Evaluation of Performance of Riyadh Urban Public Transportation Services

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Private jitneys were the only form of public transportation in Riyadh, Saudi Arabia, and an important part of its transportation scene for many decades. However, when the Saudi Arabian Public Transport Company (SAPTCO) began to operate as the city's subsidized transit company, jitney operators chose to operate only in the profitable corridors and only during periods of peak demand. Thus, SAPTCO had to operate losing routes and services without offsetting revenue from peak periods and heavy-demand corridors. The findings of a study conducted to evaluate the performance of both SAPTCO and jitney services in Riyadh are presented. The annual public transportation ridership is estimated at about 26 million passenger trips, 82 percent of which are carried by minibuses. It appears that the jitney clientele is attracted to the jitneys because they offer service qualities that are lacking in the public transit system, including shorter waiting times, shorter trip times, and a patron's ability to flag vehicles at any street corner and to get off at will. It also appears that SAPTCO cannot operate successfully in the presence of such fierce competition from minibuses. Thus, SAPTCO is not giving intracity services a priority in its operations; instead, it is using its resources in the profitable operations of intercity services and the contracts and chartered bus business. However, poor performance by SAPTCO seems to be a bigger obstacle to successful operation than fierce competition by jitneys. The dilemma facing the city officials is twofold: (a) serving the areas that lost public transportation services, either jitney or SAPTCO; and (b) integrating the jitneys into Riyadh's public transportation system without harming the SAPTCO system.

Urban transportation systems should provide adequate mobility to various locations to satisfy essential human needs. In urban areas, these needs cannot be provided by automobiles without causing severe congestion, pollution, and safety problems. On the other hand, public transit is a relatively high-capacity and energy-efficient alternative for urban passenger transportation as compared with the private automobile. If planned, operated, and managed effectively, transit can serve as an environmental safeguard for conserving energy, protecting community quality of life, and facilitating urban economic growth and development.

Public transportation is usually provided by a single publicly owned system in developed countries; typically, both capital and operating costs are subsidized. Developing countries have much greater diversity in terms of service provision—small private companies often provide a large part of the system capacity under highly competitive and poorly regulated conditions. In other cases, where the political decision has been to keep fares well below costs, a single publicly owned provider may provide fixed-route service with large buses in competition with private operators providing flexible or fixed-route service (or both) with minibuses.

Riyadh, the capital of Saudi Arabia, has experienced a rapid development in the past two decades and currently occupies an area of about 1600 km^2 with a population of about 2 million. Vehicle ownership is about 0.2 vehicles per person, and only 2.8 percent of the city's households are without vehicles (average household size is 6.17). The average trip rate is 2.14 trips per person per day, which is generally lower than what has been reported in U.S. cities, where typical trip rates range from 2.8 to 3.5 trips per person per day. However, this may be misleading since the trip rates for men and women older than 16 in Riyadh are 2.78 and 0.58, respectively. As women are not allowed to drive in Saudi Arabia, they make only 20 percent of the trips per person that men make (*1*).

Moreover, only about 1.6 percent of the total daily person trips are made on public buses, which is typical for an automobile-oriented city; thus transit use is about 0.034 transit trips per capita. Taxis carry only 0.6 percent of the weekday person trips, and the rest are made by private vehicle (*1*).

Before 1979 urban public transportation services in Riyadh were provided by a number of minibuses (25 seats) operated by individual owner-operators (i.e., jitney service.) Minibus drivers operate their buses with no time schedules and make unilateral decisions, with almost no coordination with others in regard to routes served and hours of operation. Thus, the number and frequency of service on any given route can change significantly from one day to the next.

In 1979 the Saudi Arabian Public Transport Company (SAPTCO) was established as the first bus transit company in the country, where the Saudi government owns 30 percent of its shares. Soon after its establishment, it was granted the rights of providing subsidized intercity and intracity public transportation services throughout the country. However, minibuses continued to provide intracity transportation services, successfully competing with SAPTCO on the high-demand routes serving the city center. The number of minibuses increased drastically—from 800 in 1979 to more than 2,600 in 1986, about 900 of which were in Riyadh (SAPTCO, unpublished report, 1992, in Arabic). This increase is thought to be related to the official increase of the government-set fare from SR 1.00 to SR 2.00 per passenger trip in 1983 ($1.00 U.S. = SR 3.75).

SAPTCO started its first route in Riyadh on July 30, 1979, and continued to expand its services to cover different parts of the city (Figure 1). In its first year, SAPTCO ridership was about 8 million passenger trips, which increased steadily to reach about 35 million (on more than 22 routes) in 1982. When the fare was officially increased in 1983, ridership started to decrease drastically. This forced SAPTCO to eliminate some of the nonproductive routes.

The reduction in routes served by SAPTCO, from 22 to 13, has resulted in a concentration of service by both SAPTCO and minibuses on heavy-demand routes only. Consequently, some areas have lost public transportation service. The annual number of per-

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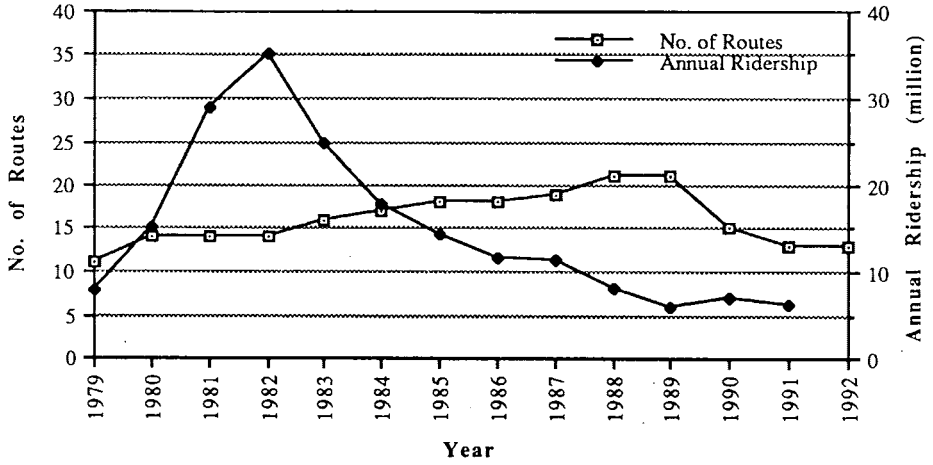

FIGURE 1 SAPTCO intracity service routes and annual ridership in Riyadh (source: SAPTCO).

son trips served in these areas before the service was cut approached 2.3 million passenger trips in 1986 (*1*).

In 1992 SAPTCO was operating 13 intracity routes in Riyadh, radially structured, with a total network length of 578 km and 252 scheduled daily runs. Service operation started at 5:00 a.m. and continued to 11:00 p.m. on most routes, with the scheduled service headway ranging from 6 min on high ridership routes to 1 hr on others. On the network level, the average scheduled peak-period headway is about 15 min, which doubles in the off-peak (peak period is 6:00 to 9:00 a.m. and 4:00 to 11:00 p.m.).

Figures 2 and 3 show the daily and monthly ridership variations, respectively. These figures show that weekend (Thursday and Friday) average daily ridership is higher than that of weekdays and that the patronage drops at the beginning of summer then builds up in fall.

Relevant literature review revealed that few studies were conducted on the performance of public transportation services in Riyadh. Probably the most involved study was that by Arriyadh (Riyadh) Development Authority (*1*). The study estimated that the 1987 daily public transit demand in Riyadh was 74,000 passenger trips, of which SAPTCO carried 35,000 (47 percent) and the Minibus Paratransit System (MPS) handles the rest.

A less detailed (and less reliable) study, which was based on a limited questionnaire survey, estimated that SAPTCO's daily ridership was about 52,000 passenger trips in 1986 and that MPS's daily ridership was 80,000 passenger trips (*2*). A third study, by the Ministry of Communication, estimated the daily public transit demand in Riyadh at about 78,000 passenger trips in 1986 and expected that it will increase at an annual rate of 3.08 percent (i.e., 97,000 passengers in 1992) (*3*).

Finally, a study by Koushki based on a questionnaire survey suggested that only 31 minibuses were operating along eight routes in 1984, with a daily ridership of 11,000 passenger trips (*4*). However, this study is questionable since actual field traffic surveys during the same period showed that the number of minibuses reached 1,016 (unpublished report).

These studies clearly show the intensity of competition that SAPTCO faces from MPS in Riyadh. However, inconsistency is evident among these studies with regard to the magnitude of passenger demand and the contribution of each of the two systems to match that demand. In addition, it appears that an understanding of the characteristics and performance of each of the two systems is lacking.

This paper attempts to evaluate the public transportation services in Riyadh by measuring the performance of each of the two operating systems simultaneously and assessing the impact of jitneys on SAPTCO ridership and revenue. This was done by im-

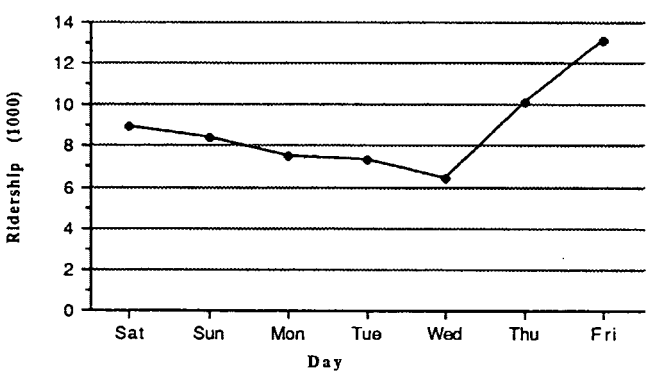

FIGURE 2 SAPTCO intracity service daily ridership variation in Riyadh, May 1992 (source: SAPTCO).

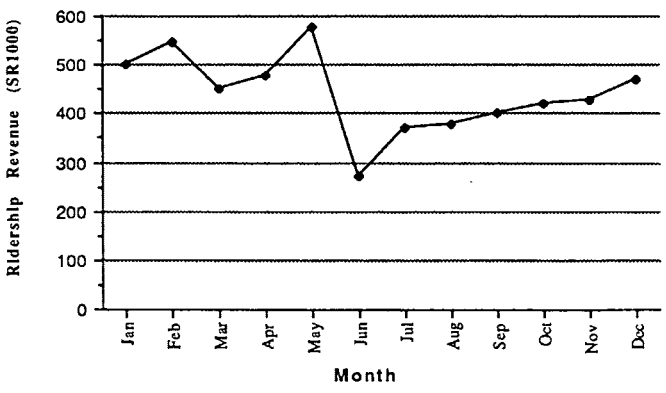

FIGURE 3 SAPTCO intracity service monthly ridership variation in Riyadh, 1992 (source: SAPTCO).

plementing a statistically based data collection program described in the next section. Study findings are presented next, followed by discussion and conclusions.

METHODOLOGY

For the purposes of this study it was necessary to establish the baseline conditions that present a snapshot of the systems' performance at a point in time. These were defined by time of day for each route in the system. Complete route profiles were developed from these data to facilitate comparisons among routes across the two systems. The study protocol is as follows:

1. The first step in the data collection program was to identify the data items required. The data items sought include: peak load, schedule adherence (SAPTCO only), total boarding in passenger trips, female boarding (SAPTCO only), revenue, passenger-kilometers, and boarding by fare category (SAPTCO only; cash or prepaid reduced tickets). Female passengers were singled out because they are only served by SAPTCO, where they have their separate compartment inside the large bus. Each data item is required at the route level for each time period: a.m. peak (6:00 to 9:00 a.m.), base (9:00 a.m. to 4:00 a.m.), and p.m. peak (4:00 to 9:00 p.m.).

2. A sampling plan was then designed incorporating the quantity of data to be collected and the timing of data collection. Two factors were taken into consideration in establishing the sampling plan: the desired accuracy and the inherent variability of the data. Accuracy has two components: a tolerance and confidence level. The tolerance indicates the range around the observed value within which the true value of the data item is likely to lie. The level of confidence indicates the probability that the true value is within the tolerance range around the observed value. In this study, a 90 percent confidence level was used for route-level data and a 95 percent confidence level for system-level data. Because of the lack of historical data, the needed tolerance levels and coefficients of variation were assumed in this study on the basis of default values recommended by UMTA (*5*).

3. The next step was to choose the data collection technique. Three techniques for positioning personnel and resources in the field for data collection were employed in this study—namely, ride checks, MPS driver questionnaires, and point checks.

–In the ride check technique, a checker was stationed on board the bus as it traveled along the route from the start of its run (for SAPTCO) to completion. A total of 665 SAPTCO trips (119 runs) covering the 13 routes were surveyed in this study; 381 trips (57 percent) were during the weekdays and the rest were on weekends.

–Because of the lack of fixed routes and schedules for the MPS, it was difficult to determine the amount of service and ridership before the on-board survey. This also made it difficult to maintain survey controls with respect to sample data expansion. Therefore, surveys were made to attempt to overcome these difficulties. A questionnaire was designed and conducted with MPS drivers (156 drivers) to determine which routes are the most used, and to estimate the relative use of each route and MPS operating characteristics. In addition, this pilot survey was used to determine the work schedule for the minibus ride checks.

A cordon count survey was conducted at eight locations surrounding the downtown area, continuously over three consecutive days (Friday to Sunday), to count the number of buses entering and leaving the city center. Data from this survey were used as a control for data expansion. In addition the MPS fleet size was established by recording the license plate number of each minibus crossing the cordon boundaries. Local authorities did not have data on the size of MPS fleet.

A procedure similar to SAPTCO's on-board survey was then used to survey minibuses. Surveyors were assigned to a specific route each day, covering one or more time periods. Since an individual minibus may not follow the same route for an entire day, the surveyor was required to inquire about his assigned route until a minibus traveling that route was found. In this manner a total of 434 trips were surveyed (223 trips were on weekdays) over nine main routes served by MPS.

–The third type of data collection technique used was that of point checks, in which a checker is stationed at the roadside and observes buses as they pass by. Ride checks were used mainly to obtain the required sample size of boarding (passenger trips) and passenger kilometers, which cannot be obtained by other survey techniques. Hence, supplementary point checks were needed only for schedule adherence (SAPTCO only), in which the sample size required exceeded that required for total boarding and passenger kilometer data items. It is less costly to gather additional schedule adherence data by using a single point checker than by using on-board checkers. The central SAPTCO station downtown was used for the point check survey.

The data collection program was then scheduled and implemented over 4 weeks during May 1992.

FINDINGS

To minimize the data entry errors, specially designed self-validating data entry screens on personal computers were programmed and used for each type of field survey. The data were then transferred to the IBM 3080 mainframe at King Saud University, and Statistical Analysis System (SAS) software was used for data analysis. In this section the measured performance of SAPTCO service is presented first, followed by that of MPS. A comparison of performance indicators from both systems is also presented.

Detailed baseline data were obtained for each of the 13 routes operated by SAPTCO and the 9 routes operated by MPS in Riyadh, by day type, direction, and time period. However, space limitations prevent these results from being presented here; they can be found elsewhere (*6*). Tables 1 and 2 present summaries of these data at the system level only for SAPTCO and MPS, respectively.

It is evident from Table 1 that SAPTCO carries, on weekdays, an average of about 16,000 daily passenger trips (17,000 on weekends), 11 percent of whom are female passengers. However, only 58 percent of the daily weekday scheduled trips were executed, mainly because of a driver shortage (82 percent of the lost trips). The percentage of lost trips decreases on weekends to about 22 percent. The recovery is attributed to the availability of more drivers on weekends, some of these drivers are assigned to school transportation services during weekdays.

TABLE 1 SAPTCO Service Baseline Data

Item	System Level	
	Weekday	Weekend
1. Routes round trip:		
travel time (min.)	1294	1306
length (km)	578	578
2. Schedule adherence (%):		
On time	50	49
Late	17	16
Early	34	35
3. Fare type (%):		
cash	98	99.5
tickets	2	0.5
4. Headway (min.):		
Scheduled	14	19
Actual	18	16
5. Avg. waiting time (min.)	20	15
6. Daily Passenger-km	120026	143859
7. Daily vehicle-trips:		
Scheduled	1538	1234
Actual	895	948
8. Daily Ridership:		
Passenger-trip	15813	16759
Female-trip	1750	1778

Furthermore, service reliability data show that only 50 percent of the trips adhered to their time schedules (+3 min), while 17 percent were late and the rest left the bus stop early. In addition, a passenger waits an average of about 20 min for the bus on weekdays (15 min for weekends), whereas the average weekday actual headway achieved was about 18 min (16 min on weekends). The average passenger waiting time, $\bar{w}$, is calculated according to the following well-known relation (*7*):

$$\bar{w} = \frac{1}{2} * \bar{h} + \frac{\text{var}(h)}{2 * \bar{h}}$$

where $\bar{h}$ is the average service time headway and var(h) is headway variance.

It is worth noting that the average peak load on any given route or period did not exceed 30 passengers for weekdays and weekends. Meanwhile, 87 percent of SAPTCO's fleet are 42-seat Neoplan buses and the rest are 29-seat Toyota coaster buses. This might indicate the inefficient utilization and mix of the fleet.

On the other hand, the analysis of the MPS driver questionnaire revealed that minibuses operate on nine main radial routes serving the city center. All these routes parallel SAPTCO's fixed routes. The data collected in this study show that minibuses operate 6,000 daily trips, on weekdays, carrying 75,000 passengers—fivefold that served by SAPTCO.

The MPS service is provided by a fleet of 671 minibuses during weekdays. However, the fleet size increases to 1,100 minibuses on weekends, carrying 95,000 passengers a day. This large increase of the fleet size may indicate that many of the minibus owner-operators have other jobs during the weekdays and use their vehicles to generate more income during weekends. Furthermore, this large MPS fleet size resulted in a passenger's average waiting time of 3 min on weekends and 7 min on weekdays.

TABLE 2 MPS Service Baseline Data

Item	System Level	
	Weekday	Weekend
1. Routes round trip:		
travel time (min.)	643	608
length (km)	356	356
2. Headway (min.)	5	3
3. Avg. waiting time (min.)	7	3
4. Daily vehicle-trips	6095	6659
5. Daily Passenger-km	595648	725639
6. Daily Ridership	74357	94661

The systemwide SAPTCO and MPS service performance indicators for May 1992 are given in Table 3. These are categorized into efficiency and effectiveness indicators, which are concerned with produced and consumed output, respectively. In other words, efficiency measures reflect resource usage, and effectiveness measures rate the degree to which the transit service achieves the needs of the riders and the community (*8*).

Efficiency indicators considered in this paper include operation cost, service production, and service reliability measures; effectiveness indicators include revenue and patronage measures. Table 3 indicates that it is about 60 percent more costly to operate SAPTCO buses than the smaller minibuses. However, the operating cost per passenger trip is less for SAPTCO than for MPS (SR 1.47 versus SR 1.54), indicating more efficient utilization of the service produced. This can also be seen from the indicator passenger kilometer per vehicle kilometer, which is 6 for SAPTCO and 4 for MPS.

Meanwhile, the average revenue per passenger trip was only SR 1.39 for SAPTCO, resulting in a revenue cost ratio of 0.94. It is obvious that SAPTCO intracity operations could not even recover the operational cost let alone the capital cost. Revenue per passenger trip should have been close to the fixed flat cash rate of SR 2.00, since excursion ticket passengers were only 2 percent. This low revenue per passenger trip could have happened because of errors in estimating the total revenue or total patronage, or because not all the revenue goes to the fare box. Detailed analysis of the data revealed that there was a leakage in the fare collection system.

Furthermore, it appears that minibuses produce more vehicle trips (and vehicle kilometer) than SAPTCO. This resulted in a shorter service headway and thus less passenger waiting time. SAPTCO service appears to be unreliable; only 50 percent of the trips were on time, and 42 percent of the scheduled trips were not undertaken. The relatively higher level of service provided by MPS might have been the reason behind its having most of the total public transportation patronage in Riyadh.

TABLE 3 SAPTCO and MPS Performance Indicators, May 1992

Indicator	SAPTCO	MPS
Efficiency Indicators		
I. Operation Cost (SR)		
1. cost per veh-hr	27.60	16.90
2. cost per pax-trip	1.47	1.56
II. Service Production		
1. Veh-hr	25,718	217,705
2. Veh-km	549,245	4,596,213
III. Service Reliability		
1. Veh-km lost due to:	227,604	-
driver shortage	186,636 (82%)	-
driver absence	25,037 (11%)	-
other reasons	15,933 (7%)	-
2. Schedule adherence (%)		
on time	50	-
late	17	-
early	34	-
3. Avg. waiting time (min)	17	6
4. Avg. headway (min)	18	3
Effectiveness Indicators		
IV. Revenue		
1. Rev./cost ratio	0.94	1.22
2. Rev./pax-trip	1.39	2.00
V. Ridership		
1. Monthly pax-trips	466,000	2,325,000
2. Monthly pax-km	3,678,000	18,351,000
3. Pax-km per veh-km	6	4

CONCLUDING REMARKS

Private jitneys were the only form of public transportation and an important part of Riyadh's transportation scene for many decades. However, when SAPTCO began to operate as the city's subsidized transit company, jitney operators chose to operate only in the profitable corridors and only during periods of peak demand. Thus, SAPTCO had to operate losing routes and services without offsetting revenue from peak periods and heavy-demand corridors. Consequently, SAPTCO eliminated some of these losing routes and now operates only 13 of the 22 routes it operated in 1988, leaving some potential bus passengers unserved.

This study estimates the annual public transportation ridership at about 26 million passenger trips, 82 percent of which is carried by minibuses. It appears that the jitney clientele is attracted to the jitneys because they offer service qualities that are lacking in the public transit system. These include shorter waiting times, shorter trip times, and a patron's ability to flag vehicles at any street corner and to get off at will.

It also appears from this study that SAPTCO cannot operate successfully in the presence of such fierce competition from minibuses. Thus, SAPTCO is not giving intracity services a priority in its operations; instead it is using its resources in the profitable operations of intercity services and the contracts and chartered bus business. However, poor performance by SAPTCO seems to be a bigger obstacle to successful operation than just fierce competition by jitneys. The dilemma facing the city officials is twofold: (a) serving the areas that lost public transportation services, either jitney or SAPTCO; and (b) integrating the jitneys into Riyadh's public transportation system without harming SAPTCO.

In general, the goal of urban public transportation is to enable all residents to use a safe, effective, and efficient mode of public transportation, especially those who do not have access to private automobiles. Regardless of who provides the service, the objectives should be to increase ridership and provide the service for the public in all city parts with the maximum control of cost (and to generate profit if possible). These two objectives should be concurrently considered and balanced.

Therefore, this study recommends, first, that public transportation services in Riyadh should be organized properly by the regulating authority (e.g., Ministry of Transport). This could be done by regulating the way in which minibuses operate in the city, probably through some sort of a cooperative association coordinating the activities of minibuses, and by dividing the city into two parts to be served by each service system (MPS and SAPTCO).

Second, the performance of SAPTCO should be improved. To do so SAPTCO should deal with intracity public transportation services as an autonomous entity (cost and profit center) with its own resources and establish service objectives that are measurable. Once this is done, service effectiveness and efficiency could be improved, resulting in more ridership, better service coverage, and probably more economical operation.

ACKNOWLEDGMENTS

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REFERENCES

1. *Demographic, Transportation, Land-Use and Economic Studies for the City of Riyadh, Stage 2.3 Transportation Studies, Task F, Conduct Public Transportation Studies.* Technical Report. Al-Shathry and CH2M Hill Consultants; Arriyadh Development Authority, Saudi Arabia, June 1987.
2. *Traffic Study: Kasr Al-Hokm District.* Technical Report. Team International Consultants; Arriyadh Development Authority, Saudi Arabia, May 1986.
3. *Feasibility Study to Determine the Need for High Capacity Transit Services, Riyadh.* Final Report. Al-Muhandis and Kirkpatrick & Partners Consultants; Ministry of Communication, Saudi Arabia, Aug. 1986.
4. Koushki, P. A. Riyadh's Paratransit System: Success Without Institutional Dynamics. *Transportation Quarterly*, Vol. 43, No. 1, Jan. 1989, pp. 75–88.
5. *Transit Data Collection Design Manual.* Report DOT-I-85-38. UMTA, U.S. Department of Transportation, June 1985.
6. AlGadhi, S. A. *Evaluation of Riyadh Urban Public Transportation Services* (in Arabic). Final Report. Research Center, College of Engineering, King Saud University, Riyadh, Saudi Arabia, Sept. 1992.
7. *Urban Public Transport: Evaluation of Performance.* Road Research Group; Organization for Economic Cooperation and Development, Oct. 1980.
8. Giannopoulos, G. A. *Bus Planning and Operation in Urban Areas: A Practical Guide.* Gower Publishing Company Limited, Aldershot, England, 1989.

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