DIAL-A-RIDE DEMONSTRATION IN HADDONFIELD: PLANNING AND INITIAL OPERATION

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The objectives of this paper are to describe some of the results of the household survey conducted in the Haddonfield, New Jersey, area by the MITRE Corporation before the dial-a-ride (DAR) demonstration project started; to indicate how some of these survey results were used in reaching decisions concerning the initial operating parameters; and to give some of the initial operating results of the demonstration.

The survey was conducted in October 1971 in 4 Camden County communities: Haddonfield, Barrington, Lawnside, and part of Cherry Hill township. The communities are located about 7 miles east of Philadelphia and are linked to Philadelphia by a high-speed rail facility, the Lindenwold Line; a station is located in Haddonfield. The surveyed area has a population of about 33,000 people. Interviews were conducted in about 500 of the 10,000 households. Socioeconomic characteristics of the surveyed communities are given in Table 1.

The objectives of the survey were (a) to measure trip characteristics in the initial service area (i.e., where people went on local trips, how many trips were made, and which modes were used); (b) to determine modal split and characteristics, such as travel time and cost (information concerning modal attributes and their ratings was used to develop a model to forecast demand for DAR); (c) to assess reactions to DAR; and (d) to obtain data that could be used to establish initial DAR operating parameters.

SURVEY RESULTS

Trips

The distribution of work locations is as follows:

Location	Percent
Home	6
Within service area	9
Outside service area	
Use Lindenwold Line	13
Do not use Lindenwold Line	72

The following modes are used for work trips:

Mode	Percent
Use Lindenwold Line	
Use automobile to get to station	78
Walk to station	18
Take bus or taxi to station	4
Do not use Lindenwold Line	
Use automobile	85
Walk or take bus or taxi	15

Table 1. Socioeconomic characteristics.

Item	Haddonfield	Cherry Hill	Barrington	Lawnside	All
Population	13,118	8,646	8,422	2,757	32,943
Black population, percent	1.7	0.5	1.3	90.4	9.0
Area, square miles	3.3	2.5	1.6	1.5	8.9
Households	4,345	2,648	2,484	669	10,146
Mean income/1966 IRS return, dollars	10,365	9,819	6,977	5,410	–
Automobiles/household	1.5	1.7	1.4	1.4	1.5
Workers/household	1.1	1.4	1.2	1.3	1.2
Licensed drivers/household	1.9	2.1	1.8	1.9	1.9
Persons/household	3.1	3.6	3.4	4.0	3.2

Of the estimated 47,630 round trips made to work each week, it is estimated that 15,400 can be made completely or partially via DAR. The remainder of these trips are to destinations that cannot be served by DAR or by DAR combined with other public transportation.

For nonwork trips, 92 percent of the trips within the survey area and 97 percent of the trips to Cherry Hill Mall, a large regional shopping center about 3 miles north of downtown Haddonfield, were made via automobile.

For those people who use the Lindenwold Line, distributions of modal attributes for existing work trips were obtained. It was felt that practically all of these trips could be diverted to DAR. Time and cost of work and nonwork trips by automobile and ratings of modal attributes are given in Table 2. Comfort, convenience, and reliability were measured by the use of the semantic differential. Respondents were asked to rate the mode on a scale from 1 (very uncomfortable) to 7 (very comfortable).

Importance Ratings

After attribute values were obtained, respondents were then asked to rate the importance of these attributes. The importance ratings obtained generally agree with the results of other such studies. People in 250 of the households surveyed were asked to rate the importance of these attributes for work trips, and people in the other 250 households were asked to rate the importance of these attributes for nonwork trips. Results are given in Table 3. Both groups rated trip cost as being least important and reliability as being most important.

User Reaction to DAR

About half-way through the interview, respondents were given a description of DAR and asked whether they could use the service. As expected, 75 percent of the people who currently use the Lindenwold Line for work trips stated that they could use DAR for trips to the station. Of those people who were not using the Lindenwold Line, however, only 25 percent thought they could use DAR. Most of these people stated that DAR, either by itself or in combination with another mode could not take them to their work destinations because they were outside of the envisioned service area. (Of those interviewed, 72 percent did not use the Lindenwold Line.)

Based on the current volume of work trips made in the service area and on the reactions to DAR obtained in the survey, it is estimated that about 3,000 round trips a day could be diverted to DAR. This

Table 2. Time, cost, and attribute rating for automobile mode.

Type of Trip	Time (min)	Round-Trip Cost (cents)	Rating		
			Comfort	Convenience	Reliability
Work trips					
To station	7.4	35	6.0	6.3	6.4
Nonwork trips					
Within survey area	9.2	48	6.3	6.2	6.4
To Cherry Hill Mall	17.2	65	6.3	6.1	6.3

Table 3. Mean attribute rating for existing modes.

Attribute	Work Trips	Nonwork Trips
Time	6.1	5.2
Cost	4.8	4.7
Comfort	5.7	5.3
Convenience	6.3	6.2
Reliability	6.6	6.4

is the maximum size of the work-trip market, and it is not expected that this trip volume will be achieved.

About half of the households surveyed indicated that they would make additional trips if DAR were available. The mean number of additional trips per household was 2.0. Information concerning the amount of latent demand that actually is being satisfied by DAR will be obtained in future on-board surveys.

The most frequent reason given (42 percent) by those who thought they could not use DAR was that trip destinations were outside of the proposed service area. Thirty-six percent of those who did think that they would use DAR stated that they were satisfied with their current mode (usually the automobile).

Those respondents who thought that they would use DAR were then asked to indicate a reasonable fare, travel time, and waiting time for various types of trips. The mean for work and nonwork trips is as follows:

Item	Work	Nonwork
1-way fare, cents	25	49
Travel time, min	12.5	13.3
Wait time, min		15.0

These values were considered in establishing initial fares and times.

About 10 percent of the people living in the service area are aged 65 and older. For persons in this category, respondents indicated mean fares to be 53 cents for those under age 65 and 41 cents for those over age 65. The randomization test for 2 independent samples revealed that these distributions were significantly different at the 0.05 level. For this reason, the DAR fare for older citizens was set 10 cents lower (40 cents versus 50 cents) than fares for other people.

Respondents were also asked to rank the relative importance of various DAR attributes for work and nonwork trips (Table 4). Fare is ranked quite high for DAR but was ranked as being the least important for existing modes. Thus, there may be some inconsistencies in people's thinking with respect to their attitudes toward the cost of various modes.

Table 4. Mean attribute rankings for DAR.

Attribute	Work Trips	Nonwork Trips
Waiting time	1.7	2.1
Fare	2.8	2.5
Door-to-door service	2.8	2.5
Travel time	3.1	3.4
Comfort of vehicle	4.7	4.4
Attractiveness	5.8	5.8

Initial DAR Attributes

Partially as a result of the household survey, the initial DAR service area was established in all of Haddonfield, that part of Cherry Hill Township that was surveyed, and those parts of Barrington and Lawnside that are north of Interstate 295. Although it is somewhat smaller than the survey area, this initial service area is about 5.4 square miles in size and contains 8,200 households. In addition, several local shopping malls lying at or beyond the perimeter of the service area are also served by DAR. Respondents in the household survey expressed a strong interest in having DAR service to these shopping areas.

Based on survey data, initial DAR fares and times were set as follows:

Item	Amount
Fare, cents	
Cash	60
10-ticket book	50
Persons over 65	40

Item	Amount
Fare, cents	
Children	None
Travel time, min	10 to 15
Wait time, min	10 to 20

INITIAL OPERATING RESULTS

Ridership

Figure 1 shows weekly ridership during the 11-week period since service began on May 15. DAR has served 27,435 passengers during this period.

Figure 2 shows average ridership on weekdays, Saturdays, and Sundays. The average number of weekday riders was 495 during this period; the peak was 580 passengers on June 23. The greatest number of riders was generally carried on Fridays, and the lowest number was carried on Sundays. Saturday ridership exceeded the average for weekdays during the first week of operation and again during the week ending June 11, when it reached a daily peak of 402 passengers. Since that time, Saturday ridership has leveled off somewhat, with a mean of 297 passengers per day. Sunday ridership during the 11-week period has remained relatively constant, increasing from a low of 92 passengers per day during the first week of operation to a mean of 136 passengers per day for the period from June 11 to July 30.

The hourly ridership on a typical weekday is shown in Figure 3. (Data shown in Figures 3 through 9 were obtained on 5 weekdays: June 8 and 16 and July 10, 18, and 26.) Trips between 9 a.m. and 4 p.m. account for 45 percent of the daily total. About 20 percent of daily trips are made between 4 and 7 p.m., and about 7 percent are made between 7 and 9 a.m. The last percentage may be low because

Figure 1. Weekly ridership (May 21 to July 28, 1972).

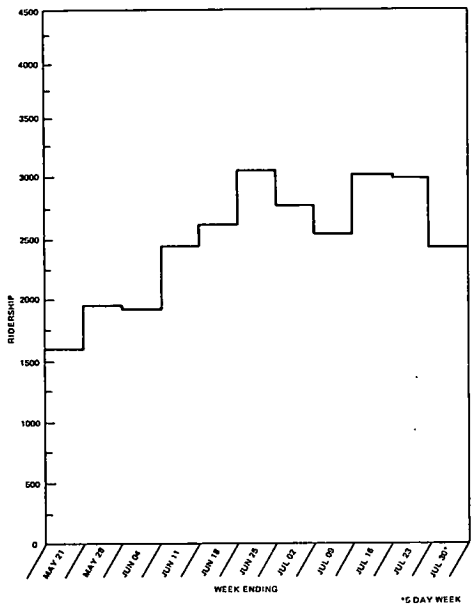


Figure 2. Average ridership on weekdays, Saturdays, and Sundays (May 21 to July 28, 1972).

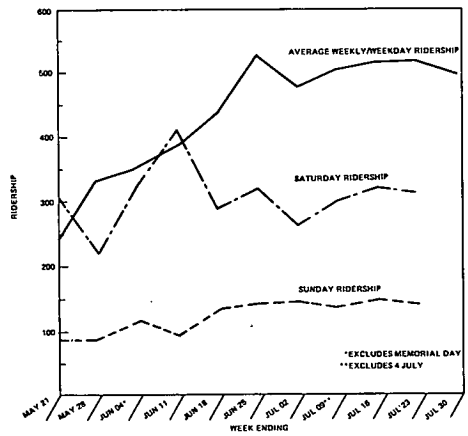
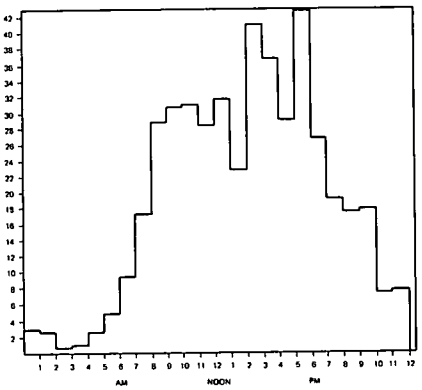


Figure 3. Average number of riders.



many service area residents live within walking distance of the station or because those who travel to the station by automobile have not yet changed their commuting habits.

The average number of riders, standard deviations, and percentage of weekly total from June 19, 1972, through July 30, 1972, (excluding July 4) are given in Table 5.

Vehicle Productivity

Vehicle productivity is defined as the number of requests received per vehicle per hour or day. It depends on the number of requests for service received and the number of vehicles available to service these requests. Vehicle productivity, however, should not be viewed as the only measure of system performance.

For a given demand rate, a large number of vehicles in operation will result in both a relatively low vehicle productivity and a high quality of service because waiting and riding times will be short. As the number of operating vehicles is reduced, productivity will increase, because each vehicle will carry more passengers, and quality of service will decrease, because there will be fewer vehicles to service customer requests.

Average hourly weekday vehicle distribution and average hourly vehicle productivity are shown in Figures 4 and 5. During the first 11 weeks, the number of requests for service was low with respect to the number of vehicles in operation. Consequently, the average productivity was 4.09 passengers per vehicle-hour. One reason for this is the experimental nature of the project. Another is that the hourly vehicle distribution during a 24-hour period was based on the typical hourly transit demand

Table 5. Average ridership and standard deviation by day of week.

Day	Mean	Standard Deviation	Percent of Weekly Total
Monday	446.3	26.26	15.19
Tuesday	491.8	48.23	16.73
Wednesday	525.7	34.78	17.89
Thursday	512.8	36.61	17.45
Friday	528.3	27.65	17.98
Saturday	299.3	21.44	10.18
Sunday	134.7	9.65	4.58
Total	2,938.9		100.00

Figure 4. Average number of vehicles in use.

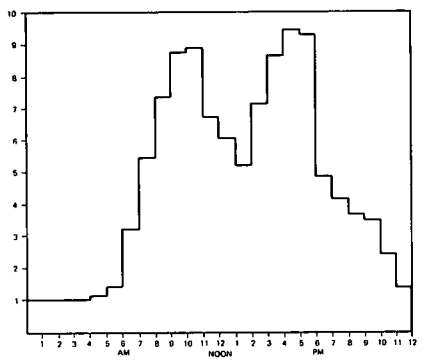
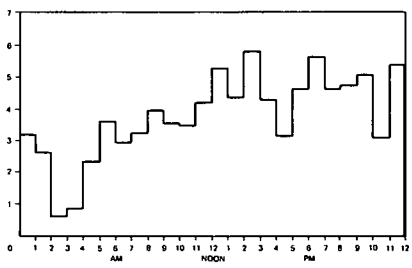


Figure 5. Average vehicle productivity.



distribution, and this has not been the case.

Productivity on a typical weekday between 5 and 11 a.m. reflects the relatively small use being made of dial-a-ride by commuters and the relatively high number of vehicles in service. Productivity between 11 a.m. and 4 p. m. is above average because the vehicle supply dips during this period and ridership continues to rise. Between 4 and 5 p.m. productivity dips sharply but then rises and remains above average from 5 to 10 p.m., reflecting a fairly good fit between vehicle supply and requests for service. A better match between supply and demand in the other hours of the day is expected after the driver rebid in September 1972.

Average hourly ridership, vehicles in service, and vehicle productivity by period of the day for the 5 representative weekdays are given in Table 6. Vehicle productivity is highest in the 2 off-peak periods—9 a.m. to 4 p.m. and 7 to 11 p.m.—reflecting the nonwork trip use that dial-a-ride is receiving in these periods.

Table 6. Average ridership, vehicles in service, and productivity by time period.

Period	Riders	Vehicles in Service	Productivity
7:01 a.m. to 9:00 a.m.	23.00	6.35	3.62
9:01 a.m. to 4:00 p.m.	31.54	7.30	4.32
4:01 p.m. to 7:00 p.m.	32.73	7.83	4.18
7:01 p.m. to 11:00 p.m.	15.40	3.45	4.46
11:01 p.m. to 7:00 a.m.	3.97	1.39	2.86

Quality of Service

The quality of service greatly influences the number of riders attracted to dial-a-ride. Although quality of service may connote a combination of factors, it is considered here to consist only of time—average wait time, pickup time deviation, and ride time.

Three types of dial-a-ride trips are offered: immediate, deferred, and periodic. An immediate trip is one that the passenger wants to start as soon as possible. A deferred trip is one that the passenger wants to start at some specified time in the future. A periodic trip is one that is made regularly, at the same time, to the same destination, on the same day or days of the week. One telephone call initiates periodic service.

Wait time is the time elapsing from the end of the telephone call requesting service to the time the vehicle arrives to pick up the customer. Of the three types of trips serviced by dial-a-ride, wait time is a measure of quality of service for immediate trips only. Three factors contribute to the average weekday wait time of 12.64 min (Fig. 6). The first is the time required to execute the control room procedures, i.e., assigning the trip to a vehicle, notifying the driver of the location of the pickup, and recording data. The second factor is the time required for the vehicle to travel from its current location to the pickup point. A third factor is a delay by the passenger who is not ready when the vehicle arrives.

Beginning with the early morning hours,

Figure 6. Average wait time.

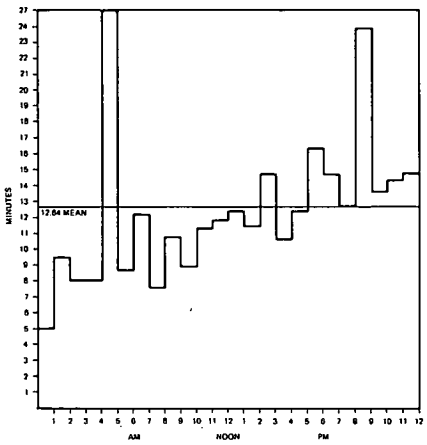
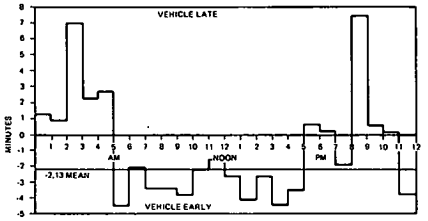


Figure 7. Average pickup time deviation.



the mean wait time gradually increases as the number of requests for service increases and reaches a maximum of 16.5 min during the 3 to 7 p.m. peak period. The relatively high wait times from 4 to 5 a.m. and 8 to 9 p.m. are not typical because on the days sampled very few trips were made during these periods.

Pickup time deviation is the difference between the pickup time promised to the passenger at the time the trip is requested and the actual pickup time. Unlike wait time, pickup time deviation can be measured for immediate, deferred, and periodic trips.

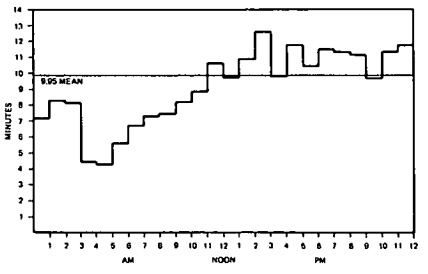
Figure 7 shows that the mean pickup time deviation is -2.13 min, indicating that on the average vehicles arrive about 2 min earlier than promised. This deviation, which usually falls within a narrow range from -4.5 to + 3.0 min, is desirable because customers are not likely to be satisfied with the service if vehicles arrive excessively early or late.

Of the 4 factors that contribute to the pickup time deviation, 3 are the same as those that contribute to wait time. The fourth is the accuracy with which the control room staff estimates the promised pickup time. This estimation process takes into account the average pickup time deviation of the previous half hour, the number of buses available, and the location of the origin of the current trip.

Ride time is the time the passenger rides on the vehicle from pickup to delivery. The average weekday ride time of 9.95 min (Fig. 8) is close to the average automobile ride time of 9 min and implies that passengers usually travel directly from origin to destination.

As with the mean wait time, the mean ride time increases on an hourly basis until peak ridership is reached during the midday period. At this point, the ride time reaches and remains at a level of

Figure 8. Average ride time.



about 11.5 min. Consequently, between 2 and 7 p.m. when the greatest number of passengers are carried, the typical dial-a-ride trip will take about 24 min (13 min wait time and 11 min ride time).

Table 7 gives average wait and ride times and average pickup time deviations by period of the day for the days sampled. As the day progresses and ridership increases, the average wait and ride times also increase. As vehicle productivity (requests per vehicle per hour) increases, so do the average wait and ride times because each vehicle will have more passengers to pick up and drop off.

The relation between vehicle productivity and unit-ride time is shown in Figure 9. The data show that, as the day progresses and ridership increases, both vehicle productivity and customer wait and ride times also increase.

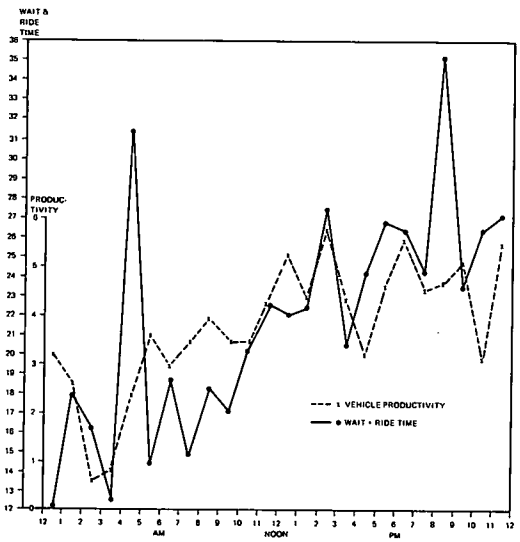
The correlation between the sum of wait and ride times and the vehicle productivity was found to be +0.52. That is sufficiently high to indicate that a statistically significant positive correlation exists between these 2 variables. When one is plotted against the other, it is found that the regression equation describing the relation is

$$\text{Wait time + ride time} = 12.89 + [2.83 \times \text{vehicle productivity}]$$

Table 7. Average wait and ride times and pickup time deviations by time period.

Period	Wait Time	Ride Time	Pickup Time Deviation
7:01 a.m. to 9:00 a.m.	9.86	7.29	-3.39
9:01 a.m. to 4:00 p.m.	12.98	10.15	-3.07
4:01 p.m. to 7:00 p.m.	14.29	11.36	-1.11
7:01 p.m. to 11:00 p.m.	16.26	10.86	+1.61
11:01 p.m. to 7:00 a.m.	15.76	8.02	-1.75

Figure 9. Average wait and ride times and vehicle productivity.



Thus, if vehicle productivity is 4.0, then average wait and ride times will be 24.21 min. Indeed, when actual vehicle productivities average about 4.0, the actual wait and ride times are about 24 min.

SUMMARY

As of August 1972, dial-a-ride vehicles in the Haddonfield area carried more than 3,000 one-way trips per week and between 500 and 600 per day. This does not represent a steady-state demand level because usage of the system has been steadily increasing since the demonstration project began. The most notable feature of demand for DAR has been the relatively high usage made of the system during the off-peak periods for many-to-many nonwork trips.

The household survey provided a great

deal of information concerning the attitudes toward and preferences of potential DAR users. Through this survey, residents of the service area had a voice in the selection of system operational parameters. The 60-cent cash fare, reduced rates for senior citizens and for those purchasing books of tickets, service to local shopping areas, 15-min average wait time and 10-min average ride time are all based on statements of survey respondents regarding dial-a-ride attributes that they preferred or felt were reasonable. As far as possible, the service has been designed to meet the needs of those whom it serves.