Title
Standard Transportation Forecasting Techniques: How They Fail

Author
Giuliano, Genevieve

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Genevieve Giuliano

Institute of Transportation Studies
University of California, Irvine

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Institute of Transportation Studies
University of California, Irvine
Irvine, CA 92697-3600, U.S.A.
http://www.its.uci.edu

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The decade of the 1980s is proving to be a critical one for transportation system choices. Our transportation infrastructure is on the verge of collapse in many areas. Boston's rail system, New York's subway, Connecticut's highway bridges, and aging urban freeways in the nation's major cities, are all in dire need of rehabilitation. At the same time, funds are being solicited for new projects, most of which have been on the drawing board for more than a decade. These include interstate highway projects, as well as rail transit projects in major cities throughout the country. In view of the massive investment our current "wish list" of projects implies, it is appropriate to examine the justification for these investments and the way we forecast the need for them.

Purpose of Transportation Investments

Investment in transportation infrastructure has long been justified by the anticipated benefits transportation facilities bring to both users and non-users. Traffic congestion is the glaring symptom, but economic decline is the dreaded disease, as the following aptly testifies:

> Frankenstein is thundering across the map of America today, spouting exhaust smoke and reeking of burnt gasoline fumes . . ..
>
> This modern Frankenstein, this mechanical monster who has broken away from the shackles of his master is the automobile.
>
> American cities are being literally strangled by that modern phenomenon-automotive and street railway traffic congestion. Millions are asking:
>
> Can the American city survive?
>
> Are business centers doomed?
>
> Can the curtailed usefulness of the automobile be restored? . . ..
>
> The answer is something like this.

> There is a solution to the traffic problem. The American city as it exists today can be preserved. The automobile can be brought back to the state of usefulness it once held. Business centers can be "anchored." Intelligent growth of communities can be mapped. Life can be made more pleasant . . ..
>
> Accidents can be reduced to a minimum.
>
> But it will cost a lot of money.[1]

Those words were written in 1938, and the city of concern was Los Angeles. The proposed solution was a 420 mile freeway network.

In 1953, a State Senate Committee studying the San Francisco Bay Area identified the same symptoms and disease, but proposed a different solution:

> The impact of traffic strangulation and congestion on downtown properties is being felt with alarming effect. It has brought about decentralization of business, ... and a consequent decrease in the volume of business conducted by downtown establishments. Thought must be given to saving the downtown areas of cities with their high tax base. The obvious step is to deal with the traffic problem . . .. Rapid transit is a major part of an over-all solution . . ..[2]

In the conclusion of its report, the Senate Committee states, "unless mass rapid transit facilities are provided the San Francisco Bay Area, that area will suffer economically with resulting impairment of the economic strength of California generally."[3]

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[1]Ed Ainsworth, Out of the Noose! Way pointed for American cities to save themselves from traffic strangulation. Los Angeles, CA: Automobile Club of Southern California, 1938, p. 1.

[2]California (State of) Senate Interim Committee on San Francisco Bay Area Metropolitan Rapid Transit Problems. Mass rapid transit: Answer to traffic congestion in the San Francisco Bay Area Sacramento, CA: California State Printing Office, 1953, p. 23.

[3]op. cit., p. 31.

These examples illustrate how investment in transportation facilities is justified. Although they are decades old, the same justifications for transportation investments are made today. Providing more capacity reduces congestion and thus generates travel time savings to users. As a result of improved travel conditions, the level of economic activity increases, generating higher land values and larger tax revenue flows. Conversely, if these investments are not made, cities will become choked with traffic, ultimately leading to the economic decline of downtown or the entire region.

Forecasting the Need for Transportation Investments

Now that the disease has been identified, the next question is, how do we identify the cure? Advances in computer technology in the 1950s made possible the development of large scale travel forecasting models, and these models very quickly became the standard method for transportation planning. Since their widespread adoption in the early 1960s, their basic structure has remained largely unchanged. Thus the forecasting techniques we use today are not very different from those of twenty years ago. These forecasting models are used to predict the future need and use of new transportation facilities. It is, therefore, of interest to take a look at some of the early forecasts, and compare them to actual outcomes. In doing so, we can perhaps gain some insight on what to expect from the transportation investments currently under consideration, and on whether these investments will yield the benefits anticipated.

The UTPS Forecasting Method

Forecasting the future is difficult at best. When forecasting travel demand, it is necessary to determine where trips are going to and coming from, how much travel will occur, and which routes and modes of travel are likely to be used. When the long term is of interest, the travel forecasting process also requires making assumptions regarding population and economic growth trends. The standard method of travel forecasting is the four step model or the Urban Transportation Planning System (UTPS).

In order to use the model, the area of analysis is divided into a set of zones. For each zone, predictions are made regarding population, employment, land use and demographic characteristics in the target year. This constitutes the input data for the model.

The model itself consists of four steps, as illustrated in Figure 1. The first step in the modeling process, trip generation, calculates the number of trips that will be generated by each zone, based on the population and employment assumptions. It should be noted that transportation system characteristics are not considered in this step. An implicit assumption of the model is therefore that total trips per zone are fixed for a given population and land use distribution. Even more serious, however, is the assumption that the future population and land use distribution is completely independent of the transportation system, which is implied by data requirements of the first step.

The second step in the modeling process is trip distribution. Trips generated in each zone are allocated to other zones, so that each trip now has a zone of origin and a zone of destination. This allocation process is based on the relative attractiveness of each zone and the travel time distance between each zone. However, since future travel times are unknown, base year travel times are used. In other words, the distribution process assumes that relative accessibility within the area is constant over time. To the extent that transportation system changes take place, this assumption is false.

GIVEN: Population and Employment Levels; Land Use and Demographic Data by Zone for the Target Year.

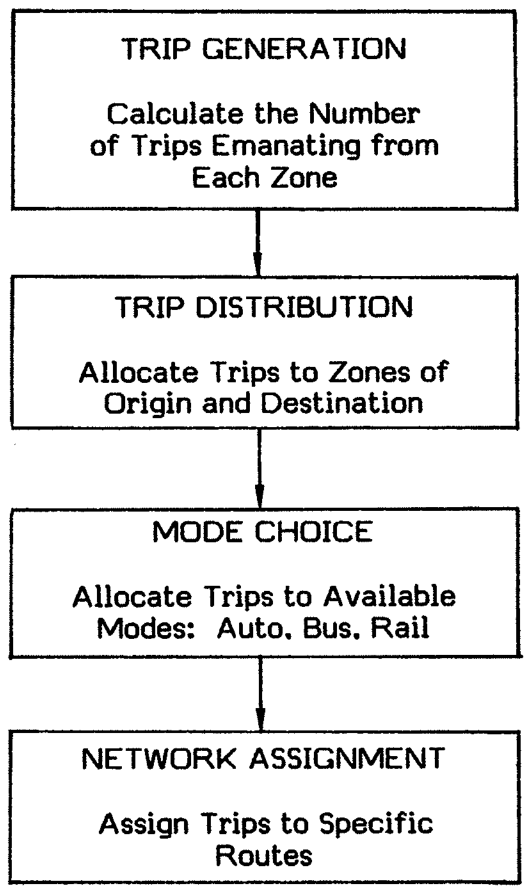

Figure 1

THE FOUR STEP TRANSPORTATION FORECASTING MODEL

Mode choice allocates the trips to the available modes: auto, bus, and rail. Thus, the person-trips of the first two steps are translated into vehicle trips. In general, mode choice is modeled as a function of relative travel times, travel cost, and the socioeconomic characteristics of the travelers. Travel times used in the mode choice models are estimates, and are independent of travel volumes. In other words, no matter how many trips are allocated to a mode, the travel time of that mode does not change.

The network assignment step takes the now determined set of vehicle trips and assigns them to specific routes on the transportation network. There are as many networks as there are modes, and each network is dealt with separately. The route assignment process works on the basis of choosing the shortest possible path in terms of travel time for each trip. In the older UTPS models, there was no capacity constraint, and trips were assigned to routes without considering route capacity. In the newer models, trips are assigned to other routes (where possible) when the shortest route reaches capacity. Since travel time is the key factor in the assignment process, the network assignment submodel has an equilibration process which adjusts travel times as congestion increases. It may be noted that this is the only step at which travel supply and demand are balanced. However, since all other travel parameters have already been determined, in actuality, there is no equilibration of demand and supply in the UTPS system.

This brief description illustrates the two fatal flaws of the UTPS method. First, the initial assumptions drive the model. That is, once population, employment and land use characteristics are identified, the fundamental parameters of travel behavior are established. Once we know where the people are and where the jobs are, it is relatively straightforward to put the two together. Thus, changes in these initial assumptions will generate the greatest differences in the model results.

The second fatal flaw of the UTPS system is illustrated by the arrows in the figure, which all go in one direction. The UTPS is completely sequential; there is no feedback from one step to another. As a result, there is no interaction between transportation supply and demand. Travel demand is calculated independently from any consideration of system supply, except in the final network assignment step. As stated previously, however, all other travel parameters have already been determined at this point.

The UTPS method is thus a naive method of travel forecasting. The volume of travel, the origins and destinations of trips, and the mode are all preselected, irrespective of the availability of capacity or of travel speeds. In this model, then, travel demand is completely independent of transportation system conditions. It is therefore not surprising that this forecasting method provides the data for predictions like the following:

> Without the investments called for in the plan, many of the county's streets and highways will turn into virtual parking lots by the year 2000. For every ten cars waiting in line in front of you today, there will be fifteen in the future. All of us will move along at less than half the speed we travel today.[4]

In reality, the basis of travel demand is the distribution of population and activities within the region. But the choice of specific destinations is a function of travel cost, meaning the cost in time as well as money, and the rational traveler minimizes travel cost. Given two similar destinations, for example, the closest (that is, the least costly) will be chosen. Over time, then, more accessible locations will attract more trips and more activities. This interaction of supply and demand, which over time implies interaction between land use and transportation changes,

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[4]Orange County Transportation Commission, It's a Matter of Motion--Facts! Santa Ana, CA: Orange County Transportation Commission, February 1984, p. 5.

cannot be captured by UTPS forecasting method. This is why we experience many fewer "virtual parking lots" than this method would predict.

The Los Angeles Region, Predicted and Actual

One of the earliest forecasting studies utilizing the four-step method was performed for the Los Angeles Region in the early 1960s.[5] Its purpose was to forecast transportation needs for the year 1980. The results of this study give us a rare opportunity to compare predicted and actual outcomes.

Population and Employment

We shall follow the UTPS sequence and begin with population and employment projections. Table 1 indicates that regional population was overestimated by 28 percent, while individual counties making up the region were overestimated by 13 percent to 42 percent. Regional employment, in contrast, was underestimated by 13

Table 1

Los Angeles Region 1980 Population
(Thousands)

COUNTY	ESTIMATE	ACTUAL	DIFFERENCE
Los Angeles	9,543	7,472	+28%
Orange	2,470	1,933	+28%
San Bernardino	999	733	+27%
Riverside	575	507	+13%
Ventura	751	529	+42%
TOTAL	14,338	11,174	+28%

[5]Los Angeles Regional Transportation Study (LARTS), conducted by the Transportation Association of Southern California, 1960-1963.

percent (Table 2). At the county level, the error ranges from -31% (Orange County) to +37% (Riverside County). If we had more disaggregate data available, by city for

Table 2

Los Angeles Region 1980 Employment
(Thousands)

COUNTY		ESTIMATE	ACTUAL	DIFFERENCE
Los Angeles		3,512	3,980	-12%
Orange		611	882	-31%
San Bernardino		236	248	-5%
Riverside		207	151	+37%
Ventura		141	172	-18%
	TOTAL	4,707	5,433	-13%

example, we would find that the range of errors would be even larger, because the smaller the unit of observation, the less chance there is for errors to offset one another. Thus, a higher level of aggregation masks more errors.[6]

By calculating the ratio of population to employment, other differences are evident (Table 3). First, the population to jobs ratio for the region is much lower than anticipated. This is a result of two factors: smaller than anticipated household size, and a greater than expected labor force participation rate. Second, the county ratios imply a different distribution of jobs and population. Orange, San Bernardino and Ventura counties were expected to remain "bedroom" suburbs. In actuality, Orange County in particular has become an employment as well as population center, while Riverside has become the "bedroom" suburb.

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[6]William Alonso, "Predicting Best with Imperfect Data," American Institute of Planners Journal, July 1968, pp. 248-255.

Table 3

Los Angeles Region Population/Employment Ratio

COUNTY	ESTIMATED	ACTUAL	DIFFERENCE
Los Angeles	2.72	1.88	+45%
Orange	4.04	2.19	+65%
San Bernardino	4.23	2.96	+43%
Riverside	2.78	3.36	-17%
Ventura	5.33	3.08	+73%
TOTAL	3.07	2.06	+49%

These unanticipated shifts of employment have very important implications for travel. For example, we would expect that work trips in Orange County are more likely to remain within the county, and thus would be shorter than predicted.

Trip Generation

We now move to the next step in the forecasting process, trip generation. In addition to population and employment projections, trip generation requires estimation of the rate at which trips will occur on a daily basis. The propensity to travel depends mainly on household demographic characteristics, economic status, and auto availability. The Los Angeles study estimated trip generation by type of dwelling unit and auto ownership. It was assumed that travel behavior would not change over time, so the only changes in trip generation would be those due to changes in household income level and auto ownership.

Comparing the expected and actual trip generation presented in Table 4 shows very large differences in some categories.[7] These errors were then compounded by the estimates used for auto ownership and the proportion of single and multiple

Table 4

Los Angeles Region Trip Generation Rates
Daily Auto Driver Trips per Household

SINGLE FAMILY DWELLINGS: NUMBER OF AUTOS	ESTIMATED	ACTUAL	DIFFERENCE
0	1.24	.15	+727%
1	4.83	4.20	+15%
2 or more	7.42	8.50	-13%
MULTIPLE FAMILY DWELLINGS: NUMBER OF AUTOS			
0	.17	.45	-62%
1	3.87	3.70	+4%
2 or more	6.86	7.30	-6%

unit housing. Table 5 indicates that two or more auto ownership was vastly underestimated in the single family category. Since that category makes up about 40 percent of the total household units, the net effect of these errors was to underestimate trip generation.

By using a hypothetical area of 10,000 dwelling units, we can calculate that trip generation was underestimated by about 21 percent. Of the total, 13.8 percent was due to car ownership error, 2.0 percent was due to dwelling unit error, and 5.7 percent was due to trip generation rate error.

At the regional level, this underestimate was largely offset by the population overestimate. The net regional underestimate was only 4 percent. However, at the

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[7]Actual trip generation rates based on 1976 LARTS survey data.

Table 5

Los Angeles Region Trip Generation Rates
Daily Auto Driver Trips per Household

SINGLE FAMILY DWELLINGS: NUMBER OF AUTOS	ESTIMATED	ACTUAL	DIFFERENCE
0	19.9%	5.8%	+243%
1	48.1%	28.2%	+71%
2 or more	32.0%	66.0%	-52%
MULTIPLE FAMILY DWELLINGS: NUMBER OF AUTOS			
0	19.9%	20.5%	-3%
1	48.1%	51.5%	-7%
2 or more	32.0%	28.0%	+14%

local or zonal level of analysis, these trip generation rates could lead to astronomical errors. For example, trip generation for an upper income residential area with a high rate of auto ownership would be drastically underestimated, while a lower income area with a low rate of auto ownership would be overestimated.

Network Assignment

Since data were not available to examine the trip distribution and mode choice steps in the forecasting process, we shall move to network assignment. The purpose of the Los Angeles study was to develop a highway network which would result in the least total vehicle miles of travel. The model had no capacity constraint, and the network was designed to serve the anticipated travel demand.

Figure 2 shows the proposed 1980 freeway system. The actual 1980 system is marked as a thicker line. The existing system is about 70 percent of the planned system in terms of mileage. The Orange County area was selected to compare

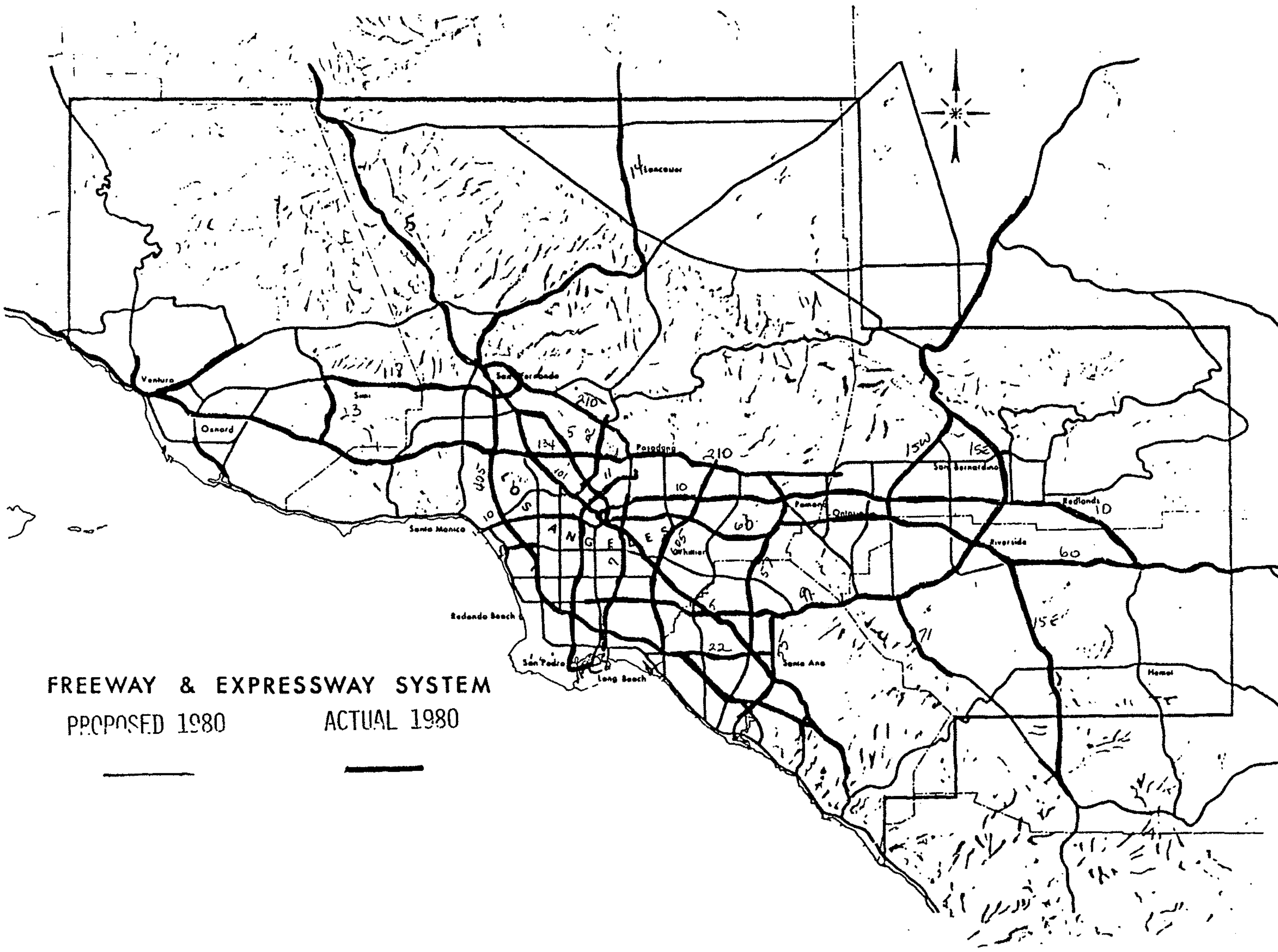
FREEWAY & EXPRESSWAY SYSTEM
PROPOSED 1980
ACTUAL 1980
Ventura
Oxnard
Santa Monica
Redondo Beach
San Pedro
Long Beach
Pasadena
Pomona
Ontario
Riverside
Redlands
Hemet
Santa Ana
Whittier
San Bernardino

Figure 2

anticipated to the actual usage. The comparisons are made at four different screenline points as illustrated in Figure 3. Screenline One is located at the intersection of the Santa Ana and San Diego freeways (I-5 and I-405) in the southern portion of the County. Screenline Two roughly parallels the Newport freeway (Rte 55); Screenline Three traverses the midsection of the County, and Screenline Four parallels the Orange/Los Angeles county line.

Table 6 gives estimated and actual ADT, "Average Daily Traffic" at the screenline locations for the Santa Ana Freeway (I-5), San Diego Freeway (I-405), and Pacific Coast Highway (Rte. 1). The 1960 projections are taken from a color-coded map produced in the original study. Since the 1960 estimates were given in intervals, the single number estimates in the table represent points at which the color changed.

The table shows that on I-5, ADT at the southern screenline is underestimated, while ADT at the northernmost screenline is overestimated. On I-405, the ADT is underestimated throughout, with the greatest differences occurring at screenlines 2 and 3. In contrast, Pacific Coast Highway is very markedly overestimated.

Part of the reason for these differences is that these forecasts represent travel desires, given the land use and population assumptions. They do not take capacity constraints into account. In reality, the Coastal Freeway was never built, and the Santa Ana Freeway is at capacity. Thus, it is to be expected that these forecasts would be in error. But given the forecast for Pacific Coast Highway, for example, it is easy to imagine that the planners of 1960 might have said, "unless we build a coastal freeway, a large part of the Pacific Coast Highway will become a virtual parking lot by the year 1980." However, since travel patterns do adjust to capacity constraints, such dire predictions do not come to pass.

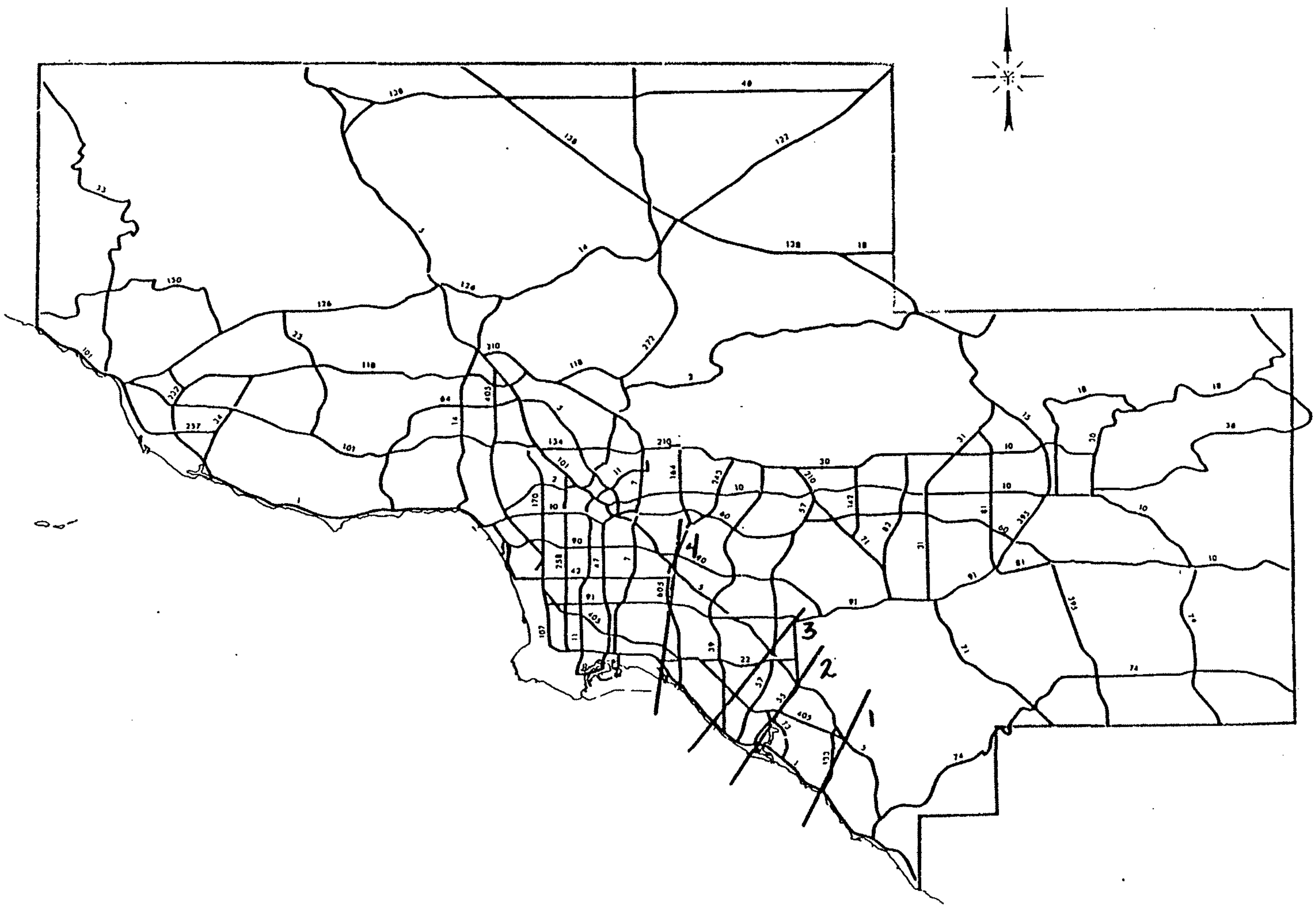

Figure 3

Orange County Area ADT Comparison Screenlines

Table 6

Los Angeles Region Trip Generation Rates
Daily Auto Driver Trips per Household

	ESTIMATED (Thousands)	ACTUAL (Thousands)	DIFFERENCE
ROUTE I-5 at:			
Screenline 1	45-85	97	-12% or more
Screenline 2	85-175	150	N/A
Screenline 3	175	162	+8%
Screenline 4	> 175	132	+33% or more
ROUTE I-405 at:			
Screenline 1	45-85	76	N/A
Screenline 2	85	169	-50%
Screenline 3	45-85	165	-48% or more
Screenline 4	175	198	-12%
ROUTE I at:			
Screenline 1	45-85	37	+22% or more
Screenline 2	85-175	57	+49% or more
Screenline 3	85	31	+174%
Screenline 4	45	38	+18%

Perhaps a more appropriate comparison is to compare all three routes combined across each screenline (Table 7). The estimates and actual are now very close, partly because of the wide range of the estimates and because errors tend to offset one another as we move to higher levels of aggregation, and partly because travel demand adjusts to supply. Also of interest in this table is the pattern of ADT moving from south to north. The first two screenline ADT are within the range of the estimates, though significantly above the average in each case.[8] The third

Table 7

Orange County Area Estimated and Actual ADT by Screenline

SCREENLINE	ESTIMATED (Thousands)	ACTUAL (Thousands)	DIFFERENCE
1	135-255	210	N/A
2	255-435	376	N/A
3	305-345	358	-4% or more
4	> 395	368	+3% or more
4 (with route 91)	> 530	491	+8% or more

screenline, which crosses the midsection of the county, is underestimated, while the county line screenline is overestimated, even when the Rte. 91 Freeway is also included. This can be explained by the assumed vs. actual population and employment distribution. Orange County has become a more self-contained economic unit than anticipated; thus intercounty travel is lower than expected.

Conclusions on the Los Angeles Example

This brief investigation of the 1960 Los Angeles Regional Transporation Study points out the major areas in which travel forecasting has stumbled in recent years.

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[8]Average at screenline 1 is 195; average at screenline 2 is 345.

First, household size had decreased, and the labor force participation rate has increased. Consequently, population growth has been slower and employment growth has been more rapid than anticipated. Second, auto ownership has increased more than expected. Third, employment has followed population to suburban areas to a much greater degree than anticipated.

These factors have resulted in very basic changes in travel behavior. As Table 8 indicates, both the trip rate and vehicle miles of travel per capita have increased much more than anticipated, while the average length of trips has increased less than anticipated. Recalling that this is an average 27 million trips, even an 8 percent difference in the average trip length is significant.

Table 8

Auto Travel Trends in Los Angeles Region

	1960	1980 ESTIMATED	1980 ACTUAL	DIFFERENCE
Driver Trips/Pop.	1.62	1.79	2.42	+26%
Auto VMT/Pop.	9.11	12.70	15.94	+20%
Average Trip Length	5.6 miles	7.08 miles	6.57 miles	-8%

Change from 1960	ESTIMATED	ACTUAL	DIFFERENCE
Driver Trip/Pop.	+11%	+49%	+78%
Auto VMT/Pop.	+39%	+75%	+48%
Average Trip Length	+26%	+17%	-53%

Rail Transit

Let us now briefly explore rail transit. Like highways, rail systems are advocated as a means of relieving congestion and promoting economic growth, but the focus is on downtown areas. Patronage is a key factor in determining the benefits to be generated by a rail transit system.

The availability of several of Atlanta's early planning studies makes it possible to compare predicted and actual outcomes for the Atlanta rapid transit system (MARTA). Planning for the Atlanta rail system began around 1960, and by 1962 a plan for a 66 mile regional rapid transit system had been developed. At that time, it was anticipated that the entire system would be operating by 1980. Additional planning took place in 1971, at which time the proposed system was reduced to 56 miles, but the completion date was still 1980. As of 1980, only 11.8 miles had been built, and today the figure is about 16 miles. Figure 4 presents the 1962 system, and the current existing and proposed system is illustrated in Figure 5.

Ridership Comparisons

The initial 1962 MARTA rail system ridership estimates were very conservative, as anticipated population growth was not factored into the patronage projections. The primary purpose of these estimates was to determine whether operating revenues would be sufficient to cover the system's cost. Since cost estimates were very low, a relatively low level of ridership was sufficient. Ridership estimates of 1971 were based on population growth expectations, as cost estimates had risen considerably, and the system's subsidy requirements became an important issue. Table 9 gives estimates and actual ridership for the East-West line. For the first two estimates, 1962 and 1971-A, the estimated system average ridership was used. The third estimate is based on this portion of the East-West line being 1.4 times as productive as the total system, as anticipated in the original study. Actual ridership is almost exactly equal to the 1971 system average estimate and about 15 percent less than the higher estimate.

These comparisons might seem to indicate that patronage estimates have been quite accurate, but the important comparison is between the last two columns in the

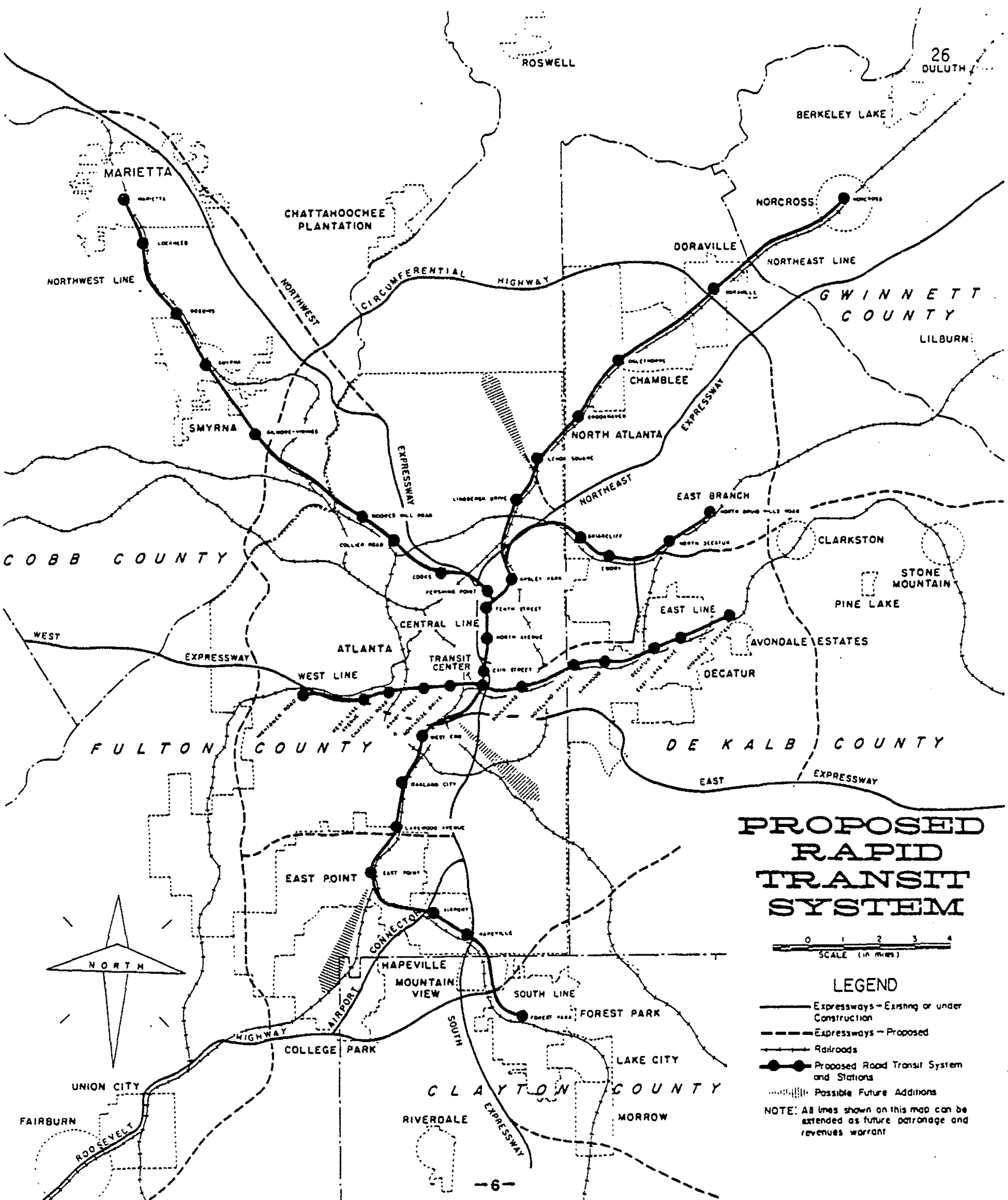
PROPOSED RAPID TRANSIT SYSTEM
LEGEND
Expressways – Existing or under Construction
Expressways – Proposed
Railroads
Proposed Rapid Transit System and Stations
Possible Future Additions
NOTE: All lines shown on this map can be extended as future patronage and revenues warrant
SCALE (in miles)
NORTH
MARIETTA
NORTHWEST LINE
SMYRNA
CHATTAHOOCHEE PLANTATION
ROSWELL
DULUTH
BERKELEY LAKE
NORCROSS
DORAVILLE
NORTHEAST LINE
GWINNETT COUNTY
LILBURN
CHAMBLEE
NORTH ATLANTA
EXPRESSWAY
NORTHEAST
EAST BRANCH
CLARKSTON
STONE MOUNTAIN
PINE LAKE
EAST LINE
AVONDALE ESTATES
DECATUR
CIRCUMFERENTIAL HIGHWAY
NORTHWEST
EXPRESSWAY
COBB COUNTY
CENTRAL LINE
ATLANTA
TRANSIT CENTER
WEST EXPRESSWAY
WEST LINE
FULTON COUNTY
DE KALB COUNTY
EAST EXPRESSWAY
EAST POINT
CONNECTOR
AIRPORT
HAPEVILLE
MOUNTAIN VIEW
SOUTH LINE
FOREST PARK
LAKE CITY
HIGHWAY
COLLEGE PARK
SOUTH
UNION CITY
FAIRBURN
ROOSEVELT
CLAYTON COUNTY
RIVERDALE
EXPRESSWAY
MORROW
26
-6-

Figure 4

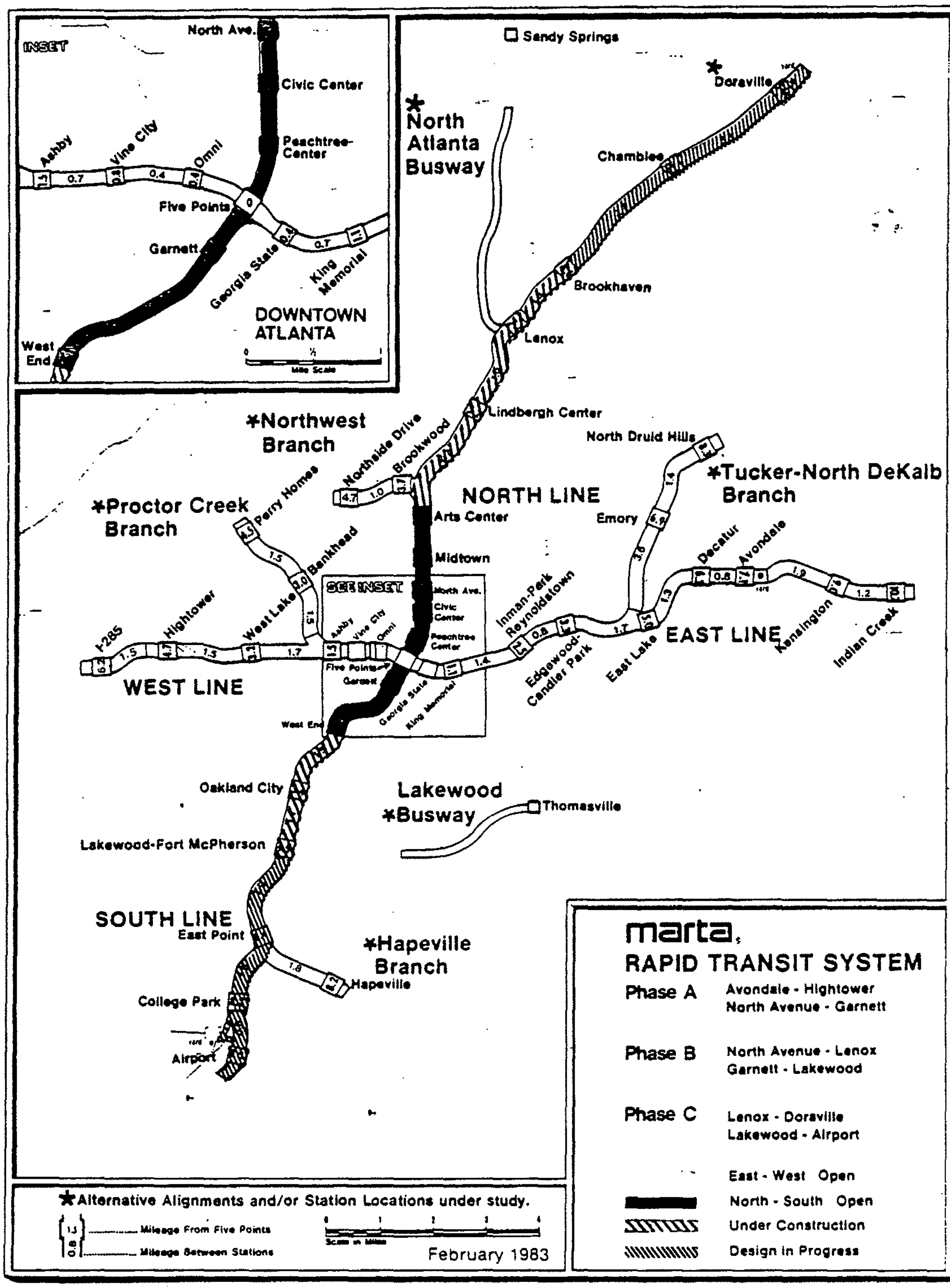
INSET
North Ave.
Civic Center
Peachtree-Center
Ashby
Vine City
Omni
Five Points
Garnett
Georgia State
King Memorial
West End
DOWNTOWN ATLANTA
Mile Scale
Sandy Springs
Doraville
North Atlanta Busway
Chamblee
Brookhaven
Lenox
Lindbergh Center
North Druid Hills
Northside Drive
Brookwood
*Northwest Branch
*Tucker-North DeKalb Branch
*Proctor Creek Branch
Perry Homes
NORTH LINE
Arts Center
Emory
Midtown
Bankhead
Decatur
Avondale
I-285
Hightower
West Lake
SEE INSET
Inman Park Reynoldstown
Edgewood-Candler Park
East Lake
EAST LINE
Kensington
Indian Creek
WEST LINE
Oakland City
Lakewood *Busway
Thomasville
Lakewood-Fort McPherson
SOUTH LINE
East Point
*Hapeville Branch
Hapeville
College Park
Airport
marta
RAPID TRANSIT SYSTEM
Phase A Avondale - Hightower North Avenue - Garnett
Phase B North Avenue - Lenox Garnett - Lakewood
Phase C Lenox - Doraville Lakewood - Airport
East - West Open
North - South Open
Under Construction
Design in Progress
*Alternative Alignments and/or Station Locations under study.
Mileage From Five Points
Mileage Between Stations
Scale in Miles
February 1983

Figure 5

Table 9

MARTA Rail System Ridership Comparisons
for 1980

	1962 ESTIMATE	1971-A ESTIMATE	1972-B ESTIMATE	1980 ACTUAL
Total System Rte. Miles	66.00	56.20	56.20	N/A
E-W Lines Rte. Miles	11.80	11.80	11.80	11.80
Annual Pass. (Millions)	12.00	17.60	20.90	17.80
Ann. Pass./ Rte.-Miles	1.02	1.49	1.77	1.51

Table. As the rail system expands, the additional route-miles will be less productive, and thus the system average will decline. The Washington METRO, for example, averaged 8,500 daily passengers per route-mile in 1978 with a 23 mile system, while in 1982 the average was 7,500 daily passengers per route mile with a 39 mile system, a decline of about 12 percent.

One might ask why the overall system productivity should be expected to decline. The answer lies with the overall trends discussed in the Los Angeles example. The Atlanta system is being constructed at a time when both population and employment is decentralizing, and when the rate of growth is most rapid in suburban areas. While the Atlanta central city area held 21 percent of the region's employment in 1962, its share dropped to 12 percent by 1980. Central city jobs grew a mere 1/2 percent between 1970 and 1980, compared to 41 percent for the region as a whole. Thus, the proportion of travel oriented to the downtown area is declining; and the potential market for rail transit is shrinking.

The impact of these trends on the MARTA transit system is illustrated in Table 10. The first column describes the actual 1962 system; the second column

Table 10

MARTA Transit Systems Comparisons

	1962 ACTUAL	1983 ESTIMATED	1981 ACTUAL
Number of Vehicles	About 400	1,167.0	1,018.0
Rail Route - Miles	N/A	56.2	11.8
Bus Route - Miles	N/A	1,530.0	1,889.0
Base Fare (1981 $)	.78	.50	.50
Annual Passengers (Millions)	51.0	102.0	88.0 (-16%)
Passengers per Capita	50.0	51.0	43.0 (-19%)
Passengers per Job	128.0	134.0	102.0 (-31%)

describes the system as it was planned in 1971, and the third column is the actual 1981 system. The planned and actual systems are very roughly comparable: total vehicles are similar, and the lower actual rail system mileage is offset by higher bus system mileage. The Table shows that although transit service has been increased by roughly two and a half times since 1962, and although transit fares have been reduced in real terms, ridership on a per capita basis has declined, and actual ridership has not met 1971 expectations.

Conclusions

This brief and admittedly superficial examination of the Los Angeles and Atlanta studies has demonstrated some of the pitfalls of our current methods of travel forecasting. It remains now to make some suggestions for improving the forecasting process and thus our evaluation of transportation investment alternatives.

First, transportation must be considered in the context of land use. Land use decisions affect travel behavior; transportation decisions do the same. Over the long term, people and jobs have time to adjust and interact with the transporation system. Forecasting models should reflect these relationships, and transportation planning should be linked with land use planning.

Second, the importance of economic and demographic trends which affect travel behavior must be recognized. The process of decentralization which is occurring is not simply a function of the highway system. Rather, many factors, including land costs, large-scale technologies of production, advances in telecommunications, and people's preferences for suburban living, have all contributed to this process. At present, there is every indication that this process will continue for some time to come. The trends of increased travel per capita and auto ownership are also important. Given rising incomes, we can expect these patterns to continue, and transportation investment decisions must take these issues into account.

Third, we need to place our expectations in perspective. In highly urbanized areas, congestion is equilibrium, though gridlock is not. Again this relates to travelers' ability to respond to changing conditions. Just as no single transportation investment has actually "relieved congestion," neither has the failure to make an investment created catastrophy. In areas which already have a well developed transportation system, even the most costly investments will have a marginal impact on the region. (This is, of course, more true for transit than for highway investments.) Consequently their justification, as publicly funded projects, becomes quite difficult.

Fourth and finally, we may be well advised to aim for flexibility: to choose investments that can be implemented incrementally and can be adapted to changing conditions. Then, even if we cannot predict the future, at least we can adjust to it.

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References

Ainsworth, Ed. Out of the noose! Way pointed for American cities to save themselves from traffic strangulation. A series of seven articles based on the 1937 Traffic Survey of the Los Angeles Metropolitan Area. Los Angeles, CA: Automobile Club of Southern California, 1938.

Alonso, William. "Predicting Best with Imperfect Data." American Institute of Planners Journal, July 1968, pp. 248-255.

California Department of Transportation (CALTRANS) District 7, Transportation Analysis and LARTS Branch. 1980 Travel Forecast Summary. (unpublished). Los Angeles, CA: California Department of Transportation, November 1983.

California State Division of Highways. Volume I - Base year report 1960, Los Angeles Regional Transportation Study. Los Angeles, CA: California State Division of Highways, December 1963.

California (State of). Senate Interim Committee on San Francisco Bay Area Metropolitan Rapid Transit Problems. Mass rapid transit: Answer to traffic congestion in the San Francisco Bay Area. Sacramento, CA: California State Printing Office, 1953.

Dunphy, Robert T. and Griffiths, Robert E. The first four years of Metrorail: Travel changes. Interim Report no. DOT-1-82-5. Washington, D.C.: Urban Mass Transportation Administration, September 1981.

Glick, Kenneth I. Travel findings report update: Changes in travel behavior. Washington, D.C.: Metropolitan Washington Council of Governments, September 1983.

Lobb, Orville and Chen, Brenda. The 1976 urban and rural travel survey. Volume IV Summary of findings: Travel data. Los Angeles, CA: California Department of Transportation and Southern California Association of Governments, October 1979.

Metropolitan Atlanta Rapid Transit Authority. The Atlanta Rapid Transit System. Atlanta, GA: Metropolitan Atlanta Rapid Transit Authority, November 1979.

Metropolitan Atlanta Rapid Transit Authority. Operating and capital development plan for fiscal years 1982-1986. Atlanta, GA: Atlanta Regional Transportation Planning Program Report, September 1981.

Orange County Transportation Commission. It's a matter of motion--Facts! Santa Ana, CA: Orange County Transportation Commission, February 1984.

Parsons, Brinckerhoff, Quade and Douglas. A plan and program of rapid transit for the Atlanta metropolitan region. Atlanta, GA: Metropolitan Atlanta Transit Study Commission, December 1962.

Parsons-Brinckerhoff-Tudor-Bechtel. Metropolitan Atlanta Rapid Transit Plan. Report PBTB A 71.1. Atlanta, GA: Metropolitan Atlanta Rapid Transit Authority, September 1971.

Transportation Association of Southern California. Los Angeles regional transportation study 1980 progress report. Los Angeles, CA: Transportation Association of Southern California, [1963].

Transportation Association of Southern California. Los Angeles regional transportation study: Appendix to the base year report. Los Angeles, CA: Transportation Association of Southern California, July 1969.