Also, Bernard P. Markowicz kept this study moving with insightful advice on some difficult problems. A polygon version of the 1980 Census Tract Boundary Coordinate File, leased by Geographic Data Technology, Inc., was made available through the Princeton University Computer Center courtesy Judith Rowe, Shirley Robbins, and Doug Mills, who also made available Summary Tape File 3A through the Princeton-Rutgers Census Data Project. Finally, Alain Kornhauser, director of the Princeton University Transportation Program, provided the overall direction of this effort.

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Abridgment

Design of a Nighttime Transit System for Salt Lake County, Utah

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ABSTRACT

Salt Lake County, Utah, has experienced tremendous population growth along with an increased demand for transit services since 1970. The Utah Transit Authority (UTA), a publicly funded organization, was conceived in 1970 and is responsible for providing public transportation to Salt Lake County. UTA has continuously modified services to accommodate the growth and changing travel patterns throughout its history. However, transit service after 7:00 p.m. had not been changed since its implementation more than 10 years ago. Analysis of the nighttime transit service in this region revealed that this service was not functioning effectively. Three conceptual systems were developed, and the system that best met the goals is described. The new system was implemented on November 22, 1982.

Currently, transit systems throughout the United States are undergoing serious financial problems (1). The transit company basically has two alternatives to balance the budget. One is to increase revenue by increasing either ridership or fares. The other is to decrease costs or service.

The Utah Transit Authority (UTA) operates approximately 27,000 revenue miles per weekday, 5.6 percent of which are operated after 7:00 p.m. Therefore, approximately 1,500 revenue miles of service make up the night system, which is defined as all trips departing from the central business district (CBD) after 7:00 p.m.

Historically, UTA's night service has been one of the least efficient in the system. The service terminated at 9:30 p.m., which is when the last trips departed from the CBD. The service was implemented during the early 1970s when the UTA system was originally conceived. Since that time, the region as well as the travel demands of the population have continued to grow.

The primary goal of this research was the development of a nighttime transit system that offers the public a better service. The first objective in accomplishing this goal was to accurately identify the characteristics of the existing service. The second objective was to determine regional characteristics such as activity centers, population densities, and trip origins and destinations. The third objective was to reduce operating costs and maintain or increase the existing ridership level. The fourth objective was to extend the hours of service.

The primary goal and set of objectives lead to the hypothesis that decreasing transit coverage during the evening and night period and extending the hours of service will improve the economic efficiency of transit service after 7:00 p.m.

OPERATING CHARACTERISTICS OF PRIOR SYSTEM

The night transit system was made up of 26 routes operating 134 one-way trips, most of which originated in downtown Salt Lake City. With the exception of one route that serviced Ogden from Salt Lake City, all of the routes operated within Salt Lake County. The service provided extensive coverage or accessibility, especially to the east side of Salt Lake Valley. The system was implemented in the early 1970s, at which time a large percentage of the population resided in the east portion of the valley. Since the early 1970s, a large amount of commercial and residential development has occurred in the southwest portion of the valley, yet little service existed within this area. Comparing the night system to the total transit service for Salt Lake County indicates the poor performance. For instance, system averages indicate that passengers per mile is 1.9, passengers per hour is 35.1, and passengers per trip is 21.7 (2). The night system averages were 0.93, 18.4, and 10.9, respectively.

In order to measure the efficiency of a route, the performance indicators of passengers per mile, passengers per trip, and passengers per hour were weighted equally. Using this method of analysis, an index was developed for the purpose of comparing the different routes of the night system. The method of equally weighting the categories was to divide the indicators of each route by the respective total and then add the three categories; the highest score indicated the most efficient route.

Efficiency index formula for route i = (passengers/hour for route i divided by the sum of passengers/hour for all routes) + (passengers/mile for route i divided by the sum of passengers/mile for all routes) + (passengers/trip for route i divided by the sum of all passengers/trip for all routes).

The night system cost approximately $800,000 per year to operate. The costs are made up of a number of components. In an effort to accurately determine the costs of the night system, it was theoretically separated from all other transit services (3).

The cost components of the night system include miles of operation, which includes revenue and nonrevenue miles, and hours of operation, which is the total time paid to bus operators.

The system operated a total of 105.48 bus driver hours. This component is separated from other costs because it is a significant portion of operating costs. Historically, operator wages account for a significant portion of total operating costs. The labor rate per hour for a bus operator is $9.28, which includes fringe benefits such as vacation time, sick leave, and insurance. On a daily basis, the bus operator labor costs $978.58.

The cost per mile less operator labor costs includes such elements as fuel, tires, maintenance labor and services, and repair parts. The average cost per mile is $0.9068. Total miles of operation per night was equal to 1,821.9, which includes 1,661.9 revenue miles and 160 nonrevenue miles. The total cost of operating the night system per day was $2,554.32.

Revenue, on the other hand, is calculated simply by multiplying the total average number of passengers per day by the average revenue per passenger. The average number of passengers per day was 1,473. This number is an average of the 12 latest calendar months.

The average revenue per passenger was determined to be $0.30. The base fare structure for service at this time of day is $0.40. However, discounts for pass users, senior citizens, children, the handicapped, and transfer users bring the average paid fare to $0.30. Therefore, the average farebox revenue per day amounted to $441.90.

Measuring the economic efficiency involves determining the percentage of the operating costs covered by farebox revenue. In the case of the prior night service, 16.5 percent of the costs were covered by revenue. This is much lower than the system average of 22 percent.

SYSTEM DEVELOPMENT

The major goals in the development of a new system were

- To reduce the operating costs,
- To improve economic efficiency ratio of revenue to cost,
- To serve major activity centers,
- To extend the hours of service, and
- To minimize the impact of current transit users.

Three alternative system designs were developed. The costs, vehicle requirements, advantages, and disadvantages of the alternative systems were then compared so that the most effective system could be selected internally by UTA staff members.

The alternative selected is made up of 13 routes. The hours of service are 7:00 to 11:30 p.m., including 100 one-way trips.

This system was designed to operate in major corridors to increase travel speed and eliminate the negative impact of bus operation on neighborhoods at a late hour. The route structure offers increased frequency instead of maximum coverage in an effort to improve the ridership of each route as well as system ridership.

The major advantages of this system are as follows:

1. Most major activity centers are accessible by transit,
2. Neighborhood impacts are reduced,
3. Routes run later in the evening than the current service provides,
4. Costs are decreased, and
5. There are minimal operator and vehicle requirements.

The major disadvantage is that there is less coverage than with the prior system.

Figure 1 shows the route structure of the new system, which is currently in operation. In the new system the miles of operation were reduced from 1,661 to 1,454. The hours of operation per day were reduced from 114 to 96.

A formula was developed to forecast ridership of the new system utilizing past average daily ridership as the data base. The logic behind this quick-estimation technique is to determine the change in ridership resulting from system design changes and the extension of the hours of service. The estimation of the impact due to the extended hours of service was obtained by taking a percentage of the total internal automobile travel for a metropolitan area the size of Salt Lake (4).

The formula is as follows and the estimated result has proved to be accurate:

$$\{[IVT_1 + W_1\ (PT)]/[IVT_2 + W_2\ (PT)]\} \cdot MF = \text{ridership change factor},$$

where

IVT_1 = in-vehicle travel time of old system;
IVT_2 = in-vehicle travel time of new system;
W_1 = access time under old system;
W_2 = access time under new system;
PT = an accepted factor of 2.5, which represents the human tendency to exaggerate time spent walking to and waiting at a bus stop; and
MF = the percentage of increase in internal urban travel due to the extended hours of service.

CONCLUSION

The first 5 months of operation of the new service proved to be quite successful. Total miles of opera-

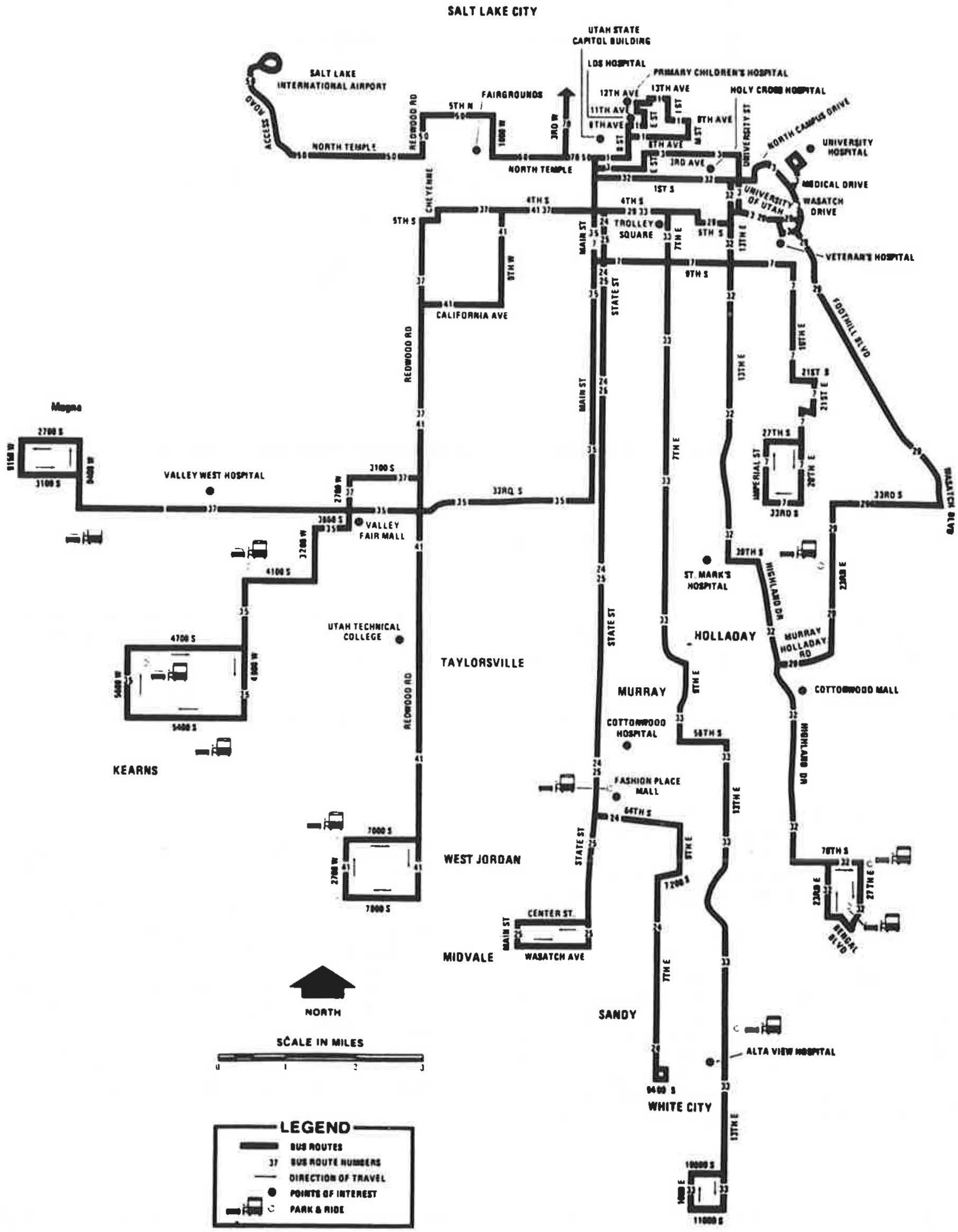

FIGURE 1 System route structure.

tion were reduced by 12.5 percent and hours of operation were reduced by 15.8 percent. The combination of increased ridership and decreased costs has led to a more efficient service.

The new service operates 100 trips per night, which includes 1,454.7 service miles. The ridership level per night has increased to 1,615, the highest level on record (Figure 2). The ratio of passengers per mile is currently 1.1 and is expected to remain at this level.

This research and the resulting service alterations have been based on the hypothesis that decreasing transit coverage during the evening and night period and extending the hours of service will improve the economic efficiency of transit services after 7:00 p.m. Comparing the economic efficiency of

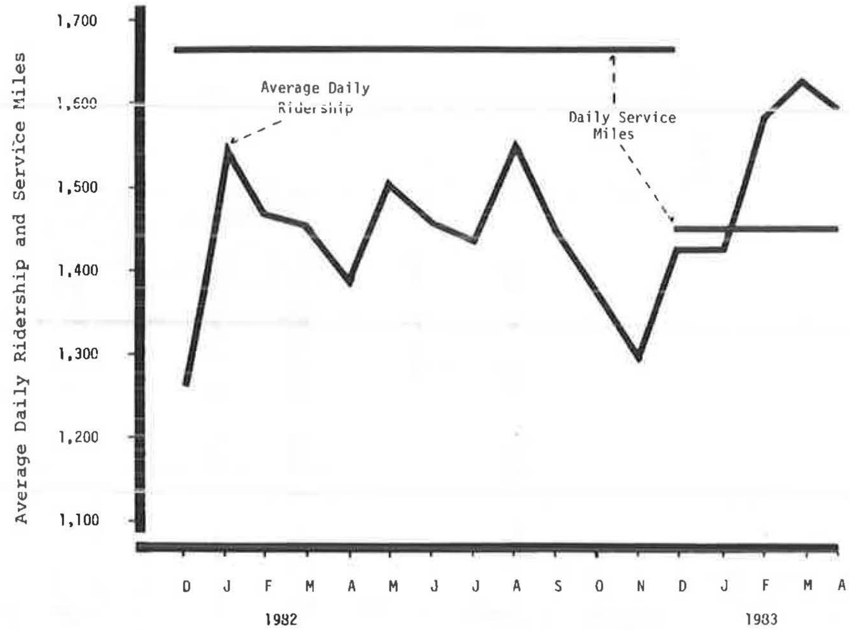

FIGURE 2 Nighttime service ridership history.

the past system with that of the new system for the same time period and the following formula, the revenue cost ratio improved from 16.5 to 20.6 percent:

Economic efficiency measure = (R/P) X P/[M (C/M) + LR (H)],

where

R/P = average revenue per passenger,
P = average daily ridership for 5-month period,
M = total miles operated per day,
C/M = cost per mile (less operator wage),
LR = labor rate per hour (includes benefits), and
H = total hours of operation.

The community of Salt Lake County has been the biggest beneficiary of the recently implemented night service. The social benefits of later service have not been measured, but late workers can now get to and from work, residents can use the bus for late night social events and evening classes, and shoppers can use the bus later. The community has also benefited from the reduced cost of providing this service.

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