TRANSPORTATION CENTER

PUBLIC TRANSPORTATION in the CHICAGO REGION PRESENT PERFORMANCE and FUTURE POTENTIAL

RESEARCH REPORT

NORTHWESTERN UNIVERSITY EVANSTON • ILLINOIS

THE TRANSPORTATION CENTER

PUBLIC TRANSPORTATION in the CHICAGO REGION PRESENT PERFORMANCE and FUTURE POTENTIAL

FOR
BURLINGTON NORTHERN, INC.
CHICAGO AND NORTH WESTERN TRANSPORTATION CO.
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FEBRUARY 23, 1973

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Ross W. Adams
Richard M. Michaels
Joseph L. Schofer
Peter L. Watson

CHAPTER I

INTRODUCTION

Urban Development Patterns

Public transportation in most major metropolitan regions has suffered marked reduction in ridership, increased costs and continuing reductions in service as a result. To a significant degree, these difficulties are related to changes in the urban structure that have made public transportation increasingly ineffective. Most public transport systems were developed during the early 1900's when both population and employment were concentrated within or around the city's central business district (CBD). Through the 1950's, the spatial development patterns closely followed the development of public transport routes. Dispersed neighborhood shops met day-to-day needs and retail trade was located within the neighborhood, while major shopping facilities were located in the CBD. Most travel took place in well-defined corridors and public transport served a large portion of the total demand for all trip purposes. While this structure existed, public transport was a growth industry, highly profitable and generally under private ownership.

Beginning in the 1950's, a marked change in urban structure occurred. First, a new kind of residential development emerged with federal and other mortgage insurance programs permitting long-term financing of single family dwellings. As a result, a large proportion of the population was able to move out of the city and to own a home. The population of most cities has remained almost constant or decreased since 1950. Suburban areas adjacent to major cities have grown rapidly throughout the 1960's. While the total number of people living within the metropolitan regions has increased dramatically over the past two decades, the density of population (the number of people per square mile) has decreased. Public transit operators found it difficult to extend service into the developing suburban communities because low passenger densities (passengers per route mile) resulted in decreased operational efficiency and revenue to cost ratios. In the absence of public transport in these newer communities, residents, of necessity, became dependent on the automobile.

Second, during the 1960's, employment opportunities also began to move toward the suburbs. Although both jobs and residences were becoming increasingly suburbanized, people did not tend to live near their work places. Instead, the work-trip travel pattern became highly dispersed, a trend facilitated by the creation of the urban component of the Interstate highway System. Lower land values in the suburbs, shifts in industrial technologies, and the preference for highway rather than rail service for moving freight accelerated this trend.

It was difficult, if not impossible, for public transportation to respond to these changes. In the total metropolitan region, with both residential and employment density decreasing and with increasing numbers of private vehicles, it was impossible for public transport to provide service economically. The demand per unit of area was too low to support traditional public transport services. The change from an urban, city-centered structure to a suburban, metropolitan structure has gravely affected the financial and operational future of most public transport carriers. Many have changed from private companies to public agencies, and most have passed from profitable enterprises to deficit or marginal operations.

The social, economic and structural changes that occurred in most urban regions are the underlying reasons for many of the problems of public transportation in the Chicago area. A new set of personal transport and service principles, and an era of dispersed metropolitan growth, have emerged to diminish the importance of the central city as a center of population, employment and retail trade. In the Chicago metropolitan area, there are an estimated 2.5 million daily work-trips, of which 213,000 (8%) are directed toward the city's central business district. Of the CBD directed work-trips, nearly 85% (181,000) are carried by the commuter railroads and the Chicago Transit Authority (CTA) which continue to fulfill the role of a centrally focused transport system. Major non-work and non-CBD directed work-trips, within the region, are made primarily by the automobile.

The CBD in Chicago, of course, continues to play an essential, if changing role in the life of the region. It has fared far better than the central areas of most large cities, growing in importance as the major center for offices, institutional activities and cultural facilities. It is clear that the CBD of Chicago must continue to be the functional center for the region; similarly, the dependence of the CBD on the rest of the region must be recognized.

Transportation Service Development

Mass transport services in the Chicago region have developed as independent and competitive enterprises. Street railways, subways and elevated rail systems were established within Chicago to meet the high demand requirements. Railroads provided higher speed, long-distance commuter service along high and medium density corridors. Suburban bus services in outlying areas provided circulation within and between satellite communities, with limited service to the CBD. All systems were operated toward goals of individual profitability, without coordination and with little cooperation in terms of scheduling, routing, and interconnections. Many small transport corporations were selling services in a relatively compact market area. Sprawling growth of the metropolitan area reduced the density of demand for these enterprises. And in isolation, few carriers were able to respond effectively or economically. Many have curtailed services or are petitioning to do so.

Thus, the difficulties of public transportation within the Chicago area are, in part, a consequence of changes in urban structure, travel demands and life-style preferences. In the face of these changes, a fundamental question is: can the public transport facilities of the region be organized and operated in a way responsive to these changes and provide services attractive to current automobile users?

In order to answer this question, it is first necessary to establish the criteria used by travelers to select among alternative modes of transportation. Research on mode choice over the past decade suggests that four factors largely determine the choice of travel mode. These are: (1) cost to the user, (2) door-to-door travel time, (3) frequency of service, and (4) accessibility in time and space. If a destination cannot be made accessible within a reasonable amount of time by public transport, that trip will not be made, or will be made by private automobile. If public transport is to compete with the automobile for personal travel, it must link the homes of users to their destination sites in such a way that the time required to make that trip is acceptable. Can the public transport system be organized to meet these accessibility requirements? If so, it may again become a primary and attractive means of meeting regional mobility needs. The remainder of this report focuses on this question by examining accessibility provided by the existing public transport system in the Chicago region and the potential accessibility that can be provided by a coordinated and integrated system.

Study Goals

The major concern of this study was to answer two questions concerning public transportation service characteristics. First, what are the accessibility characteristics of the public transport system of the Chicago region as it is currently operated? Second, can the public transportation system be modified in such a way that accessibility can be significantly increased?

The present public transport system was evaluated to determine levels of accessibility between population and employment centers. The resultant focus on home to work travel was adopted because of the importance of such trips to the economy of the region, because of the relative magnitude of the work-trip set, and because resource limitations for this study did not permit the examination of other trip purposes. After establishing existing levels of accessibility, a number of promising system modifications were tested to determine the potential increases in accessibility benefits to the region which might be achievable.

Travel time provided the basis for measuring accessibility. Travel costs were not considered in part because it was felt that the pricing scheme for public transport services is not a fundamental system variable. It is not representative of the true costs of providing services, and it is considerably more flexible than travel times, being easy to change in response to policies.

The first step in the evaluation was the development of a quantitative description of the existing public transportation facilities in the region, including routing and scheduling of the CTA, the commuter railroads and the suburban bus services, and locations of stations and transfer points. From this information, it was possible to determine the area of coverage of each of the components of the regional network, their interconnections in both time and space, and the functional characteristics of the public transportation system within the region.

The second step was to delineate the metropolitan region for analysis purposes. Several possible boundaries have been used to define the region, any of which is adequate but arbitrary. For the purpose of this study, the central portion of the six-county region representing the Chicago metropolitan area was selected for analysis. This area is shown in Figure IV-1. It includes about 75% of the population and 84% of the employment in the region, as defined by the Northeastern Illinois Planning Commission (NIPC). This delineation was adopted in order to minimize the size of the study area for computational economies. Because both population and employment densities outside of the study area are relatively low, it was felt that enlarging the size of the analysis area would not add significantly more information. Furthermore, it became clear that generalizing the results of this study to a larger area presented no conceptual difficulties.

Within the study area, a system of uniform, one-square mile zones was defined to permit the identification of accessibility measures between relatively well-defined places.

Data from NIPC, representing estimates of 1975 population and employment, were summarized by these analysis zones.

Given the public transport structure and the location of employment sites and residences, it was possible to determine the accessibility of those employment sites. The methodology, described in detail in Chapter III, involved determination of the specific employment zones that are accessible from residential zones by public transport within one hour travel time between the hours of 7:00 a.m. to 8:00 a.m., with an 8:00 a.m. desired arrival time. Inputs to this model were the actual routes and travel time schedules of the various components of the mass transit system, providing a reasonable and realistic measure of accessibility within the region.

The output of the model permitted a determination of the area of accessibility around any specified employment site. It also permitted a determination of the proportion of the population that has accessibility to any given proportion of employment opportunity within the region. Using this model, it became possible to evaluate the existing transport system in absolute terms. Given this base for comparison, four alternative levels of system modifications were developed and tested. Relative improvement in accessibility provided by each of these modifications, and combinations of them, were measured.

The four modifications which we tested were: (1) operation of the commuter rail system on an outbound schedule during the morning peak period; (2) utilization of the suburban bus stock to provide collector-distributor services routed to commuter railroad stations or to rail rapid transit lines and scheduled to meet the train service; (3) the addition of a circumferential rail rapid transit line, largely lying within the city limits of Chicago, but linked to and interconnecting with the commuter rail stations; and (4) the addition of a second circumferential rail line running in the suburban portion of the region, again linked to the radial commuter rail lines.

The selection of these four modifications was based upon two assumptions: (1) that each promised to increase accessibility within the region, and (2) that the modifications were technically feasible. While all of these alternatives did not serve to offer significant increases in accessibility, it was not possible to know at the outset how extensive a modification was required to significantly increase accessibility within the region. Hence, the analysis was carried to the point of diminishing returns.

It should be recognized that the ultimate purpose of this study was to evaluate the level of accessibility provided by mass transit within the region and the changes in that level that could accrue from integrating and coordinating the structure and operations of the transport system. It was not the concern of this study to define institutional strategies for implementing the modifications tested. Rather it was to determine whether the potential benefits in terms of accessibility were sufficient to warrant any structural, operational, or institutional changes.

The remainder of this report details the methodology and the results of its application. The final chapter contains the conclusions of the study and a discussion of their implications for the Chicago metropolitan region.

CHAPTER II

CHARACTERISTICS OF THE CHICAGO REGION AND THE EXISTING PUBLIC TRANSPORT SYSTEM

In the previous section, general patterns of shifts in population and employment within metropolitan regions were discussed. Although it is apparent that these changes have occurred in the Chicago area, it is essential to the evaluation of public transport to determine the geographic and demographic characteristics of the region. From this base, the location and service characteristics of the public transport stock can be defined and related to residential and employment locations, current and projected. Furthermore, this base provides the criteria for identifying the alternative levels of integration of the public transport system—those that will most likely increase accessibility for home to work trips. In sum, the purpose of this section is to dimension the present and expected characteristics of work-trip travel in the region as a means of concretely evaluating the present and potential benefits to the region of an integrated and coordinated public transport system.

Population and Employment

The six-county area, representing the Illinois portion of the Chicago metropolitan region, is shown in Figure II-1. These counties had a 1970 population of nearly 7 million, which represented 63% of the total population of Illinois. Populations of selected regional subdivisions are shown in

TABLE II-1: 1970 POPULATION, CHICAGO REGION, ILLINOIS PORTION*

Regional Subdivisions	Persons (In 1,000's)	% of Region	% of State
Cook County	5492.4	78.7	49.4
Chicago	3367.0	48.2	30.3
Remainder	2125.4	30.5	19.1
Other Counties	1486.5	21.3	13.4
Total Region	6978.9	100.0	62.8
Rest of State	4135.1	—	37.2
Total State**	11114.0	—	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-1.

** Total State Figure obtained from Regional Office, U.S. Department of Commerce, Bureau of Census.

Table II-1. Projected population values and percentages for these regional areas, for the years 1975 and 1985, are given in Table II-2. These tables indicate that the population of the City, as a percentage of the region, will decrease from 48.2% in 1970 to 40.6% by 1985. Further, the population of Cook County will drop from 78.7% to 72.6%. Thus, growth in the region will occur in the remaining counties in the region, increasing from 21.3% to 27.4%.

In 1970, there were approximately three million employees in the region. Projected employment figures, for manufacturing and non-manufactur-

TABLE II-2: PROJECTED POPULATION VALUES FOR REGION*

Regional Subdivisions	Projected 1975 Persons (In 1,000's)	%	Projected 1985 Persons (In 1,000's)	%
Cook County	5830.0	76.7	6350.0	72.6
Chicago	3440.0	45.3	3550.0	40.6
Remainder	2390.0	31.4	2800.0	32.0
Other Counties	1770.0	23.3	2400.0	27.4
Total Region	7600.0	100.0	8750.0	100.0

* Northeastern Illinois Planning Commission (NIPC), Planning Paper No. 10, Population, Employment and Land-Use Forecasts for Counties and Townships in Northeastern Illinois, 9/68, revised 1/72.

ing, are illustrated in Tables II-3 and II-4. As may be seen, these tables indicate that changes in employment location are expected to be slight, although manufacturing employment will increase mainly outside of the City of Chicago through 1985. Non-manufacturing employment is expected to continue to drop within the City itself.

Within the region there are 2.4 million persons commuting daily to places of employment. Employment locations are given in Table II-5, which indicates that only 8.3% of this commuting work force was employed within the CBD, while 44.6% was employed within the City, but outside of the CBD. A total of 82.2% worked within Cook County. The locations of employment for residents of the City are given in Table II-6, which indicates that 11.2% of the people work within the CBD, 71.6% were employed elsewhere in the City and 15.5%

TABLE II-3 : PROJECTED MANUFACTURING EMPLOYMENT FOR REGION *

Regional Subdivisions	Projected 1975 Persons (In 1,000's)	%	Projected 1985 Persons (In 1,000's)	%
Cook County	848.6	82.8	842.5	81.0
Chicago	520.0	50.7	510.0	49.0
Remainder	328.6	32.1	332.5	32.0
Other Counties	176.6	17.2	197.5	19.0
Total Region	1025.2	100.0	1040.0	100.0

* Northeastern Illinois Planning Commission (NIPC), Planning Paper No. 10, Population, Employment and Land-Use Forecasts for Counties and Townships in Northeastern Illinois, 9/68, revised 1/72.

TABLE II-4 : PROJECTED NON-MANUFACTURING EMPLOYMENT FOR REGION *

Regional Subdivisions	Projected 1975 Persons (In 1,000's)	%	Projected 1985 Persons (In 1,000's)	%
Cook County	1933.4	83.2	2087.2	78.2
Chicago	1429.8	61.5	1476.2	55.3
Remainder	503.6	21.7	611.0	22.9
Other Counties	391.4	16.8	582.8	21.8
Total Region	2324.8	100.0	2670.0	100.0

* Northeastern Illinois Planning Commission (NIPC), Planning Paper No. 10, Population, Employment and Land-Use Forecasts for Counties and Townships in Northeastern Illinois, 6/68, revised 1/72.

TABLE II-5 : PLACE OF WORK FOR COMMUTING RESIDENTS BY COUNTY IN REGION *

Regional Subdivisions	Persons (In 1,000's)	% of Total
Cook County	2094.9	82.2
Chicago (CBD)	212.5	8.3
Chicago (non-CBD)	1136.9	44.6
Remainder	745.5	29.3
Other Counties	453.8	17.8
Total Region	2548.7	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-2.

TABLE II-6 : PLACE OF WORK FOR COMMUTING CHICAGO RESIDENTS BY COUNTY IN REGION *

Regional Subdivisions	Persons (In 1,000's)	% of Total
Cook County	1180.0	98.3
Chicago (CBD)	134.1	11.2
Chicago (non-CBD)	860.2	71.6
Remainder	185.7	15.5
Other Counties	20.8	1.7
Total Region	1200.8	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-2.

were employed outside the City in Cook County. Only 5.8% of non-Chicago residents were employed within the CBD, as shown in Table II-7.

These population and employment figures indicate that a large percentage of 1970 work-trips were not CBD oriented. Thus, most work-trips were made to the outlying areas of the City and into various parts of Cook County. Given projected values for employment in 1985, the trend toward decentralization of work-trips is expected to continue. Hence, work-trip distances have markedly increased and have become increasingly diffused throughout the region. Further, there is every indication that there is a decreasing relation between work place and residence location.

In sum, this review of the patterns of population, residential and employment location indicates the magnitude of the changes, actual and expected, that have occurred in the Chicago metropolitan region. Population growth is occurring largely outside the City itself in suburban locations. This has caused a major shift in travel patterns which must profoundly affect the attractiveness, utility, and acceptability of mass transit as a means of satisfying work-trip travel needs. Given this changed regional travel structure, it is reasonable now to examine the operations of public transport to determine how effectively it is matched to that travel structure.

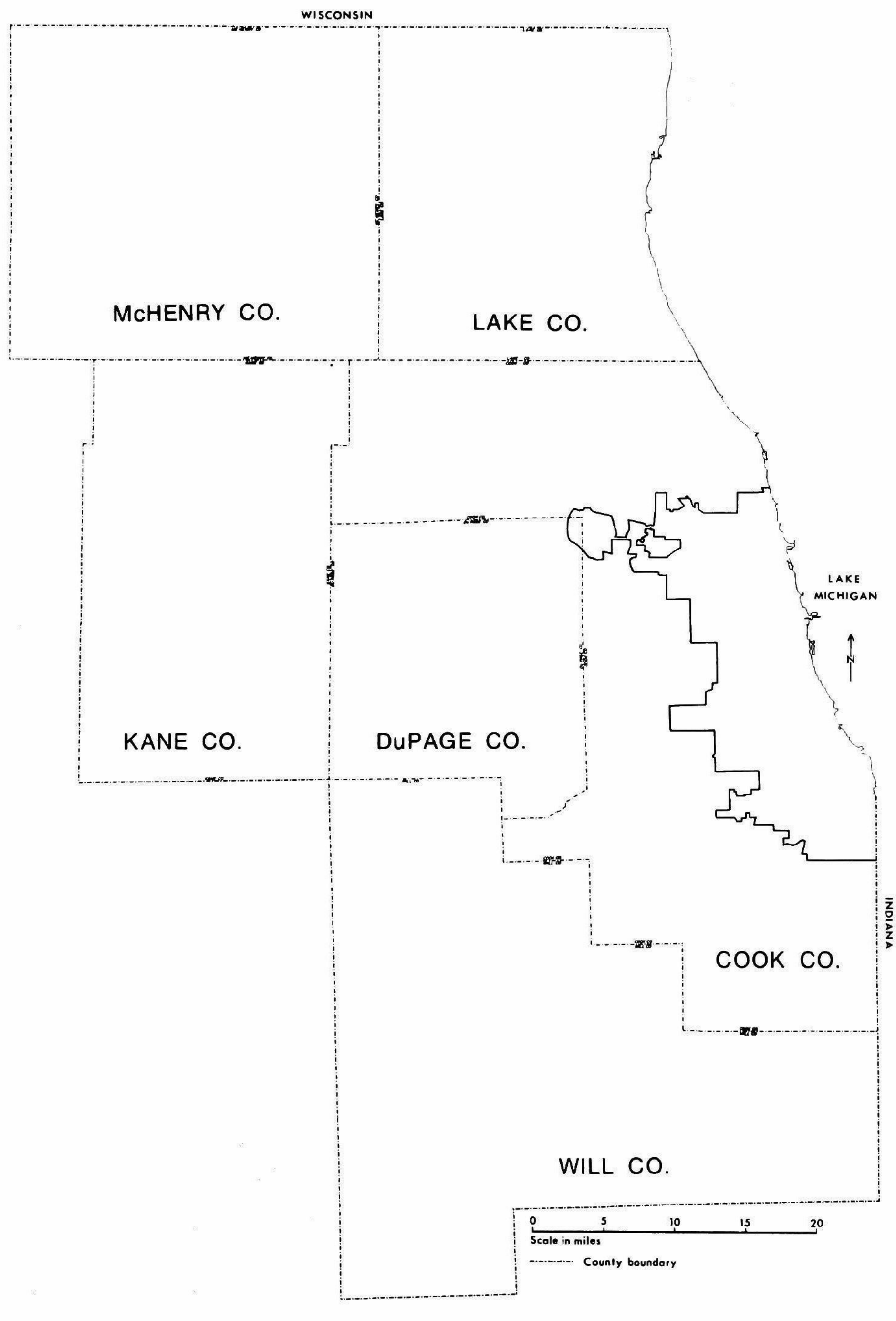
TABLE II-7 : PLACE OF WORK FOR COMMUTING NON-CHICAGO RESIDENTS BY COUNTY IN REGION *

Regional Subdivisions	**Persons (In 1,000's)**	**% of Total**
Cook County	914.9	67.9
Chicago (CBD)	78.4	5.8
Chicago (non-CBD)	276.7	20.5
Remainder	559.8	41.6
Other Counties	433.0	32.1
Total Region	1347.9	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-2.

FIGURE II - 1

SIX COUNTY AREA OF NORTHEASTERN ILLINOIS REPRESENTING STANDARD METROPOLITAN STATISTICAL AREA OF CHICAGO



CHAPTER III

THE EXISTING PUBLIC TRANSPORT SYSTEM

The public transport system in the Chicago region is made up of three major components. These are the CTA, the commuter railroads, and the suburban bus lines. All have been in existence in whole, or as a result of merger, for decades and have served commuter needs over that time span. Their service areas have been well defined and all have operated as independent entities within the region. The purpose of this section is to locate these systems within the social organization of the region and examine the functions they now perform and what portions of the work-trip travel market they serve. Again, the purpose of this analysis is to evaluate the existing public transport system and its potential for providing improved levels of service within the region. The first part of the chapter describes the systems and their interconnections, while the second part defines the utilization of the system as a whole.

The Chicago metropolitan region in general has a large stock of public transit elements. Service to the Loop is of special high quality. Each of the three components provides different points of service in their market area. Each will be discussed in turn.

Eight railroads operate commuter service to the Loop area. The commuter railroad routes are shown in Figure III-1. Of these, six railroads operate with a high level of service. Table III-1 gives the number of trains operated during the morning peak period on various routes. The principal routes are the Chicago and North Western North Line to Kenosha, Wisconsin; the Milwaukee Road North Line to Fox Lake, Illinois, with one round trip a day extending to Walworth, Wisconsin; the Chicago and North Western Northwest Line to Harvard, Illinois, with a branch line to Lake Geneva, Wisconsin with two round trips a day; the Milwaukee Road West Line to Elgin; the Chicago and North Western West Line to Geneva; the Burlington Northern to Aurora; the Rock Island to Joliet with a branch line that reconnects with the main line at Vermont Street in Blue Island; the Illinois Central Gulf to Richton with the Blue Island and South Chicago branch lines; and the Chicago, South Shore and South Bend, utilizing the Illinois Central Gulf main line as far as 115th Street, to Gary, Indiana with limited service to Michigan City and South Bend, Indiana. Routes with only limited service are the Penn Central with two round trips a day from Valparaiso, Indiana; the Norfolk and Western with one round trip from Orland Park; and the Illinois Central Gulf from Joliet, with one round trip a day, over the former Gulf, Mobile and Ohio main line. At present, the commuter railroads play a specialized role in that most of their riders are commuting to work places in the vicinity of the Loop. Passengers carried and passenger miles for 1971 are summarized in Table III-2.

TABLE III-1
Between 7 :00 AM and 9 :00 AM on Weekdays

	Trains Arriving at Loop	Trains Departing from Loop
C&NW - N	14	3
Milwaukee - N	8	1
C&NW - NW	18	2
Milwaukee - W	8	1
C&NW - W	11	3
BN	18	2
ICG - to Joliet	1	0
N&W	1	0
RI	15	2
PC	2	0
ICG - electric	37	11
CSS&SB	5	2

TABLE III-2

	1971 Passengers	1971 Passenger Miles
C&NW	24,762,814	521,073,441
ICG	17,746,291	300,658,622
BN	9,934,397	179,807,681
Milwaukee	6,087,882	139,026,950
RI	5,900,476	96,986,631
CSS&SB	2,030,973	63,456,824

The Chicago Transit Authority is a municipal corporation, operating bus and rapid transit within the Chicago city limits, though a few extend beyond the city limits. A map of the CTA network can be found in Figure III-2. The CTA's rail rapid transit network is basically radial, focusing on the Loop. All sectors of the City are reasonably well covered by rapid transit routes except the Southwest. The bus routes form a grid pattern because of the City's predominantly grid street system. Some bus routes run on radial streets that are imposed on the grid pattern. Coverage by the CTA's bus system is good. The route spacing is one-half mile in much of the City. Only a few locations in the City are more than a half-mile from the CTA bus network. There are some express bus routes utilizing the Stevenson Expressway, Lake Shore Drive and the Kennedy Expressway. Bus headways vary greatly between routes and the different periods of service.

There are eight suburban bus companies that operate scheduled local bus service in the Cook County/City of Chicago area of the metropolitan region. Figure III-3 shows the areas where bus service is operated. The rolling stock of these companies ranges from the 138 buses of West Towns Bus Company to the single bus of the Lindberg Transportation Company, as indicated in Table III-3. In general, these bus companies have their own market areas, though there is some overlapping of service. Some companies operate bus service from the suburbs into the Loop.

TABLE III-3 : SUBURBAN BUS FLEETS, WITHIN STUDY AREA*

West Towns Bus Company	138
South Suburban Safeway	130
Evanston Bus Company	89
Calumet District Transit	80
United Motor Coach	72
Suburban Transit	38
West Suburban Transit	32
Glenview Bus Company	24
Lindberg Transportation Co.	1
	604

* Bus & Rail Rolling Stock, CATS, page 11, 10/71.

Since the CTA has good coverage in the City of Chicago, most commuter railroad stations within the city limits are close to a CTA bus or rapid transit line. However, there are only a few cases of active coordination between the CTA and the commuter railroads. Some bus lines passing Union and North Western Stations have reduced fares for passengers between the depots and the Loop during certain hours. Another case of coordination is the placing of transfer stamps at Randolph Street Station and Bryn Mawr Station on the Illinois Central Gulf, so that passengers can use the CTA at both ends of the rail trip without paying two full fares. Other cases of coordination are the joint CTA and Chicago and North Western station at Jefferson Park, which allows easy transfers but no break in fares, and the Northwest Passage, an enclosed walk-way between the North Western Station and the Clinton Station on the CTA Lake Street rapid transit line.

Very little coordination exists between the CTA and suburban bus companies. Some suburban bus companies have bus routes that feed CTA rapid transit stations or run on the same streets as CTA, but there are no cases of joint fares.

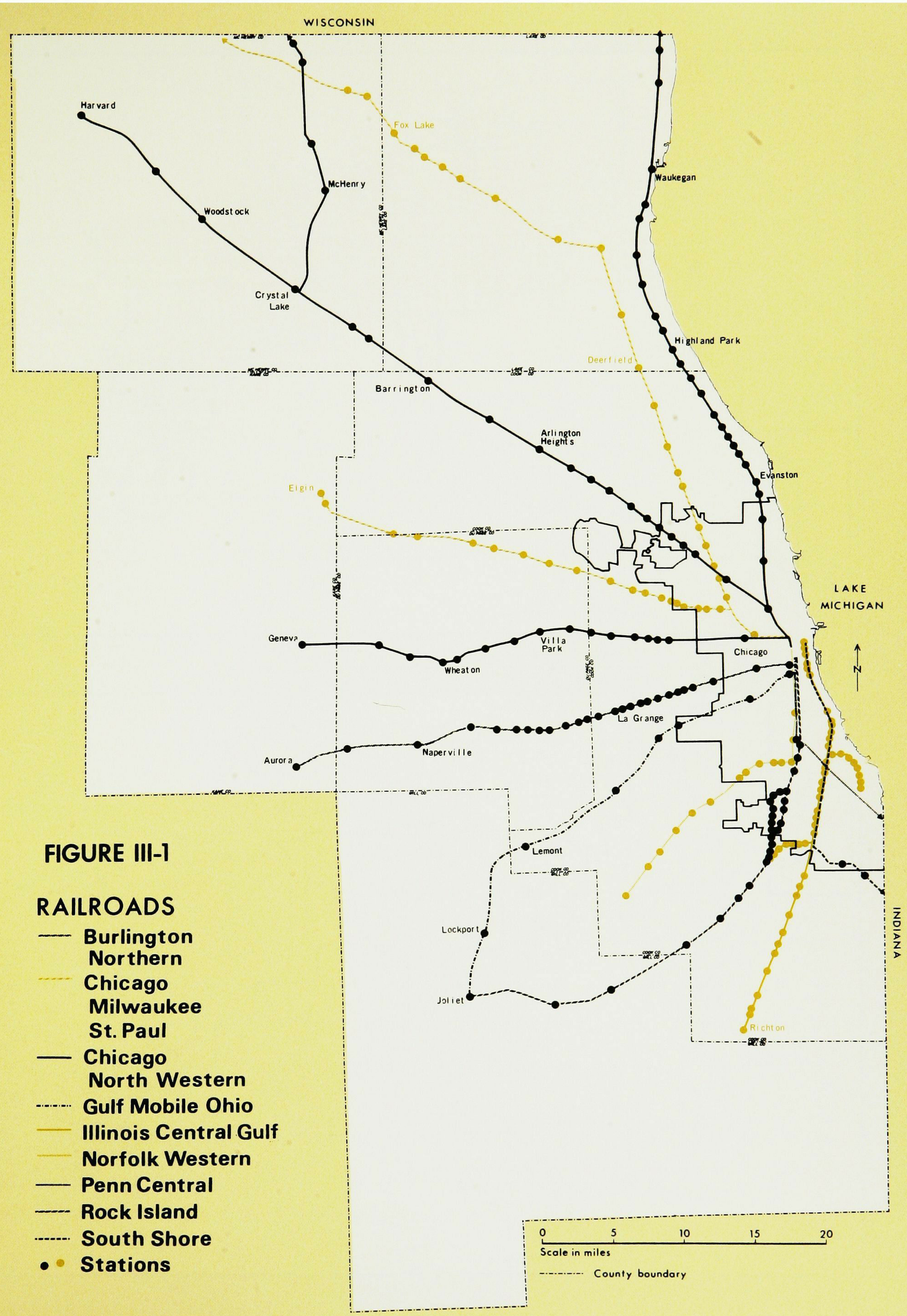
Except for a few cases, coordination between suburban buses and the commuter railroads is poor. The Northwestern Transit Corporation and the Milwaukee Road have a joint fare from Hoffman Estates and Schaumburg to the Loop, but there is only one round trip on weekdays between Schaumburg and the Milwaukee Road station at Roselle and between Hoffman Estates and Roselle. Some suburban bus companies have scheduled connections with trains, but this is the exception rather than the rule. Three notable examples of this are the Illinois Central Gulf and South Suburban Safeway at the 211th Street Station, the Rock Island and Suburban Transit at 95th Street and Chicago and North Western and the Evanston Bus Company at Central Street. Still other suburban bus routes pass by railroad stations, but usually the connections are not emphasized.

The interfaces between the commuter railroads are also poor. At present there are a number of separate terminals in the vicinity of the Loop. Chicago Union Station, located at Canal and Adams west of the Loop, is used for commuter service by the Burlington Northern, the Milwaukee Road, the Penn Central, and the Illinois Central Gulf for its one round trip between Joliet and Chicago. The North Western Station at Madison and Canal is used exclusively by the Chicago and North Western. LaSalle Street Station, located at Van Buren and LaSalle, is used by the Rock Island. The Illinois Central Gulf's and the Chicago, South Shore and South Bend's electrified trains terminate at Randolph and Michigan. The Norfolk and Western's single round trip uses a platform close to the old Dearborn Street Station. The necessity of transferring between terminals for most trips using different railroad lines is another factor impeding the generation of such trips.

Existing Public Transport and Travel Characteristics

The route structures of the railroads and the CTA rapid transit reflect convergence on the CBD of Chicago. Several suburban bus lines also operate service to the CBD. The CTA surface routes provide comprehensive network coverage following the grid pattern of the major arterial streets, but these routes provide primarily local service within the City of Chicago. Some CBD oriented express service is offered on certain routes.

The structure of the CTA network and the commuter rail lines has been developed around CBD central service. The commuter rail is a set of independent radial lines, all converging on the center of the City. In effect, public transport efficiently


WISCONSIN
Harvard
Woodstock
McHenry
Crystal Lake
Fox Lake
Waukegan
Highland Park
Deerfield
Barrington
Arlington Heights
Evanston
Elgin
LAKE MICHIGAN
Geneva
Villa Park
Wheaton
Chicago
N
La Grange
Aurora
Naperville
Lemont
Lockport
Joliet
Richton
INDIANA
RAILROADS
Burlington Northern
Chicago Milwaukee St. Paul
Chicago North Western
Gulf Mobile Ohio
Illinois Central Gulf
Norfolk Western
Penn Central
Rock Island
South Shore
Stations
0 5 10 15 20
Scale in miles
County boundary
FIGURE III-1

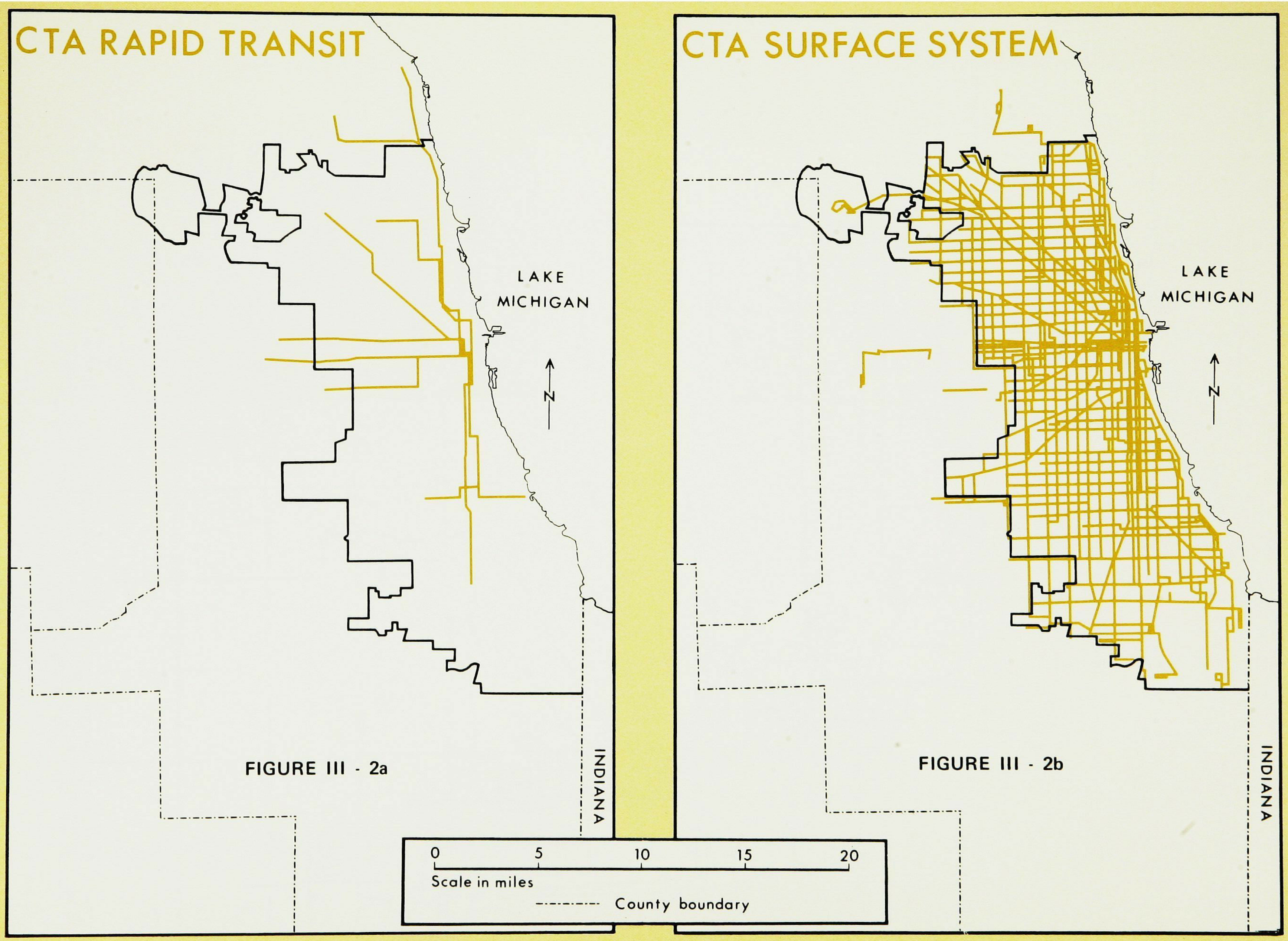


FIGURE III - 2a

FIGURE III - 2b

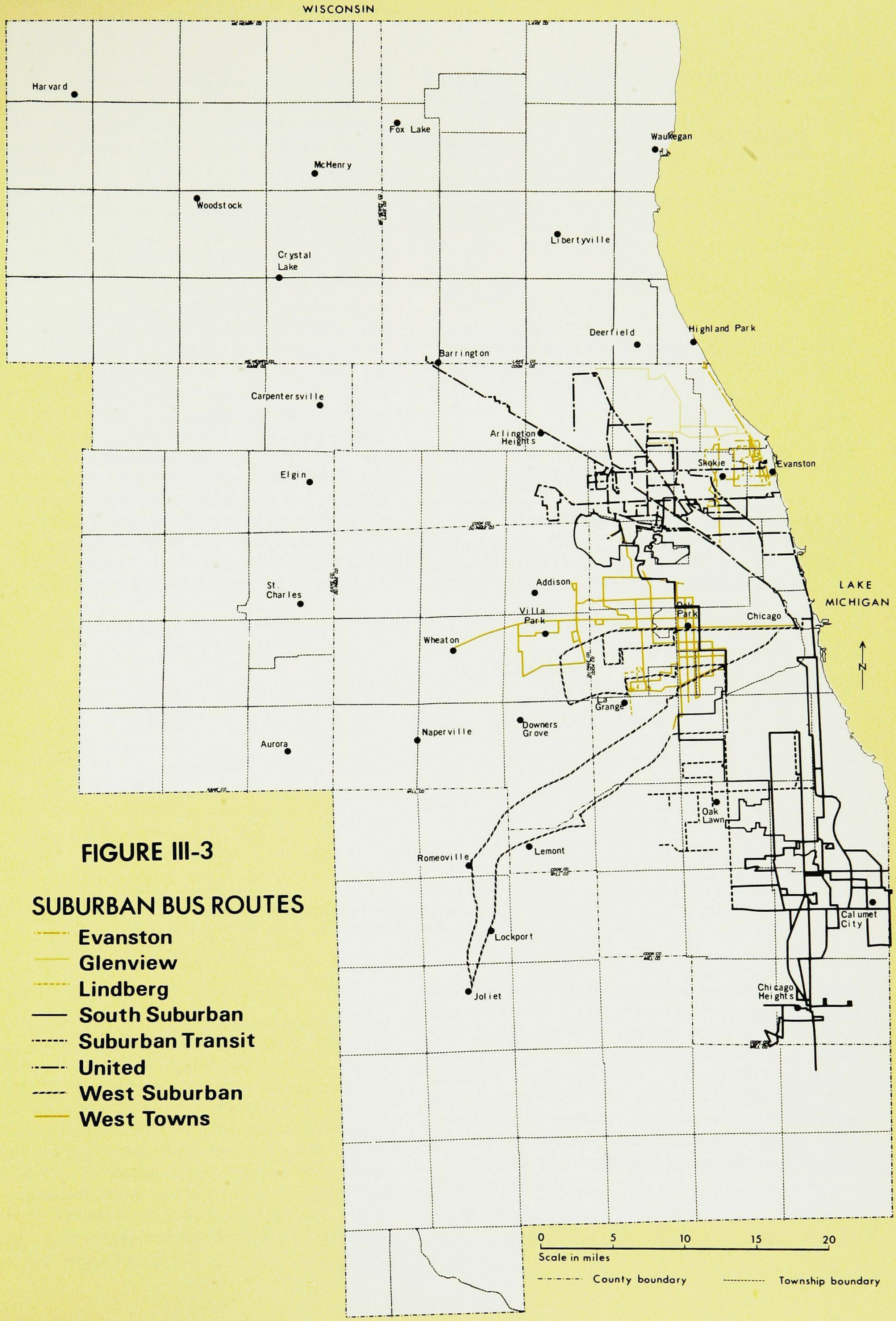


FIGURE III-3

SUBURBAN BUS ROUTES

- Evanston
- Glenview
- Lindberg
- South Suburban
- Suburban Transit
- United
- West Suburban
- West Towns

serves only 8.3% of the region's work-trip travel. For the remaining 92%, the service is limited at best. The commuter rail lines provide relatively few trains in scheduled service outbound during peak hours, and, of course, have no interconnections except within some stations. Consequently, it is difficult, if not impossible, for work-trip travelers to make much use of the public transport system. The consequences in terms of mode split are obvious.

Table III-4 shows the 1970 work-trip mode-split within the region. Of these work-trips, 23.2% were carried by the public system, and 68% were by automobile. This information, broken down by residential location, is given in Table III-5. Nearly 80% of non-Chicago residents use private vehicles and only approximately 11% use public transport. Of Chicago residents only 36% use public transport, with 26% using buses. Given the limited accessibility associated with the existing CBD oriented transport system, it is difficult for persons wishing to make non-CBD work trips to use public transport. Thus, they find it necessary either to commute by automobile or to abandon the trip. This finding was confirmed by a recent evaluation of job accessibility in Chicago.*

TABLE III-4: MODES OF TRANSPORTATION TO PLACE OF WORK*

Transport Mode	Persons By Mode (In 1,000's)	Percent By Mode
Auto	1880.2	67.7
Bus/Streetcar	389.8	14.0
Rail	254.3	9.2
Walked	212.0	7.6
Other	42.8	1.5
Total Region	2779.1	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-2.

*Job Accessibility for the Unemployed: An Analysis of Public Transportation in Chicago, Mayor's Committee for Economic and Cultural Development, (3/72), Conclusions, p. 56.

TABLE III-5: MODE OF TRANSPORTATION TO PLACE OF WORK BY RESIDENTIAL LOCATION*

	Residential Locations			
	Chicago		Non-Chicago	
Transport Mode	Persons (In 1,000's)	% of Total	Persons (In 1,000's)	% of Total
Auto	715.0	53.9	1165.2	80.2
Bus/Streetcar	351.7	26.5	38.1	2.6
Rail	129.4	9.7	124.9	8.6
Walked	116.4	8.8	95.6	6.6
Other	14.4	1.1	28.4	2.0
Total Region	1326.9	100.0	1452.2	100.0

* 1970 Census of Population and Housing, Part 1, U.S. Department of Commerce, Bureau of Census, PHC (1)-43, Table P-2.

Summary

Population and employment opportunities have shifted away from the CBD of Chicago where it was concentrated through the 1940's. Public transportation for the region was originally planned to provide transportation within the City and into the CBD along radial corridors. The needs for public transport differ today from those of the 1940's, given shifts in population, employment, travel desire patterns, time requirements, and the use of private vehicles. In 1960, estimates of public transport users indicated that in that year, approximately the same volume of ridership used public carriers as did in 1910.* Since that time, ridership has shown a steady decrease. If the public transport system cannot be modified to meet changes in commuter accessibility demands and travel patterns, more people will be obliged to use private vehicles for the work-trip. Therefore, it is necessary to consider to what extent a comprehensive integrated transport system could meet the present and expected travel demands in the Chicago region.

*CATS, Final Report, Volume III, 4/62, Ch. V, p. 80.

CHAPTER IV

MEASUREMENT AND EVALUATION OF LEVELS OF ACCESSIBILITY

In order to evaluate the existing public transport system and different levels of integrated operation of that system two things are required. One is a criterion for service efficiency. The second is a methodology for measuring that criterion. As was described earlier in the report, accessibility was selected as the criterion for evaluating public transportation. Essentially, this is defined as the proportion of the population in the region that can reach employment locations by public transport and can reach them by travelling no longer than one hour.

Given this criterion, a methodology was developed that permitted the measurement of accessibility. A computer program was developed capable of determining accessibility within the whole region. Furthermore, this model permits an evaluation of any configuration of the transport system. Although it is applied in this report to a limited set of public transport alternatives, the methodology is perfectly general.

In this chapter, the methodology will be developed. Then the results of its application to the existing public transport system and then to increasing levels of regionalization of that system will be developed. Finally, the physical requirements for obtaining those levels of integration will be evaluated.

Method of Analysis of Accessibility

For the purpose of this investigation, the six-county regional area shown in Figure II-1 was reduced to a study area of 32 townships of 36 square miles each. The relation of this study area to the six-county region is shown in Figure IV-1. Although it is considerably smaller, these 32 townships contained, in 1970, nearly 75% of the population and 85% of the employment in the region. The deletions of counties and townships outside the study area have no effect on the generality of the methodology and their current low densities of population and employment could have little effect on the evaluation. However, this restriction markedly reduced the time and cost of operating the computer model. The 32 townships were subdivided into one square-mile zones identified by a 3-digit code. The residential population and employment population in each were derived from CATS, Forecast Data Township Summaries. The percentage of each as a part of the total region was then computed. All these items become base data for the model. In addition, all commuter rail stations were identified and located in the center of the appropriate zone. The scheduled running times for all trains were determined for the time period under study (7 to 8 a.m.). Thus, in the model, travel time among zones by commuter rail were actual scheduled routes.

With few exceptions, the location of most stations in the actual network coincided with the zones used in the model. The exceptions were always cases in which more than one station was located in the same one square-mile zone. In these cases, one station was deleted or relocated in an adjacent zone.

Bus schedules during peak periods were analyzed and it was found that there were only a very few sub-sections of the study area in which scheduled service interconnected very many zones or interchanged with zones containing a rail station. Whenever it was appropriate and applicable, bus schedules and travel times were used in the model.

With this information, it was now possible to select one square-mile zones containing a number of jobs. Then for any residential zone, the time required to reach the selected employment zone could be computed. In essence, the minimum time path through the public transport network was determined. It should be noted that the times were real in the sense that they were derived from the actual scheduled running times of the various components of the transport system. The mathematical model used a weight for each zone which was determined by the running speeds of suburban buses, commuter trains, CTA buses or rail rapid transit, or walking if no transport services were available. Park-ride was not considered and it was assumed that each zone had a single weight. Travel across zones by whatever means available was done at a constant speed. Zero travel time was considered within a particular node and feasible transfers were assumed to be made without delay, depending only on the pertinent train and/or bus schedules available at the time of the transfer.

Starting with the arbitrary employment zone, every residential zone that could reach the job location within an hour was determined. Since the number of people in the residential zone was known, it was possible to sum the population in all accessible zones and estimate the proportion of the population of the region that could reach the job site within an hour. By repeating this procedure for all employment zones it was thus possible to determine the total proportion of the population that had accessibility to any proportion of the jobs in the region. This was used as the regional measure of accessibility.

In addition to a regional measure, the model provides, for each employment zone, a map of the residential zones that are accessible to it. It is produced to scale for the study area. It is thus possible to determine what the area of accessibility actually is, measured in square miles. Finally, because the output is to scale, it is also possible to measure the effect of distance from the CBD on accessibility. The algorithm developed to make this model operational is described in the Appendix.

For this evaluation, the model was applied to five cases. The first was the public transport system as it now exists. This was used as the base for measuring improvements in accessibility that might accrue from different levels of regionalization of public transport. Each of these modifications will be discussed below.

Description of Modifications of Public Transport

Two points should be stressed before describing the modifications in detail. First, it should be recognized that the set of system changes tested represents examples of what might be done—they do not represent an attempt to produce an exhaustive list of potential modifications, nor can they be construed as physically realizable alternatives. Only complete engineering studies can determine this feasibility. However, they are logical for a regional system. More important is that the model allows the evaluation of the improvement in accessibility which might result from different levels of system integration and coordination.

For this study, four alternative service modifications were considered:

1. **Reverse schedules for commuter rail.**
2. **Collector-distributor bus service integrated with commuter rail.**
3. **Inner circumferential rail rapid transit line.**
4. **Outer circumferential rail line.**

These alternatives were evaluated as incremental additions to the base system. Comparisons were made of the increase in accessibility they provided relative to the existing situation of uncoordinated modes.

1. Reverse Schedules for Commuter Rail

This alternative was designed to reflect the growing level of suburbanization in the Chicago region which results in both people and employment being located in the outer city and beyond. It was argued that there existed an increasing number of employment opportunities in the suburban sections of the region, which are inaccessible at present because the commuter rail service is primarily designed to transport people from the suburbs to the CBD. This modification was designed to evaluate whether accessibility to suburban jobs would be increased if outbound commuter rail service were provided during peak hours. Thus, the commuter rail system was modified so that it would operate on an outbound schedule with fifteen-minute headways, in addition to its normal inbound schedule.

2. Collector-Distributor Bus Service Coordinated with Commuter Rail

Initial investigations of the spatial distributions of both population and employment indicated that a significant proportion of the population may lack access to suburban employment opportunities. This was suggested by the fact that these zones were far removed from commuter rail stations. Consequently, the suburban bus system was constituted into a comprehensive collector-distributor service linked to the commuter rail or rapid transit stations. Schedules were coordinated for the modes. A routing scheme for a regional collector-distributor network is shown in Figure IV-2. It was set up as a pulse-type system operating with fifteen-minute headways.

3. Inner Circumferential Rail Rapid Transit Line

The third alternative was developed in response to the fact of suburban work-trip travel. The first two levels of regional system integration would still require the suburb commuter to travel into the CBD and then take a train back out to a suburban employment site. If a circumferential route were provided, this circuity would be eliminated and, of course, travel time reduced. A circumferential rail rapid transit line was selected. It was located in a corridor lying just within the city limits of Chicago. It was designed to interconnect with existing commuter rail and rail rapid transit stations. The routing is shown in Figure IV-3.

4. Outer Circumferential Rail Line

The reasons for selecting this alternative are conceptually the same as for the inner circumferential addition. It is aimed at servicing outer suburban travel in the study area. A rail line was thus added. It was designed to connect with the existing commuter rail lines. Trains were operated on fifteen-minute headways. A schematic of this and the two previous modifications is illustrated in Figure IV-4.

Results of the Evaluation

Increase in accessibility resulting from the four alternative modifications will be presented in three ways: (1) area of accessibility, (2) average accessibility, and (3) measures of accessibility.

1. Area of Accessibility

As described above, the study area was divided up into zones of one square mile. Improvements in the level of accessibility to employment zones were considered. Initially, we used as a measure of accessibility, the set of residential zones from which a commuter could travel to the chosen employment zone within one hour for the existing system. This set of residential zones is shown diagrammatically in contour maps, which illustrate the area within which travel to the employment zone is possible within one hour given the different levels of modifications. Figures IV-5 through IV-10 show the increases in the areas accessible to a series of representative zones as each of the modifications is added.

a) Figure IV-5: A Loop Zone—between Madison and Roosevelt, State and Halsted.

The Loop is accessible to a large part of the metropolitan area with the existing system. Reverse service does not increase the number of zones accessible to the Loop. The further addition of feeder bus service increases the ability of some zones without direct access to commuter rail service to reach the Loop in one hour. The inner circumferential rail adds service to a very few additional origin zones.

b) Figure IV-6: A Far West City Zone—between Roosevelt and Cermak, Cicero and Central.

As in the previous zone, the base system provided one-hour service for this zone on the West side of the City. Reverse rail does not increase accessibility. Feeder bus service slightly increases the number of West suburban zones having access to this city zone. The addition of circumferential rail provides a significant number of North and South suburban zones' access to this zone.

c) Figure IV-7: A West Suburban Zone—in Proviso Township, between Roosevelt and Cermak, from 9600 to 10400 West.

Access under the base system is notably low. Reverse rail does not add significantly to the zone. When feeder bus service is also added, the area of accessibility doubles, with the central portion of the City becoming possible origins. Further, circumferential rail service allows people slightly away from the center of the area access to this outlying central zone.

d) Figure IV-8: A South Side City Zone—between 71st and 79th Streets, Halsted and Ashland.

Fairly substantial access to this zone exists under the present system. Reverse rail does not affect the number of zones. The feeder bus modification extends access to some far South origin zones, a strip along the associated South zones, and a strip along the associated rail tracks. Inner circumferential adds a portion of the Northern suburbs within the Skokie area and some new outlying Western zones.

e) Figure IV-9: A Far South Side City Zone—in Bremen Township, between 119th and 127th South, Halsted and Ashland.

Only the immediate area is accessible by rail under the existing system. Reverse rail service enlarges the coverage area considerably, bringing in the near Southeast part of the City, including a strip up to the Loop. The effects of additional modifications are minimal.

f) Figure IV-10: A North Side City Zone—between Lawrence and Bryn Mawr, Western and Kedzie.

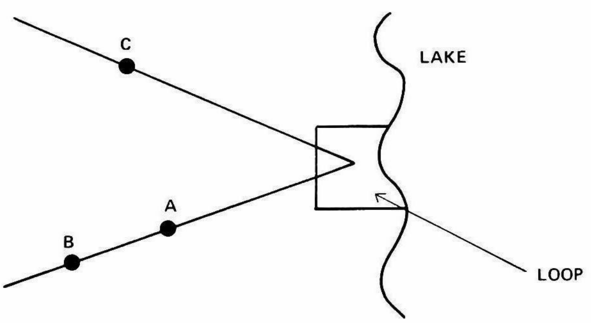
Considerable access (including near Northern suburbs, Northside, and near South) presently exists. Reverse rail adds no new zones of possible origin. Feeder bus addition increases access for a small section in the near Northwest and in the suburbs just north of Skokie. The circumferential rail service adds the near Southwest, and a part of the Western area of the City.

Average Accessibility

If we continue to consider accessibility measurement in terms of accessibility to employment zones, the number of zones which can reach a selected employment zone within one hour may be used as a measure of accessibility. An increase in the number of zones which can reach an employment zone due to a system modification can be interpreted as an increase in the level of accessibility. In order to avoid the problems of dealing with a series of "representative" zones, we have calculated these measures as the average of a random set of zones, and have further broken down the sets of zones by distance so that the accessibility benefits of the various modifications can be interpreted in terms of distances from the Loop. The results are presented in Figures IV-11 and IV-12. Figure IV-11 shows the increases in the average number of residential zones which can be linked with the selected employment zones within one hour, and also indicates the way in which the average number varies over distance. The distances between the curves representing the different modifications are not constant across distance. These variations indicate that the benefits in accessibility resulting from the different modifications are not spread uniformly across the region, but are more localized. Figure IV-12 demonstrates this even more clearly by expressing the benefits (increased number of zones accessible to employment zones) as percentage increases over the base system so that the areal distribution of benefits shown in Figure IV-11 are more clearly delineated.

Although it is not possible to make precise statements about the distribution of benefits on the basis of these figures, certain generalizations can be made.

1) The reverse rail modification has little impact on its own. This is probably because the population on a rail line which wishes to have access to employment opportunities further out on that rail line is relatively small.



Thus, the system helps those who wish to go from A to B, but not those who wish to go from C to B, since they cannot travel into the Loop *and* out again within one hour, even with the reverse service.

The benefits from the reverse system are felt mainly by zones in the 8 - 12 mile belt.

2) The feeder bus service, however, impacts mainly on the inner and outer belts. The inner (Loop) zones are more accessible because commuters from the suburbs have improved station access; the outer zones have improved access largely due to the use of the feeder bus service for local access to employment sites.

3) The inner circumferential improves accessibility considerably but its impacts are felt mainly in the 6 12 mile belt. However, the fact that it improves accessibility for zones across the region reflects the improvements in system connectivity which result from the introduction of an inner circumferential beltway.

4) Little may be said about the outer circumferential beyond saying that it has little effect. It may be that the apparent increase in its impact as distance increases may continue, but such extrapolations are not justified at this point. It may well be that the outer circumferential represents the onset of diminishing returns.

In general, one can conclude from the evidence presented in this section that the suggested modifications have a considerable impact on the accessibility of the region. It is also clear that the incidence of the impact differs both by modification and by distance. These differences may be analyzed by the methodology developed above.

Macro (Regional) Measures of Accessibility

In order to make general statements about the effects of the modifications considered in this study, a macro-level measure of accessibility was required. The measure developed attempts to relate the proportion of employment that can be reached by a percentage of the population using public transit within the chosen travel time of one hour. The algorithm used in calculating this accessibility measure is explained in the Appendix.

The macro measures of accessibility for the base system and for the four levels of modifications are illustrated in Figure IV-13. The proper interpretation of the measure is that the best served X percentage of the population is accessible to at least Y percentage of the employment opportunities during the specified time frame. For instance, with the base system the best served 10% of the population can reach at least 66% of the employment opportunities during the hour time frame, while after all four modifications, the same percentage of population can reach 82% of the employment opportunities. Likewise, the best served 50% of the population can reach at least 53% of the employment opportunities with the base system, but 66% with all four modifications. Thus, changes in accessibility can be measured by examining the shifts in the population/employment curves that result from implementation of the different levels of modification.

Some explanation is required in order to facilitate the interpretation of these curves. In essence, if the whole population could reach all the employment opportunities the population/employment curve would be a step which would make up the top and right-hand side of the box in Figure IV-13. Thus, movements in a Northeasterly direction from the origin represent improvements in accessibility. It should be noted that the subset of the population that makes up a given percentage is not necessarily the same under different levels of modification. Also the employment opportunities that are accessible to a given population percentage are not the same for every part of that population percentage. However, the most interesting feature of the measures is that they show whether a transit improvement primarily affects a small segment of the population or a large part and whether the improvements benefit primarily those who already have good service or those who have poor service, or whether the benefits are well distributed over the region. For instance, the reverse commuter train modification affects those who already have good transit service. The accessibility measure of the feeder-distributor bus modification alone, shown in Figure IV-14 on the other hand, indicates that it benefits primarily those who have poor service. This confirms what one would expect from increasing service in an outlying area. Figure IV-15 shows the results of testing the inner circumferential alone added to the base system. The changes in accessibility accounted for by this facility would be felt by most of the population. It appears to shift the whole base system accessibility curve upward rather than having a differentiated effect for various population percentages. Though the inner circumferential would be a high investment alternative, it allows many non-CBD oriented trips not to be forced through the CBD, which is a characteristic typical of radial networks.

A certain degree of returns to scale is obtained by sequentially adding links to transport networks. Adding a link increases the possible routings more than proportionately. In other words, the effects of two modifications together are greater than the sums of their effects, though the difference would depend on the nature of the modifications. This is well illustrated in Figure IV-16. When reverse commuter trains are added to the feeder-distributor bus and inner circumferential modifications, the difference in curves is greater than when reverse commuter trains were added to the base system.

Thus, in spite of the difficulty of interpretation, the macro-accessibility curves presented in this section give some extremely useful insights into the effect on accessibility of various possible modifications, alone and cumulatively. Some generalizations can be made from the macro-analysis. (1) The feeder-distributor bus modification mainly serves to increase the market area of public transit; (2) the inner circumferential has a great effect on accessibility by improving the connectivity of the network; and (3) the reverse commuter trains, which serve as a link from the city as a place of residence to the suburb as a place of employment, have their greatest effects in combination with the expanded market area of the feeder-distributor bus modification and the greatly improved connectivity of the public transit network made possible by the inner circumferential.

Requirements for Implementation of Alternatives

The Chicago metropolitan region has a large stock of public transit facilities. However, the utility of this stock is not at its fullest potential because of the lack of coordination between the components of the public transit system.

1. First Modification—Reverse Commuter Rail

The first modification to the base system was to increase the level of service on the commuter railroads by offering two-directional flow during the peak period. Because demand for commuter service is very peaked, many trainsets can operate only one schedule in the predominant flow direction. Table IV-1 indicates the number of trainsets operating during the morning peak on the various routes. Some trainsets working the first schedules during a peak period would be able to turn around and deadhead, or run a schedule in the reverse direction to some point on the line and from there work another schedule in the predominant flow direction during the peak. Conducting passenger schedules in the reverse direction instead of deadheading the equipment nonstop increases the round trip time of trainsets and of equipment and crew requirements. Predominant flow direction trains terminating in the latter part of the peak period could not deadhead back in time to run another predominant flow direction schedule, but could be used for reverse direction schedules without increasing equipment requirements.

The modification, calling for reverse service on fifteen minute headways, would likely require some additional equipment and crews on every line, which would vary from line to line, depending on changes in schedules. Where additional trainsets would be needed, information on the demand for the reverse direction would be essential to determine the number of cars needed for each trainset, on each line.

Another consideration in providing reverse service would be track capacity. Again, track capacity is variable among railroads. Many of the commuter lines are jointly used by freight operations, and reverse service would interfere with these operations. Arrangements could be made for the commuter service to use the tracks exclusively during the peak periods. However, the exclusive use of track for commuter service represents an inconvenience to the railroads and their shippers.

The type of signaling to be used would be as important as the number of tracks. At present, some commuter lines are not reverse-signaled. There must be two-directional signaling to permit the operation of trains, outbound as well as inbound.

The train crew requirements for reverse service would depend on the same factors as the trainset requirements. Where additional trainsets would be needed for reverse service, so would crews. The present mileage conditions of the existing labor contracts may be the determining factor in crew requirements. However, it does appear that only a relatively small increase in capital equipment would be required to provide fifteen minute schedule outbound services.

2. Second Modification—Feeder Bus Service

The second modification was the addition of collector-distributor bus service in the outlying areas. This service was assumed to operate at an average speed of 12 mph with headways of fifteen minutes. The buses were routed directly to the closest station. If the routing placed the bus line equidistant from two or more stations, the route was adjusted to serve the station closest to Chicago. Three-hundred forty-nine square miles were integrated into the public transport network by the addition of this collector-distributor system. A rough approximation of fleet requirements can be derived fairly simply. If walking distances are a maximum of 1/2 mile, one bus route bisecting the zone would be sufficient. Since buses have to traverse the zone in each direction, two miles of routes are involved. At 12 mph, two miles requires ten minutes. With a fixed headway of fifteen minutes, approximately 2/3 of a bus would be required for each zone served. If it was desired to keep walking distances to a maximum of 1/4 mile, twice the number of buses would be required. Since people seem to be unwilling to walk more than a quarter-mile to public transit, the figure of 1-1/4 buses per zone appears more reasonable. To provide this level of service, between 400 and 500 buses would be required.

In any form of regional system, which would include suburban bus companies, the stock of buses now operating in the region could be employed as the collector-distributor system. The size of the suburban bus stock was given in Table III-3. Approximately one-half would be required to provide the desired service. What part of this stock could actually be taken for this modification is difficult to estimate, because some of the buses would be required for needs that these bus companies presently serve. However, it would appear that a larger part, if not all, of the buses required for the collector-distributor operation can be provided by the existing stock.

3. Third Modification—Inner Circumferential Rapid Transit Line

This modification would require a large public investment because of needed new construction. The magnitude of the investment can be understood by a review of costs related to two recent CTA rapid transit extensions. In 1969, an eleven-mile rapid transit line from the Loop to 95th Street was opened, utilizing mostly the median of the Dan Ryan Expressway. The cost of this facility was $51,700,000, including the cost of the new cars. The five-mile extension of the CTA Milwaukee rapid transit line, from Logan Square to Jefferson Park, needed some subway construction and used the median strip in the Kennedy Expressway. Total costs for this facility were $55,800,000, including required rolling stock. The route used for the inner circumferential route would require about twenty-two new route miles. The exact costs would depend on whether the facility was built in connection with an expressway project or built independently, thus incurring full right-of-way costs or costs for tunneling a subway. The least investment for the rapid transit line would be constructing this rail rapid line in connection with an expressway project. The amount required would approximate one-hundred million dollars.

Conclusions

The aim of this analysis was to consider the potential benefits from integrating the public transport system in the Chicago region. To quantify these benefits and obtain a feeling for their dimensions, a series of modifications were postulated and their effects were determined on the accessibility between population to employment sites for the region. While this analysis should not be viewed as a finalized version, it clearly indicates the order of magnitude of the potential benefits. The results suggest that the level of accessibility to employment sites for the population of the Chicago region could be significantly increased if such integration and coordination of the existing components of public transport were implemented.

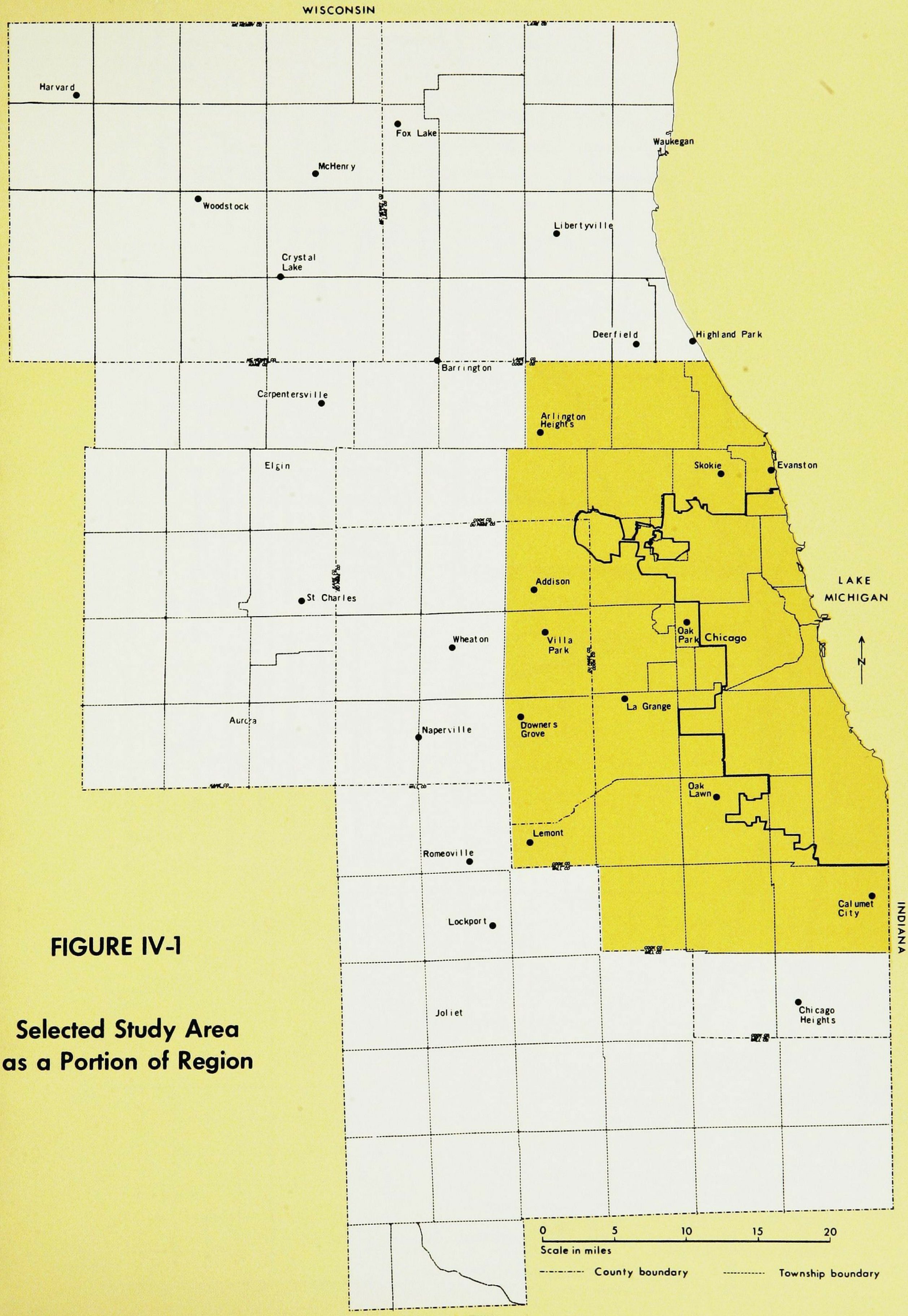


FIGURE IV-1

Selected Study Area as a Portion of Region

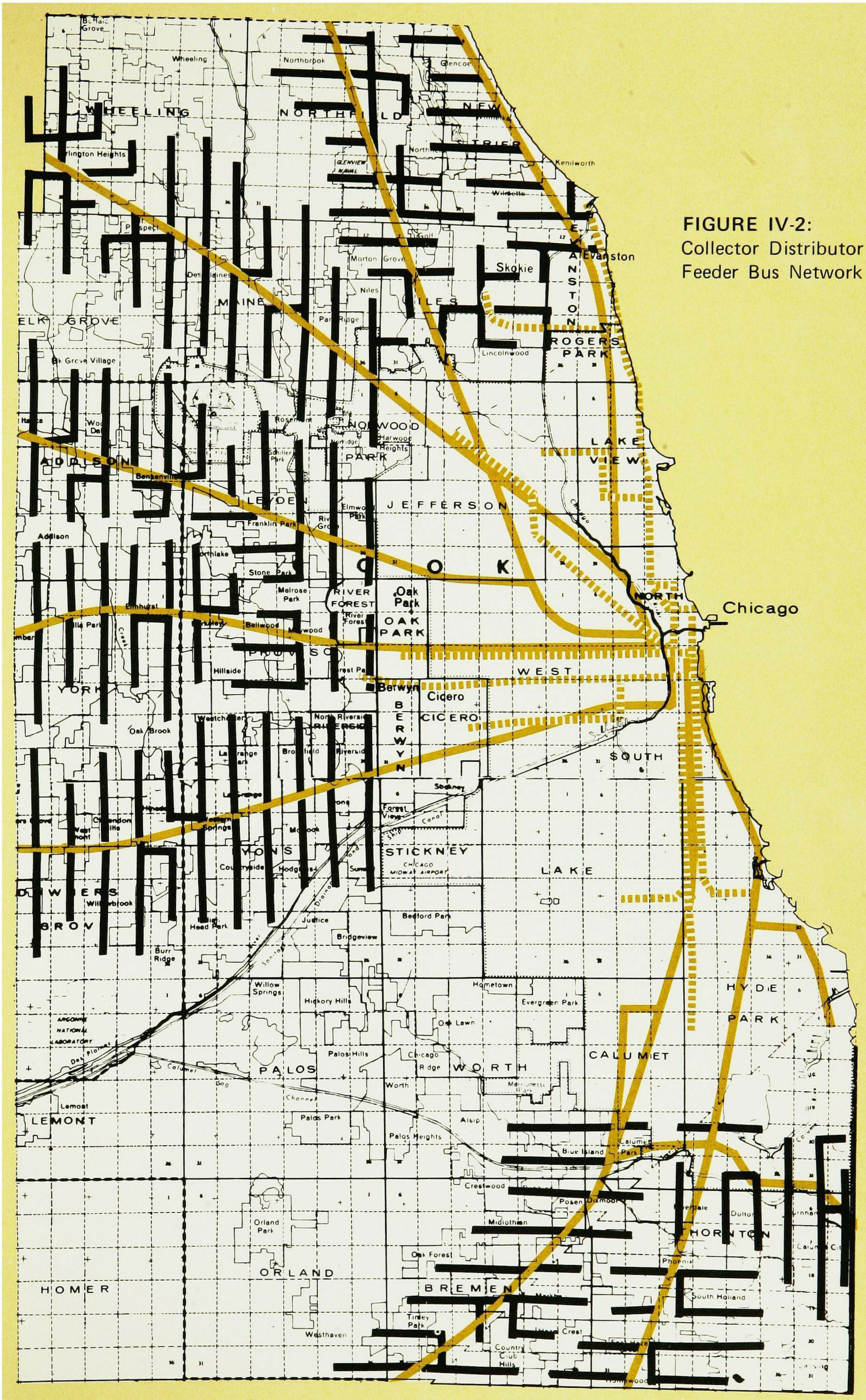


FIGURE IV-2:
Collector Distributor
Feeder Bus Network

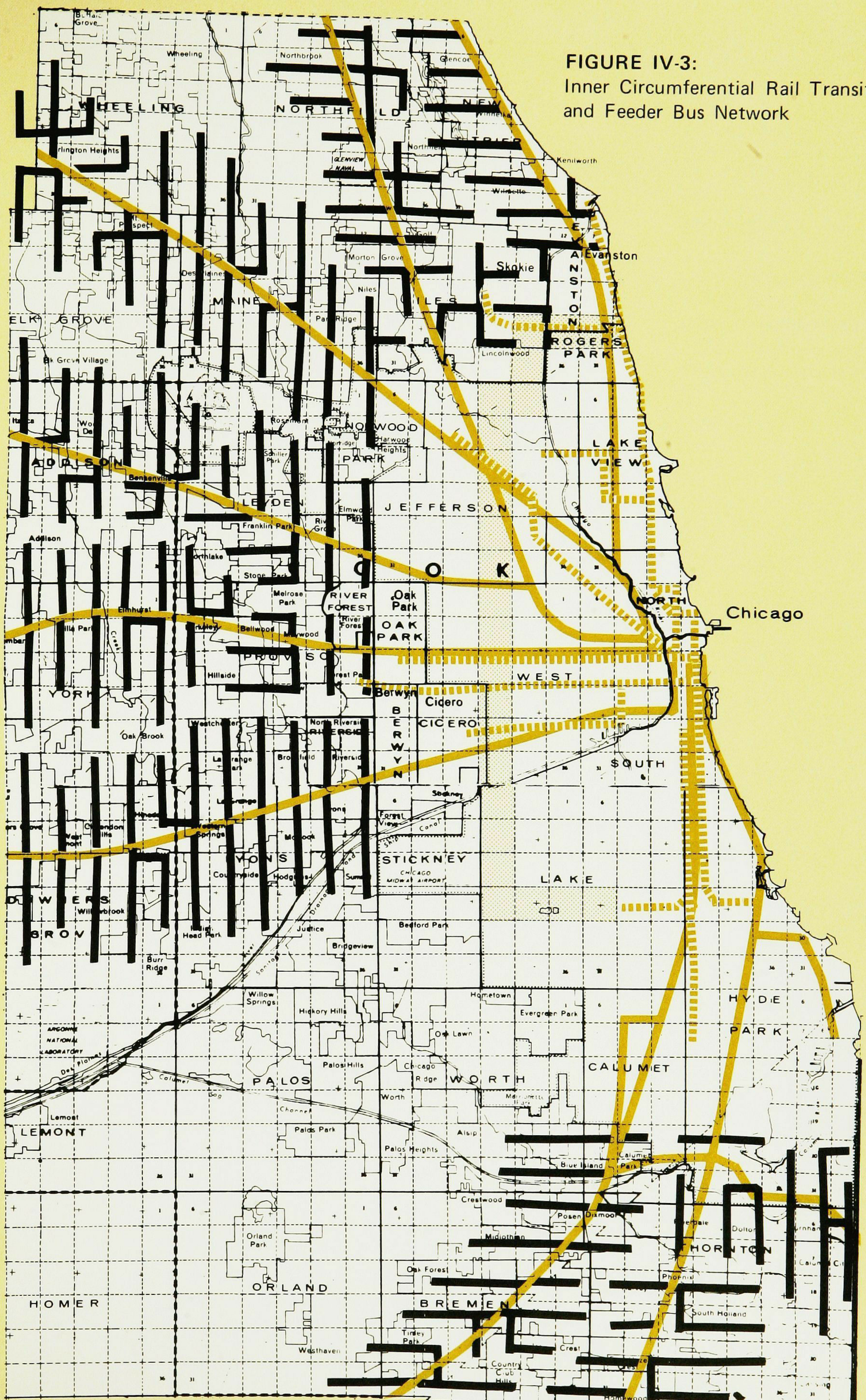


FIGURE IV-3:
Inner Circumferential Rail Transit and Feeder Bus Network

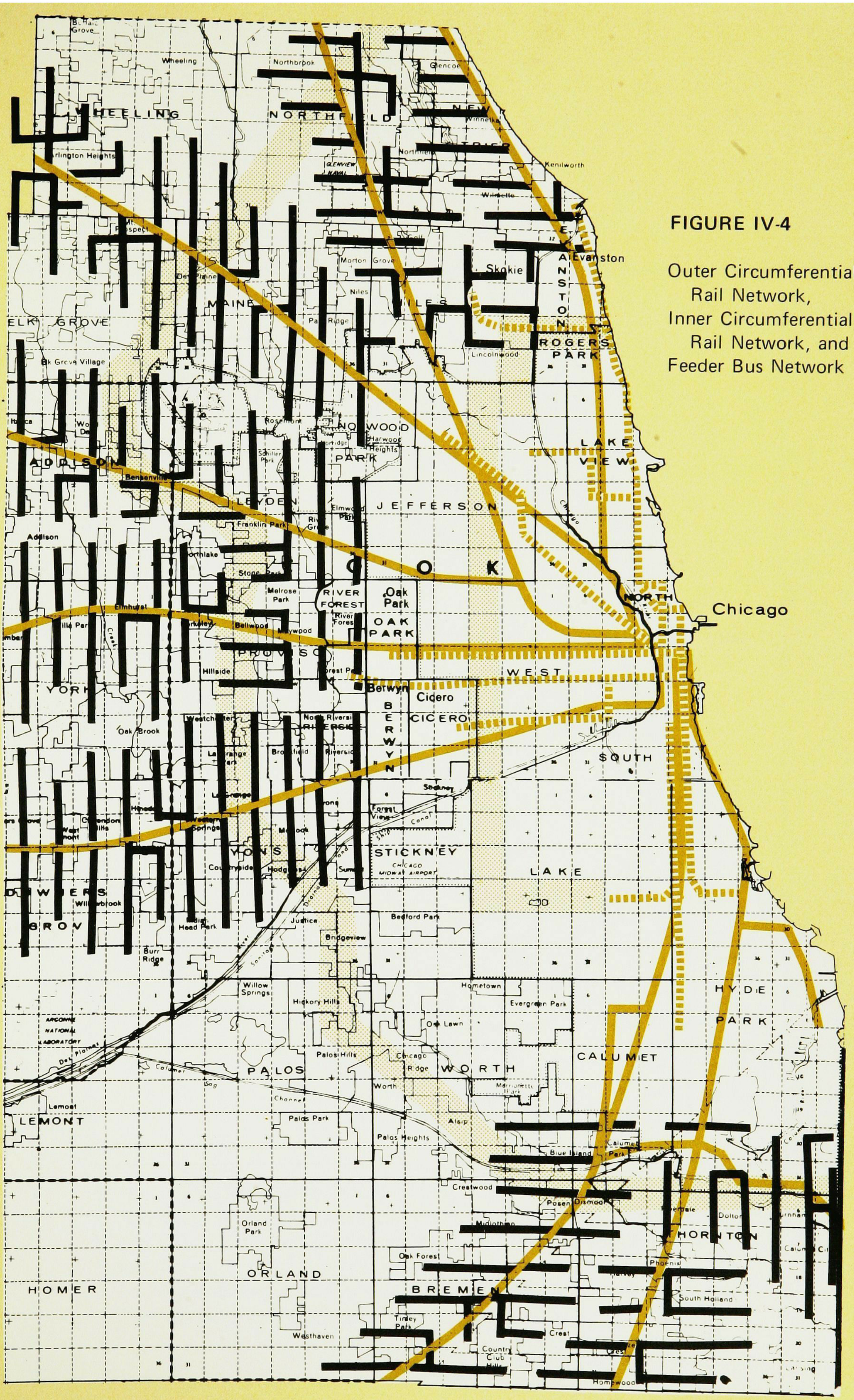
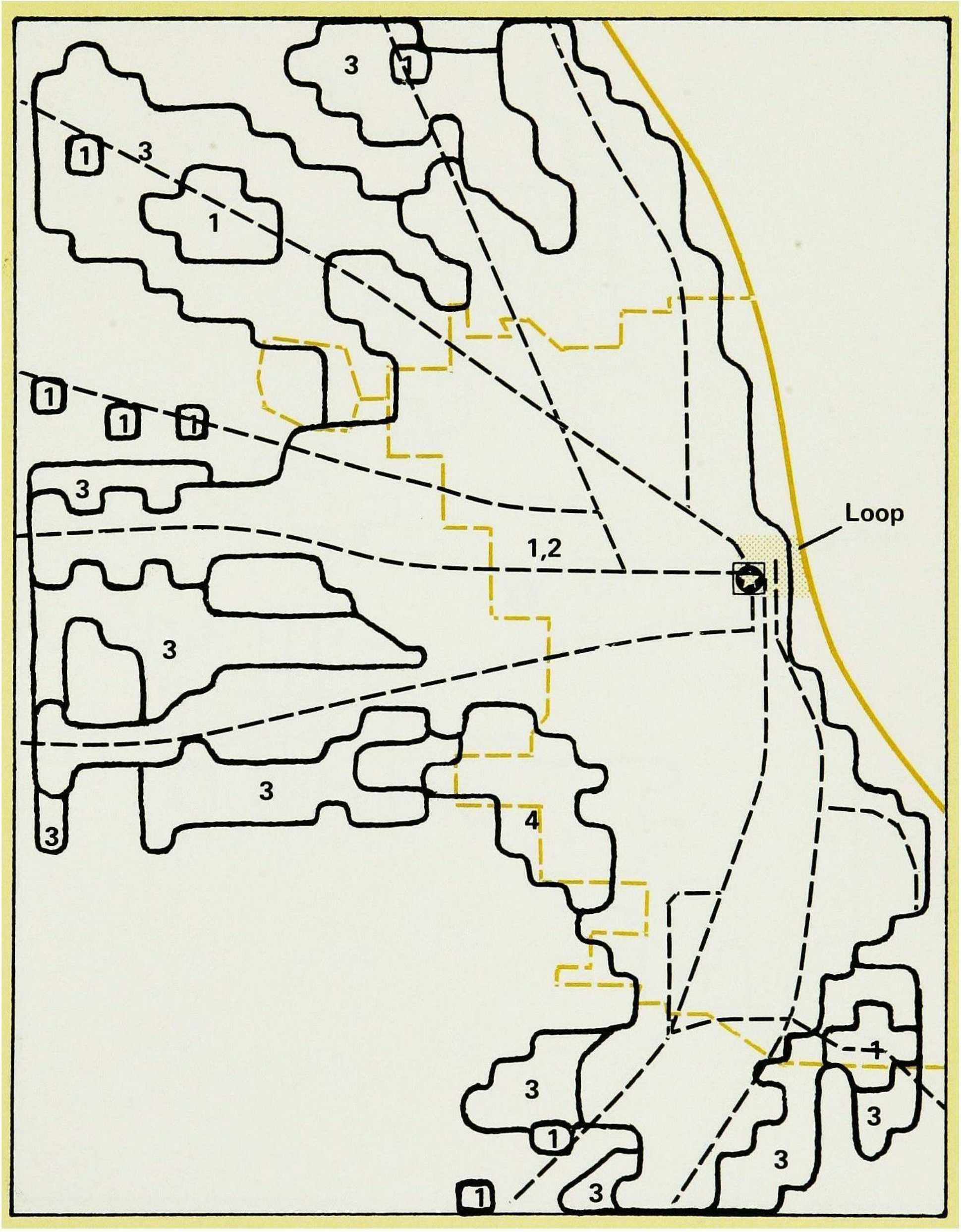


FIGURE IV-4

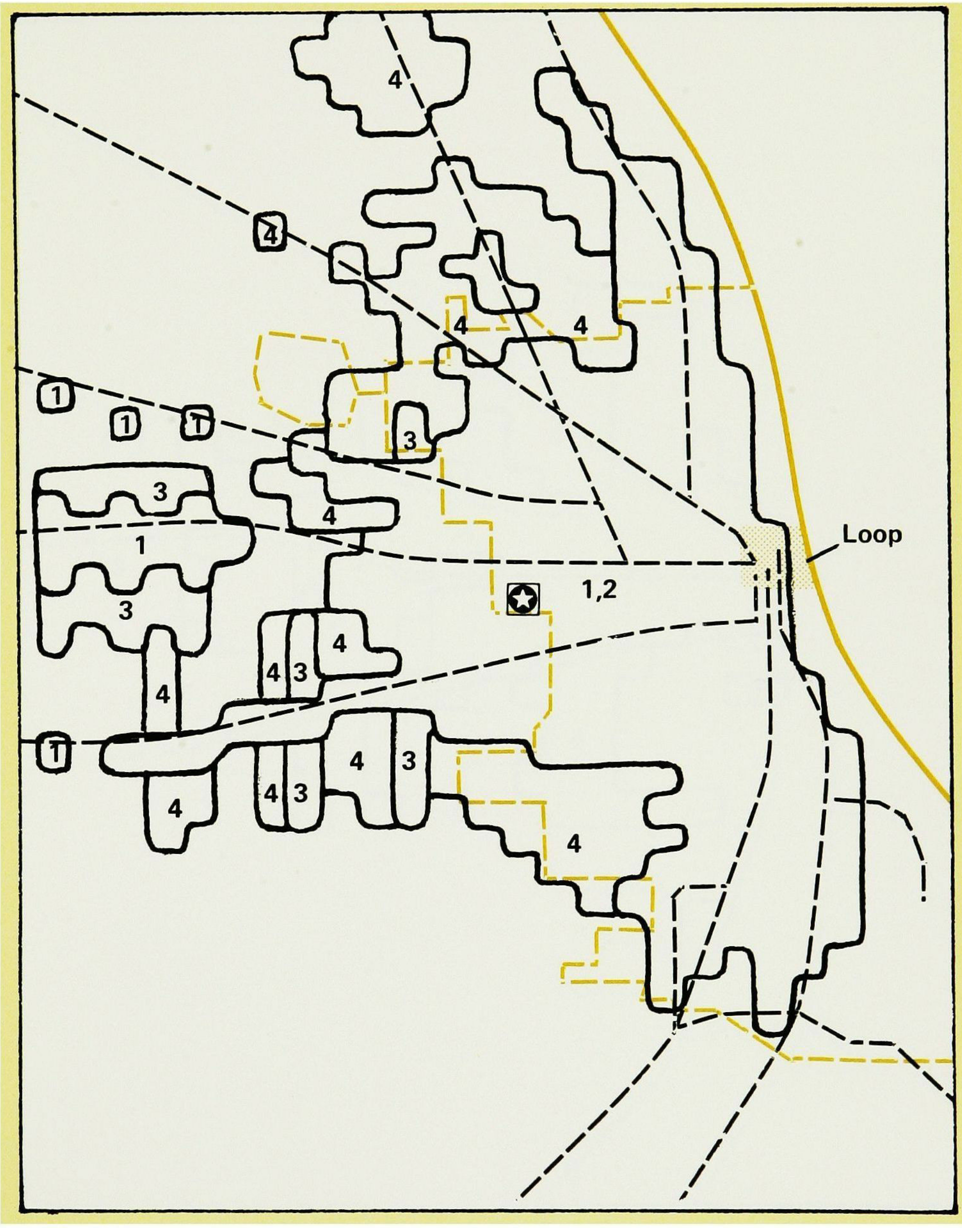
Outer Circumferential Rail Network, Inner Circumferential Rail Network, and Feeder Bus Network

Figure IV-5:
A Loop Zone—between Madison and Roosevelt, State and Halsted.



1. Service area coverage by Base System.
2. Additional service area coverage, given Reverse Rail modification.
3. Additional service area coverage, given Reverse Rail plus Feeder Bus modifications.
4. Additional service area coverage, given Reverse Rail, Feeder Bus and Inner Circumferential modifications.

Figure IV-6:
A Far West City Zone—between Roosevelt and Cermak, Cicero and Central.



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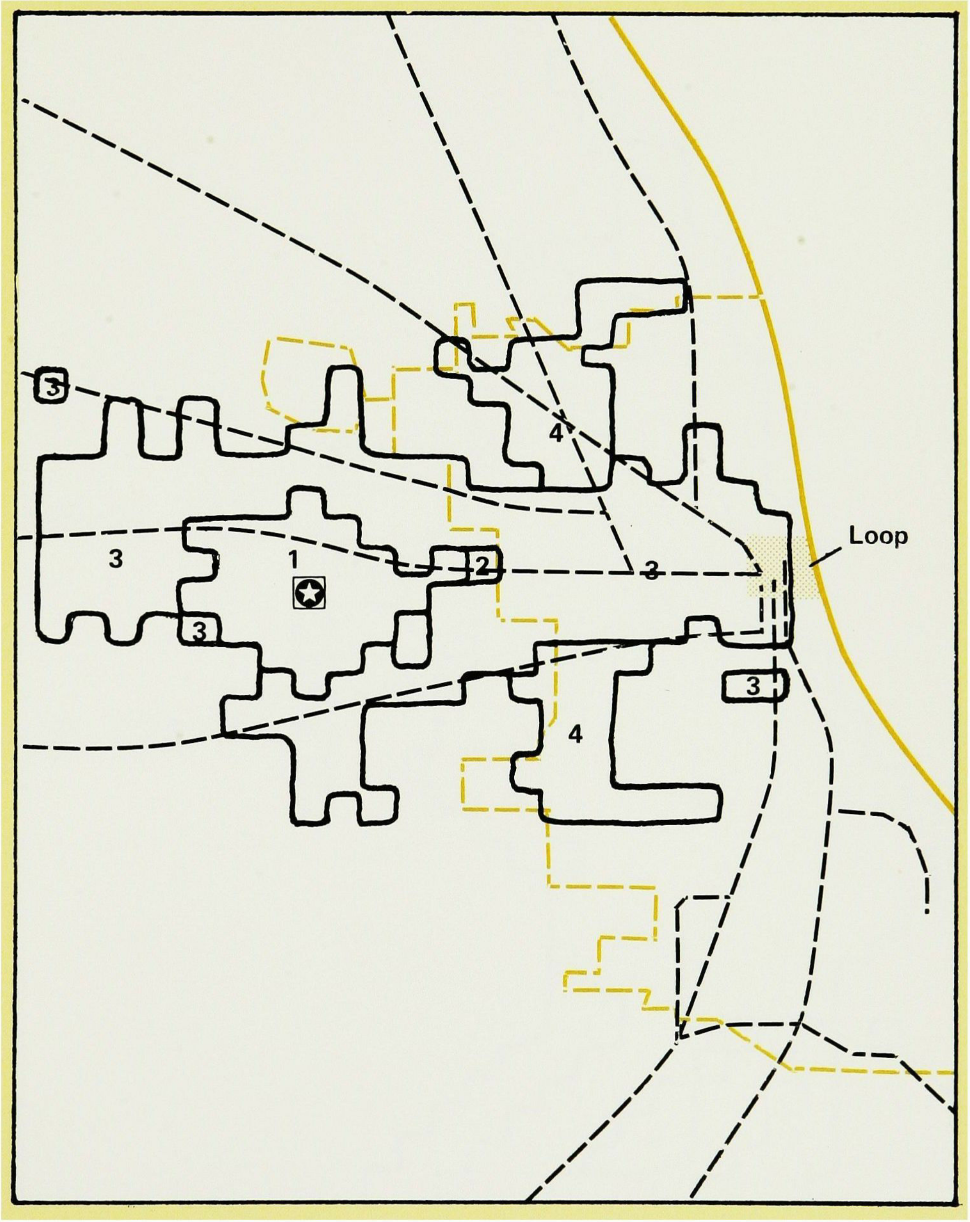
3. Additional service area coverage, given Reverse Rail plus Feeder Bus modifications.
4. Additional service area coverage, given Reverse Rail, Feeder Bus and Inner Circumferential modifications.

Figure IV-7:
A West Suburban Zone—in Proviso Township, between Roosevelt and Cermak, from 9600 to 10400 West.



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4. Additional service area coverage, given Reverse Rail, Feeder Bus and Inner Circumferential modifications.

Figure IV-8:
A South Side City Zone—between 71st and 79th Streets, Halsted and Ashland.

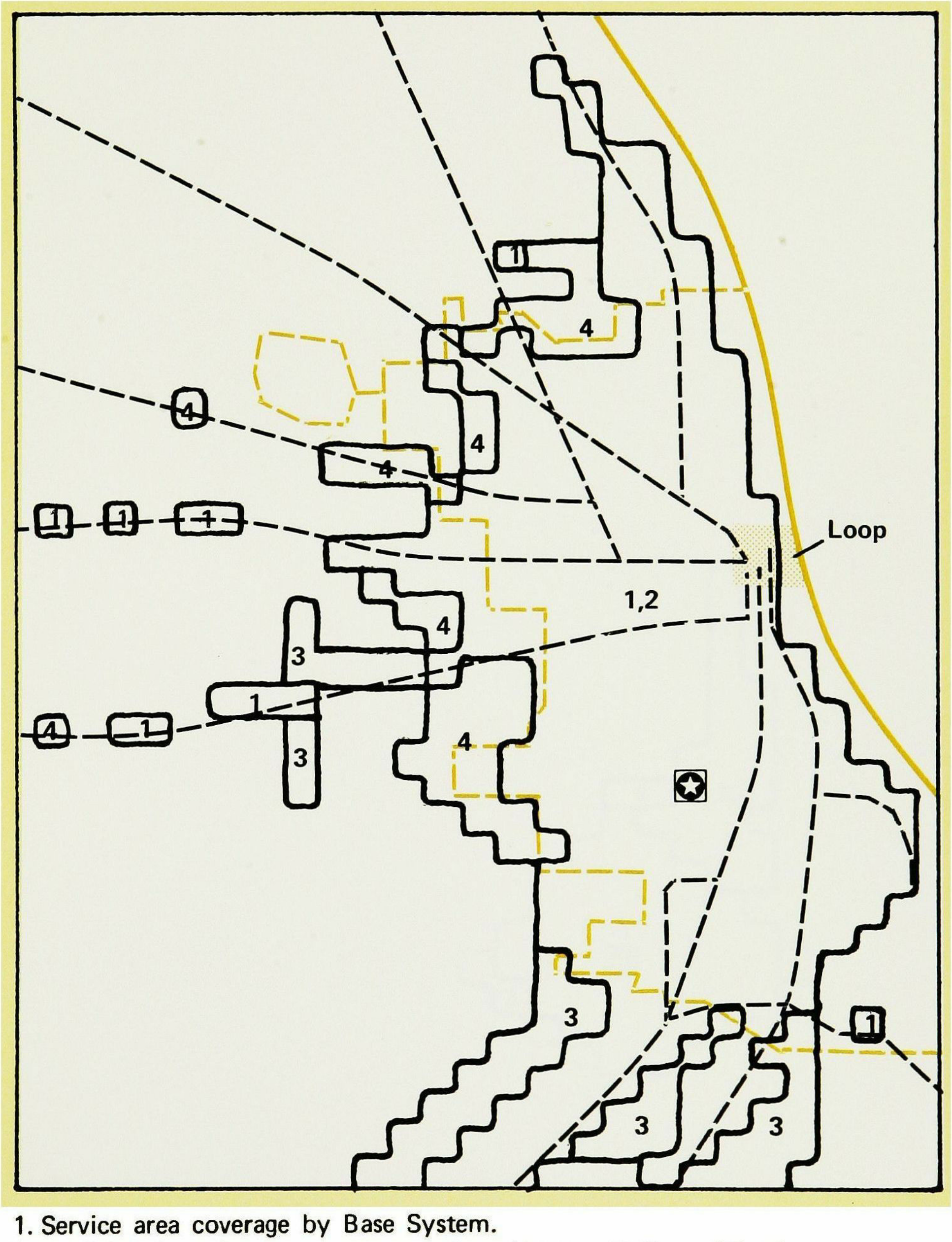

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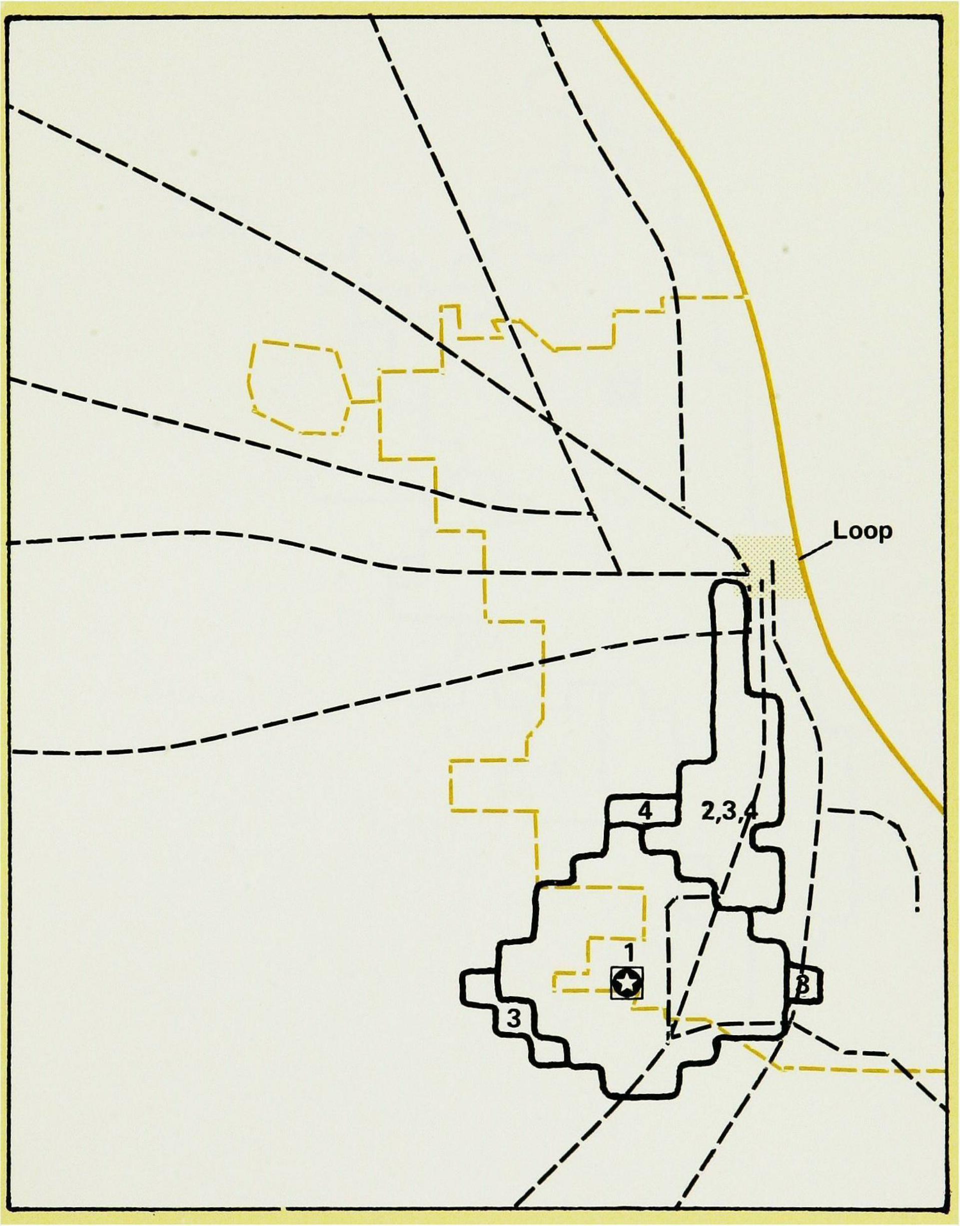
Figure IV-9:
A Far South City Zone—in Bremen Township, between 119th and 127th South, Halsted and Ashland.



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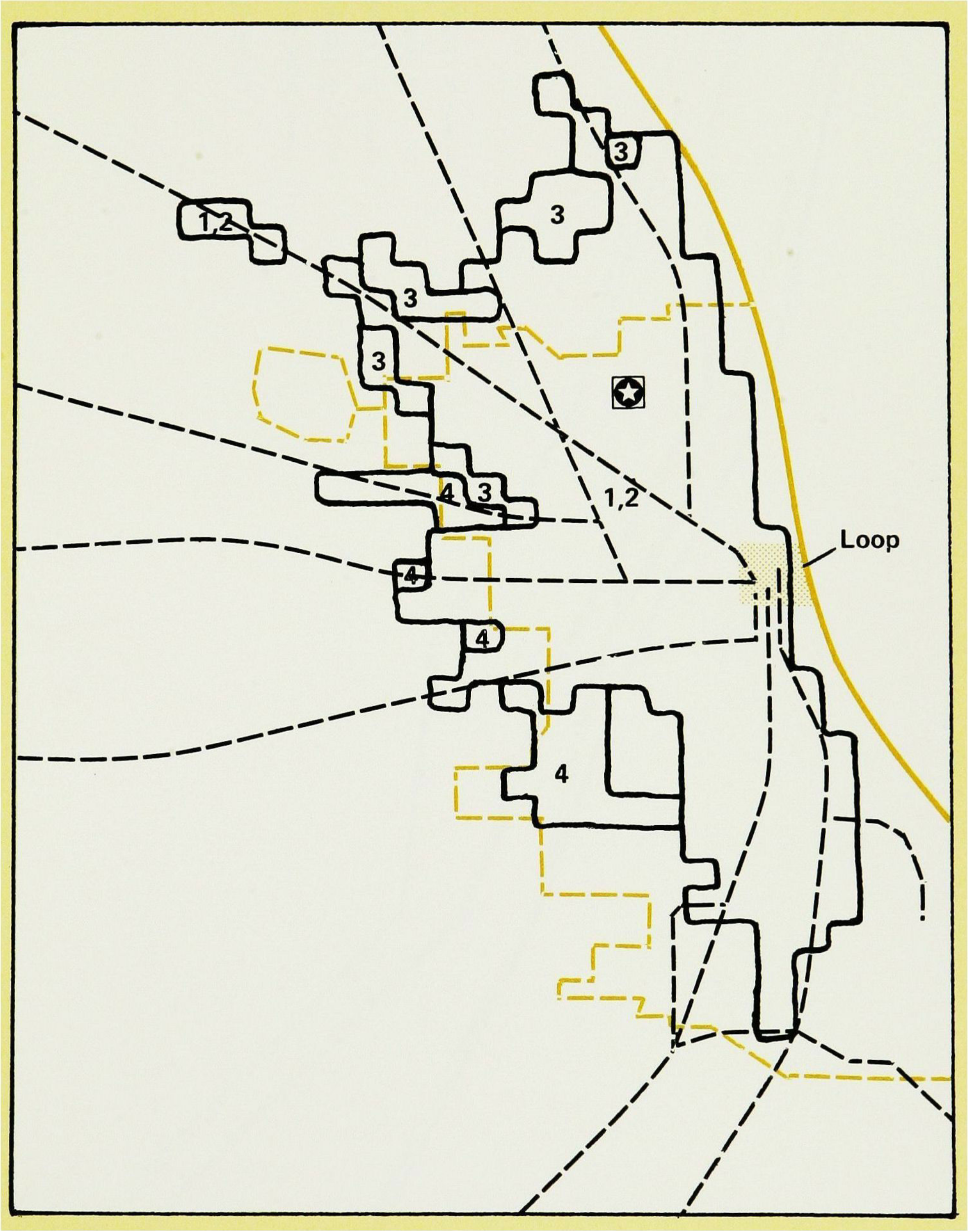
3. Additional service area coverage, given Reverse Rail plus Feeder Bus modifications.
4. Additional service area coverage, given Reverse Rail, Feeder Bus and Inner Circumferential modifications.

Figure IV-10:
A North Side City Zone—between
Lawrence and Bryn Mawr.



1. Service area coverage by Base System.
2. Additional service area coverage, given Reverse Rail modification.
3. Additional service area coverage, given Reverse Rail plus Feeder Bus modifications.
4. Additional service area coverage, given Reverse Rail, Feeder Bus and Inner Circumferential modifications.

FIGURE IV - 11

INCREASE IN ACCESSIBILITY TO EMPLOYMENT SITES UNDER FOUR LEVELS OF SYSTEM INTEGRATION

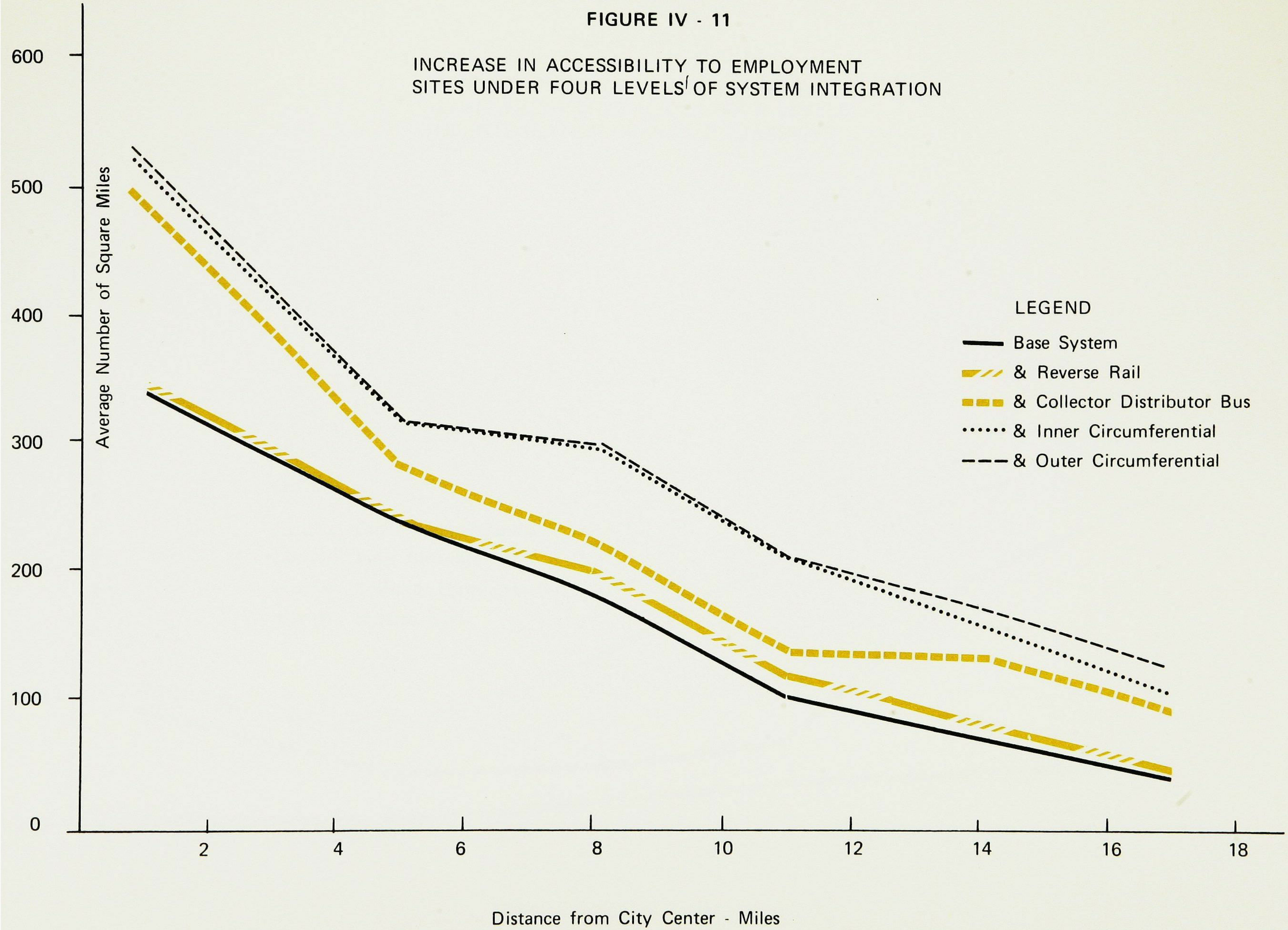


FIGURE IV - 12

PERCENT INCREASE IN ACCESSIBILITY TO EMPLOYMENT SITES UNDER FOUR LEVELS OF INTEGRATION OF PUBLIC TRANSPORT

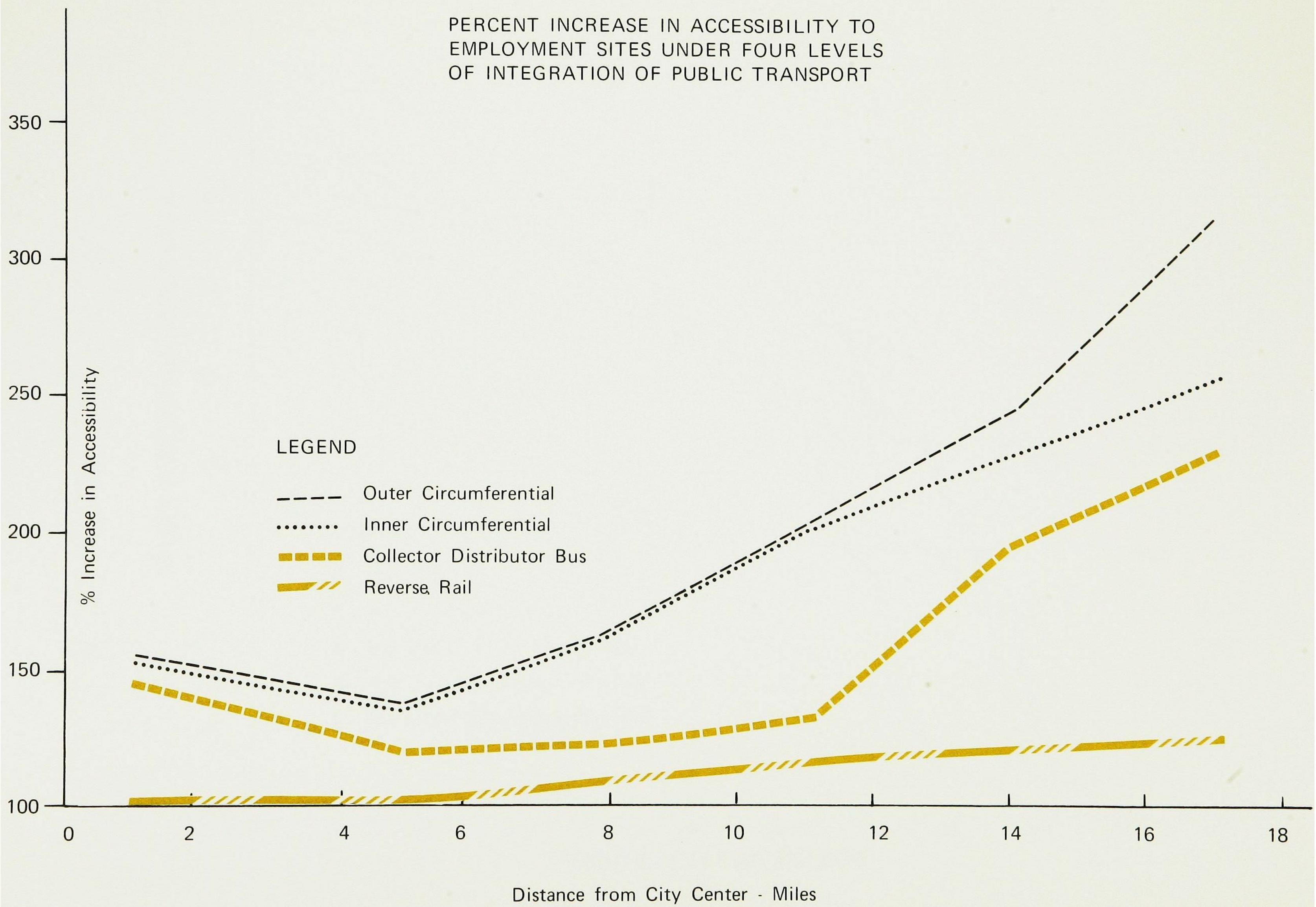


FIGURE IV-13

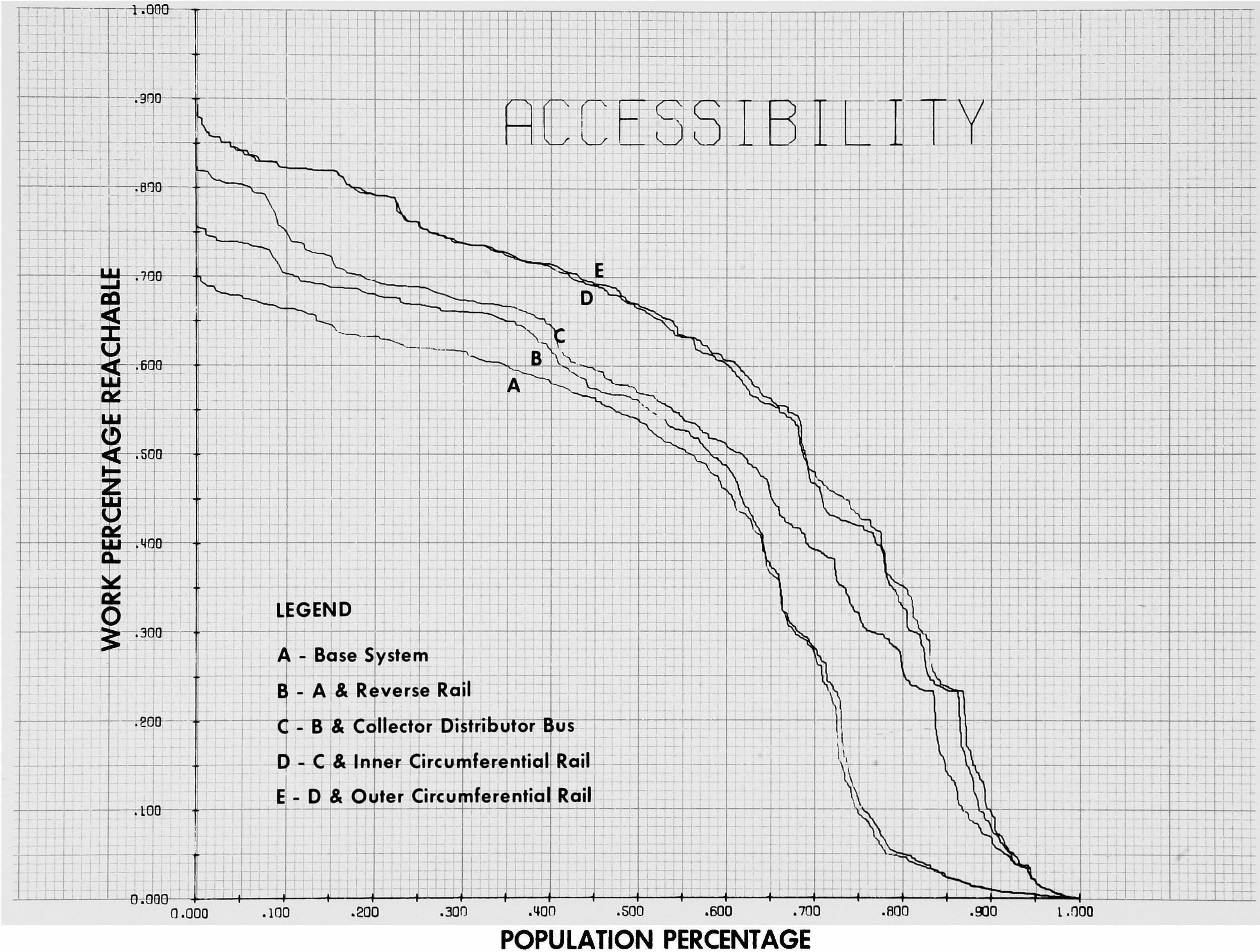

ACCESSIBILITY
WORK PERCENTAGE REACHABLE
POPULATION PERCENTAGE
1.000
.900
.800
.700
.600
.500
.400
.300
.200
.100
0.000
.100
.200
.300
.400
.500
.600
.700
.800
.900
1.000
A
B
C
D
E
LEGEND
A - Base System
B - A & Reverse Rail
C - B & Collector Distributor Bus
D - C & Inner Circumferential Rail
E - D & Outer Circumferential Rail

FIGURE IV-14

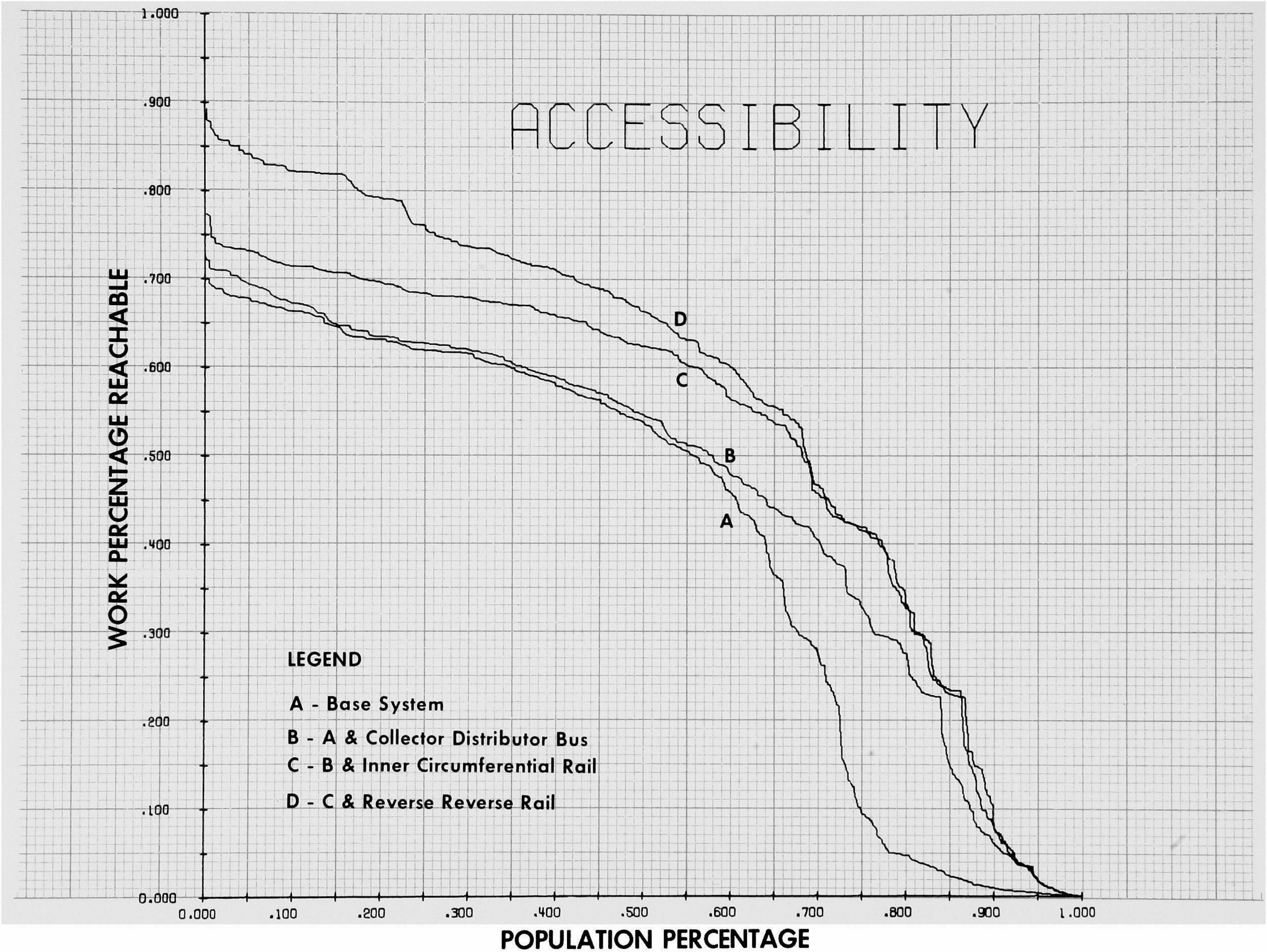
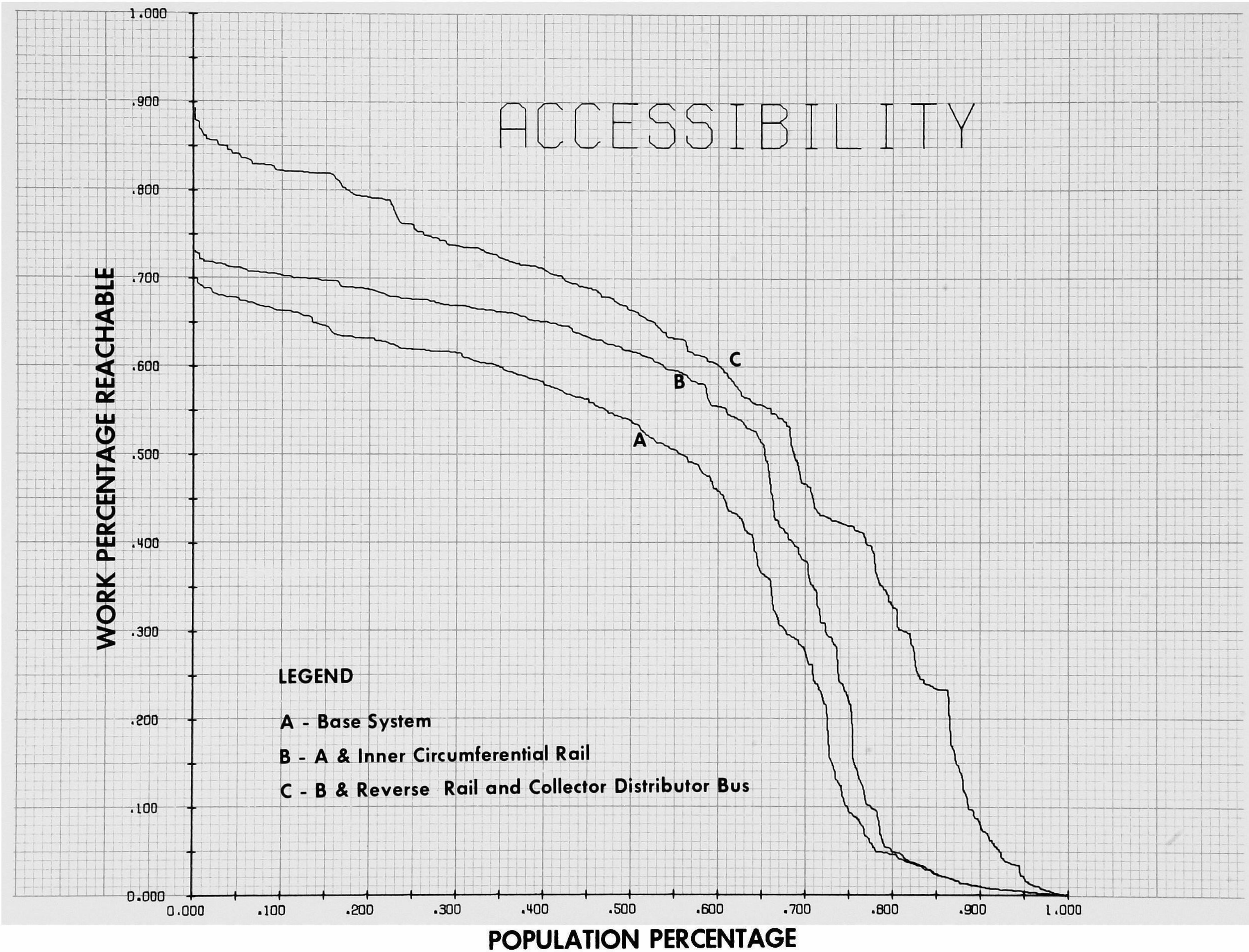
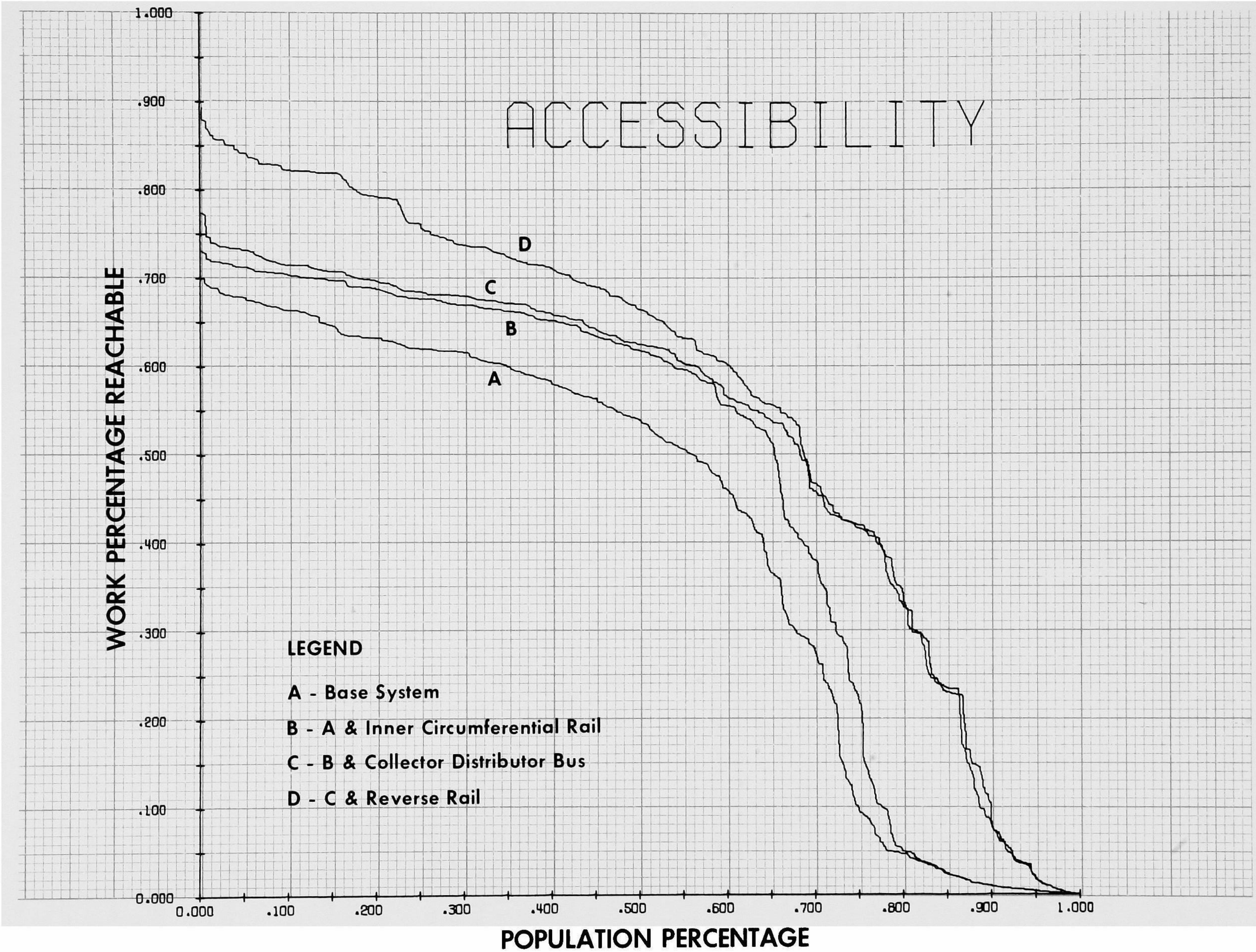

ACCESSIBILITY
WORK PERCENTAGE REACHABLE
1.000
.900
.800
.700
.600
.500
.400
.300
.200
.100
0.000
0.000
.100
.200
.300
.400
.500
.600
.700
.800
.900
1.000
POPULATION PERCENTAGE
A
B
C
D
LEGEND
A - Base System
B - A & Collector Distributor Bus
C - B & Inner Circumferential Rail
D - C & Reverse Reverse Rail

FIGURE IV-15



ACCESSIBILITY
WORK PERCENTAGE REACHABLE
1.000
.900
.800
.700
.600
.500
.400
.300
.200
.100
0.000
0.000
.100
.200
.300
.400
.500
.600
.700
.800
.900
1.000
POPULATION PERCENTAGE
A
B
C
LEGEND
A - Base System
B - A & Inner Circumferential Rail
C - B & Reverse Rail and Collector Distributor Bus

FIGURE IV-16


ACCESSIBILITY
WORK PERCENTAGE REACHABLE
POPULATION PERCENTAGE
1.000
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.800
.700
.600
.500
.400
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.200
.100
0.000
0.000
.100
.200
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.700
.800
.900
1.000
A
B
C
D
LEGEND
A - Base System
B - A & Inner Circumferential Rail
C - B & Collector Distributor Bus
D - C & Reverse Rail

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Conclusions

This study seeks to determine what effect regionalization would have on the usefulness of public transportation in the Chicago metropolitan region, measured in terms of accessibility. We asked the question, would a single regional system provide significant new transport benefits to the people of the region? Do increasing levels of integration expand the opportunities for residents to reach jobs within a reasonable time?

The results of this analysis demonstrate quite clearly that integrating the public transport components into a coordinated service can significantly increase accessibility to jobs for the population of the region.

We are led by the data to several conclusions:

1. A major reason for the decline in the use of public transportation in the Chicago metropolitan area has been the diffusion of residences and jobs away from the central business district of Chicago into the suburban portions of Cook County and into other outlying suburbs. These shifts have generated travel patterns that the existing structure and modes of operation of public transportation are unable to serve efficiently. This is especially true in the light of public transportation's competition with the private automobile.
2. Were schedules, routes and service frequency of the commuter railroads, the CTA and the suburban bus fleets to be coordinated, 80 percent of the region's population could have a five-fold increase in accessibility to jobs. This is demonstrated by the accessibility curve, Figure IV-13.
3. Were an inner circumferential rail rapid transit route to be added to this coordinated system with stations coordinated with the stations of the commuter railroads, 80 percent of the population could have a seven-fold increase in job accessibility.
4. Such an integrated regional system would provide this added accessibility principally to two segments of the population: persons living within the City of Chicago whose jobs are located in the outer section of the City or in suburbs, and persons who live in suburbs and whose jobs are in other suburbs.
5. The existing inventory of transportation components—trains, buses, rights of way, employees, etc.—will largely satisfy the requirements of the regional system for capital equipment and labor. The only exception would be the rail rapid transit circumferential route.
6. Individual carriers operating in isolation from each other cannot realize the potential for improvements in accessibility discussed in this study. Only a single regional institution capable of planning, integrating and operating the entire system can do so. This institution must be responsive not to immediate economic considerations but to the social, environmental and developmental goals of the region as a whole.
7. Conversely, simply establishing a regional agency is not sufficient in itself. The agency must be so constituted that it can integrate and operate the type of regional system described in this report. Otherwise it cannot attain the full benefits of regionalization. The regional agency must furthermore be able to plan and continually evaluate regional services. If not, it will at best save only administration expenses.

Individual carriers functioning as subregional mass-transport units cannot hope to accomplish the highly attractive improvements in public transportation identified by this investigation. Indeed, each carrier now, within its own sector of the market, offers a relatively good spectrum of transportation services. But problems arise at the interfaces between the carriers. The traveler's needs can be met effectively only if the services he seeks to use function together. Yet today there is an absence of "connectivity."

To insure that its services meet the need, a regionally integrated system must include integration which improves services, unified operational objectives, and long-range planning.

Integration for service improvements

It is well documented that commuters will elect to make their trip by automobile when the alternative is a trip over public transportation that involves a considerable amount of walking, waiting and transferring from vehicle to vehicle or from mode to mode. Improving connections between the existing services will increase the number of travelers who find it convenient to leave their cars at home, take a conveniently scheduled and conveniently routed uniform-cost bus to a train station, ride the train to a point close to their destination within a reasonable time and for a moderate cost, and complete their trip by bus or on foot.

This kind of service integration cannot be accomplished under current institutional arrangements, with the carriers being separately managed and separately operated. Each carrier sees only a small portion of the travel market, and it tries to optimize its service in this context. There is no motivation to achieve coordination—and, in fact, the concern for profits and losses faced by individual carriers discourages changing any part of the service which might improve the total multi-carrier system.

Unified operational objectives

Current commuter services in Chicago are operated in response to the rational objectives of the individual carriers: maximize profits or minimize losses. Coordination among the railroads, and between railroads and carriers of other modes, exists on a voluntary basis through various committees.

To the current or potential rider, however, all public transportation services appear as a system; the user is concerned not with how well a particular carrier fares economically but with how effectively a group of carriers meets his or her particular travel needs. Each traveler views travel needs from the perspective of unitary trip objectives and evaluates alternatives on the basis of time, cost and convenience—for the entire trip.

A system consistent with traveler needs and criteria cannot be operated by independent carriers acting in their own self-interest. Hence, there is a clear and apparent need to plan public transportation services in the Chicago area from the perspective of overall regional "goal sets." These "goal sets" must synthesize individual traveler objectives and long-term regional development and environmental quality considerations.

Despite its financial difficulties, the Chicago Transit Authority represents an initial approach to coordinated public transportation. The CTA, itself an integration of previously independent and privately operated transit services, has a mandate to offer relatively frequent service and dense coverage over the entire City of Chicago. Previous studies have shown that the CTA meets this mandate rather well. This is due in part to the fact that its operating objectives are unified, that each component of its service is treated as part of a larger system, and that interlocking of the components is essential to maintaining the overall quality of the service.

CTA coverage breaks down, primarily, at the Chicago city limits. Integration of services to and from the suburban areas is poor. It may be argued that the growth of the CTA's deficit is in part due to the fact that the growing, changing pattern of work-trip travel has now made a City-only system obsolete. Because it has no way effectively to interconnect with transport services to the outlying and suburban job centers, the CTA can be effectively utilized only by a decreasing proportion of the total travel market.

The irony of this is that the Chicago metropolitan region already functions as an integrated system in its economic and social relations. It is also integrated in many of its vital public services, of which highway transportation is the most obvious. Here, all major highway construction, operation and maintenance is planned and coordinated. Yet public transport is not, even though it is a vital means of mobility and even though effective interconnections are to the advantage of every political jurisdiction, offering benefits to every citizen regardless of home address or workplace. From the perspective of rational management objectives suggested in this study, it is apparent that some kind of institutional integration is a necessity.

If, on the services they now offer, the individual operators are to continue to face the internal mandate to make a profit or to avoid losing money, their decisions on improving operations must respond to a limited agenda and must naturally be quite conservative. Only by adopting a uniform set of operating goals, goals that are underwritten by the public, can a coordinated transportation system be established that can attract riders. The only obvious way to accomplish this is through a regional public institution responsible for providing public transportation services.

Long-range planning

Long-range planning in the public transportation sector is a critical need for at least two reasons.

First, plans to meet the public transportation needs of the coming decades must be formulated now because the implementation of these plans, including facility design, right of way acquisition, and construction, typically takes many years.

Second, adopting a short-range view, and ignoring the long-recognized effect which transportation has on the spatial arrangement of activities in a region, at best ignores a potentially powerful tool for land-use control. At worst, a short-sighted planning strategy can lead us to forget about the long-term, land-use implications of transport change. Since land-use changes are slow to occur, these issues must be considered in the context of a relatively long planning horizon.

The public transport carriers in the Chicago region perform almost no long-range planning. Their planning-related activities are limited largely to concerns for day-to-day operations. The long-range planning institutions are public bodies such as the Chicago Area Transportation Study and the Northeastern Illinois Planning Commission. While these organizations are actively planning public transportation over the long-range, their plans must be implemented by the private and quasi-private carriers. The weakness in this implementation procedure, caused by the management objectives forced on the carriers, reduces the effectiveness of the long-range planning that is done. Contrast this process with that of highway transportation, where the implementation of long-range plans has been rather effective—because, to a large extent, plans developed by public bodies could be implemented by sister public bodies.

Maintaining the Chicago region's living and working environment in the future makes essential the establishment of a meaningful long-range public transportation planning process. To do so will require supplanting private-enterprise objectives with public-enterprise objectives. It will also likely require effectively integrating the planning activity and the short-term, management function. Again, accomplishing these ends will require the structuring of a new regional public transportation institution.

Implications

Preserving environmental and energy resources

Transportation facilities and systems have major effects on the characteristics of our environment, particularly in terms of air and noise pollution but also in terms of community disruption—the need to relocate homes and businesses for the construction of facilities. The current fragmented approach to transportation management in the Chicago region fails to be responsive to environmental issues in a number of interrelated ways:

1. Highway and mass-transit planning and management are conducted separately. Needless competition between the modes is the result. Resources, particularly land devoted to transportation purposes, are wasted.
2. The lack of coordination among transit carriers, and between transit and highway goals, results in inferior transit services relative to the automobile. As a result, transit utilization declines, private vehicle travel increases—and congestion increases and the need for additional highways arises. Congestion itself increases air pollution and noise, as well as traffic accidents. It is wasteful in terms of energy consumed. Additional highways force the relocation of urban activities and often cut or impede social interaction in the neighborhoods they cross.
3. The absence of intermodal coordination at both the planning and implementation levels leads us to ignore the positive and negative interrelationships between the modes. It becomes easier to respond to congestion with more highways; the resulting improvement in auto service attracts more riders from transit—who in turn add to the congestion. Examining the possibility of meeting more of the region's travel demands through multimodal service—fringe parking, access bus service and the like—becomes increasingly more difficult.

Integrated public transportation should increase the possibility that these failures can be avoided. Integrated public transportation should at least make more feasible planning transportation in order to promote a desirable urban environment, rather than simply expanding facilities to meet extrapolations of current demand trends. Improved regional transit service designed to meet total, door-to-door travel needs is likely to attract riders away from the autos and on to public transportation.

In the long term, the Chicago region and the nation must recognize the limitations on the availability of energy in various forms. Rationing motor-vehicle fuels has been discussed as a strategy to reduce air pollution in Los Angeles. Farsighted policy-makers are also beginning to discuss the need to ration fuels simply because their supply is likely to be limited in the future. Rationing is an unattractive and potentially inequitable alternative for encouraging increased efficiency in passenger transportation. Perhaps a more palatable approach would be to find ways to improve the quality of service on more efficient modes of travel. Studies have shown that in terms of fuel consumption commuter railroads and buses are as much as seven times more efficient than full-size automobiles.

Transportation and land-use development

A century ago, the public transportation carriers stimulated community growth and regional land-use development through their location of routes and stations. However, the automobile currently is the primary mode of transportation in the region. In newly developing areas, the auto tends to be the only mode of transportation. The effects of improved accessibility by auto, resulting from better and more extensive highways and from increased auto ownership, can be seen in the sprawling suburbs around Chicago.

At present, transportation is following rather than leading urban development—a distinct reversal. Service for the automotive mode of commuter travel tends to respond to travel demands measured in terms of current travel behavior and patterns of congestion. Service by other modes than automotive does not.

If the resulting patterns of development were acceptable socially, economically, and environmentally, the situation would be reasonable. However, uncontrolled urban sprawl made possible by the ubiquity of the automobile and the high relative level of service offered by it removes valuable agricultural and recreational land; increases the demand for auto transportation; restricts the benefits offered by modern urban life to those who can afford one or more cars; increases air, land, and water pollution; and consumes unnecessarily large amounts of energy.

Public transportation can once again become a primary means of guiding urban growth, but only if the level of service can be significantly increased. High-speed line-haul services such as those currently offered by the commuter railroads, supported by fringe parking lots and access and egress bus services, as well as good rail rapid transit and bus services in existing higher-density areas, can bring about the necessary increase.

Learning for the future

Improving and maintaining the quality of public transportation services in the Chicago metropolitan region requires a comprehensive information base. Transportation planning has evolved to where it is more a science than an art. Thus, given the required information, one can perform objective analyses and evaluate proposed service improvements with known levels of confidence. Planning and operating transportation systems at the regional scale can no longer be done on the basis of experience and judgment alone.

During the course of this study, however, it became apparent that the kind of information necessary to plan and operate a regional transport system is generally unavailable. Carriers do collect data for their present management needs, such as total operating costs and monthly ridership on various services. Effective planning requires much more detailed—and highly specialized—information describing the travel patterns of individuals and groups and how they are utilizing the service components.

The Chicago Area Transportation Study recently has updated its data base on regional travel patterns, but these data are collected infrequently and can meet the needs of operating and planning an integrated system only over a short time period. Furthermore, data of this type usually do not focus on the ways in which travelers respond to changes in service which occur on a daily basis. Without this type of information, the impact of future service changes cannot be evaluated effectively.

Yet the existing public transportation network can be considered as a laboratory from which specialized data may be collected frequently in response to specialized needs and opportunities. While the individual carriers have no logical mandate to maintain such a data base, an integrated regional transportation institution responsible for long-term planning as well as for system operations must do so. It must attempt to maximize the learning potential offered by the current system in order to maintain and improve that system. It must continuously monitor system performance and utilization, assess the degree to which the system is meeting its objectives, and determine the ways in which travelers respond to changes in service characteristics. If it does so as a regular activity, the data are likely to be both more timely and more responsive to the needs of decision-makers, and less costly to collect.

Monitoring performance should be closely associated with implementing improvements to the system such as those considered in this report. The learning potential connected with service changes will thus be maximized; unknown and irreversible errors will be avoided.

Given the relatively high level of uncertainty associated with estimating how major service changes will be received, changes logically will be made in the form of sequential experiments, with adequate care given to monitoring and evaluating the results of each modification. The early experiments should provide much data about the way later changes will be received. Impact monitoring must be conducted from the broadest possible perspective. Social, environmental, economic and developmental effects all must be considered.

As an example, integrated feeder bus service might be initiated in a single transit corridor or at several stations in all corridors. Careful observation of traveler responses to these new services could then be used as the basis for making decisions about additional feeder bus improvements.

We must emphasize the necessity for this type of ongoing planning data. Without comprehensive and timely information, even a regional transportation institution will be unable to provide services which meet the needs of the region. The result, rather, would most certainly be a regional management which operated public transportation much the same way in which separate carriers operate it today. Under these conditions, the value of integrating the services in the region would be small. The contribution of transportation toward achieving the region's social, economic, environmental and developmental goals would be minimal.

TECHNICAL APPENDIX

METHODOLOGY FOR THE EVALUATION OF EXISTING LEVELS OF TRANSPORTATION SERVICE

To compare the relative changes in efficiency associated with the four selected, alternative integrated transportation networks for the study area, a computational procedure (algorith) was developed to measure differences in the population that has accessibility to employment, within a specified time interval. This appendix will illustrate the methods used to make these evaluations.

A. Methods of Evaluation

The study area represented a nearly rectangular area, approximately 40 miles by 25 miles, or 1000 square miles. Each one-square mile tract was assigned population and work percentages correlating those of the actual area. For computational efficiency, the location of each square was identified by a one-dimensional variable. All information on employment and population associated with the area was stored in two one-dimensional vectors.

Train routes were normalized to corresponding stations in the grid system without changing timetables for the time period under study, i.e., between 7 and 8 a.m. With few exceptions, the location of most stations in the actual network coincided with those of the grid system. The exceptions were always cases in which one of two stations located in the same one-mile tract was deleted or slightly displaced for relocation in an adjacent tract. A comprehensive review of bus schedules during peak periods indicated that there were several distinct subareas in which access and travel time between two adjacent one-mile tracts remain fairly constant. Whenever it was appropriate and applicable, bus schedules were substituted by an equivalent Friction Factor Coefficient representing the mean time required to go from any tract to an adjacent one within the same subarea. Tracts belonging to a particular subarea shared a common value for their Friction Factor Coefficients. Due to the rectangular shape of the grid overlayed on the study area, some of the one-mile tracts coincide with points in Lake Michigan. These squares comprised a subarea whose Friction Factor Coefficients were given an exceedingly large value to prevent access to and from these tracts. The system defined constituted a fully interconnected network of 1000 nodes, with a node representing the center of a one-mile tract. The network's connectivity varies in time according to train and bus schedules available at each specified point in time. Zero travel time was considered within a particular node (tract) and feasible transfers were assumed to be made without delay, depending only on the pertinent train and/or bus schedules available at the time of the transfer.

In ranking the percentages of employment offered by the 1000 tracts, 452 tracts were found to contain 95% of the total employment within the study area. Only these 452 tracts were used in this analysis, since use of the remainder did not justify the greater increase in computing time. The percentages of population were assigned for all 1000 tracts in the study area. Computer runs were made to measure accessibility between population and employment tracts. The first computer run evaluated the transportation system existing at the present time. Subsequent runs evaluated (1) the addition of reverse trains during the same peak period, (2) the addition of a feeder bus system, and (3) the addition of a circumferential system, and other combinations described in Chapter I of this report.

B. Basic Algorithm

The basic computational algorithm was composed of three concatenated phases. Phase I transforms all explicit train and bus schedules into a list of links which interconnect pairwise the nodes in the network. Each of these links was identified by its tract of origin, tract of destination, time of departure, and time of arrival. The implicit bus links defined through the set of Friction Factor Coefficients were not manipulated by the algorithm at this point. These coefficients were read directly and constituted the remaining set of connecting arcs of the network.

Phase II of the algorithm determined which tracts of this study area have access to a selected, specified tract (each of the 452 tracts was selected) with the condition of departing earlier than some specified time, Td, and arriving at destination not later than some time, Ta. By this procedure, the algorithm determined a Latest Possible Departure Time from each tract and the corresponding Access Path associated with it.

The algorithm began to search from destination tracts and proceeded outwards, along previously computed Access Paths, evaluating links inbound to those nodes which were already members of an Access Path, and to select the latest departing link which would satisfy the prevailing local constraints, namely Td and feasibility of immediate connection. New nodes were added to form longer Access Paths until all possible candidate nodes were identified.

In order to facilitate the process and to avoid multiple tracing of already computed Access Paths, two LIFO lists A and B were created. The entries of these lists were candidate nodes through which new branches of Access Paths could be established. List A contained only candidate nodes having incoming links explicitly defined in Phase I of the algorithm. List B contained those candidate nodes which have only implicit bus links defined through the Friction Factor Coefficients. Both lists were emptied at the onset of the analysis for each one of the 452 destination tracts.

List B was not examined until all candidate nodes in List A had been evaluated and removed from List A. This shortened the computing and convergency times.

Both Latest Possible Departure Time and the Access Path for a given node were transient and could be subsequently updated by the algorithm if an improved LPDT was found. When this occurred, the node in question was immediately placed as a candidate in one of the lists. Reevaluation of all LPDT from that node and outwards was undertaken. Convergency was guaranteed since all time schedules were finite and reevaluation of already computed LPDT's was precluded unless an improvement in departure time from a node was found.

Phase III of the algorithm was undertaken once all 452 destination tracts had been run by Phase II. The accessibility information was stored cumulatively in Phase II and used to compute population accessibility to employment in Phase III.

NOMENCLATURE AND STEPS OF THE BASIC ALGORITHM

A. Nomenclature

$L^k_{ij}(a)$	Arrival time of the k-th. link from node i to node j.
$L^k_{ij}(d)$	Departure time of the k-th. link from node i to node j.
HW	Headway for a fixed headway service.
$LPDT_i$	Latest Possible Departure Time computed from node i.
T_a	Lastest possible arrival time at destination node.
T_d	Earliest possible departure time from origin node.
I_i	Number of inbound links to node i.
LISTA	A LIFO list containing only nodes where $I_i \neq 0$.
LISTB	A LIFO list containing only nodes where $I_i = 0$.
W_m	Work offered at destination node m.
FFC_i	Friction Factor Coefficient associated with node i.

B. Steps of the Basic Algorithm

Steps Phase I	Description
1.	Define all links L_{ij} from information on schedules.
2.	If train has fixed headway service, define all subsequent feasible links such that: $L^k_{ij}(a) = L^k_{ij}(a) + HW \leq T_a$ and $L^k_{ij}(d) = L^k_{ij} + HW \geq T_d$
3.	Repeat steps 1 and 2 for all schedules.

4. For each $i \varepsilon (0,1000)$, define:

I_i = Number of inbound links to node i defined in Steps 1 and 2.

5. GO TO PHASE II.

Steps Phase II	Description
1.	Initiate iteration for each destination (employment site) m.
2.	$LDPT_i = 0$, for all i.
3.	$LDPT_m = T_a$: If $I_m \neq 0$, file m in LISTA, If $I_m = 0$, file m in LISTB.
4.	If LISTA $\neq 0$, remove top entry j; otherwise go to Step 5. For each feasible i: $L^*_{ij} = MAX_{*k}(L^k_{ij}(d)/L^k_{ij}(a) \leqq LPDT_j,\ L^k_{ij}(d) \geqq T_d\ \&\ LPDT_i < L^k_{ij}(d))$. $LPDT_i = L^*_{ij}(d)$. If $i \notin$ LISTA and $I_i \neq 0$, file i in LISTA, If $i \notin$ LISTB and $I_i = 0$, file i in LISTB. Go to Step 4.
5.	If LISTB $\neq 0$, remove top entry j. Otherwise go to Step 6. Let $S_j = (i/i$ is adjacent to j, $T_d \leqq t > LPDT_i)$ where $t = LPDT_j - \frac{1}{2}(FFC_i + FFC_j)$ For each $i \varepsilon S_j$: $LPDT_i = t$ If $i \notin$ LISTA and $I_i \neq 0$, file i in LISTA, If $i \notin$ LISTB and $I_i = 0$, file i in LISTB. Go to Step 4.
6.	Let $R = (i/_{LPDT_i} \neq 0)$. for each $i \varepsilon R$, $CW_i = CW_i + W_m$. IF PROCESSED ALL EMPLOYMENT SITES, GO TO PHASE III, IF NOT RETURN TO STEP 1.

Steps Phase III	Description
1.	Rank all CW_i in descending order; LISTW = $(Cw_i / CW_{i+1} \geq CW_i$, all i)
2.	Define LISTR containing the node corresponding to each entry in LISTW: $LISTR_i$ = node of i-th. entry in LISTW.
3.	Compute the total population contained in the first n nodes as given by the first n entries of LISTR: $CP_n = \sum_{i=1}^{n}$ Population (from $LISTR_i$)
4.	Let LISTW(n) be the n-th. entry of LISTW; Then: CP_n of the total population can reach at least LISTW(n) of the total employment. Repeat this statement for all entries n, n = 1,2, ...,1000. END