there will be a parking authority or other designated municipal agency to lay out the complete pattern of fringe facilities. It is to be hoped too that the city or designated agency could by the right of eminent domain take the properly located fringe facility sites if necessary, equip them, lease them thus equipped, or lease the sites themselves without equipment to private operators; not necessarily leaning on transit for this. Another approach would be to have private enterprise furnish sites, equipment, and operation, so long as the right pattern of fringe facilities is obtained.

One final word about transit, since big cities are dependent upon transit for their basic means of transportation. Transit vehicles, together with all downtown traffic will flow more freely, as off-street parking is provided and curb parking removed. But there appear to be several additional solid benefits coming to transit, when a proper pattern of fringe parking is installed. First as the fringe facilities function to keep the cars of workers and other long-time parkers out of the downtown area, and secondly, because of advantages accruing to transit from more short-haul business within the fringe, and less nonprofit or low-profit long-haul business outside of it, as greater numbers of all-day parkers drive to fringe facilities, and ride transit facilities from there in.

Then it is that fringe parking will fully take its place alongside of downtown off-street parking, to bring back accessibility to our cities, letting them function as they were intended to do, and stabilizing their position as centers of needed concentrations which cannot be decentralized, because there is no true substitute for them in the American social and economic cultural pattern.

APPLICATION OF METROPOLITAN ORIGIN-DESTINATION SURVEYS TO TRANSIT PLANNING

LLOYD BRAFF, *Staff Engineer, DeLeuw, Cather and Co.*

SYNOPSIS

Transit officials have not generally taken advantage of the data concerning travel habits of all persons within a metropolitan area which have been revealed through origin and destination surveys. To utilize these data desire line charts are prepared for transit passengers. These indicate whether or not existing routes best serve the passengers.

The use of O-D data to test parts of the transit patterns of Nashville and San Francisco is outlined, and an example is given showing the manner in which Cincinnati O-D survey data were applied to determine the type and amount of express or rapid transit service from outer areas to the central business district. The applicability of O-D data to central business district transit routing, and to through routing is discussed, and their limitations for use in studies of line characteristics are pointed out.

The transit official charged with the responsibility of planning and rehabilitiating his system to serve the community best is vitally concerned with the travel habits of all persons within the area served by his system. Since the metropolitan origin-destination survey reveals the travel habits of a representative sample of all persons within the metropolitan area, the data are as important to the transit planner as to the highway planner. In several cities where origin-destination surveys have been conducted, transit officials have not availed themselves of the comprehensive data of the O-D survey since they considered it merely as another highway survey.

The purpose of this paper is to indicate in a general way several applications of the metropolitan origin-destination survey to transit planning. While there are many applications, those enumerated are several which

have been used with success in Portland, San Francisco, Cincinnati, Nashville, Atlanta and Providence.

TESTING THE TRANSIT PATTERN

The existing pattern of many transit systems is a hand-me-down from original street car lines installed years ago with routes frozen to definite streets by rigid franchises. In many cases the routes originally were competing lines of independent companies which later were consolidated into one system, but which still retained the competing routes. In many systems, the inner—or older—area is served by the original street car routes while the outlying, newly developed areas are served by buses. The present trend of replacing street cars with rubber tired vehicles as transit equipment is modernized is permitting many companies to radically change the pattern of their system, since the vehicles are no longer tied to the rails. New routes, therefore can be installed which will more adequately fit the demands of the existing travel habits of the citizens.

The comprehensive data obtained in the metropolitan origin-destination survey are ideal for testing the adequacy of the existing transit system or planning for a modernized system. To utilize these data it is necessary to prepare desire line charts of transit passengers, as well as automobile drivers and passengers. The desire line charts of the transit passengers indicate whether or not the existing routes are serving the travel habits of transit passengers. In certain areas, for instance, a situation may arise where there is little demand for crosstown service based on the analysis of the origins and destinations of transit passengers. This may be due to the fact that those persons presently destined from one area to another now not served directly by transit routes are forced to use automobiles as a means of transportation. Thus it is necessary to determine the amount of travel that is now being made between those areas by automobile drivers and automobile passengers. By studying the automobile origins and destinations in conjunction with the transit origins and destinations it is possible to determine the needs for service not now provided by an existing transit route.

The transit operators in Nashville, for example, had been under pressure to provide crosstown bus service along several new routes. Analysis of the origin-destination data revealed possibilities of several crosstown routes, the desirabilities of which were then investigated in detail, including field surveys to locate suitable streets for bus operation on the approximate alignments indicated. Determination of how many riders would use a potential route took into consideration the convenience of the contemplated service, the headways which would be justified, the number of transfers required, and other factors. The possibilities of improving service by means of crosstown routing were surprisingly few. The proposed Fairfax-Murphy-Belcourt-Wedgewood crosstown route, for example, would be 7.0 street miles in length. If service could be made sufficiently attractive, it would generate over 3800 total rides per day. Of these, nearly 2600 would be revenue riders equal to 368 revenue rides per day per mile of street. This would justify an average of a 30-min. headway over a 12-hr. period. Patronage at this headway would fall, headways would necessarily be widened, and the service and use of the route would gradually approach the vanishing point. For these reasons, establishment of this route was not recommended.

The proposed Lafayette-Broad-Seventeenth crosstown route, on the other hand, would serve more than 7500 people per day, of whom more than two-thirds would be revenue riders. This would justify an average headway of 7½ min. throughout the business day, indicating that the route had definite possibilities. It was recommended, therefore, that service as outlined be installed for a 60-day trial period.

The Golden Gate Park in San Francisco extending from the Pacific Ocean approximately three miles inland creates a barrier for transit travel between the Richmond District to the north and the Sunset District to the south. The first transit route to cross the Park is at 19th Avenue, approximately two miles from the ocean. Preliminary analysis of the origin-destination survey indicates very few transit trips, but many automobile trips, between the Richmond and Sunset Districts west of 19th Avenue. While the study, now under progress, has not been completed, it appears desirable to provide a new crosstown service midway between 19th Avenue and the

ocean in the vicinity of Sunset Boulevard. The number of persons involved and the probable service justified are yet to be determined.

The metropolitan origin-destination survey gives the transit operator the tools to test the adequacy of his existing routes and a means of estimating the amount of service to be installed and probable business to be derived from new routes.

EXPRESS SERVICE

Another useful application of the origin-destination survey to transit operators is the determination of areas which can be served by express buses or other types of rapid transit. Analysis of the origin-destination tabulations makes it possible to determine the portion of persons in outer areas which are destined to such concentrated areas as the central business district. In areas where there are substantial volumes of persons travelling from the outer areas to the core of the city, the transit operator can determine what portion of service he could make express and what portion he could retain as local service. Where a large portion of persons in an outer community, for example, are destined for the central business district, several operators have changed their service, so that a bus would start at the outer edge and run local to a certain point and run express from that point to the center of the city. The persons who originated on the outer edges of the city and had destinations in the intermediate zone not served by the express service would be afforded an opportunity to transfer to a local service line at the point where the express bus would begin its express run. In some communities the express bus makes intermediate stops at important transfer points.

The following example shows the manner in which the Cincinnati origin-destination survey data were applied to determine the type and amount of express or rapid transit service to be provided from the outer areas to the central business district.

Facilities now available in Cincinnati or planned for early construction which might be used for rail rapid transit or express bus service include:

The existing subway and rapid transit right-of-way extending along Mill Creek Valley to Central Parkway at Walnut Street;

The projected Mill Creek Valley Expressway;

The projected Northeast Expressway; and

The projected Third Street Distributor and connections to Suspension Bridge.

The existing rapid transit right-of-way and the proposed Mill Creek Expressway had a common location through a substantial section in and north of Cincinnati (See Fig. 1). Studies were made of the possibilities of express services along the Mill Creek Expressway or the subway-rapid transit right-of-way to the areas served by existing lines north and west of the expressway and rapid transit right-of-way location. These include a line from Lockland and Elmwood, a College Hill route and a route to the northwest serving White Oak and Cumminsville. Another major tributary area considered lies west of Mill Creek and could be connected to either the expressway or subway by the Western Hills viaduct. Tributary lines considered in this area were the Beekman Street route, North Fairmount route, Harrison Avenue-Westwood-Cheviot route, Queen City Avenue-Cheviot route and Westwood Avenue-Quebec Road route.

On the Northeast Expressway, express services were considered along the following routes: Reading Road Branch: Montgomery Avenue through Norwood; Ridge Road and Montgomery Road to Kennedy Heights; and Madison Road and a route to Mariemont.

For the purpose of this study, the service assumed for the subway-rapid transit alternate on each of the above routes would be furnished by modern high-speed street cars making local service stops through the pick-up areas to the intersection with the rapid transit railroad section and through the subway with overall speeds of about 25 miles per hour.

In the case of express buses, a similar operation was assumed. The buses would make local stops in the tributary areas served. After entering the expressway they would make limited stops at suitably planned ramps to serve local centers and to provide for transfer of passengers at intersecting local routes. Overall speeds for express bus operation would approximate those estimated for the rail operation.

The 1945 comprehensive origin-destination survey in Cincinnati metropolitan area was available for use in estimating probable rapid

transit traffic. The survey divided the city into approximately 100 zones. The study revealed the origins and destinations of people by these zones and by the various modes of travel according to the following classifications: automobile drivers, automobile passengers, and street car and bus passengers. In estimating rapid transit traffic, analyses were made of the number of persons travelling from downtown district were shown in the third through the ninth columns. Transit passengers from each origin area destined for the six downtown areas were listed in the 10th through the 16th columns. The number of transit passengers as a percentage of the total between the outer areas and the central business district was shown on the 17th column. Total automobile passengers were shown in

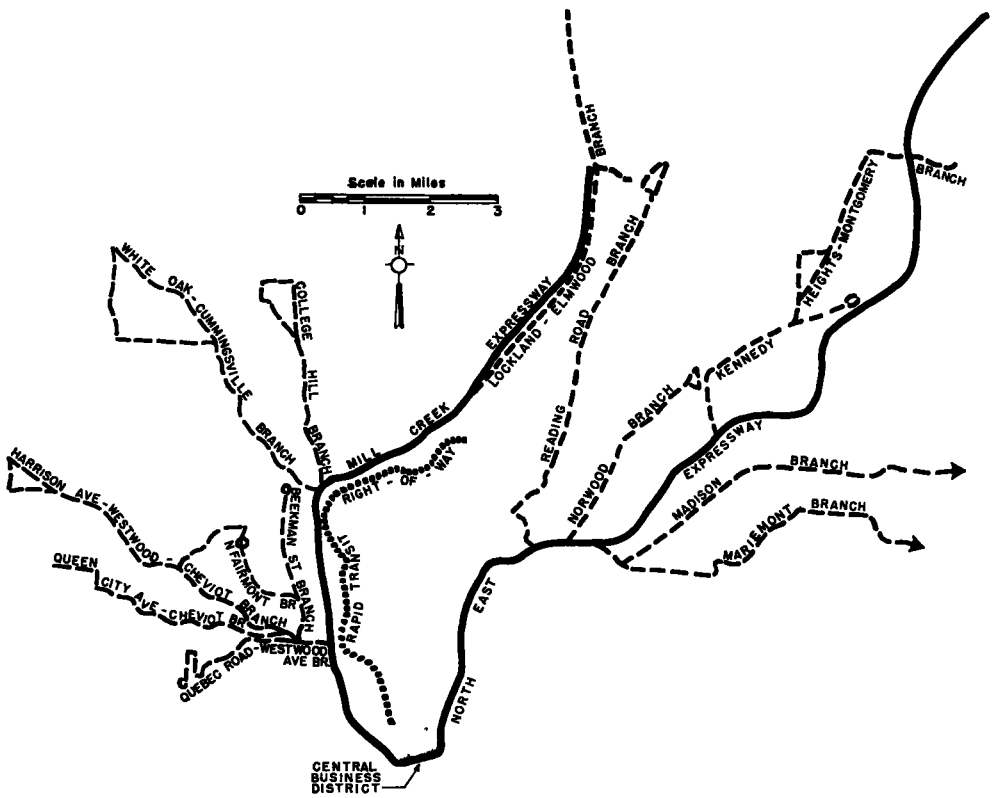

Figure 1. Transit Routes—Tributary to Expressway and Rapid Transit Right-of-Way Used in Analysis of 1945 Origin-Destination Survey

each outer tributary area to the downtown area. The working table (see Table 1) in which this was accomplished set up a number of columns, as follows the first column showed the percentage of each area which was estimated to be tributary to the existing or proposed rapid transit feeder branches. The second column was the area or zone of origin. The number of persons originating in each origin area by all modes of transportation bound for the six destination areas in the column 18. The estimated portion of the automobile passengers who would be attracted to public transit by the greatly reduced travel time resulting from rapid transit service either by rail or by bus, was shown in columns 19 and 20. The total estimated number of rapid transit passengers from each originating zone, including both the existing car and bus riders, as well as the number of automobile riders who would be attracted, were indicated in column 21.

The estimates of rapid transit traffic thus obtained were also an important factor in determining the type of equipment and character of rapid transit facilities to be planned for Cincinnati. For this reason, a careful study was made of the probable population in the several areas of origin of rapid transit passenger as of the year of 1970 and similar estimates were made for the probable rapid transit riding in the year 1970. These computations are shown in columns 23 and 24.

In order to determine the probable hourly flow of rapid transit passengers, it was found that the hourly variations, as determined by analysis of the origin-destination data in a sample of the outer areas served, corresponded almost identically to the hourly variations as determined by local transit checks at the same

TABLE 1

CITY OF CINCINNATI—ESTIMATED NUMBER OF RAPID TRANSIT PASSENGERS WHO WOULD USE SUBWAY OR EXPRESSWAY

Percent of Area Tributary	Origin Area	A All Modes of Transportation: Destination Area 1	2	3	4	5	6	Total	B Street Car and Bus: Destination Area 1	2	3	4	5	6	Total	Transit Pass as Percent of Total	A–B: Total Auto Passengers	Estimated Percent to Use Rapid Transit	Autoists to Use Rapid Transit	1945 Grand Total Rapid Transit Passengers	1936 Survey Expanded to 1945	Estimated 1970 Population Percent Over 1945 Population	Rapid Transit Riders Expanded to 1970 Population
1	2	3	4	5	6	7	8	9	10	11	13	12	14	15	16	17	18	19	20	21	22	23	24
Lockland-Elmwood Branch																							
50	40	71	127	91	278	39	20	626	20	61	52	139	29	10	311	49.7	315	15	47	358		19.9	429
100	41	100	671	988	1,040	456	235	3,490	0	183	363	671	218	20	1,455	41.7	2,035	15	305	1,760		199.5	5,280
60	32	48	12	73	744	106	37	1,020	12	12	37	501	47	12	621	60 9	399	20	80	701		54.4	1,083
100	24	60	142	122	1,184	368	59	1,935	40	60	81	868	240	20	1,309	67.6	626	20	125	1,434		−0.1	1,430
100	42	80	20	20	591	60	0	771	60	20	20	139	20	0	259	33.6	512	15	77	336		56.6	526
100	69	37	53	43	258	52	10	453	0	20	0	42	20	0	82	18.1	371	15	56	138		121.1	305
33⅓	43	7	7	6	132	0	8	160	7	0	6	43	0	8	64	40.0	96	5	5	69		242.5	236
Total								8,455							4,108		4,354		695	4,796	4,864		9,289
Weighted Average																48.5							
College Hill Branch																							
66⅔	43	13	13	13	274	0	18	331	13	0	13	86	0	18	140	42.2	191	5	10	150		242.5	514
100	44	80	60	40	1,480	40	0	1,700	0	40	20	933	20	0	1,013	59.6	687	15	103	1,116		70.0	1,895
100	64	20	20	40	616	20	0	716	20	20	20	536	20	0	616	86.0	100	20	20	636		8.8	691
66⅔	65	67	13	66	1,128	61	0	1,335	40	13	40	681	28	0	802	60.1	533	20	107	909		70.1	1,545
100	66	0	21	19	78	62	0	180	0	0	19	39	0	0	58	32.2	122	5	6	64		195.5	183
33⅓	60	107	64	127	733	67	0	1,098	67	27	101	603	53	0	851	77.5	247	20	49	900		−14.0	775
Total								5,360							3,480		1,880		295	3,775	3,474		5,603
Weighted Average																64.9							
White Oak Branch and Cumminsville																							
100	68	25	5	17	127	12	1	187	0	0	0	0	0	0	0	0	187	5	9	9		267.0	33
33⅓	65	34	7	33	563	20	0	657	20	7	20	340	13	0	400	60.9	257	20	51	451		70.1	767
100	61	0	0	0	20	0	0	20	0	0	0	0	0	0	0	0	20	20	4	4		−1.6	4
33⅓	60	108	64	127	733	67	0	1,099	134	27	101	603	53	0	918	83.5	181	20	36	954		−14.0	820
								1,963							1,318		645		100	1,418	2,616		1,624
Weighted Average																67.1							
Grand Total								15,778							8,899		6,879		1,090	9,989	10,954		16,516
Weighted Average																56.4							

NOTE: B ased on 1945 Origin-Destination Survey.

points. Hourly variation for each feeder branch, therefore, was obtained by applying percentages determined by transit checks at each point.

Through similar analyses of metropolitan origin-destination surveys in other cities, it has been possible to determine the locations justifying express or rapid transit service, as well as the type and frequency of equipment required to provide this service.

CENTRAL BUSINESS DISTRICT DISTRIBUTION

Since routing of transit passengers is one of the most basic jobs of transit operators, the problem of routing transit vehicles in the central business district close to the destination of the greatest number of transit riders is made possible through application of the data obtained in the origin-destination survey. Since the survey reveals the concentrations of persons in the central area by small zones, it is possible for the transit operator to study the downtown destinations of his passengers from any section of the city. It is possible, moreover, for the operator to reroute his equipment to provide direct delivery within the central area to the greatest portion of his passengers with a minimum of walking distance or minimum number of transfers required.

THROUGH ROUTING

In many downtown districts transit routes from one side of town enter the central business district and loop back. If a sufficient number of routes entering the central business district are thus routed, the turning movements of buses and cars add to the congestion in the crowded area of the city. In order to minimize such turning movements and loopings, many transit operators desire to through-route lines from one side of the city to the other. While the main criterion for such through-routing is that the lines should be balanced as nearly as possible so far as the headways are concerned, it frequently happens there are a number of lines from one side of the city which might be tied to lines from another part of the city. The metropolitan origin-destination survey can be utilized to determine which of the several lines has the greatest portion of people travelling from one side of the city to the other, so that the amount of transferring would be cut to a minimum.

LINE CHARACTERISTICS

In the operations of any individual transit route, there are certain characteristics of that line which determine the portion of cars or buses which will be operated to the end of the line and a portion which may be turned back short of the outer terminals. To determine such characteristics, transit operators have usually found it necessary to conduct boarding and alighting surveys. The metropolitan origin-destination survey will also provide the operators with similar information through analysis of the minute details provided by the travel from one small zone to another by the time periods of the day. For such a purpose, however, an analysis becomes so cumbersome and time-consuming that it has been found it would be much more advantageous for this purpose to conduct a boarding and alighting survey rather than use the data provided by the origin-destination survey. This is one of the few instances in which the origin-destination survey will not provide adequate basic data with a minimum of effort for use of the transit operator.

CONCLUSIONS

The examples illustrated herein are only a few of the great number which are possible in the application of the metropolitan origin-destination survey to transit planning. The need for impressing upon transit operators the value of the survey data derived to transit planning must be brought emphatically to the attention of highway officials. In most instances, it is merely a matter of acquainting transit operators with the scope of the origin-destination survey.