do was to use this money as well as excess funds generated by the increased demand for public transportation during the gas rationing days to accelerate the redemption of the system bonded indebtedness. As a result, by December 1, 1944, the outstanding balance of bonded indebtedness had been decreased to $9,310,000.

2. Original Debt Refunded

Interest rates in general had decreased since the Cleveland Transit System came into being. Furthermore CTS had established a short but successful history of operating the transit system. The balance of the 1942 bond issue was refunded December 1, 1944, in the amount of $9,310,000 by issuance of 1-1/2% bonds due serially to September 1, 1952. The original scheduled time for retiring the bonds of 20 years was thereby reduced to 10 years. The savings in interest payments by virtue of the reduced rate of interest and the shorter term of the bonds was very substantial. The 1944 refunding was also with a mortgage bond issue, without the credit of the city behind the bonds.

3. Financing for New Equipment

After the end of the war, with new transit vehicles again being manufactured, CTS found itself in a position opposite to that a few years earlier -- new buses could be purchased, but it did not have the money for buying a substantial number of vehicles. This problem was solved in 1946 through the issuance of two series of equipment trust certificates, each carrying a six year term. The first series, dated June 1, 1946, was for $2 million at an interest rate of 0.875%. The second series, dated December 1, 1946, was in the amount of $4 million at an average interest rate of 1.12%.

These equipment trust certificates added another $1.1 million per year to the debt service burden. Their issuance was timed to coincide approximately with the scheduled delivery date of new vehicles. Economies resulting from the new vehicles were expected to carry the added debt service. However, delivery of the vehicles was delayed. CTS found itself in trouble for about a year by having more than a million dollars a year added to its expense of operation for new vehicles, but with no new vehicles to produce savings to apply toward the added cost.

4. Failures in Efforts to Finance

The very low interest rates established in the refunding of 1944 and the equipment trust certificates of 1946 might suggest that money was available to CTS for the asking. The system soon learned that borrowing money for a construction project during a period of rapidly rising costs was quite different from borrowing for a going system. In 1947 and 1948 CTS made several attempts to obtain additional capital through new revenue bond issues for financing a rapid transit. In one case, the quoted interest rate was higher than the city council had authorized. In another attempt, the investment bankers said, "Get your rapid transit built and come back to us when you know its exact cost and have a year's operation of it behind you, and we shall be glad to handle your financing."

5. R.F.C. to the Rescue

After another year or two had passed, with construction costs rising, the system received a conditional commitment on April 13, 1949, from the Reconstruction Finance Corporation to lend CTS $22,000,000. A major portion of this money was to be used for construction of an east-west rail rapid transit line. One of the conditions imposed was an amendment to the charter of the city of Cleveland making the Transit Board independent of city council.

Formal acceptance and signing of the RFC loan agreement and mortgage indenture did not occur until August 16, 1951, after all conditions, agreements and general engineering plans were concluded. By then, inflation had taken a further toll, and at this time the RFC agreed to increase the amount loaned by $7,300,000 to cover increased labor and material costs.

The mortgage indenture ultimately provided for the issuance of transit revenue bonds in the amount of $29,500,000 at a 4% interest rate. Serial bonds were scheduled to mature between 1952 and 1973, with term bonds forming a balloon at the end and maturing in 1974. It was expected that most of the term bonds, totalling $17,300,000, would be paid off by 1974 from "surpluses" accrued between 1952 and 1974. It is likely that there will still be outstanding about $5,500,000 in Term bonds December 1, 1974. The total outstanding bonds as of December 31, 1966, amounted to $15,315,000.

The Reconstruction Finance Corporation sold the Cleveland transit bonds to a private underwriter in 1954.

6. The Bond Authorization Not Used

The rapid transit being financed out of the fare box admittedly was only a start toward a more extensive rapid transit system for Cleveland. The attitude of the Transit Board was that if something was started to the limit of financing by CTS, necessary public funds for extensions would follow. Up to a point this proved to be correct. While the rapid transit was still under construction, strong public interest was expressed in extending the rapid transit through the central business district by means of a downtown subway. A move was started to get Cuyahoga County to finance the construction of the downtown subway. The Ohio Legislature amended the state statutes in June, 1953, to make it permissive for the county to issue bonds for the subway. At the November, 1953, elections, the citizens of Cleveland, by a majority of two to one, voted a $35,000,000 issue.

After strong opposition to the building of the subway had been expressed by the County Engineer, the three man Board of County Commissioners, by a two to one vote, declined to move forward with the building of the subway. A time limitation required that the bonds for the subway be issued by February 11, 1960. The County Commissioners declined to move forward, and the authorization for selling the bonds expired. *

7. Expansion with Self Financing

Although the conditional commitment to loan money to CTS for a rapid transit and other improvements was made in 1949, delay was encountered in working out the terms of the Indenture of Mortgage and in completing agreements with other parties involved. Ground for the rapid transit was not broken until February, 1952. Money was not drawn from the RFC except as needed, thereby minimizing interest costs during the construction period. Under the terms of the Indenture of Mortgage, debt service payments were minimized between 1952 and 1954, but jumping back to more than one and one-half million dollars in 1954.

Rather substantial surpluses were expected during the hiatus in debt service. The bond indenture required that surpluses should be used to retire debt. Likewise, funds received from the sale of assets no longer needed by the transit system must be used for debt reduction if not spent for other capital improvements within six months. Harvard Shops was sold for $1,500,000 at about this time. Proceeds from this sale would normally have been used for debt reduction.

The Transit Board requested of RFC that it be permitted to use the funds from abnormal surpluses and from the sale of Harvard Shops to construct a 2-mile extension of its rapid transit from West 117th Street to a point near West 143rd Street and Lorain Avenue instead of paying off bonds. This permission was granted by the RFC. It permitted diversion of about $4,000,000 from debt reduction to extending the rapid transit. The total cost of this extension, including 20 more cars, was about $5,000,000. It was paid for entirely with funds generated within the transit system and without need for further outside borrowing.

8. Financing Rapid Transit Extension to the Airport

The Cleveland Transit System is now financing rapid transit from fare box revenues to the extent that prudent operation of the system will permit. Furthermore, restrictions imposed in achieving this financing make impractical, if not impossible, the raising by the system of additional funds necessary for the construction of rapid transit extensions until after the outstanding bonds have matured.

The extension to the Cleveland Hopkins airport, now under construction, is therefore being financed by public funds outside of the transit system. This the first time in its 25 years of existence that there has been any public financial support to the Cleveland Transit System.

The cost of the rapid transit extension to the airport is estimated to be $13,965,000. Source of these funds is as follows:

a. Cuyahoga County -- The county was requested to pay for grade crossing eliminations which are essential if the extension is to be built. These originally were estimated to cost $5,000,000. The public in the fall of 1960 voted an authorization of a bond issue of not to exceed $5,000,000.

   The estimated cost of two of the grade separations subsequently was reduced as a result of coordinating engineering of new federal highways with that of the rapid transit extension and of changing the rapid transit alignment at Brookpark Road. Participation by the County is now estimated to cost $3,700,000.

b. City of Cleveland -- A bond issue in the amount of $800,000 was submitted to the voters of Cleveland in the fall of 1960 to assist in the rapid transit extension by providing parking areas for riders of rapid transit.

   The proposed location of one of the stations required a new access driveway be built from Puritas Avenue. Funds from the City of Cleveland were sought for this purpose. The Cleveland City Council authorized this further participation in the airport project by agreeing to pay for land and construction of

*An interesting sidelight is that at the same time the voters overwhelmingly approved a bond issue for the subway, they turned down a bond issue for a County Administration building. The County Commission went ahead with the building anyway, using general funds without voter approval, but rejected the project authorized by the voters.

a driveway to be used exclusively for access to the proposed station and parking lot. The cost of this is estimated at $250,000, bringing the total estimated cost to the city of Cleveland to $1,050,000.

c. Federal - Department of Housing and Urban Development -- In April 1965 the Cleveland Transit System applied to the federal Housing and Home Finance Agency for the balance of funds needed - $9,215,000. HHFA officials indicated that a grant then would have to come under Section 5 of the Mass Transportation Act, which limited a grant at that time to one-half of the net project cost, or $6,697,500. An additional Federal grant was contemplated for the balance when and if the requirements of Section 4(a) of the Act are fully met within a three year period (i.e., a comprehensive coordinated plan).

The Federal agency (now Department of Housing and Urban Development) approved the grant, but only after the Council of the City of Cleveland authorized the Mayor of the City of Cleveland to enter into an indemnity agreement with the Housing and Home Finance Agency. This was required because of the intention of CTS to temporarily use some of its money from its Replacement Fund to complete the project, pending the time it would be eligible for the full two-thirds from the Federal government. HHFA indicated that use of Replacement Fund money could be considered only if some public money (other than CTS) committed itself to replace such money in the event that eligibility requirements for an additional one-sixth Federal grant was not met within the specified time period. The City of Cleveland made this commitment.

9. Retrospect on Financing

a. Lack of city's credit behind bonds -- As indicated above, the several bond issues sold by the city for transit purposes had only the revenues and property of the transit system to secure the loans. It seems reasonable to assume, if CTS ran into an adverse operating experience, that the city of Cleveland would never let things go so far as to result in a default on the bonds and loss of the system to the bondholders. Why then not have the credit of the city behind the bonds?

If the credit of the city had backed CTS bonds, financing for the rapid transit in the late 1940's would have been relatively simple. The long delay in working out details with RFC added $7,000,000 to the cost of the project. In addition, the higher interest rate paid added more millions of dollars of expense during the life of the bonds. A reduction of one and one-half percent in interest rate, applied to the lower amount of the loan if the financing had been done sooner with city credit, would have saved another $7,000,000 or more in interest charges. The intent of public ownership of a transit system is to provide better transportation service to a community. The Cleveland Transit System could have done a better job in its community with the money that would have been saved if the credit of the city had been behind its bonds.

b. Lack of full authority by Transit Board to carry out financing -- The Cleveland Transit System legally is a part of the City of Cleveland, although its service extends into all of the major cities in the county. Issuance of bonds must be authorized by the City of Cleveland. The transit system lacks the authority to go to the voters for approval of a tax supported bond issue for implementing its plans. The transit system may have the finest plans, but they will not be carried out unless some other agency of government will act to make possible the financing. The experience with the subway financing illustrates that, even with overwhelming approval of the voters for the subway proposal, a publicly approved authorization for transit improvement or expansion can die if it depends upon another agency of government which chooses to ignore the expressed will of the public at the ballot box.

This leads to the suggestion that agencies responsible for the development of plans and operation of a transit system should have the authority to move ahead with the financing. Support is growing for the idea that Transit Boards or

Authorities should be creatures of a larger area of a community or government than that of a single city. This has merit if the larger area, such as an entire county, is to be looked upon for tax support of capital improvements for transit. It would be hoped that such a County or regional board would also have authority to move ahead with financing, subject to voter approval. The legislature of the state recently made such regional authorities permissive in Ohio.

E. Efficiency and Good Transit

1. General

The nature of its business is such that the transit industry pays from 60 to 70 percent of its revenue for payrolls and employee benefits. It is higher than this for some transit companies. Few, if any, other industries have payroll costs which absorb such a high percentage of income. Effective use of its manpower is therefore especially important in transit. It is basic to a good transit operation. CTS has made a determined effort to improve the effectiveness of its employees and thereby the efficiency of its system.

2. Motormen, Conductors, and Operators

CTS inherited a predominately streetcar operation, manned with two men on each car. Most other cities had gone to one-man operation of its streetcars long before this.

The immediate post war years found wage rates rising rapidly, and transit riding falling off as gas and tire rationing were discontinued and new automobiles became available. CTS started the year 1947 with a wage settlement just made which added $1,800,000 per year to expenses. It was noted previously that more than a million dollars a year was added to expenses in 1947 for payment on equipment trust certificates issued in 1946 to pay for new equipment expected that year, but with delivery of the vehicles delayed. A fare raise seemed inevitable. However, a decision was reached that no fare increase would be sought until steps were taken to improve the efficiency of the system and improve the service.

The most obvious way to reduce expenses and not curtail service was to convert two-man streetcar operation to one-man operation. Union officers formerly had taken a strong stand against this, and it was difficult for them to retreat from that position.

Management and the Transit Board resolved to move with a programmed conversion to one-man operation, faced several strike threats, but finally started the program in August, 1947. Frequency of service was increased with each conversion -- in other words, the riding public shared in the resulting economies. No employees were laid off, which helped gain acceptance among employees and union leaders.

3. Maintenance and Other Non-operating Expenses

The Cleveland Railway Company demonstrated that deferring maintenance is not a long run economy. It eventually adds to total costs.

In a sense, one of the functions of management of a transit system is to determine how its biggest single item of expense, labor costs, shall be distributed among the various groups of employees. CTS constantly has emphasized the importance of reducing "non-operating" expenses so that more of the revenue dollar would be available to operators (bus drivers) for maintaining an attractive level of service. Improving the effectiveness of maintenance personnel was given particular attention -- both to reduce road failures of vehicles and to reduce non-operating expenses.

Fast modernization of the fleet of equipment after the war, well planned maintenance procedures, and well trained personnel have improved CTS maintenance efficiency and reduced costs. The number of employees in the equipment department of CTS was reduced from a peak of 871 at the end of 1948 to 671 at the end of 1951, and stood at 352 at the end of 1966.

Reduced number of vehicles and reduced mileage should bring about some reduction in number of equipment department employees. Credit should be given to the bus manufacturers and parts suppliers for improved vehicles and materials which also permitted some reduction in maintenance employees.

The reduction in number of equipment department employees in the last 15 years from December 31, 1951, has exceeded the reduction in miles operated as shown in Table 10.2.

TABLE 10.2 - REDUCTION IN CTS EQUIPMENT DEPARTMENT EMPLOYEES

5-Year Period Ending Dec. 31	PERCENTAGE REDUCTION IN:	
	Equipment Department Employees	Vehicle Miles Operated
1956	20%	12%
1961	25	15
1966	11	8
15-years ending Dec. 31, 1966	48	31

In 1966, Fleet Owner Magazine presented its Maintenance Efficiency Award to CTS for the 13th consecutive year as a result of continued improvements in the CTS maintenance program.

At the start of each calendar year, department heads have been requested to establish new goals and objectives. These are reported at staff meetings so that all department heads may become acquainted with the new objectives of other departments and thereby be better able to be helpful to one another.

The basic philosophy that has prevailed with respect to "non-operating" employees and to accidents is -- no matter what has been accomplished in the past, new goals of improvement must be established each year. This seems to have paid off, for the total number of non-operating employees (employees other than bus operators or train crews on rapid transit) was reduced from 1903 to 812, for a 57% reduction over the past 15 years. A breakdown of the improvement by five year periods is shown in Table 10.3.

TABLE 10.3 - REDUCTION IN NON-OPERATING EMPLOYEES

5 Year Periods ending Dec. 31	No. of Employees	Reduction in -	
		Number	Percent
1951	1903		
1956	1339	564	30%
1961	1066	273	20%
1966	812	254	24%

4. Planned Vehicle Replacement

Analysis of maintenance costs by separate fleets showed that some buses were being retired after considerable money had been spent on them in the years immediately before their retirement. The conclusion was reached that there had been poor communications between the top level of management and those responsible for maintaining vehicles. By establishing a policy of purchasing a certain number of buses each year, maintenance personnel were able to reduce costs by programming ahead the retirement of a given number of buses each year. This meant:

a. Retirement of a fleet over several years.

b. No major expenditure for buses soon due for retirement. Some buses from previous retirements kept in dead storage might be put back in active service to displace an old bus needing major repair work.

c. "Cannibalizing" retired buses and using good parts to replace units on older buses.

F. Management Development

1. Improvement by Working At It

CTS, like other companies, has many skilled employees with many years of experience behind them. As some of them move up into supervisory positions, it may be assumed they will be good supervisors, too. CTS tries not to trust to luck that the new supervisor or department head will quickly acquire the skills of management needed in his new position. It believes that no matter how good they are, all levels of supervision and management can be improved by working at improvement. It has carried on an organized program of management development for a number of years, changing the type of program every few years to keep it alive and challenging to the employees. Some of the programs and approaches to developing more competent key people are as follows:

a. Transportation Supervisory Training -- Special courses have been prepared for the development of supervisory people in the transportation department. Four of the courses, given at various times, are:

   (1) Fundamentals of Supervision
   (2) Communications
   (3) Safety
   (4) General Supervisory Principles

b. Management appraisal -- This was a program where all supervisory employees were periodically appraised by others, with the immediate superior reviewing with a supervisor his appraisals and suggesting areas and means for improvement.

c. Counselling -- For a while a professional psychologist from a reputable firm of industrial psychologists met with department heads and top level of management to personally counsel them on how to be more effective in their work.

d. Management by objectives -- Another program carried on was known as management by objectives. Here, a supervisor and his immediate superior sat down and worked out together the objectives toward which this supervisor should be working. This was reduced to writing and followed up. It is in contrast to the approach that deals mostly with personal traits of an individual.

e. Management forum -- This program consisted of three or four evening meetings during the year, to which nearly all supervisory employees were invited. The meetings usually consisted of a presentation by the general manager or top level of management, followed by a question and answer period. An attempt was made to have someone outside of CTS make at least one of the formal presentations each year.

f. Industrial management workshops -- This activity consists of 8 meetings a year with representatives of 20 leading companies in Cleveland. The workshop sessions are of the discussion type, led off by a presentation of a company's experience by a representative of one of the companies which had been successful in the subject area being discussed. Two CTS employees attend each one of these sessions -- a different pair at each meeting.

g. American Management Association program -- CTS employees have attended courses and seminars put on by the American Management Association. A number of its supervisory employees will take the course in "Basic Principles of Supervisory Management" developed by this organization.

G. Attention to Basic Economics

1. Transit Has Some Unique Characteristics

Among the unique characteristics of the transit industry is its pricing policies. The price paid for a transit ride often is quite unrelated to its cost. The nature of the business -- as a mass carrier -- necessitates this to some extent. However, it does not warrant completely overlooking or ignoring the relationship of price to cost. It is hard to think of any other business which is successful and does not more nearly relate its price structure to its costs.

If the fare for an adult ride on transit is properly priced in relation to its cost, how can transit systems carry school children at a half fare, especially those who ride in the rush hours and in the direction of heaviest travel? This is not to infer that the transit fare for going to and from school should be the same as the fare for going to and from work. It does suggest that the sociological and community values attached to low student fares might better be supported by the entire community than by just adult transit riders.

The cost of providing passenger rides usually will differ for every line on a system, yet in some communities the adult transit fare may be the same on most or all of the lines. CTS has made some attempt to vary its fare structure to meet variations in cost. The basic adult fare is 25 cents. Yet, CTS has lines on which the maximum fare is only 10 cents. There are two or more different adult fares for a ride on each express. This difference is not related to the distance of the passenger ride, but is determined by the part of the route in which the ride is taken.

2. Length of Vehicle Trip Versus Length of Passenger Trip

A complete zone fare system disregards the basic truth that the cost of a ride is more related to the length of route or of a vehicle trip than it is to the length of a passenger's ride. Example: Two passengers board the same bus on a four-mile route to downtown. Passenger A gets on at the end of the line, and passenger B boards only two and one-half miles from downtown, both riding pastthe maximum load point on the line. The cost of serving these two passengers will be the same and unrelated to the length of their ride.

Another example might be passenger A boarding at the end of the line on the four-mile route, but passenger B boarding a parallel route, also to the same downtown terminus. Passenger B also boards the parallel route at a point four miles from downtown, but his route is six miles long, with the vehicle trip starting at the end of the line. Although their rides are of identical distance, it will have cost more to serve passenger B than passenger A.

Other things being equal, to meet all costs, longer route or vehicle trips require either, (a) more passengers for a given average fare, or (b) a higher fare per passenger for a given average number of passengers per trip. (See Table 10.4).

TABLE 10.4 - EFFECT OF DIFFERENCES IN ROUTE LENGTH

Cost item	Round-trip miles			
	8	12	16	20
Round-trip cost at 80¢ per mile	$6.40	9.60	12.80	16.00
a. No. of passengers required to meet cost at average fare of 17 cents.	38	56	75	94
b. Fare required at 60 passengers per round trip (cents)	10.7	16.0	21.3	26.6

3. Zoned Service

CTS has tried to take into some account the relationship of cost to trip or route length. It established what might be called a zone service by making two lines out of one longer line. One of the two lines might be half to two-thirds the length of the other. This shorter line was able to provide transportation to people in its service area at a lower cost than if the vehicle trips were longer. The longer line operated as an express service when it met and paralleled the shorter line, stopping only at transfer intersections. The outer end of the longer line provided a local service in that area -- and at a local fare within that area. A five cent premium is charged for any ride within the express zone -- regardless of where passengers may board such vehicles. The intended effect of this is to separate the long riders from the short riders, with a higher fare charged to those whose service cost more.

4. Express Lines

The largest single item of expense in running a bus system is for wages and fringe benefits of the drivers. Today it is not at all uncommon for the fringe and welfare benefits to bring the total cost per hour of driving or on duty time of the bus driver to $5.00 per hour. This item

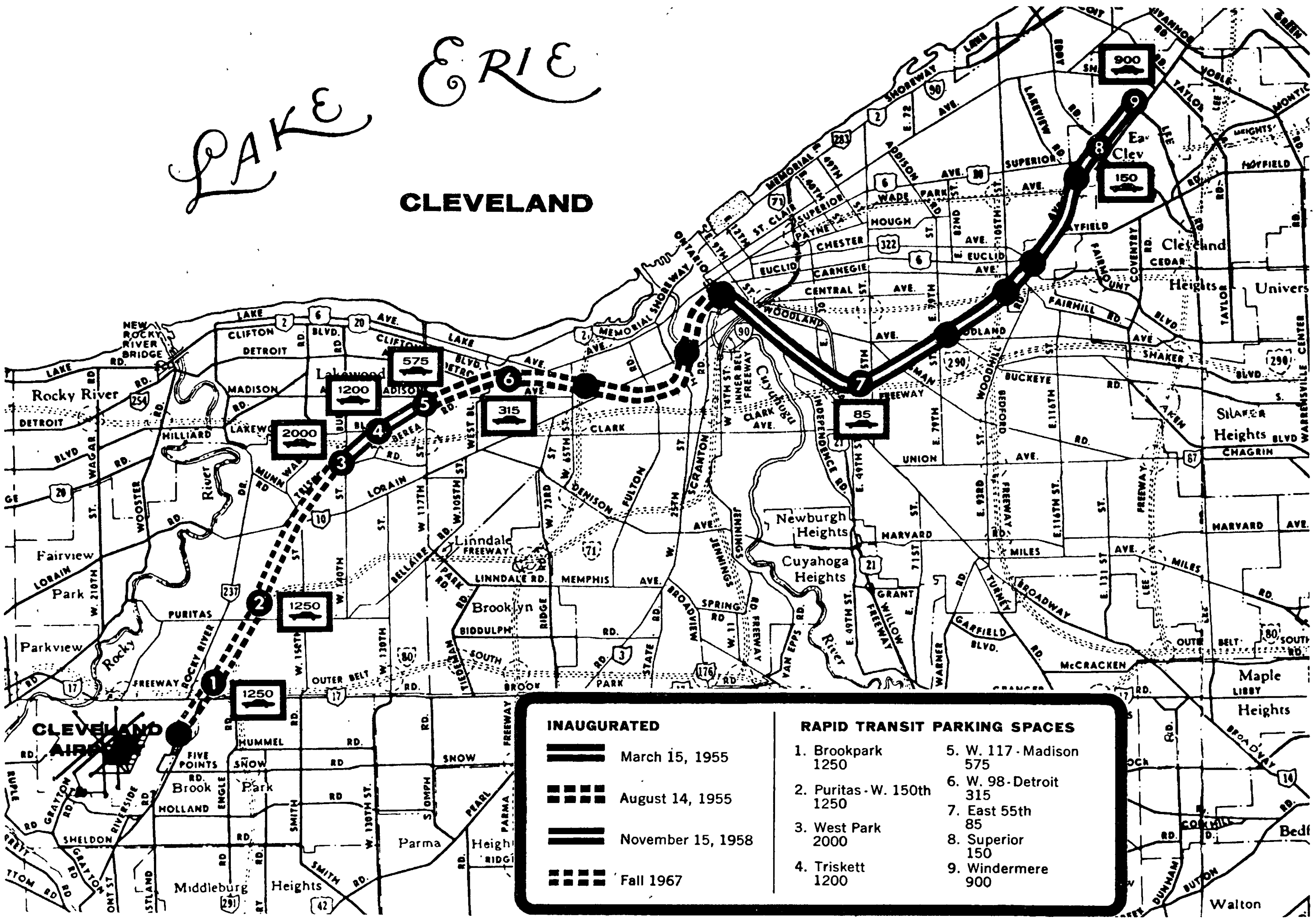

Fig. 10.1 - Cleveland rapid transit route and airport extension, showing off-street parking spaces at stations.

of expense per mile of service varies considerably with variations in scheduled speed. The increase in expense is not in direct proportion to a decrease in speed, as is illustrated in Table 10.5. These figures also show the high cost of operating buses within congested business districts, where speeds are often only 8 mph or less.

TABLE 10.5 - BUS DRIVERS COST PER MILE FOR VARIOUS SPEEDS

Speed (Miles/hr.)	Cents per Mile	Added cost per mile of reducing speed by 2 miles per hour, cents
20	25.0	
18	27.8	2.8
16	31.2	3.4
14	35.8	4.6
12	41.6	5.8
10	50.0	9.4
8	62.5	12.5

CTS has attempted to speed up its vehicles through congested areas. Bus stops are spread out all along Euclid Avenue in the downtown area to reduce time at stops.

CTS has established express lines radiating from the central business district in all directions where service is operated. These serve the longer routes. Although the cost per mile may be lower for an express line because of the higher average speed, a 5 cent premium is charged because of the higher cost of a trip due to its longer length.

5. Extension Zones

The growth in population has been, and is expected to continue to be, in the suburbs. The Cleveland Transit System has willingly made extensions into newly developed areas where it has appeared likely that increased income will meet an increase in out of pocket expenses. CTS recognizes full well the added cost resulting from extending the length of its routes. It has met this problem of added cost by establishing extension zones on some of its longest lines or as other lines are extended.

The first extension zone, generally starts about 8 miles from the central business district in Cleveland. An additional 5 cents is charged for riding from the regular fare area into an extension zone, and vice versa. On the other hand, passengers whose ride is wholly within the extension zone add nothing to the cost once such service is established. In order to attract as many of these riders as possible, they are permitted to ride wholly within an extension zone for only 15 cents.

H. CTS Rapid Transit

1. General Description

After nearly forty years of studies, talk, meetings, and more talk about the need for a rapid transit with nothing completed due to a lack of anyone putting up the necessary funds, the Cleveland Transit System in 1955 started operation of the first phase of its rapid transit system. Cleveland almost had a rapid transit back in the 1920's when the Van Sweringen brothers actually started construction of a "rapid" to East Cleveland from downtown Cleveland. The crash of 1929 wiped out their empire and with it the completion of their rapid transit.

The 14.9-mile long rapid transit line (Fig. 10.1) is briefly described as follows:

a. Stages, with dates of start of operation:

(1) From Windermere terminal to the Union Terminal (downtown) - 7.8 miles - started March 15, 1955.

(2) From Cleveland Union Terminal to West 117th Street & Madison - 5.3 miles - started August 15, 1955.

(3) From W. 117th Street to West Park station, near West 143rd & Lorain Avenue - 1.8 miles - started November 15, 1958.

Fig. 10.2 —Windermere Terminus, Cleveland Rapid Transit, showing off-street loop and shelter for feeder buses.

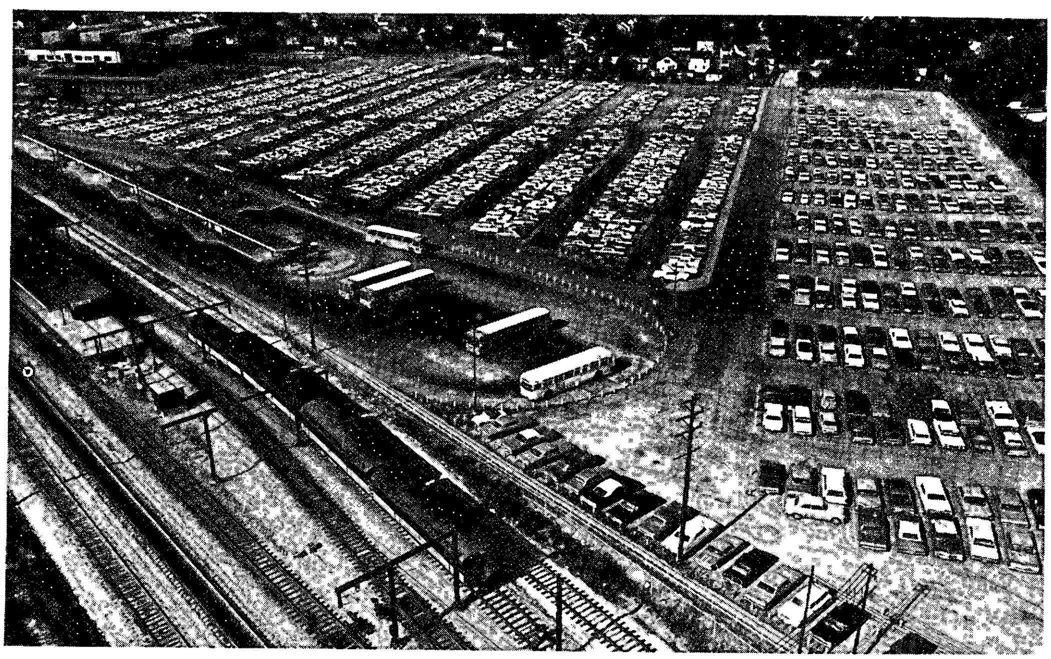

Fig. 10.3 —West Park Station, Cleveland Rapid Transit; showing parking area, feeder bus transfer and storage facilities. Note leading island between bus station and parking area for kiss and ride.

b. Right of way -- The CTS rapid transit is a completely grade-separated, high level platform, rail operation constructed alongside of mainline railroad right-of-way. The 600-volt direct current for propulsion is distributed by means of an overhead catenary system. Overhead wire was selected instead of third rail at the insistence of the railroads whose right-of-way CTS had to share.

c. Stations -- The rapid has 14 stations which are spaced on the average of more than a mile apart. A serious shortcoming of the system is that there is only one station in the central business district, and that is located near the fringe of downtown.

d. Cars -- Eighty-eight cars are used in this service. CTA has declined to accept the usual standard of 10 percent or more cars as spares for maintenance, etc. It schedules 84 or the 88 cars to provide its passengers the maximum possible number of seats. Seventy of the cars are semi-permanently coupled to operate in two car units, with a motorman's cab at the ends of each unit. The remaining 18 cars are single car units with motorman's cabs at both ends of each car. Twenty new cars are on order and will be delivered in the fall of 1967. They will be needed for the extension to the airport, but will be put in service sooner. These cars will be single units. They will be faster, air conditioned, and give a better ride than the original 88 cars.

e. Fares -- Fares on the rapid transit are the same as those charged on express buses. This is 5 cents more than the regular basic adult fare on local lines.

2. Feeder Buses

At all rapid transit stations, convenient transfer is provided with surface buses. More than 50 CTS bus lines plus one line operated by the North Olmsted Municipal Bus Line provide feeder service to one or more rapid transit stations. Figs. 10.2, 10.3, and 10.4 show the special off-street bus terminals that have been constructed adjacent to the "Rapid" so as to provide a sheltered connection.

3. Designed to Serve Auto Drivers

When the first sections of the rapid transit were built, some facilities were provided for convenient drop off or pick up of auto passengers at several of the rapid transit stations. Several parking lots were also provided for parking of automobiles by persons who might choose to continue their ride on the rapid transit. Admittedly, management underestimated how many persons would want to park at a rapid station or how far they would walk between their parked cars and the "Rapid."

The extension to West Park, opened in 1958, was designed with the auto driver in mind. Rather than have the terminus right at Lorain Street, a main west side artery, it was located short of Lorain Street because much more parking and other facilities could be provided for the auto driver who found it more convenient to leave his home by his private car, but who preferred to go downtown by rapid transit.

More than 3,000 parking spaces are provided at the two westerly stations of the present line; the total number at the seven stations presently open exceeds 5,000. Provision for parking is also being made at two stations on the airport extension (See Fig. 10. 1).

A survey of the nearly 7,000 passengers who boarded the rapid transit at West Park station in a twelve hour period in March, 1964, showed more than 1,000 being dropped off by an auto driver, and more than 2,000 coming by automobiles and parking at the rapid station. Of the total passengers boarding, 46.0% arrived by auto and 52.8% arrived by bus. Only 1.2% walked. A similar survey made at Triskett Station showed a still higher percentage arriving by automobile. The detail of this survey, showing arrival by time of day is shown in Table 10.6.

4. Attention to Customer Services and Comfort

In designing the rapid transit, thought was given to making it as comfortable and convenient as possible to use. Some of the things which were included in the rapid transit planning and development were:

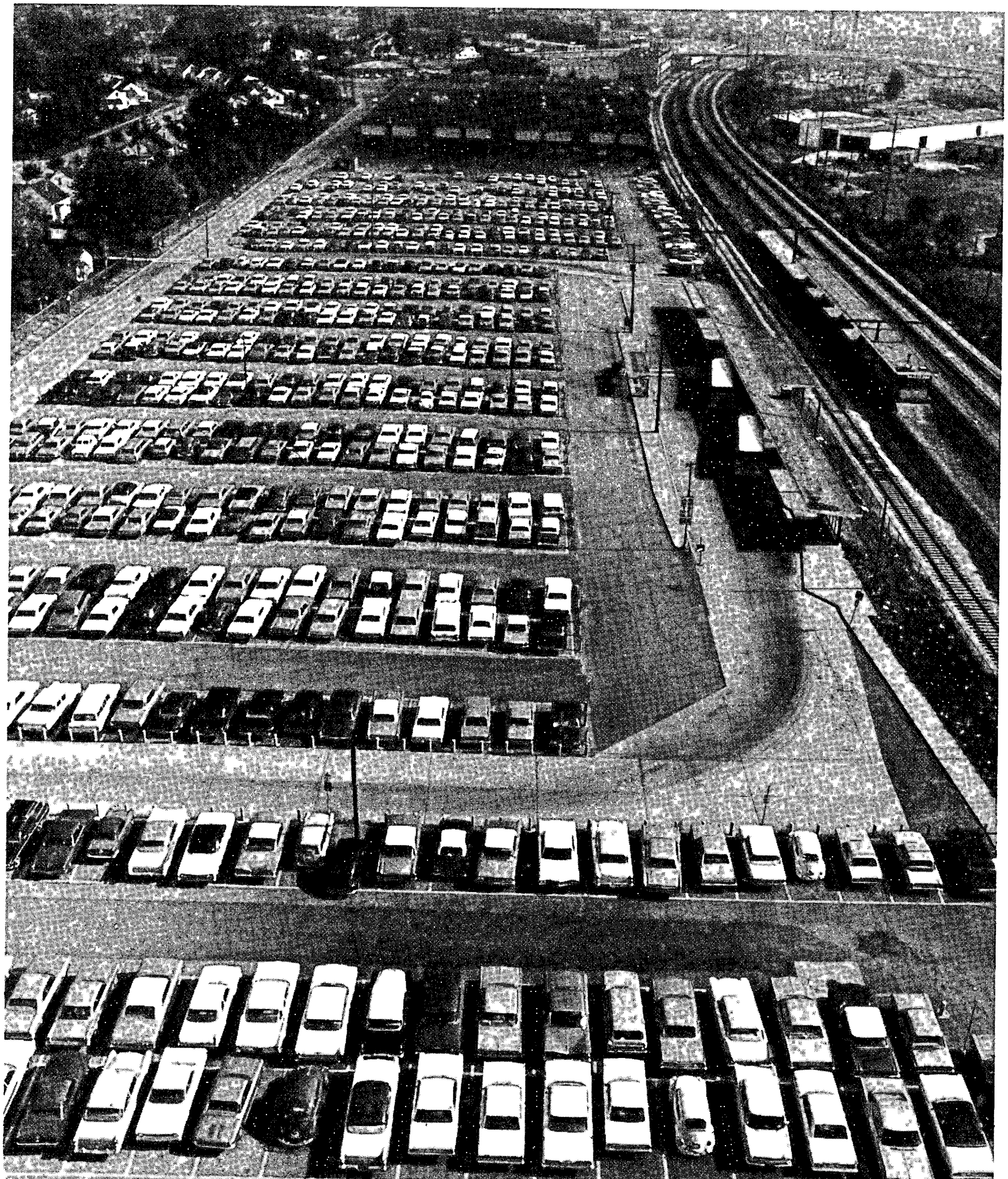

Fig. 10.4 - Triskett Station, Cleveland Rapid Transit, showing parking area, feeder bus and kiss-and-ride facilities.

TABLE 10. 6 – SURVEY OF INBOUND PASSENGERS BY MODE OF TRAVEL AT WEST PARK STATION

Tuesday, March 24, 1964 - 6 a. m. to 6 p. m.

	Total Automobiles & Auto Passengers Entering Station			Park'n Ride				Drop Off				Sub Total Park'n Ride and Drop Off									
	Auto	Pass.	Pass. per Auto	Auto	Pass.	Pass. per Auto	%	Auto	Pass.	Pass. per Auto	%	Auto	Pass.	Pass. per Auto	%	Pedes.	%	* Bus Pass.	%	Total Pass. to Rapid	Turnstile Count 3-24-64
A. M.																					
6-659	281	397	1.4	209	247	1.1	37.6	72	76	1.1	11.6	281	323	1.1	49.2	1	.2	332	50.6	656	656
7-759	1204	1790	1.5	807	924	1.2	35.2	397	453	1.1	17.2	1204	1377	1.1	52.4	27	1.0	1226	46.6	2630	2630
8-859	499	775	1.6	325	412	1.3	32.8	174	183	1.1	14.5	499	595	1.2	47.3	25	2.0	638	50.7	1258	1258
9-959	165	244	1.5	120	150	1.3	42.1	45	48	1.1	13.5	165	198	1.2	55.6	6	1.7	152	42.7	356	356
10-1059	141	235	1.7	101	116	1.1	35.5	40	52	1.3	15.9	141	168	1.2	51.4	1	.3	158	48.3	327	327
11-1159	106	161	1.5	76	87	1.1	39.5	30	32	1.1	14.6	106	119	1.1	54.1	0	---	101	45.9	220	220
P. M.																					
12-1259	80	113	1.4	58	67	1.2	41.6	22	23	1.0	14.3	80	90	1.1	55.9	1	.6	70	43.5	161	161
1-159	70	95	1.4	50	57	1.1	30.8	17	21	1.2	11.4	(3) 67	78	1.2	42.2	2	1.1	105	56.7	185	185
2-259	60	90	1.5	23	26	1.1	16.4	19	19	1.0	11.9	(18) 42	45	1.0	28.3	4	2.5	110	69.2	159	159
3-359	84	127	1.5	34	38	1.1	14.9	24	27	1.1	10.6	(26) 58	65	1.1	25.5	7	2.7	183	71.8	255	255
4-459	138	210	1.5	24	25	1.0	5.8	40	52	1.3	12.0	(74) 64	77	1.2	17.8	10	2.3	345	79.9	432	432
5-600	248	309	1.2	9	10	1.1	3.2	47	52	1.1	16.6	(192) 56	62	1.1	19.8	2	.6	249	79.6	313	313
TOTAL	3076	4543	1.5	1836	2159	1.2	31.1	927	1038	1.1	14.9	2763	3197	1.2	46.0	86	1.2	3669	52.8	6952	6952

*--Latest available data 12/63; 1/64; 3/64 adjusted to 3-24-64 turnstile reading.

()--Pick up autos.

CTS
Research & Planning
April 1, 1964

a. Parking -- This has been described above.

b. Convenience for Drop off and Pick up -- This is commonly referred to as the "Kiss-and-Ride" facility. The wife who drops the downtown worker off at the sheltered facilities next to the station, kisses him goodbye, and has the auto for the rest of the day. There are also many husbands who need the auto to get to work or in their work who drop off or pick up their working wives at the same location.

c. Shelters -- Convenient shelter is provided at rapid transit stations for those transferring between a bus or automobile and the rapid transit. To make its bus service more attractive, whether for the complete journey or a feeder trip to the rapid transit, CTS has installed more than one thousand shelters at bus stops throughout the system.

d. Time tables -- Single time tables showing both the leaving time of an outlying bus and the arriving time of the connecting rapid transit downtown have proved to be a convenience. CTS mails timetables to its passengers whenever schedules are being changed. It has a mailing list of 72,000 names to whom timetables for one or more lines are sent. Last year, CTS printed public timetables for 80 different routes.

e. Restaurant and bakery -- At both of the outer termini CTS has provided facilities which are leased to others to operate a restaurant and bakery shop. The Cleveland Union Terminal has leased out similar facilities adjacent to the rapid transit entry and exit at the downtown station. These facilities provide a time saving convenience to many passengers.

f. Escalators -- Escalators were installed at the major stations when the rapid transit was built for operation in 1955. Their popularity became more evident since then, and escalators were installed in both stations of the extension opened in 1958 and will be installed in all stations of the extension now under construction.

g. Station markings -- Careful attention has been given to direction signs. Station platforms are painted in different colors for quick identification of location.

h. Infra red heaters -- Although the waiting time between trains is short, infra red heaters have been located over the passenger platforms at the Cleveland Union Terminal station and at Cedar-University station.

5. Time Savings

The running time from the easterly terminus to the downtown station is 17 minutes. To make the same trip by surface bus takes more than 30 minutes. The rapid transit running time from West Park, the westerly terminus, is 15 to 16 minutes. This compares with more than 30 minutes on the Lorain Express bus.

In the critical peaks of the morning and evening rush hours, CTS runs express trains in the controlling direction between the Cleveland Union Terminal and W. 117th Street, a distance of 5.3 miles. Obviously, an express train cannot run around a regular train, but time saving is achieved by scheduling an express train to start from the downtown station shortly before a regular train is due there. The express train just about catches up to the previous regular train by the time it reaches W. 117th Street. This separation of passengers destined for W. 117th Street or beyond from those to and before West 117th Street enables CTS to turn back some trains at W. 117th Street in the critical peak, and thereby provide more trips in the rush hour with its limited number of cars than it could otherwise operate.

6. Patronage

Riding on the rapid transit increased from 14,733,163 in 1956, the first full year of operation to a peak of 18,329,372 in 1960. Since then, it has declined to 16,645,597 in 1966. The volume of riding on the rapid transit has been almost constant for the past two years, while there has been a greater decline on the surface lines.

Fig. 10.5 - New apartments built on vacant land adjacent to rapid transit station, Cleveland.

Urban renewal programs wiped out many businesses and homes in the central business district, and construction of new buildings to replace them has lagged. In addition, the opening of a huge shopping center on the east side brought a reduction in number of persons coming downtown to shop, whether by automobile, bus, or rapid transit.

An analysis of weekday turnstile counts by hours of the day, shows that rapid transit riding has increased in the peak hour of both rush periods over the past several years while total riding has decreased. A review of the turnstile counts on Saturdays and Sundays shows that the sharpest decline has occurred then.

7. Economic Development Along the Rapid Transit

Adjacent to a rapid transit route which is alongside railroads for its entire length, it is not reasonable to expect a development of building such as was sparked by the new rapid transit in Toronto. Nevertheless, a survey and report made a few years ago stated: "Since the CTS rapid was inaugurated in 1955, over 30 nearby commercial and apartment buildings have been constructed or are in the planning stage. These buildings are valued at $169,000,000." The report listed the buildings and indicated their proximity to the rapid transit.

Fig. 10.5 shows two apartments of what will be a three apartment complex opposite the rapid transit station at 98th and Detroit Streets. These apartments were constructed on land formerly not used. A pedestrian bridge over the tracks will connect these apartments to the rapid transit station. In May 1967 the air rights over a part of CTS property at Windermere terminus was sold for $1,500,000 to a developer who contemplates building two fourteen-story office and apartment buildings there.

8. Lack of Downtown Distribution

The Cleveland rapid transit is severely handicapped by having only a single downtown station. Even that is not centrally located, but at the western edge of the downtown business district approximately one-half mile from its center. A report of Cleveland's Planning Director in 1959 indicated that only 21% of those employed in the main core area of downtown were within 800 feet of that station. The stations of the proposed subway would bring four times that number within 800 feet of the rapid transit.

Engineering studies reported that the subway extension would more than double riding on the rapid transit. Fig. 10.6 shows the route of the present rapid transit and the proposed subway extension and how they related to the downtown employment.

I. Rapid Transit Extensions

1. Planning for Rapid Transit Expansion

Failure of the County Commissioners to build the subway extension did not cause the CTS Transit Board or its management to forget about any further expansion of its rapid transit. Early in 1960 the Transit Board passed a resolution authorizing the expenditure of money for and directing its management to make a series of feasibility and engineering studies of a number of possibilities for extending its rapid transit. It requested that the first of these studies should be of an extension to the Cleveland airport. The purpose of making these studies was to have a

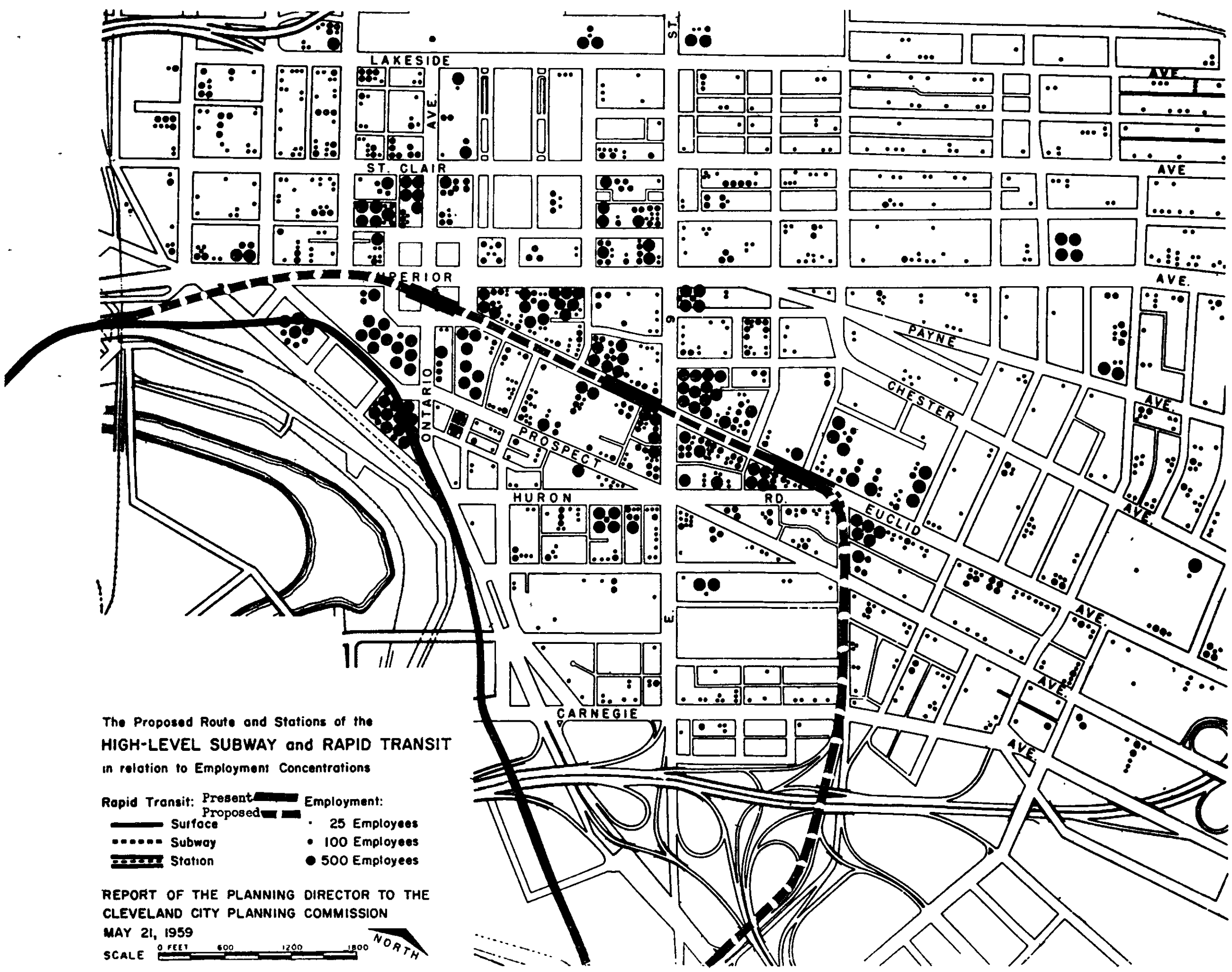

Fig. 10.6 - Proposed subway loop through Cleveland downtown area (broken line) and present route (solid line).

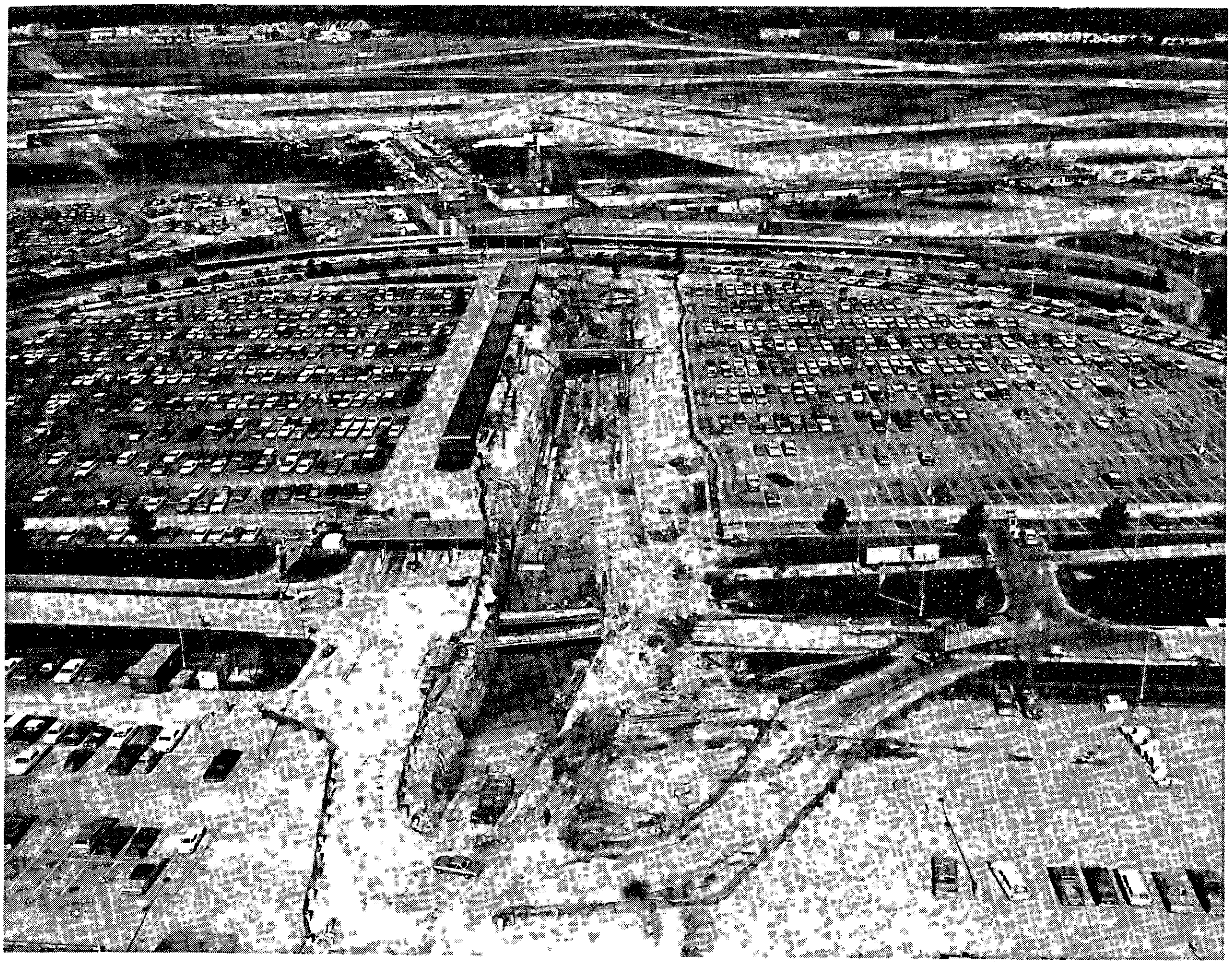

Fig. 10.7 - Cleveland Hopkins Airport, showing new rapid transit station under construction.

background of useful information which would expedite making sound decisions when money became available for expanding rapid transit in Cleveland.

Seven engineering and feasibility reports on rapid transit extensions have been made by the staff of the Cleveland Transit System. These are:

a. Rapid transit extension to the airport -- March, 1960.

b. Southeast rapid transit extension -- December, 1960.

c. Southwest rapid transit extension to Brooklyn-Parma area -- July, 1962.

d. Southwest extension to Brooklyn-Parma area; Bus rapid transit supplementary report -- March, 1963.

e. Rail rapid transit extension via Northwest Freeway -- November, 1963.

f. Bus rapid transit via Northwest Freeway -- February, 1965; revised February, 1966.

g. Heights rapid transit extension -- July 1966.

2. Rapid Transit Extension to Cleveland Airport (Fig. 10.7)

The extension now under construction to the airport is probably the least feasible of the proposals studied, when measured by the number of new riders per capital dollars spent. It is expected that the yearly operating and maintenance expenses for this extension will be met from fare box revenues produced by the extension. The communities immediately to the north and west of the airport are among the fastest growing in the entire county. The consulting engineers estimate that more new riding on the extension will come from those communities than from airport passengers or employees.

Although the extension to the airport may not have been the most feasible financially, it certainly was the most popular with the public. Public interest in any one of the other possible extensions came mostly from the people living or working in the corridor of the extension, who might become daily riders. Interest in the extension to the airport was quite different -- it came from all areas of greater Cleveland, the majority of its from people not living adjacent to the extension or likely to become daily riders. More different persons will use the airport extension at some time or another during the year than would use other possible, outlying extensions, but the total riding per year would be greater on most of the alternate projects.

The new cars ordered as a part of the airport extension project will be 70 feet long and seat more than 80 passengers. Their higher speed will permit a running time of 22 minutes from the airport downtown. Racks for carrying luggage will be located at each end of the new cars. Plans call for using the new cars exclusively throughout the entire line during non-rush hours. These faster, air conditioned cars, will thereby improve the attractiveness of the rapid transit at all stations of the present route.

J. Additional Things Learned From Cleveland's Experience

1. Rapid Transit for Tomorrow Must Be Different and Better

a. Must serve auto drivers -- There is no reason for disputing the predictions for increased ownership of automobiles. The predictions for intolerable traffic conditions in central cities may also come true unless public transit is able to attract and divert riders from the auto. Rapid transit would seem to offer the best chance of holding present and attracting new riders -- especially if it caters to the automobile owner. This means planning rapid transit stations in the outlying areas for the convenience of the auto driver, as CTS did with West Park and Puritas stations.

Proof of this is illustrated by the passenger figures for West Park and Triskett stations compared with the rest of the system. As explained above, riding on the rapid transit has declined since 1960 (but to a lesser extent than bus lines radiating from downtown). The experience of the two stations designed to serve the auto driver has been contrary to the rest of the line -- riding has increased at both of these stations while declining elsewhere. Also, about 85% of the increase for the entire rapid transit in 1960 over the year 1959 took place at these two westerly stations . (Table 10.7)

TABLE 10.7 - RAPID TRANSIT PASSENGER TRENDS AT AUTO-ORIENTED STATIONS

Year	Total Rapid Transit Psgrs. (000's)	West Park		Triskett	
		Psgrs. (000's)	% of Total	Psgrs. (000's)	% of Total
1959	17,882.1	1,769.7	9.9	765.4	4.3
1960	18,329.4	2,088.5	11.4	876.4	4.8
(Change)	+507.3	+318.8		+111.0	
1965	16,656.4	2,157.1	13.0	873.6	5.2
1966	16,645.6	2,166.9	13.0	966.9*	5.8*

*Not comparable to other years due to feeder bus line added in 1966.

Experience of CTS demonstrates that where ample parking is provided at a rapid transit station, many auto drivers prefer the "rapid" to driving and parking in the central business district. Automobile parking at the two westerly stations has increased steadily, and both lots have been expanded. A survey at these two parking lots showed that the number of auto drivers who parked at the stations and used the rapid increased, while riding on the rest of the rapid transit was declining.

Count of Autos Parked - 2:00 PM

Station	2-28-'64	2-25-'66
West Park	1,613	1,860
Triskett	944	1,057
Total	2,557	2,917

b. Stations in outlying areas will be further apart -- This will make possible faster scheduled speeds which is important in attracting people to public transit. With the majority of riders reaching a rapid transit station by either feeder bus or automobile, wider spacing between stations is warranted.

c. Greater passenger comfort and appeal -- The standards that prevailed when rapid transit systems were built 40 or more years ago are not good enough today. More attention must be given to improved seating ratios, air conditioning and ventilation, better lighting, more quiet cars, pleasing decor in stations and cars, and convenient transfer facilities to feeder buses.

2. Dense Populations Not Required for a Modern Rapid Transit

Some persons still contend that rapid transit is not feasible except where population densities approach those of New York City. This is tantamount to saying that future rapid transit systems will be similar to those constructed forty of fifty years ago when most of the patronage came from persons who walked to and from rapid transit stations. On future rapid transit systems stations outside of the central business will be spaced further apart. The feeder bus and automobile will extend the area from which patrons at a given station are drawn. This area easily may be ten to twenty times greater in size than the area of the 50-year old station whose passengers arrived as pedestrians.

A system based on density and requiring pedestrians for passengers will attract its riders from an area with a radius of about a quarter of a mile from the station. In such a case the area served would be about 1/5 of a square mile. A system built for the lower densities of population which generally prevail in many cities will have its stations about a mile apart and will be designed to attract passengers from feeder buses and automobiles as well as pedestrians. Stations of this system will draw patronage several miles from both sides of the route from an area of 3 to 4 square miles or more -- which is 15 to 20 times the area of attraction of a station of the old systems.

The apartment buildings which have gone up at or near rapid transit stations in Cleveland follow the experience in other cities -- that density builds up around rapid transit stations. This trend has been slower in Cleveland than in cities like Toronto because of the location of the rapid transit along a railroad right-of-way.

3. Financial Support for Transit

a. Public pay for capital facilities -- Most transit systems, private or public, are unable to finance the capital improvements or extensions which may be important to a community. Increasingly, public funds will be spent for mass transit, just as public funds support other activities which are for the general good of a community. Perhaps one fault in the past has been that transit people have thought of why public funds were needed for transit rather than thinking broadly of the community needs and what transit can do for urban areas. The Department of Housing and Urban Development of the federal government is forcing transit to think and plan on a broader scale.

With 20/20 hindsight, it might be contended that the Cleveland Transit System should not have committed itself "to the hilt" for the start of a rapid transit system. It has been contended that it should have moved forward on a more comprehensive system and done nothing until the necessary public funds were available for such a system. Perhaps CTS paid a penalty for some measure of success in rapidly paying off the cost of the system and the cost of a fast and complete modernization, as well as putting more than two and one-half times as much of present and future fare box revenues into a rapid transit than it paid to The Cleveland Railroad for the original system. When CTS continued planning extensions of its rapid transit but said, "We have gone as far as we prudently can with transit revenues; we now need public funds to continue the extensions" it met with some criticism and expression of surprise that it could not keep right on doing everything out of the fare box. Perhaps CTS lagged in laying out a comprehensive program of rapid transit and strongly asserting that public funds would have to pay for the capital facilities.

b. Broader Transit Board Authority -- CTS was fortunate to always have whatever support was required from the mayors and council of the city of Cleveland. A transit system should not have to rely on good fortune. The Board responsible for the good operation of a system should have the full authority for that operation. The amendment to the charter of the City of Cleveland in 1949 was a forward step.

The demise of the subway, for which the voters authorized the issuance of tax supported bonds, illustrates what may happen elsewhere or again in Cleveland. It points to the virtue of a Transit Board having authority to carry out public financing, subject to voter approval, rather than to have to depend upon the whims of other public officials who have no responsibility for the transit system.

11. CASE STUDY: WASHINGTON, D.C. CONFLICTS IN RAPID TRANSIT PLANNING

MICHAEL LASH

Planning for rail transit in Washington, D. C. has attracted a good deal of national attention in recent years. One reason is that events in the nation's capital are often better publicized than those in most other cities. Another is that other cities struggling with their own intractable problems of traffic congestion looked to Washington, D. C. for guidance on a solution. And a third reason is that in 1963 transportation planning in Washington erupted into a major debate between pro-transit and pro-freeway groups over whether freeways or rail transit should be given the major emphasis in solving the area's transportation problem. Although transit and highway advocates had exchanged glancing blows in other American cities, this was the first time the two groups had collided head-on — and the sparks reached all parts of the country.

Accusations were exchanged at meetings and in the newspapers; numerous congressional hearings were held in an effort to unravel the issues. Experts were brought to Washington to testify at Senate and House subcommittee hearings. And city officials and planners in all corners of the United States watched and listened in hopes that out of the Washington melee they would find the answer to their own transportation problems.

The fact that the battle just seemed to fizzle out with no clear solution coming from the Washington, D. C. debates showed how difficult the issues really are. It also showed that a battle between highway and transit advocates is a futile struggle to find a single one-sided solution. The battle was hopeless from the start because it pitted against each other as adversaries parties who can only solve the problem they both face — namely urban transportation — if they attack it as allies.

A review of the Washington, D. C. experience in planning a new transit system is useful to a student of urban transportation for a variety of reasons. That controversy did raise to the surface many of the crucial issues involved in the development and promotion of transit plans. Secondly, the mass transportation studies made in Washington, D. C. beginning in 1959 are well worth studying in their own right. They illustrate many good techniques that can be used elsewhere. Moreover, reviewing the Washington, D. C. experience shows the enormous difficulties and complexities of many kinds that face any large city which seriously undertakes to find and carry out a solution to its transportation problems.

Background

The Washington, D. C. metropolitan area is made up of the District of Columbia plus portions of the States of Virginia and Maryland. The third fastest growing SMSA (Standard Metropolitan Statistical Area) in the country, the area's population climbed to 2,002,000 in 1960, an increase of 36.7 percent over 1950. By 1964 the population reached 2,339,000, a rise of 17 percent since 1960.

About a third of the area's population lives in the central city, the District of Columbia. Fifty-five percent of the District's residents are negro, the largest percentage of all large American cities. The suburbs on the other hand are typically almost entirely white, although a growing acceptance of open housing in the Washington area in recent years may represent the beginning of a more uniform geographic distribution of the population by race.

Thirty-seven percent of workers in the metropolitan area are government employees, the highest percentage of all SMSA's. Metropolitan Washington is also high in terms of average family income — the third highest ($7,577 in 1960) of all SMSA's, with only Stamford and Norwalk, Connecticut exceeding it ($8,745 and $8,002, respectively). But while the average family income for the Washington SMSA is high, the income of those living in the central city itself is just slightly above the average for all central city families in the U. S. ($5,993 in D. C. as compared to $5,945, the average for all central cities).

The area's employment is predominantly white collar. Only 7.5 percent of workers in the SMSA are in manufacturing, while the national average for SMSA's is 29.2 percent.

Washington is a mecca for the citizens of the U. S. People from all parts of the nation and the world converge on Washington for business and as sightseers. Tourism alone accounted for an expenditure of $352,000,000 in 1957. Because of the large numbers of visitors to Washington, this factor is an important consideration in transportation planning for the area.

The metropolitan area encompasses 1500 square miles of rolling countryside. The area is penetrated by two rivers, the Potomac and the Anacostia. Both rivers, but particularly the Potomac, constitute major obstacles to free traffic movement between the central city and the suburbs to the east, south, and west.

The Washington Transportation Problem

The region's transportation problem arises primarily from rapid population expansion; it is expected that the 1960 population of the region of 2.0 million will grow to 3.4 million in 1980. There is now congestion of streets and highways, which is predicted to grow steadily worse unless improvement is made in transportation facilities. Virtually all the population growth is taking place outside Washington itself but the city will continue to be by far the greatest center of employment in the region. It is estimated that by 1980, some 254,000 persons will travel to or through the downtown area in the peak hour, a 44 percent increase over the 1955 level of 176,000.

Most of the local public transportation in the District of Columbia is performed by D. C. Transit System, Inc. This was once primarily a streetcar operation but is now entirely converted to bus; 2,752 miles of bus routes are operated in the region. The D. C. Transit System owns 1,074 buses and the cash fare is 25 cents (but will be raised to 30 cents in the near future). The President and Chairman of D. C. Transit is O. R. Chalk, well-known in transportation circles. Statistics for D. C. Transit for 1960, as reported by Moody's, were:

Revenue Passengers	134,925,430
Passenger Revenues	$27,934,933
Net Profit.	$ 785,677

Other bus lines operate between suburban areas, particularly in Virginia, and downtown Washington, providing the only other commuter service except for a small amount by railroad. However, today less than 45 percent of peak hour travel to downtown Washington is by public transportation (bus), as compared to 70-90 percent in other large metropolitan areas.

The 1959 Mass Transportation Study

The latest rapid transit plan for Washington, D. C. is an outgrowth of two studies, one completed in 1959* and the other in 1962. The first study was made jointly by the National Capital Planning Commission and the National Regional Planning Council, and was on the subject of future transportation needs of the Capital Region. Earlier studies had been made by the Planning Commission, but in 1955 the Congress had directed these two bodies to "jointly conduct a survey of the present and future mass transportation needs" of the region. Extensive surveys and studies were carried out, with the result that the 1959 report, in brief, recommended the construction of 33 miles of rail rapid transit line with estimated cost of $458.5 million; 66 miles of express bus facilities (routes) with cost of $68 million; parking facilities for the rail and bus services at $37.6 million; and downtown parking facilities at $119 million. The proposal also included 329 miles of new freeways and expressways (81 miles already in existence) with estimated cost of $1.8 billion. Total cost for the entire transportation program thus was estimated at about $2.5 billion.

Some $500 million of the proposed highway system was not included in the then current highway program and this cost would require additional financing. Income from the rail transit and bus facilities was expected to cover operating costs with some contribution to capital costs but a net annual deficit of $16.1 million was expected in 1980, for which funds would have to be provided.

The report of the two agencies was subsequently considered at length in Congress by the so-called "Bible Committee," a Congressional Joint Committee on Washington Metropolitan Problems. From the hearings held by the committee it seemed apparent, 1) that the appeal of a rail

*DeLeuw, Cather and Company. Mass Transportation Survey: National Capital Region; Civil Engineering Report. Washington, D. C.: National Capital Planning Commission, 1959. 34 pp.

transit system had been underestimated and, 2) that there was great local opposition to the effect new highways would have upon the community. It was said that these would "demolish residential neighborhoods, violate parks and playgrounds, desecrate the monumental portions of the nation's capital, and remove much valuable property from the tax rolls." It was certainly apparent that the proposed highways would not follow established, existing streets but would take new right-of-way through the city. One critic of the highway plan probably summed up the fears that many shared in his letter to the Editor of the Washington Post, a portion of which reads:

> "And each highway requires one or two more highways to connect it properly. And so on until the highway's inventors have exchanged the attractive city of Washington for a field of cement. Instead, let's choose to keep the city a place worth driving to."

As a consequence of the hearings, there came the enactment in 1960 of the National Capital Transportation Act. The Agency created by this act (the NCTA) was directed by Congress to evaluate the 1959 plan, to consider alternatives to that plan that might be less costly and damaging to the City, and to coordinate transportation planning in the region. Congress had stated as a matter of fundamental policy that there should be planning on a regional basis of a unified system of freeways, parkways, express transit on exclusive rights-of-way, and other major transportation facilities. Congress also directed the Agency to prepare the Transit Development Program as a prelude to construction of transportation facilities, and empowered the Agency to construct and provide for the operation of regional mass transit facilities, subject to Congressional approval.

In early 1961 President Kennedy appointed C. Darwin Stolzenbach as NCTA Administrator, and it was Mr. Stolzenbach and the strategy he would choose to follow that would dominate events on transit in Washington for the following four years. Stolzenbach was a civic leader in nearby Montgomery County and prior to taking the leadership of NCTA was employed by the Operations Research Office of Johns Hopkins University located in the Washington suburbs.

<u>The NCTA Unveils Its Transportation</u>

Work must have been feverish at the offices of NCTA in the next 18 months. During this period from April 1961 to November 1962 the study staff with the help of several consultants in certain specialized areas completed its review and developed its report. But during this period the NCTA conferred little with other planning groups. Consequently in November 1962 when its report and recommendations were finally submitted to President Kennedy and released publicly it was the first time many local groups had seen it.

The most controversial parts of the NCTA plan were:

1. A proposal to more than double the mileage of rail transit over that recommended in the 1959 plan, from 33 miles to 83 miles; also to cut the area's proposed freeway system by almost 40 percent, from 410 miles to 255 miles.

2. An estimate that future revenues would be sufficient to pay almost the entire capital costs of the rail transit system (87 percent).

In support of its recommended plan, the NCTA claimed the following benefits over the plan recommended in the 1959 study:

1. Capital outlays for the combined highway-transit system for the area would be lower by $367 million.

2. Annual operating costs for new highways would be cut in half.

3. A reduction of 75 percent in the taxable land taken by highways and transit in the District of Columbia.

4. Fewer people displaced in D. C. by transportation improvements (5,400 instead of 33,000).

The rail transit system proposed was estimated to cost $793 million. It would be 83 miles in length with seven rapid transit lines and one commuter railroad serving major travel corridors. There would be 19 miles in subway in downtown Washington designed to provide an extensive distribution system. Construction in the outer areas would utilize freeway median strips and existing railroad rights-of-way for the most part. Feeder bus service and parking areas at transit stations were elements in the plan. Financing was proposed by a rather complex arrangement of U. S. Treasury loans, federally-guaranteed revenue bonds, federal, state and District of Columbia grants, and revenues from the transit system. The system's revenues were expected to cover operating costs and to make a major contribution toward the capital costs. If the estimated net revenues were realized the system could become debt-free by the year 2000, provided the recommended financing plan was adopted.

Submission to Congress

The NCTA plan for rapid transit was submitted to Congress with a Presidential message supporting it, in May 1963.

NCTA had recommended in its 1962 report* the construction of certain expressways and other highways although it held no actual authority with respect to highway planning. This recommendation, however, represented some curtailment and revision of a highway program based on a 1959 study then being promoted by highway advocates, even though the cost of the NCTA recommended highways was estimated at $826 million. The Presidential message to Congress supporting the rapid transit bill called for reevaluation of certain controversial highway projects and a special study group was established for that purpose. These NCTA highway recommendations were the subject of strong disagreement at the subsequent Congressional hearings on the rapid transit bills.

The President's request for reevaluation of certain highway proposals resulted in stopping most of the Interstate Highway construction in Washington, D. C. This action further divided groups with an interest in Washington's transportation programs into two camps, the proponents of the highways and those in favor of rail transit. Members of Congress also found themselves divided on the issue.

Opposition Mounts

Highway user groups entered the fray. Their position was summarized in a publication of the National Highway User's Conference, The Highway User (June-July 1963 issue), as follows:

> "In addition to the importance of the suspended highway projects in the nation's capital from the standpoint of representing a broken link in the Interstate System, the Washington controversy has far-reaching implications for still another reason.
>
> "In at least one of the publications issued by the National Capital Transportation Agency appeared this paragraph:
>
> " 'The nation's capital, because of its unique relationship to the country, can well be considered a model area. The mass transportation system of this area will have the same character. It is imperative that what is done in the nation's capital must be done well. The 212 metropolitan areas of this country will look upon the National Capital Transportation Agency and its work as a model from which they can draw knowledge to help them in their growing problems of mass transportation.'
>
> "Highway users feel that the inference to be drawn from this is obvious: that the campaign to supplant freeways with subways in Washington is the opening gun in what could lead to a national movement to slow down or curtail the highway program which two Presidents and Congress have said are so vital to the national economy and security.
>
> "Highway officials are firmly convinced that this would be a grave mistake, as they are certain that it will be catastrophic for Washington in terms of mounting congestion if the scheduled bridges and freeways are not constructed as planned—and quickly. "

The bus companies which provide existing public transportation within the District of Columbia and to and within suburban areas vociferously opposed the NCTA plan. Their spokesmen asserted that buses could do the job as well or better than rail rapid transit, would be more

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*U. S. National Capital Transportation Agency. Recommendations for Transportation in the National Capital Region. Washington, D. C.: GPO, 1962, 92 p.

flexible and provide better service. They supported additional highways with reserved lanes for buses. It was their view that operating buses as feeders to the rapid transit system would be ruinous to them. They were sharply critical of NCTA as being uncooperative in the study and questioned the validity of NCTA's estimates of patronage and finances. D. C. Transit System, Inc. claimed that it holds an exclusive franchise for public transportation in the District and that it should be the sole operator of any rapid transit system. It professed to have plans for an adequate rail rapid transit system which would cost no more than $400 million, utilizing mono-rail, hydrofoil or other "modern" methods.

A spokesman for the American Automobile Association objected to any curtailment of the highway program but claimed to have no opposition to rapid transit. There were reports that the NCTA program was opposed by the Bureau of Public Roads and the District Commissioners, but no one testified on their behalf at the hearings. There was also reference to a report critical of NCTA which had been prepared by Martin Wohl of the Department of Commerce but there was little testimony on this and the report is not part of the record. It was thus evident at the July hearings that much of the opposition to NCTA's transit plan arose from the proponents of the maximum highway program. The subcommittee also expressed its concern with any rapid transit system which might result in harm to the existing privately-owned bus companies serving the area; the 1960 Act which established NCTA contained provisions intended to protect the bus companies.

Questioning by members of the subcommittee of NCTA representatives also suggested some doubt on the part of the subcommittee as to the merits of the NCTA plans, at least of the magnitude to provide the full $793 million regional system. This doubt seemed particularly directed to NCTA estimates of patronage and financing, as to whether the system could in fact be self-supporting as estimated.

The "Bobtailed" Plan

Little is known of what occurred with respect to the NCTA plan in the period July-November 1963 except for news articles commenting on the strong opposition of highway proponents. However, the House Subcommittee issued a supplement to the original hearing report, dated November 12 and 13, 1963. This supplemental report is limited to a compromise bill (H. R. 8929) filed by Chairman Whitener of the Subcommittee.

The compromise bill would authorize NCTA to undertake the construction and acquisition of only a part of the rail transit system which was contained within the original NCTA proposal, under similar provisions and conditions to those in the earlier bills. The "bobtail plan" would be confined in large part to the District of Columbia but with routes extending to Woodside, Maryland, and to the Pentagon and Rosslyn, Virginia, all short distances beyond the District boundaries. Part, but not all, of the downtown distribution subway was included. Cost of the compromise plan was estimated at $400. 6 million (down from $793 million) although the mileage was reduced from 83 miles to a reported 23 miles. The reason for the higher relative cost was that the compromise plan represents in large part a downtown system in subway, with most of the lower-cost suburban lines eliminated.

In response to the subcommittee's inquiry, NCTA announced its support of the abbreviated transit system as a first step and submitted estimates of capital costs, traffic and revenue, and operating costs. The agency recommendations for financing found that the shorter system would pay all operating costs and 65 percent of capital costs, the remaining 35 percent of capital costs to be covered by the federal and D. C. grants. The required funds, other than grants, would be obtained by sale of bonds supported by the Federal Government, as in the earlier plan, and NCTA estimated these could be retired in 36 years.

Most of the controversial features of the highway program appear to have been settled as shown in the report of the Subcommittee for November 12 and 13, 1963. At the time of submitting the NCTA report to Congress with recommendation for legislative approval, in May 1963, President Kennedy had asked for an investigation of the controversial highway projects. On November 7, 1963, the Board of Commissioners for the District of Columbia sent a letter to the President indicating that a special study commission appointed by the President had recommended, with the endorsement of the District Commissioners, acceptable design solutions for the controversial freeway sections. The President acknowledged the Commissioners' letter, stating that the recommendations were acceptable to him and the projects would be included in the next budget recommendations, noting that the entire District highway program could then move forward.

Legislative Action on the "Bobtailed Plan"

Although the rapid transit plan had its opponents, it also had substantial public support. Even so, on December 9, 1963 the NCTA met its most severe setback yet; the House of Representatives voted 278 to 76 to return the bobtailed plan bill back to committee.

This action was taken without comment or instructions, and the size of the recommittal vote was interpreted as a decision against that or a similar program unless drastic changes were made in plans for financing and operating the system. One member of the NCTA staff commented recently:

> "That was a devastating defeat. The transit program almost died then and there."

A Washington Post editorial two days after the House vote, attempted to explain the bill's defeat:

> "Mr. Stolzenbach committed three errors of political judgment. He believed that he could build the subway only by vehemently attacking the Inner (freeway) Loop. He believed that he could build the subway only if revenue estimates promised to pay its whole cost; the figures were demonstrably incredible. He believed that he could build the subway only by refusing to answer questions, however legitimate. He offered no reassurance whatever to the bus companies that he proposed to displace, or to their employees. They worked hard, and successfully, to beat the bill. It is now time to replace Mr. Stolzenbach.
>
> "The basic map of the future subway is well conceived. But the new administrator will have to develop a more rational financial and economic plan. The city and the Administration now have a responsibility to begin work quickly to construct the broad support required for the bill that they will, we hope, introduce in the next Congress.
>
> "First of all, the vote in the House was a sharp and explicit personal repudiation of Mr. Stolzenbach, the administrator of the National Capital Transportation Agency. He can now serve the city best by promptly resigning. He is so widely distrusted that it is doubtful if any bill can succeed while he retains office. A new administrator will have to work out, in detail, the relationship between the bus companies and the transit system, protecting the interests of the companies and of their employees. He will have to meet and dispose of the absurd proposal for private ownership; one might as well talk of private ownership of the post office, or of the sewers."

1964 Events

In a message to Congress in January on District of Columbia affairs, President Johnson urged that an acceptable rapid transit program be formulated at the then current session of Congress. He noted that ten years of study have made it abundantly clear that such a system is critically necessary.

Engineer Commissioner Duke of the District of Columbia said that there were no plans for additional freeways beyond those now programmed and that City highway planners were counting on a full-sized rapid transit system to keep the freeways from being clogged by traffic. He predicted Washington commuters eventually might be forced to change their jobs or homes unless the transit system was built. Mr. Duke said that while they wanted the most efficient bus service possible, it would not be enough without the rail transit system.

A Transit Bill is Resubmitted to Congress

In February 1965, fourteen months after the transit bill's initial rejection by the House, President Johnson sent the bobtailed plan back to Congress requesting approval. Three months later, the President named Walter J. McCarter the new Administrator of NCTA, replacing Mr. Stolzenbach. Mr. McCarter was General Manager of Chicago Transit Authority during its first 17 years of existence (1947-64), formerly with Cleveland and Milwaukee transit systems. He was also President of the Institute for Rapid Transit.

In August of 1965 (three months after Mr. McCarter's appointment) Congress enacted a bill authorizing construction of the 25-mile $431 million rapid transit system recommended by

NCTA. * The act was signed into law two weeks later. Though this act authorized construction of the system, it did not appropriate funds for construction to actually begin. Only $6. 2 million were given to NCTA for more detailed planning.

1966: A New Crisis

During the first eight months of 1966 the NCTA moved forward rapidly in the development of plans for the rail transit system. Design engineers from all over the country were brought in to draw the blueprints. The expectation was that by the summer of 1966 Congress would make additional funds available so that right-of-way acquisition and construction could at last begin. This expectation, however, was frustrated by a new roadblock in the form of Congressman William Natcher (Ky.), Chairman of the House Appropriations Committee.

Mr. Natcher was obviously incensed over delays caused in the construction of the Interstate System in Washington, D. C. as a result of anti-freeway groups, some of which happened also to be supporters of the new transit system. The NCTA under McCarter, however, stayed clear of the battle. Mr. McCarter gave little encouragement to the anti-freeway forces. On the contrary, he was quoted in the press as having remarked on several occasions that D. C. needed both the freeways and the transit system. He also pointed out that the Washington freeway proposals were more modest than in any comparable city.

Opposition to the freeways actually came to focus in the District of Columbia's official planning agency, the National Capital Planning Commission. Encouraged by various anti-freeway groups throughout the area, including some representing people who would be displaced by the highways, a strong segment of the commission succeeded in stalling highway construction ever since President Kennedy had given the green light to the District's freeway program three years before. Therefore, the target of Congressman Natcher's displeasure was really the National Capital Planning Commission.

Mr. Natcher's position is described in the following from an editorial in the Washington Post of September 10, 1966:

> "Washington's future subway system is once again in the gravest jeopardy, and this time the city was given months of forewarning. Congressman Natcher, the chairman of the District Appropriations Subcommittee, repeatedly let city officials know that the subway could go forward only if the highway program also was going forward. The Planning Commission has continued to delay all major highway construction and now, predictably, Mr. Natcher has deleted the District's share of the subway construction money. The sum is small, but without it the entire project is frozen.
>
> "Mr. Natcher is in a strong position. For years public officials, including planners, have been preaching that roads and rails must complement each other. Now both systems are blocked because a few members of the Planning Commission are seized by a dogmatic opposition to all urban highways, regardless of design and location. The next series of highway projects will come before the Planning Commission on Thursday. If it fails to clear the pending highway projects at that meeting, it will automatically delay the subway for a period of at least two years.
>
> "The subway is to be built by the National Capital Transportation Agency, which has now brought in some 70 design engineers from all over the country to draw the blueprints. The NCTA's current funds will last only one more month. If the next appropriation is not passed rapidly, the NCTA will have to lay off these engineers at the end of September. The same thing happened after the first authorization bill was defeated three years ago. The next time, the Agency would have real trouble recruiting first-rate men to a city that could not make up its mind."

A meeting of the Planning Commission was scheduled within a week after the House Appropriations Committee made known its refusal to approve the subway funds. The commission's meeting on September 16 was a lively affair. Spectators jammed the meeting room and anti-freeway pickets marched outside.

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*U. S. National Capital Transportation Agency. Rail Rapid Transit for the Nation's Capital. Washington: 1965. 39 pp.

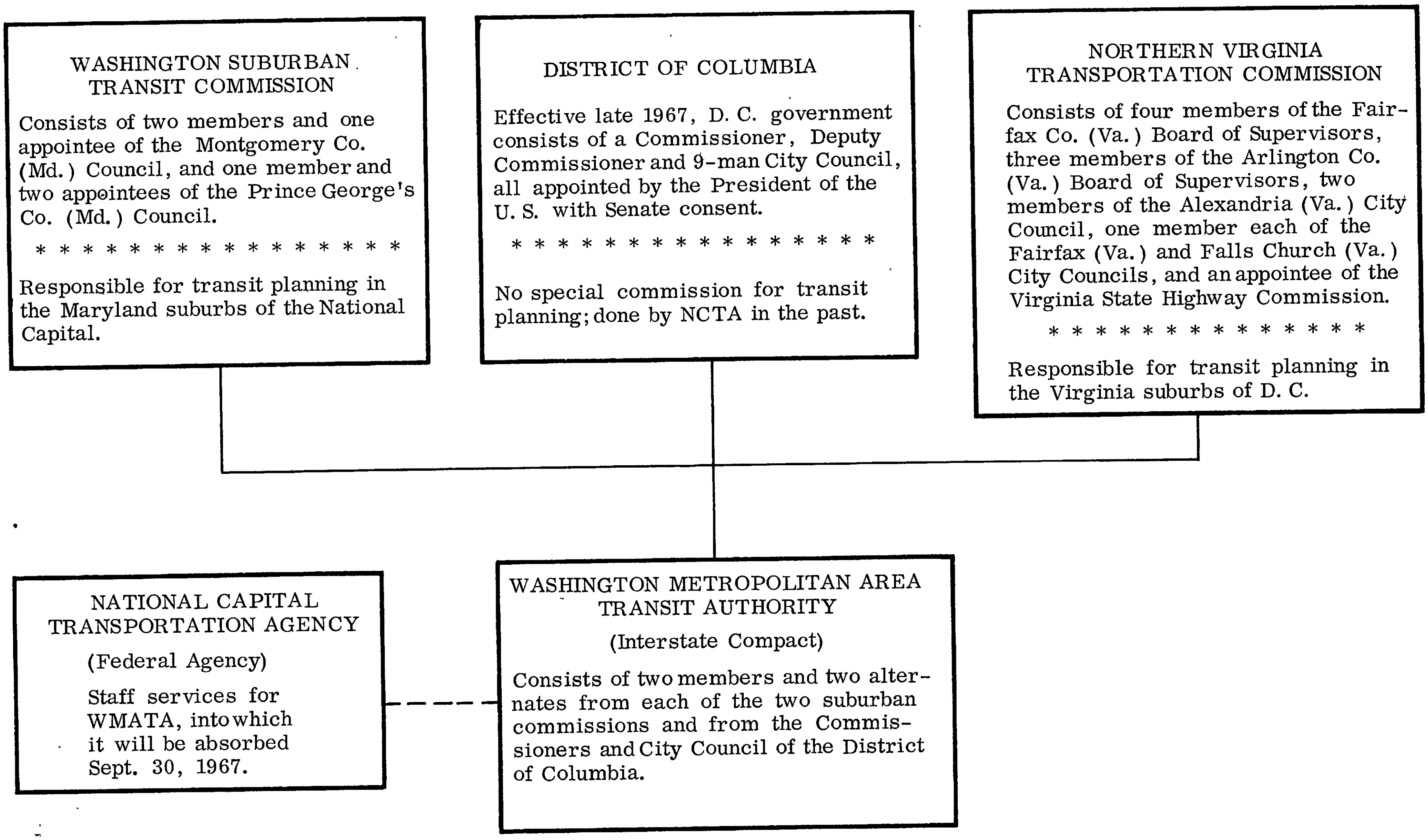

Fig. 11.1 — Organization of the Washington Metropolitan Area Transit Commission.

Near pandemonium broke loose when the commission finally voted — a 6-to-4 vote in favor of the controversial freeway. Angry spectators shouted their outrage and the room had to be cleared before the commission could resume its meeting.

Within a week or so after the Planning Commission's action approving the freeways, the subway funds were released by the House Appropriations Committee.

1967: The Washington Metropolitan Area Transit Authority Comes Into Existence

The "bobtailed plan" approved by Congress in 1965 was a limited system confined largely to the boundaries of the District of Columbia. Expansion of the system to penetrate the suburbs could only be accomplished through the creation of an interstate compact since the metropolitan area included not only D. C. but parts of Maryland and Virginia. The major activity of the National Capital Transportation Agency during late 1966 and early 1967 was to bring about the creation of such a compact. The compact would create a Washington Metropolitan Area Transit Authority (WMATA) empowered to plan, finance, construct and provide for the operation of a transit system for the entire National Capital Region. The new authority would replace the federally created NCTA and provide a framework within which the expanded system could be developed cooperatively by all the governments of the region.

The proposal for the compact generated some but no great amount of opposition. It readily cleared both houses of Congress as well as the governments of D. C., Virginia, and Maryland; it came into existence in February 1967.

Beginning on September 30, 1967 the new authority will take over all financial, political, policy and other responsibilities for completing the 25-mile basic rapid transit system authorized by Congress in 1965 and begin plans to expand that service into the suburbs to create a regional system. On that same date the NCTA will be absorbed by the new authority.

The authority represents a transfer of ownership and control of the rapid transit system from the Federal Government to the 2,500,000 people of the 1,500 square mile region, through their elected representatives.

The interstate authority board is made up of two representatives from Maryland, two from Northern Virginia, and two from the District of Columbia. These are chosen from the boards of the Washington Suburban Transit Commission (Montgomery and Prince George's County in Maryland), the board of the Northern Virginia Transportation Commission (Arlington and Fairfax Counties, the cities of Alexandria, Fairfax and Falls Church in Northern Virginia), and the Commissioners and City Council of the District of Columbia. (See Fig. 11. 1)

The Future of Rapid Transit in Washington, D. C.

As of mid-1967 the ultimate fate of the Washington, D. C. rapid transit program remains uncertain. Although a great deal of planning and many blueprints have been completed, no construction has yet begun. The amount of rights-of-way purchased to date has been insignificant, perhaps one or two parcels.

The Washington transit program has weathered many problems and conflicts in the past, but perhaps its most trying times are still ahead. Now under the control of a loose coalition of local governments, the rapid transit program becomes susceptible to the difficulties of achieving consensus by competing local governments and to the vicissitudes of local politics.

Even more troublesome may be the search for a solution to a profound but thus far neglected problem — financing. How the total program will be paid for is still unresolved. Beyond the commitment of $150,000,000 by the D. C. and federal governments, no one now knows how the balance of the cost will be raised. And it is unlikely that Congress will be willing to release much of its initial commitment until a convincing scheme is presented for financing the total system.

The cost of the total system is also an unknown. It is unknown because even the configuration of the expanded system is yet unsettled. The new Transit Authority is exploring a variety of new systems and it may be many months yet before they settle on a single plan. Knowledgeable persons estimate that the system finally adopted will cost over $1 billion, perhaps even as much as $2 billion if some of the elaborate systems now being considered should be selected. This will be more than double the original estimated cost of $431 million for the bobtailed plan.

How to pay for the transit system cannot be left hidden and silent much longer. The earlier expectation that the system can be largely financed from fare revenue is questioned both in Congress and by transit experts.

Eventually the voters of the communities involved will be asked to vote on a bond issue that will mean higher property taxes. Will they follow the lead of the voters of San Francisco and elect to pay more taxes for rapid transit? Of course no one knows, but few expect this to be an easy battle. Ominous signs for the future may be reflected in the following from a March 17, 1967 issue of The Washington Post:

"To begin with, an overwhelming majority of the residents in the metropolitan area apparently think a rapid transportation system would be worthwhile.

"This has been shown by all the public pronouncements that have been made, both by politicians (with and without political office) and spokesmen for dozens of civic organizations, who have testified on Capitol Hill.

"But the National Capital Transportation Agency is finding that popular enthusiasm for rapid transit does not extend to paying for it.

"An NCTA staff man who has gone to at least 700 meetings in the last six years, preaching the benefits of rapid transit, talks of two basic reactions.

"District residents, he says, sometimes have trouble understanding why they should pay for a system that is going to be used heavily by suburbanites, while people in the county tend to take the view that they don't want to pay for a Negro subway system in the District.

"In addition to not wanting to pay for the other guy's transportation, people in the District betray their animosity toward Virginia and Maryland residents with such oftheard questions as: 'When are you going to get rid of those Maryland and Virginia license plates in front of my house?' "

With financing and other problems still to be faced, those who have struggled for a rapid transit system in Washington, D. C., after several false starts in the past 50 years, are probably ready to agree with Justice Oliver Wendell Holmes, Jr. that:

"Certainty generally is illusion, and repose is not the destiny of man."

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*From Potomac Watch, a column by Richard Severo, Washington Post, March 17, 1967.

12. EXPLORING THE BENEFITS OF IMPROVED MASS TRANSIT

MICHAEL LASH

Nature of the Problem

Until recent years the question of whether or not to build a new transit line was decided almost entirely on whether the new line could pay its own way from fare revenue. Since World War II, however, it has become clear that transit patronage no longer can be expected to reach levels where receipts for a new system could cover both capital and operating costs. While patronage during the weekday morning and afternoon peak hours continues to be high, usage outside these peak periods and on weekends invariably drops to profit-draining levels. As a result, very few new transit systems have been installed in American cities since WWII.

Moreover, in the past, even where subsidies were required, it was universally assumed that the benefits were so clearly associated with the local population that the local area itself should provide the subsidy. But local tax funds for support of transit have not been easy to come by.

Within the past decade there has been a change in attitude on both these questions. Many arguments are now heard that transit is necessary even if its financing can only come from some form of general revenue. Also there now exists a wide acceptance of the idea that State and Federal governments have a responsibility to help cities financially to improve their mass transit systems. This view at the Federal level is reflected in the following quotation from a 1962 letter to the President of the United States by the Secretary of Commerce and the Administrator of the Housing and Home Finance Agency:

> "Mass transportation must be viewed as a public service and often cannot be a profit-making enterprise. While mass transportation is provided on a more or less limited scale in hundreds of localities, it is generally not possible to support a large-scale investment program from the fare box. But the price to the community and to the Nation of inadequate mass transportation can be uneconomic uses of land and higher than necessary costs of public facilities, excessive travel and increasingly aggravated congestion at peak hours."

Interest in the mass transit problem by the Federal government, and increasingly by State governments, plus the availability of Federal and, in some cases, State funds to assist in financing improved mass transit has brought new life to transit planning. But it has also greatly complicated the problem of judging when a new transit facility is justified. No longer relying strictly on a cost-revenue calculus, those favoring expanded transit systems for our urban areas attribute a wide variety of benefits to improved transit.

In evaluating the arguments for increased emphasis on mass transit in urban areas, the planner cannot avoid pondering the following three key questions:

1. What can an improved transit system do for our metropolitan areas?
2. How much is it worth investing to achieve these benefits?
3. Where is the financing to come from?

This chapter will explore the first of these questions. The word "explore" is used advisedly; the reader should not expect to find more than a general treatment of the questions in this chapter. Conclusive answers are simply not available today. We have had little experience with modern transit systems in the U. S., and the experience with such systems in other countries is generally inapplicable to U. S. conditions. It may take actual experience with the operation of a modern transit system, such as the San Francisco system which is now under construction, to finally answer the question about what transit can do for an urban area.

As for questions 2 and 3 listed above, no effort is made here to answer them. The fundamental question is really the first one. Once the general benefits are known, reasonable judgments can be made as to the scale of the public investment that should be made to achieve those benefits.

Question No. 3 is also related to question No. 1, since the nature of the benefits expected to be achieved should begin to suggest the appropriate distribution of financial responsibility between the local, State and Federal governments, as well as suggesting the form of taxation most appropriate for raising the necessary revenues.

Now that public policy at many levels of government accepts the notion that transit improvements need not be justified strictly through the usual profit-loss calculus, the problem of evaluating the soundness of investments for improved transit becomes far more difficult. It now becomes necessary to probe more deeply to ascertain both the character and the degree of benefits to the general welfare that are likely to be realized.

General benefits ascribed to proposed transit improvements are many and varied. The following appear most consistently.

1. Reduce the aggregate costs of transportation.
2. Provide transportation for nondrivers (children, physically handicapped and the aged).
3. Provide transportation for low-income families unable to afford automobiles.
4. Provide a variety of good transportation to make personal travel as easy and convenient as possible for all urban residents.
5. Reduce street congestion.
6. Revitalize the economic growth of the CBD.
7. Create higher real estate values.
8. Reduce air pollution.
9. Promote a more desirable pattern of land use development.

To what extent a public transportation system contributes to the above objectives is far from clear. As has been mentioned earlier, one of the problems is that we have had very little experience with modern transit systems on this continent, and even where we have some reasonably up-to-date systems, their effects have not been objectively studied and reported on.

Some discussion of each of the nine frequently mentioned benefits, however, should be useful to help sharpen our focus on the issues.

The Potential of Transit for Reducing the Costs of Transportation

Perhaps no feature of urban transportation has been talked about so often but examined so inadequately as the cost of comparable urban transport services by different modes. The problem is far more difficult than it often seems at first inspection. The first question to be answered is what is meant by costs.

Public costs or personal costs or both?
Money costs only?
Should interest costs be included?
Should any value be given to comfort, convenience, and time savings?

The really difficult problem is how to evaluate time savings, comfort, and convenience. These factors are highly valued by the public and must be included in any comparative analysis of competing facilities.

Usually comparisons of personal costs of transportation are limited to the work trip. This is because of the repetitive nature of these trips and also because there is more competition for these trips between the auto and transit than for any other trip purpose.

A comparison of only the monetary costs a person must pay (fare for the transit trip and operating and parking costs for the auto trip) does not reveal how the average worker views the matter or how he makes his decision. Based on an analysis of an extensive survey of urban residents, Lansing found that people simply do not know what it costs them to drive to work (Ref. 11, page 96). The implication is that people do not greatly care exactly what it costs to drive to work.

In his computation of costs, Lansing made no attempt to include time savings, comfort, and convenience. His survey did show, however, that these are all important influences on the workers' choice of mode. As difficult as it may be to assign values to factors of this kind, they cannot be excluded from a valid analysis of trip costs.

Past urban transportation analyses have also tended to either ignore or deal casually with the costs of travel between the line-haul system and both the home and place of work. A common pattern has been to pass over parking expenses on the part of auto riders, and to pass over additional transfer or other expenses required of the transit rider at both ends of the line-haul portion of his trip. Such comparisons covering less than the entire trip are spurious and misleading. Valid comparison of alternate systems should cover costs for the total journey rather than simply for a selected segment.

One part of the problem does seem clear, however: there is a practical limit to the space that can be allocated to additional highways and parking facilities in cities. In large compact cities it is simply not feasible to provide all the roads and parking spaces that would be necessary to serve the transportation requirements of existing land use densities entirely with automobile transportation. A common view of the problem is described by Senator Harrison Williams as follows:

> "Even if we were to try (to solve urban transportation problems by highways alone) with an urban highway program averaging $10 to $20 million a mile in high density urban areas, there is every possibility that the remedy would only succeed in killing the patient — by replacing valuable tax ratable property with nontaxable concrete and asphalt, by creating huge downtown parking demands which would further remove land for commercial and cultural purposes, and by slowly carving away the very activities that created the demand for access in the first place."*

Thus, the question of the proper balance of transit and highways for a city is not alone a question of the comparative transportation economics involved, but in an important way it is also a matter of the tolerable limit on the amount of land space that a city can allow for transportation use. To the extent that transit can conserve the cities' limited land resources, this is a strong point in transit's favor in many space-short cities. This consideration has been one of the chief factors influencing many cities to seek a more extensive future role for transit. This has been a prominent factor in shaping the decision to seriously explore the possibility of installing a rapid transit system in Washington, D. C., in Minneapolis-St. Paul, in Baltimore, and in Atlanta.

The Potentials of Transit for Providing Transportation for Non-Drivers

A large proportion of the population is either too young or too old or otherwise unable to drive. Without some form of public transportation, this segment of the population simply would be immobilized. There is wide acceptance of the contention that government has a responsibility to provide some form of public transportation for people in this category. But there is less agreement on the quality and cost of the system that should be provided for this purpose.

In some transit planning reports the service provided by mass transit to the physically handicapped tends to be somewhat overstated. For example, the blind and those with walking difficulties have serious difficulties using public transit.

The Potential of Transit for Serving the Low-Income Population

Since our decisive entry into the auto age in 1946 (the year in which mass transit ridership began its drastic decline) mobility has increased for those who can afford to own an automobile, but it has diminished for those who cannot buy automobiles. This is a consequence of both poorer transit service as well as new trends of land use development that create business and employment centers virtually inaccessible by public transportation.

An average of about 33 percent of household units in central cities have no automobiles available. This ranges from 39 percent for central cities in SMSA's of 1,000,000 or more population down to about 20 percent for central cities in SMSA's of 50,000 to 100,000 population. In the SMSA outside the central cities, an average of about 11 percent of the household units have no automobiles.

While the greatest concentration of low-income people live in the central cities, the growing market of unskilled jobs is in the suburbs.

1. Herring was one of the first to observe the trend toward reverse commuting in his study of trans-Hudson passenger travel from 1948 to 1954 (Ref. 2). Noting the rise in peak hour trips outbound from New York City, Herring attributed this to the growth

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*U. S. Congress, Senate Hearings on Urban Mass Transportation, 1961, page 26.

of employment opportunities in the counties west of the Hudson River. He also observed that the New York City counties had been increasing in population without corresponding increases in employment. The city, therefore, was becoming a bedroom for suburban employment, a twist over the commonly held notion that New Jersey counties were the bedrooms for New York City workers.

2. Vernon describes the work travel problems of the poor with jobs in the suburbs as follows: (Ref. 3)

> "The poor, meanwhile, have begun to confront a new kind of transportation problem... Some of them have had to face the difficulties of the reverse commuting trip, and more are likely to face it in the future. Reverse commuting presents problems calculated to try men's souls. One difficulty stems from the fact that the public carrier schedules were never set up to deal with the pattern; and few public carriers see enough in such business today to justify changing their schedules. But more serious still is that fact that the final destination of the out-commuter is not some giant hub where all streams end, such as the central business district, but rather many diffused points in the thinly settled suburbs. As a result, after the commuter leaves the highway or the railroad line on which the public conveyance wends its way, he still has a final phase of his journey to overcome.
>
> "Wherever they can, therefore, the out-commuters travel by car. Their second-hand vehicles, crammed to the doors, can be seen headed out from many American cities on any weekday morning. This is their 'solution' but it is not an easy one. There is still the problem of financing the purchase of the car; and, if that can be handled with the combined resources of the car pool, there is also the problem of storing and maintaining it somewhere in the crowded city from which the daily journey starts."

A 1964 study by Singleton analyzed the transportation problems of the poor in the Watts area of Los Angeles (Ref. 4). He reported:

1. 57.5 percent of the Watts unemployed owned no car, and therefore are heavily dependent on the public transportation system.
2. Those without cars find the high costs of metropolitan public transportation prohibitive.
3. Whites tend to live outside and work in the city. Nonwhites tend to work outside and live inside the city.

> "The implications of this fact for the unemployed are clear. If the job opportunities for nonwhites are relatively greater outside the city, many unemployed nonwhite persons looking for work are relatively more at the mercy of the transportation system in its most inadequate areas. This might be one of the bottlenecks which cause proportionately more nonwhite to remain in the ranks of the unemployed." (Ref. 4, page 10.)

We cannot consider the poor an unchanging constant, either as to their numbers, their residential locations, or their travel patterns and needs.

1. Because of rising incomes, the number of families too poor to afford automobiles is steadily diminishing.
2. Government programs, such as the proverty program, is likely to speed up the pace of improving the lot of the poor.
3. Open occupancy in housing may bring about a greater geographic distribution of housing for the poor (who are often nonwhites).
4. All these trends may greatly alter the travel patterns and transportation needs of the poor in the future.
5. Because so little study has been given to the travel needs of the poor, it is difficult to make generalizations as to the kinds of transportation improvements that can best facilitate their economic betterment.

The Potential of Transit for Making Personal Travel in Urban Areas Easier

An efficient and extensive transit system can be advantageous, at one time or another, to almost everyone in an urban area. Even for those who do not use it regularly it provides a standby system for service when the family car is unavailable or during emergencies. For example:

--when family car is in the garage for repairs
--when wife needs car for medical appointment, shopping, etc.
--when cub scout troop goes to a downtown museum
--when heavy snowfall makes driving downtown undesirable

Such standby service can help some families avoid the expense and problems of acquiring a second car.

Another related consideration is the safety of transit as compared to automobiles. In New York City, for example, the subways during 25 years of service have not suffered a single fatality due to operational failure. The apparent safety advantage of transit is not lost on the public. In a 1959 public-opinion poll in San Francisco on the public's attitude toward rapid transit, of the 79 percent of the respondents who favored rapid transit, three out of four emphasized safety as a strong factor. *

Unfortunately not much information is available on the safety experience of mass transit. The fragmentary evidence that is available suggests that rail transit is safer than auto travel; however, this may not be true for bus transit.

Recognition by the public of the advantages provided by rapid transit in its capacity as a standby service and its relative safety advantage might help explain why in San Francisco over 60 percent of the voters approved the bond issue for the transit system when only about 12 percent of the people are expected to use the system regularly.

The Potential of Transit for Reducing Street Congestion

There is very little objective evidence that demonstrates whether or not an efficient off-street transit system has any significant effect on street congestion during peak periods. Subjective opinions vary greatly. Knox Banner's observations on the effects of the Paris subway are as follows:

> "Paris, France, which has a remarkably efficient subway system, providing transportation quickly, conveniently and cheaply to all parts of the city, where virtually no parking facilities have been provided, is hopelessly engulfed in an automobile problem that grows worse by the day. The fact that surface travel is at times impossible, and the knowledge that there will be no place to leave one's car at the destination, has not affected the Parisian's use of his car." (Ref. 11)

Many people in Cleveland, Ohio, however, hold a contrary view. Interviewing, a small but knowledgeable group of local residents, this writer found a strong subjective opinion, that since the rapid rail line was completed in 1959, congestion on downtown streets has eased appreciably. Unfortunately, no objective studies were made in Cleveland to substantiate this.

There is little doubt, however, that when it is first opened a new rapid transit line will reduce congestion on parallel streets. The question is whether traffic on those streets might not build up and eventually again reach almost the same level of congestion. Anthony Downs theorizes that this is what happens on streets paralling freeways, and his theory would seem to apply to a new rapid rail line as well. (Ref. 10) He suggest that congestion does tend to develop again but that it is not likely to quite reach the same high level that existed before the new facility.

The Potential of Transit for Revitalizing the Economic Growth of the Central Business District

Many public officials see an improved mass transit system as an essential requirement for the stability and growth of the CBD. This is particularly true of downtown business men and city newspaper editors who are often in the vanguard to promote mass transit.

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*San Francisco Examiner, August 20, 1959

We have already seen in Chapter 2 that, in both population and economic activity, the larger central cities are showing virtually no growth and many are showing losses. One of the most crucial questions associated with proposed new mass transit systems is whether such systems can reverse such decentralizing trends.

Studies by Meyer, Kain, and Wohl (Ref. 5) of the correlation between urban areas' levels of transit service and the rates at which they are decentralizing, found the following:

1. The largest absolute declines in central-city employment and population occurred in central cities experiencing highest transit use. (It should be pointed out, however, that this inverse relationship between transit use and growth is probably attributable to the fact that central cities with well-developed public transit systems are usually older cities, which ordinarily are slower growing and have less vacant land.)

2. A high level of transit use by central-city workers is not a guarantee against the decline of central cities and CBD's.

Cleveland, Ohio is the best city in the United States for the study of the effects of a new transit system on the CBD economy. The installation of the 14.9 mile Cleveland Rapid, completed in 1958, provides an excellent laboratory for examining the effects of improved transit on a CBD.

Although the Cleveland system is not as fast or as modern as those now being constructed or planned for some cities, it is certainly superior to those installed elsewhere prior to WW II. The two radial lines provide rapid and comfortable transit service to the suburbs, and excellent management of the system gives riders many of the amenities associated with more modern projects now under design.

One weak point of the Cleveland Rapid System is that it has only a single station to serve the entire CBD. and this is located not at the center but at the CBD's edge.

No full-scale analysis of the effects of the Cleveland Rapid on the CBD has been made. However, the following fragmentary information fails to show any reversal in the trend toward decentralization.

1. Between 1958 and 1963 retail sales in the city of Cleveland dropped 15 percent and in the CBD retail sales dropped 20%.

2. Between 1950 and 1960, the city of Cleveland lost 38,000 of its population while the SMSA grew by 22.6 percent.

The time periods covered by the data may be too small for a valid evaluation. More time will be necessary before the effects on the city of Cleveland can be fairly judged. Also a proper analysis must include consideration of other events and forces at work in Cleveland.

The Potential of Transit to Create Higher Real Estate Values

The value of land is in part determined by its relative accessibility. The construction of a superior transportation facility, such as a rapid transit line or a high-type highway, invariably induces a rise in the value of lands within its corridor to which accessiblity has been improved. In most cases, however, such increased values do not represent a net gain in the total value of land in the entire area, but rather a shifting of values. In other words, the benefits associated with properties whose value has increased as a result of a new transportation facility have probably been achieved at the expense of other properties whose value has decreased because of a relative decline in their transportation accessiblity. Thus, no net benefit to the total community results.

Not all increases in property value are due to such transfers, however. There can be a net gain when the transportation facility opens up otherwise unproductive lands for economic development. This would take place where a transportation facility provides transportation access to areas that formerly were virtually isolated.

The benefits attributed to new urban transportation facilities through increased real estate values are often oversimplified and misleading. Such benefits can be determined only after searching analysis and not simply through the sales experience of only properties located along the new facility.

The Potential of Transit for Reducing Air Pollution

Pollution of the air has become a worrisome national problem. Various steps have already been taken at local, state, and federal levels to control and hopefully to reduce air pollution. Additional measures will undoubtedly have to be taken. One of these that is frequently mentioned is the elimination, or at least the reduction of automobile travel in urban areas and substituting travel by rail transit in its place.

This proposal, although drastic, appeals to some because over half of the pollutants that contaminate the air in most urban areas come from motor vehicles. This varies from area to area, depending on local conditions such as the number and size of smoke-producing industries and on the type of fuel commonly used for home-heating. One of the highest percentages attributable to the motor vehicle is in Los Angeles where it is estimated that they are producing about 80 percent of the air pollutants.

Exhaust control devices on vehicles, now required by Federal and some State laws, do not offer a long-term solution. Such devices when first installed on new cars can reduce the emission of harmful pollutants up to 2/3. But such devices will diminish in effectiveness as cars get older. By 1980 we will probably be back to the level of air pollution that we have today because the increase in the number of motor vehicles will cancel out the gains from the installation of exhaust control devices.

But the reduction of a significant amount of air pollutants in an area through the substitution of transit for motor vehicle travel hardly seems a practicable remedy.

Because of the increasing diffusion of local trip origins and destinations, rail transit cannot be expected to serve the needs of the vast majority of trips. Even as extensive a rail transit system as is now being constructed in the San Francisco area is estimated to carry only about 5 - 10 percent of all the trips in the three county area that it will serve. The rest will still be made by automobiles and buses. Thus, even with a rail transit system, there is little basis for expecting that our streets and highways will be other than heavily-travelled by cars and buses. This is not to ignore the possible contribution from rail transit ridership to the reduction of air pollution, but rather to discourage any unrealistic hopes that the contribution can be substantial.

A permanent solution for the motor vehicle air pollution problem will probably come eventually through the substitution of battery-powered electric motors for the internal combustion engine. But in the interim, some relief may be found through more effective exhause control devices and further refinement of gasolines to eliminate the source of some of the pollutants. Either of these solutions seem far more practicable than the substitution of rail transit for most of the auto travel in an area.

The Potential of Transit for Promoting a More Desirable Pattern of Land Use Development

Transportation is generally regarded by city planners as a key lever for directing the form of development of an area. And in many circles an improved mass transit system is viewed as an effective tool for bringing about more compact urban development. The efficacy of mass transit in shaping the broad outlines of an urban area's physical growth pattern, however, is open to question.

The effect of local transportation on an area's growth pattern was probably much greater in earlier days when good transportation facilities were scarce resources. Today, however, because of motor vehicle and a widespread system of good roads, transportation may be less of a controlling influence in determining the form of urban development. By the time a metropolitan area begins to seriously consider adding a rapid transit system, much of its transportation system, in the form of an extensive network of roads and streets, is already well established.

Also, a rapid transit system with parking lots at the outlying stations is calculated to serve and thus encourages low density suburban development to the same extent as does automobile transportation alone.

But, even so, there is good reason to expect that a rapid transit system can have some effect. For example, it will tend to promote high-density development in the CBD and along each of the corridors its lines traverse. But this effect is probably of a much smaller scale than is sometimes imagined.

But before a satisfactory judgment can be made about the value of a high-type mass transit system for promoting a more desirable pattern of land use development, it is necessary to reach some agreement on an idea of the way we want to live in the future, a picture on which there is little agreement.

Existing conceptual forms for the most desirable future urban areas vary between various extensions of existing forms to proposals for creating new forms. Kevin Lynch identifies a variety of possible urban forms (Ref. 6): the sheet form, the core form, the galaxy form, the star form, the linear form, the ring form, and the polycentered net.

In the United States the problem of urban design is not one of capacity; our land can support 2.6 billion people by Dutch standards. It is mainly a problem of the quality of life. But it is not easy to see the virtue of one land use pattern over another.

Variety of choice in all aspects of living and working has come to be regarded by many students of urban affairs as the basic goal of the metropolitan community. Put another way, this means creating fundamental opportunities for higher incomes, a wider choice of modes of living, a way of life that could be more stimulating, more enlightened, and more conducive to innovations.

Amos H. Hawley, Professor of Sociology, University of Michigan, summarizes what many will accept as a fundamental goal of urban planning. (Ref. 9)

> "Perhaps the planner will be asked, or will ask himself: What are urban goals? That is a question which often is put forward as though the urban unit were a deliberate invention addressed to specific objectives.
>
> "Actually the city or urban unit has no more particular objectives than has society at large. Yet the question has an answer that is not hard to find. The goal is, or should be, the maximization of opportunity for personal development and constructive living.
>
> "A first requisite for the achievement of such a goal is the freest possible circulation of people, of ideas, and of materials. The planner's primary responsibility, therefore, should be obvious."

The primary question to be resolved, therefore, is the extent to which an improved transit system can help mold a preferred form of urban development which has been judged to be conducive to the quality of living to which we aspire. Chapter 8 describes how one community went about selecting its preferred form of physical development and the role determined for an improved mass transit system in helping to achieve that plan.

Summary

Various combinations of the above assumed benefits of an improved mass transit system are found in all studies and reports for the expansion of mass transit. Even so, there is a glaring lack of supporting facts and penetrating studies to permit planners to reliably judge the consequences that are likely to follow from the installation of an improved mass transit system.

Even though conclusive answers may not be possible until after some of the newer systems are in place, there is much to be gained from more searching and objective analyses of existing systems, both in the U. S. and Canada, and also from more extensive research into the possible benefits that can be expected from transit improvements. For the information now available on this question is entirely too meager to properly support the degree of study of the mass transit question that now must be made in many cities around the country.

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APPENDIX A

AN ANALYSIS OF DIFFERENT FORMS OF RAPID TRANSIT (SUMMARY OF A REPORT BY K. LEIBBRAND FOR FRANKFURT, GERMANY)

WOLFGANG S. HOMBURGER

A report published by the City of Frankfurt am Main, Germany* contains several items of special interest to those concerned with analyzing mass transportation modes. Perhaps most valuable for U. S. transportation engineers is the detailed comparison between a monorail system (Alweg type) and a standard rapid transit system; a further comparison with a system of streetcars operating underground in the central business district has less applicability in the U. S. but serves to illustrate the difference between systems requiring a relatively high investment per route mile and an alternate requiring a much lower investment.

This appendix summarizes the results of comparing the three alternates, gives sufficient background about the locality to make this summary meaningful, and also includes translations (into English, miles, and dollars) of some of the more interesting data from the report.

Introduction

Frankfurt am Main is a city of 657,000 inhabitants (1960) with a projected population increase of about 20% to 789,000 by the horizon year (1990). Its present mass transportation system consists of a streetcar network of 94 route miles, supplemented by 88 route miles of bus service on less heavily used routes. The streetcars operate in trains consisting of a motor coach and one or two trailers. The tracks are generally located within the roadways of the streets, but are placed in the median of some wide boulevards and on private right-of-way in some suburban areas.

Traffic conditions in the city, especially in and surrounding the central business district (c. b. d.) have been deteriorating to the extent that a decision on improving the mass transportation network had to be made. To provide sufficient transport capacity, it was felt that all streetcar tracks in the c. b. d. should be removed from the street surfaces, and that bus movements in the c. b. d. be held to a minimum. Consequently, the city retained a group of consultants to report on three possible alternates:

Alternate A: An Alweg monorail system.

Alternate T: Improvement of the existing streetcar system by placing c. b. d. tracks underground, placing substantial sections of suburban tracks on private right-of-way, and some extensions; a few stretches of route in the outer areas would remain on city streets. (This will be referred to as the the "tramcar" system to correspond to the designation "T" - for Tiefbahn - used in the report.)

Alternate U: A rapid transit system on standard gauge rails (This will be referred to as the "Usual rapid transit" system to correspond to the designation "U" - for Untergrund - used in the report.)

Under Alternates A and U, all existing streetcar routes would be abandoned with the exception of two suburban lines which would terminate at the outer terminal of one of the new rail routes. Under all alternates, necessary supplementary bus routes are included in the analysis.

The work was under the general supervision of Professor K. Leibbrand of the Eidgenossische Technische Hochschule of Switzerland. Detailed construction costs and schedules were developed by a group of Frankfurt construction firms. The Alweg Forschung G. m. b. h. (Alweg Research Corporation) prepared most of the section of the report dealing with Alternate A.

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*Leibbrand K. et al. Stadtbahn Frankfurt am Main. Planerische Gesamtübersicht (Planning Summary). Frankfurt, Germany, Bauverwaltung der Stadt. Bethmannstrasse 3. June, 1961, Vol. 1: Text and tables. Vol. 2: Figures.

Networks

As might be expected, the networks for Alternates A and U are fairly similar in extent and location. One important difference is that there are fewer connections between different "A" routes at crossing points than there are with "U" routes, because of the problems of designing and operating track switches over which trains can operate at speed. The "T" network makes possible a much better coverage of the outlying areas by branching routes, and a corresponding lesser amount of bus routes needed to feed the rail network.

For each of the three alternates the consultants submitted two subalternates. In the case of the "T" and "U" networks, these are first-stage and ultimate networks. In the case of the "A" network, one alternate provides for much of the downtown structure to be aboveground, while in the second all but one of the routes are below ground. In the case of the "T" and "U" track layouts downtown, a few grade crossings of branching lines are permitted; this is, of course, technologically impossible for an Alweg system which, if confined to no more than two underground levels, must also resort to elevated levels or else restrict the number of routes meeting at any focal point to two.

In this brief note the first-stage proposals of the "T" and "U" systems are not included, but both ultimate Alweg networks (A_o - Alweg over downtown streets; A_u - Alweg under downtown streets) are mentioned occasionally. It must be kept in mind that in network A_o not all tracks are aboveground, and in network A_u not all of them are below ground.

Traffic Service

Table No. A. 1 compares the traffic service offered during a typical peak hour by each of the three systems. Little difference in total trip times for peak hour passengers were found when the "A" and the "U" systems are compared. The "U" system produces slightly lower figures, accountable in part to less transferring required through better connecting tracks between the various routes. 21.0% of the "A" passengers need not transfer in the peak hour, while 24.6% of the "U" passengers need not do so.

TABLE A. 1 — TRAFFIC SERVICE COMPARISON FOR PEAK HOURS

	System A		System T		System U	
Passengers in peak hour, total	95,600	100.0%	95,600	100.0%	95,600	100.0%
Neet not transfer	20,100	21.0%	35,078	36.7%	23,490	24.6%
Must transfer once	42,440	44.3%	45,778	47.8%	43,273	45.3%
Must transfer twice	27,900	29.3%	13,507	14.1%	23,210	24.3%
Must transfer more than twice	5,160	5.4%	1,237	1.4%	5,627	5.8%
Trip Time of peak hour passengers, in thousands of hours, total	52.5	100.0%	49.3	100.0%	51.3	100.0%
Access time, to/from stations	14.9	28.4%	13.5	27.4%	14.7	28.6%
Waiting time	2.7	5.2%	2.7	5.5%	2.8	5.4%
Train travel time	27.2	51.9%	27.9	56.7%	26.8	52.1%
Transfer time	7.6	14.5%	5.1	10.4%	7.1	13.9%

However, alternate "T" produces slightly lower total trip times than either "A" or "U". While actual travel times on the trains are longer than by monorail or usual rapid transit, the greater coverage of outlying areas, made possible by the lower cost per route mile, substantially reduces the amount of time required to reach the nearest station of the system and the amount of transferring required. It must be borne in mind that Frankfurt is a compact city and that most of the lines terminate 6 miles or less from the c. b. d. Hence, little time is gained by using a higher-speed system. (An American equivalent might be the analysis of a mass transit system for San Francisco if there were no major suburbs.)

First Costs

Table No. A. 2 summarizes the first costs of the two Alweg networks and of the ultimate "T" and "U" networks. While this table has been translated into dollars, it should not be con-

TABLE A. 2 — FIRST COSTS OF VARIOUS SYSTEMS
(in millions of dollars)

Item	A_o	A_u	T	U
Construction of System				
Underground	(2. 83 mi. @ $6. 30) 17. 81	(4. 31 mi. @ $6. 13) 26. 41	(13. 16 mi. @ $5. 35) 70. 36	(23. 78 mi. @ $5. 39) 128. 25
On or aboveground	(36. 33 mi. @ $2. 01) 72. 93	(34. 92 mi. @ $2. 01) 70. 02	(50. 94 mi. @ $0. 12) 6. 09	(15. 52 mi. @ $1. 43) 22. 19
Subtotal	(90. 74)	(96. 43)	(76. 45)	(150. 44)
Other Fixed Facility Costs				
Street widening, arcades, moving utilities, land	25. 72	22. 78	35. 79	42. 45
Yards and Shops	7. 85	7. 85	3. 40	4. 10
Rolling Stock				
Alweg or Rapid Transit Trains	30. 77	30. 77	-	21. 43
Tramcar Trains	0. 38[a]	0. 38[a]	17. 75	0. 38[a]
Buses	8. 67	8. 67	4. 90	7. 70
Subtotal	(39. 82)	(39. 82)	(22. 65)	(29. 51)
Signalization and Safety	b	b	0. 25	2. 34
Administrative Costs	7. 13	7. 30	6. 74	11. 59
Total First Costs/of New System	171. 26	174. 18	145. 28	240. 43
Available Yards, Shops, Vehicles, Tracks, Land, etc. which can be incorporated in new system (Deduct)	2. 28	2. 28	10. 62	4. 51
Costs of Detours during Construction	0. 71	0. 73	0. 29	0. 64
Actual Costs of Building System	169. 69	172. 62	134. 95	236. 56

a. Two tramcar lines in the northern suburbs would continue to operate under plans "A" and "U".

b. Signalization and safety costs for system "A" included in construction costs.

sidered to be an accurate guide to any American situation. The official rate of exchange ($1. 00 = 4. 20 Deutsche Mark) does not truly reflect the comparison of what a dollar or a Deutsche Mark actually buys; nor is account taken of the fact that labor costs are relatively cheaper and material costs relatively higher in Europe than in the United States.

Table A. 2 indicates that:

1) per mile costs of Alweg system are generally higher than of usual rapid transit construction.

2) ability to place much of Alweg system network above ground, while much of usual rapid transit system must remain below ground, results in considerably lower construction cost for the Alweg system.

TABLE A. 3 — OPERATING DATA

		A_o/A_u			T_2			U_2		
Extent of Network (Miles)	Rail network	39.16(A_o); 39.23(A_u)			64.10			39.30		
	Rail routes operated	45.74			137.79			56.07		
	Bus routes operated	99.32			71.97			90.79		
	Taunus tram routes	3.46			Included above			3.46		
	Total length of routes	148.51			209.76			150.33		
Rolling stock required		Peak periods	Base period		Peak periods	Base period		Peak periods	Base period	
	Rapid transit trains	93	58		-	-		104	65	
	Tramcar trains	4	2		203	116		4	2	
	Buses	313	118		187	71		279	114	
Available passenger miles in peak hour		1,056,400			1,097,000			1,182,000		
No. of operating employees, and employee-hours per day (*Savings if a universal fare is charged)		Peak Hr.	Base Hr.	Hrs/Day	Peak Hr.	Base Hr.	Hrs/Day	Peak Hr.	Base Hr.	Hrs/Day
	Train crews	198	122	2737	609	311	7555	220	136	3047
	Station attendants and ticket sales personnel	340 (120*	220 80*	4840 1740*)	7	-	38	360 (130*	230 90*	5085 1930*)
	Traffic Supervisors	15	15	285	2	2	38	15	15	285
	Rail Subtotal	553	357	7861	618	313	7631	595	381	8417
	Bus crews	626	236	6607	374	142	3976	558	228	6148
	Total	1179	593	14468	992	455	11607	1153	609	14565
Daily operating costs ($)		Labor[a]	Vehicles[b]	Total	Labor[a]	Vehicles[b]	Total	Labor[a]	Vehicles[b]	Total
	Rail	9,510	15,871	25,381	9,539	10,564	20,103	10,181	14,962	25,143
	Bus	8,579	4,454	13,033	5,067	2,779	7,846	7,956	4,484	12,440
	Total	18,088	20,325	38,413	14,606	13,342	27,948	18,137	19,446	37,583
Annual operating Costs ($)	Labor[a]	6,512,000			5,257,000			6,529,000		
	Vehicles[b]	7,317,000			4,802,000			7,000,000		
	Total[c]	13,829,000[c]			10,060,000			13,529,000[c]		
	Savings if universal fare is charged	733,000			-			814,000		
	Total if universal fare is charged	13,096,000			10,060,000			12,715,000		

a. Labor costs are for operating employees only; maintenance and repair labor is included under "Vehicles".
b. Vehicle costs include fuel or power, daily maintenance and major repair and labor costs associated with this.
c. After preparation of the table, consultants made minor change in routing of "A" and "U" systems. New total annual costs are: A - $14,162,000; U - $13,310,000. These new values are used in Table No. A. 5.

3) related construction costs — street widening, movement of utilities — are lower for the "A" system than for the "U" system, again because of the amount of elevated construction possible in the "A" system.

4) yards, shops and rolling stock costs for the "A" system are considerably higher than for the "U" system.

5) total first costs (not taking into account any existing facilities) for the "A" system are almost 30% less than for the "U" system.

6) the tramcar system, as might be expected, involves lower costs than either of the other alternatives.

Operating Costs

Table A. 3 summarizes some of the important operating characteristics of each system. A study of this table indicates that:

1) the total length of operated routes for systems "A" and "U" are about the same, but much less than for system "T". (The figures include duplications where two or more routes use the same tracks or streets.)

2) the proportion of the total network operated on rail is higher for system "T" than for the other alternates and the latter require a higher number of buses than the tramcar network as feeders.

3) the number of employees for systems "A" and "U" are about the same, but in each case almost 20% more than for the "T" system. (This is caused partly by the need for platform attendants and ticket sellers in the "A" and "U" systems — with some savings possible if a universal fare were charged instead of the present stage fares — and partly to staff the larger number of buses needed; train personnel are considerably less on the "A" and "U" systems than on the "T" system.)

4) total operating costs for the "A" system are about 2.5% higher than for the "U" system, attributable entirely to a higher cost of vehicle items; both these systems cost over one-third again as much to operate than the tramcar system (25 - 30% higher if a universal fare is charged).

Annual Charges

To compute total annual costs for each alternate, depreciation of fixed facilities and rolling stock was assumed to be on a straight-line basis. The factors used are shown in Table A. 4; the consultants expected a somewhat lower rate of depreciation for Alweg track and aboveground

TABLE A. 4 — DEPRECIATION AND MAINTENANCE FACTORS

(Annual costs as percent of first costs)

Item	SYSTEM A		SYSTEM T		SYSTEM U	
	Depr.	Maint.	Depr.	Maint.	Depr.	Maint.
Tunnel, including stations	1	0.1	1	0.1	1	0.1
Beam or track in tunnel	2	0.5	5	3	5.5	3
Track on or aboveground, including stations	2	1	4	5	4.5	5
Yards and Shops: Buildings	2	1	2	1	2	1
Equipment	5	3	5	3	5	2
Signals and Safety Devices	4	4	4	4	4	4
Rolling Stock: Alweg or Rapid Transit Trains	5	*	4	*	4	*
Tramcar Trains	4	*	4	*	4	*
Buses	12.5	*	12.5	*	12.5	*

*Included in annual operating costs, as summarized in Table A. 3.

TABLE A. 5 — ANNUAL COST SUMMARY

(in millions of dollars)

Item	A_o	A_u	T	U
Operation Cost (footnote c. Table A. 3)	14.16	14.16	10.06	13.31
Administration, etc.	2.24	2.24	2.24	2.24
Financing and interest costs	Not included in this table			
Depreciation of fixed facilities	1.98	2.02	1.18	2.59
Maintenance of fixed facilities	1.01	0.99	0.53	1.43
Depreciation of rolling stock	2.64	2.64	1.32	1.80
Annual Costs	22.03	22.05	15.33	21.37
Write-off during first ten years for present book value of existing system and vehicles to be abandoned	0.96	0.96	0.60	0.95
Annual cost during first ten years	22.99	23.01	15.93	22.32

facilities but a slightly higher depreciation rate for Alweg rolling stock when compared to the alternates. Table A. 4 also includes the factors used to estimate annual maintenance costs of fixed facilities. Alweg track and aboveground facilities were felt to have a lower maintenance cost than the corresponding items in the other systems. (Maintenance costs of rolling stock are included in Table A. 3).

Table A. 5 brings together all annual costs chargeable to each system, except the cost of financing, which the consultants were instructed not to include. This omission is, of course, most important in the complete analysis. The much larger capital cost of system "U" as compared to system "A" would require a much higher annual charge for financing costs and therefore would bring the total annual charges for system "U" well above those for system "A". If a pay-as-you-go financing plan were developed, the annual charges in Table A. 5 would have some validity; however, the "U" system would require several years longer to build than the "A" system, and the benefits to transit passengers and other street users would not be available at as early a date. Also, obviously, the annual appropriation for construction would have to continue for a longer period of years.

If the city of Frankfurt were to have available up to about twelve million dollars per year for construction of a mass transportation network and acquisition of rolling stock, the consultants indicated that system "U" could be built in about 20 years, with individual route segments put into operation much earlier. The total "T" network would require only 13 years. No corresponding figure for network "A" was developed; the schedule here called for completion in 6-1/2 years with annual expenditures ranging from eleven million dollars to twenty-five million dollars.

Conclusions

The consultants found that, for Frankfurt's geography, transportation needs, construction cost pattern and other appropriate conditions, the first cost of an Alweg monorail system would be considerably less than for a usual rapid transit system. The cost per underground mile and per aboveground mile would be somewhat higher, but most of the Alweg system could be built aboveground without objectionable effects on the streets below and adjacent property; most of the usual rapid transit system would have to remain below ground, resulting in the higher total costs.

If the number of difficult switches in a monorail system are to be kept to a minimum and because grade crossings of tracks are completely impossible, the Alweg network is less flexible than that of a usual rapid transit. In the "U" system, all routes have connections in the c. b. d., some for regular operations, others for occasional use. This is not possible in the "A" system. In fact, it was necessary to include two special single-track connections where routes meet in outlying areas to permit trains to be transferred between routes enroute to or from the main workshops.

Differences in operating costs between the "U" and "A" systems are minor, the vehicle costs for "A" type trains being slightly higher.

Neither the "A" nor the "U" system can compete — in Frankfurt — with an improved tramcar system, because of the much lower per mile cost of tramcar fixed facilities. This permits a much more extensive network with much better coverage and lower access and transfer times, while keeping total construction costs to a level considerably below that of the other systems.

Subsequent to receipt of the report, the Frankfurt city government voted to proceed with construction of the "T" tramcar system, so designed that conversion to "full" rapid transit (completely separate right of way, long trains, high platforms) will be possible in the future. Construction on the first section of 2 miles, including a major central transfer station and four other stations, began in 1964. Operation of streetcars through this section is planned for summer 1968. *

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