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Dial-A-Ride: Opportunity for Managerial Control

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Competent management requires the ability to perceive problems, the ability to conceptualize solutions, and the skill to communicate both the problem and the solution to those responsible for carrying out management directives. It also requires that managers infuse the issue with a sense of urgency so that the solution is implemented. For the most part, public transit has not been managed by these objectives. Rather transit management has been totally absorbed with service, maintenance, and escalating costs. Policy decisions in public transit are often based on inadequate, outdated, or incomplete information or have come too late to reverse system inefficiency. Costs rise, the level of service falls, and patronage drops to levels so low that many operations are in desperate financial situations. And yet transit systems continue to be managed by heirarchical control. Effective management through the control of information flow will reverse this trend. Dial-a-ride transit, with its capability of providing real-time information about system status, is an ideal medium in which innovative management techniques can be tested. This paper explores the opportunities dial-a-ride offers for developing innovative systems for the management, control, and interpretation of information and outlines information flow techniques that can be useful in the optimization of system efficiency.

Dial-a-ride, dial-a-bus, telebus, call-a-bus, demand jitney, computer-aided-routing system, call-a-ride—these are all names for demand-responsive bus systems (1).

The concept combines the door-to-door convenience of the taxi ride with the economics of bus service to create a new approach to transit. The characteristics of this type of service have been adequately described elsewhere, and the achievements of dial-a-ride in Orange County have been outlined (2). Dial-a-ride is a financially feasible system of local public transportation both as a pickup and delivery system in low-density suburban areas and as a tributary system for fixed-route buses on arterial highways. All transportation modes can be integrated with dial-a-ride; this flexibility has prompted the Orange County Transit District to begin planning for the expansion of dial-a-ride from the present experimental unit to 12 or 15 "modules" and 180 vehicles during the next 4 years.

Dial-a-ride is most often proposed as a method of improving the level of service provided by transportation agencies. The large dial-a-ride system planned for Orange County would indeed achieve this goal. However, the potential that dial-a-ride has for improving the management and control of transit organizations has not been previously considered. Moreover, innovative techniques of management may be critical to the ultimate success of such a system.

The emphasis in this paper is on the elements of organizational theory that can make management of public transit more responsive to public needs, more efficient through the control of communication, and more satisfying for employees by establishing reasonable performance goals and allowing them the satisfaction of achieving these goals.

Public transportation is a labor-intensive enterprise, yet too little attention is paid to the enhancement of the individual dignity of operators, whether they be bus drivers, trainmen, or those who help them. Operators are the primary means of public liaison; unless methods are developed that facilitate the development of favorable attitudes toward the traveling public and the sharing with them of management's enthusiasm for the improvement of transit service, then expenditures for capital equipment and a promotional campaign will not benefit service.

Managers of public transit enterprises face a twin dilemma: There are neither widely accepted, explicit goals to attain nor a tangible, identifiable product. Interest groups expect different kinds of achievement: Senior Americans desire ubiquitous service, but they and low-income families expect this service to be paid for from the fare-box rather than by taxes; members of upper income families approve of subsidy payments for commuter service to reduce highway congestion; and transit employees desire security and job satisfaction. Transit enjoys widespread public support, but the reasons for this support differ and are often contradictory. In fact, the highest level of support comes from those least likely to use public transit (3). Furthermore, how can the attitude of people who use and operate the service be changed so that they will express more positive attitudes toward public transit? It is those people, the low- to middle-income blue-collar workers who make limited use of transit and sometimes rely on the system for their livelihood, who defeat transit funding issues (4).

And how can the causes for these negative attitudes be detected early enough for management to recognize that problems exist, to examine the symptoms, and to implement solutions?

Service is the product of transit, but the quality is difficult to measure. Patronage, passengers per mile, operating deficit, and cost per mile are all used to measure effectiveness, but they are weak indicators of the level of consumer satisfaction. They are merely statistics gathered each month; they have meaning for other transit operators, but tell little about the quality of service. More often than not, they are indicators of the numbers of people who have no other choice than to use public transit.

An additional deficiency of these operational statistics is that they do not provide early indicators of service failures. Patrons are lost before management realizes that buses are too crowded, uncomfortable, or not going to the right places or that drivers are surly because they cannot maintain schedules. So many of the problems that deter the public from using public transit result from management's inability to deal with operational problems and to transform public transit into a pleasant experience.

Managing public transit is like managing a restaurant. The quality of the food, like the comfort of the vehicle, is important, but it is also the quality of service that causes patrons to return. The performance of employees who meet the patrons is of critical importance, but the methods available for encouraging and rewarding employees for superior service have not been accentuated.

When definitive goals for an organization cannot be established and when there is no tangible product whose quality can be assessed, it is difficult to improve organizational performance. But monitoring and improving the communication system within the organization can afford the transit manager with a means of controlling and improving the organization.

COMMUNICATIONS

Improvement of communications within an organization can achieve 3 purposes.

1. It can promote harmony by facilitating the sharing of organization goals among all employees, even though these goals may be poorly defined.
2. It can generate favorable opinions toward the organization by employees.
3. It can serve as a feedback mechanism to judge whether desired changes are occurring in response to new managerial directives.

Improving communications within transit organizations is not a simple task. They tend to be large organizations; and the larger they are, the more complex the communication system is. In addition, transit organizations are heirarchically structured. A few in top management attempt to control many operators through foremen and supervisors. Usually communication is from the top down, and little effort is made to monitor feedback. Yet feedback can be critical to making an accurate assessment of system performance.

For the most part, large transit organizations are uncontrolled; they may even be uncontrollable. Operators do not share the aspirations of management; there is often hostility between them for which the passenger suffers, and there is little attention given to developing a feedback system even when genuine attempts are made to improve communications between top management and operators.

Dial-a-ride is a means whereby the communication system can be improved and the level of bus service in communities can be increased. It provides public transit that is built on a 2-way communication system. Furthermore, it is a communication system that management can control.

The flow of information in complex organizations is critical to the attainment of system efficiency. However, many transit administrators have failed to maintain effective lines of communication as their organizations have increased in size. The input-output sequence in dial-a-ride, involving an orderly progression of easily monitored events, provides an excellent medium for examining methods by which information flow can be improved.

Dial-a-ride is a public transportation system made up of a fleet of small vehicles that are radio dispatched. The vehicles operate on city streets with a flexible schedule, responding to requests for transportation as they are received by a central dispatcher. The dispatcher-scheduler combines customer information regarding location, number of riders, and desired pickup time with information regarding vehicle positions, tentative routes, and trip characteristics of other passengers. Using preplanned scheduling and dispatching procedures and a radio communication link to a fleet of small buses, the dispatcher assigns a vehicle to pick up and deliver each customer from origin to destination. The customer is advised of the expected pickup time and, perhaps, the fare and then waits until the vehicle arrives.

A large metal-backed map and magnetic pieces are used in a control center. The magnetic pieces hold trip tickets containing customer trip data—different pieces denoting origins and destinations. When a trip is assigned, colored markers corresponding to the vehicle are placed on both pieces. These markers also serve as pointers to the vehicle's next stop and effectively trace out a tentative route for each vehicle.

When the bus arrives at a stop, the driver notifies the control center, which updates the bus position on the map and in turn notifies the driver of the next stop. The map, therefore, represents quite accurately the true state of the system, i.e., vehicle position, customers on-board, and customers waiting. Given this full view of the system, the control staff can alter tentative routes as necessary to accommodate new trip requests (5).

This orderly process of operation is extended to evaluation of the system. A significant amount of information is available about a number of variables related to the level of service the system is offering.

Most of these variables relate to the measure of time as an indicator of system efficiency. Four means of service quality are used (5, p. 10). Data are derived from time stamps on tickets at the time the call is received, the pickup and delivery times, and the dispatcher's estimate of wait time.

1. Customer wait time is the elapsed time between the receipt of a customer's request for service and the boarding of the vehicle by the customer. (In La Habra, this averages 15 to 20 minutes during off-peaks and as much as 30 to 40 minutes during peaks.)
2. Customer ride time is the elapsed time between boarding and exiting of a vehicle by a customer. (Average travel time in La Habra is 11 minutes.)
3. Level of service is the ratio of customer wait plus ride time to the corresponding automobile travel time for the same trip.
4. Pickup time deviation is the difference between the actual arrival time at a customer's origin and the expected arrival time quoted to the customer when the trip was requested. (In La Habra, actual pickup time averages 2.2 minutes earlier than promised.)

Other methods of determining system efficiency involve comparative analyses between the level of service of dial-a-ride and that of competing modes, in particular the automobile.

LEVEL OF SERVICE AND SYSTEM EFFICIENCY

A key to analyzing the efficiency of dial-a-ride service is to determine its level of service. One way of measuring level of service is to determine the ratio of wait time plus trip length on dial-a-ride to an estimate of the time the same trip would take in an automobile. Dial-a-ride systems normally operate at a ratio of about 3:1; the La Habra system normally operates at this ratio (for example, a 10-minute automobile trip would take 30 minutes on dial-a-ride). A ratio of 3:1 may be considered acceptable. However, assessing the efficiency of a dial-a-ride system solely in terms of level of service can be misleading. Level of service is relatively insensitive to absolute differences in dial-a-ride and automobile trip times, whereas potential users are not likely to be so insensitive. For example, if the dial-a-ride travel time were 5 minutes and corresponding automobile travel time were 1 minute, the resulting level of service of 5 would be acceptable to many users, for the absolute difference is only 4 minutes. If, however, the respective times were increased to 50 minutes and 10 minutes, the level of service would remain at 5, but the absolute time difference would be 40 minutes, which could well be unacceptable to many dial-a-ride users (5, p. 12). Consequently, other variables must also be taken into consideration.

The key factor is wait time (the elapsed time from phone call to actual pickup). In an average system, dial-a-ride wait times are normally 15 to 30 minutes, and travel time may average 11 minutes (as in La Habra). This will vary, depending on time of day, number of vehicles in service, and weather. Under unusual circumstances, wait time can range from 5 minutes (a bus happens to be on the same street when the request for service is received) to an hour (it is a rainy day, or the call was made during the peak period). A reasonable wait time is 20 minutes, and riders who call well in advance of their desired pickup times are usually picked up 1 to 5 minutes prior to the time promised.

Previous analyses have yielded relations between quality of service, demand rate, vehicle supply, and area size (6, 7). For a dial-a-ride system operating in a contiguous service area, the expected effect on wait time plus ride time of changes in area, fleet size, and demand is expressed by

$$T = 2.2\sqrt{A}\left\{1 + \left[\frac{A(0.82 + 0.087D)}{N}\right]^2\right\} \tag{1}$$

where T is the dial-a-ride wait plus ride time, in minutes; A is the size of a square service area, in square miles; D is the demand density rate in terms of trips per square mile per hour; and N is the number of vehicles in service. (The assumption is that trips randomly arrive on time with ends uniformly distributed in the service area. The factor $2.2\sqrt{A}$ represents the automobile, or direct, travel time required to make a trip of average length in the service area at a speed of 15 mph.) Thus, for a given number of vehicles, wait plus ride time varies essentially as the square of demand density rate and the 2.5 power of area.

There are various means by which level of service for any area can be established through negotiation among labor, management, and the public. Improved service can be achieved through increasing labor and capital investment, and lower fares can be charged if the public is willing to accept a lower level of service. But once a level of service is established as a goal, and agreed to by all parties, then there is an objective against which management can assess performance. Any deviation is immediately revealed to both operators and management.

Evaluation is assisted when there are several dial-a-ride modules in operation. Comparative analyses of modules reveal opportunities for systemwide improvement.

SYSTEM PRODUCTIVITY

An important measure in assessing the economic characteristics of a public transportation system is system (or vehicle) productivity, defined here in terms of passengers per vehicle-hour.

In a dial-a-ride system, the upper limits on vehicle productivity are considerably lower than in a fixed-route and fixed-schedule system. In the latter, any increase in demand that does not cause the vehicle capacity to be exceeded causes only a slight delay at a stop and a near linear increase in vehicle productivity (5, p. 13). In a dial-a-ride system, however, each additional user typically generates not only additional vehicle stops, but additional diversions to the stops as well. The effect on vehicle productivity is, therefore, considerably more severe (1, p. 5).

The impact of additional demand is easily assessed in dial-a-ride. Because trip tickets are produced for each demand, documented material for analysis is readily available. The trip ticket, listing origin, destination, number of riders, and estimated pickup time, provides a thorough record of areas where demand is greatest (or minimal). Furthermore, time-stamping of the ticket when the ride request is placed and when the pickup and delivery is made provides continual information to the manager about variations in level of service, vehicle productivity, and employee efficiency (e.g., how well a dispatcher estimates wait time and how well a driver can keep to the schedule). Because a wealth of information is available to the analyst, a high level of system efficiency is much easier to maintain. Real-time information is available to management about the efficiency of the system, and comparative analyses of various parameters of level of service (vehicle productivity versus peak-demand periods versus wait and ride time) can be used to adjust the system operation. Here, the utility of an effective communication and information system is a key to efficient management and control.

For example, the La Habra dial-a-ride operates at 5 to 7 passengers per vehicle-hour, but productivity varies greatly throughout the day. Productivity peaks between 7 and 9 a.m. and again between 2 and 4 p.m. at about 7 passengers/vehicle-hour.

When the actual is compared to the theoretical by using Eq. 1 to solve for productivity, $V = DA/N$, and the average wait time, ride time, and density rates encountered in La Habra, the result is 5.67 passengers/vehicle-hour. This corresponds fairly well with the 5 to 7 passengers/vehicle-hour actually achieved. Thus, the use of dial-a-ride theory, when combined with empirical knowledge of system or service area characteristics and the data base inherent to dial-a-ride, can provide the manager with a sound basis for decision-making.

Realistic and identifiable system goals (such as a level-of-service ratio of 3:1 and a system productivity factor of 7 to 10 passengers/vehicle-hour) can be established. Constraints on the system such as vehicles/square mile, available manpower, costs, and geographic and demographic characteristics and a real-time data base can be combined to result in the setting of realistic goals that can be defined and given to employees as an incentive to work toward increased efficiency (5, p. 21).

Two factors often compared when transit is planned and its success is assessed are potential or real demand and actual use (patronage).

A common experience in transit is to develop a system in response to public outcries for service only to be astonished at how little the system is used. Marketing considerations aside, the key here is perceptions of service versus the realities of operation. An interest group or city may support the formation of a transit system only to find that a fixed-route, fixed-schedule operation has fallen short of expectations in terms of frequency of service, route alignment, or, simply stated, "taking me when and where I want to go."

Dial-a-ride can respond to this problem—indeed it can avoid the problem altogether—because of the characteristic flexibility in routing and scheduling of a demand-activated system. The only constraints to the innate responsiveness of dial-a-ride are at the managerial level. Given an adequate and reliable fleet, a well-trained labor force, and an adequate operating budget, the responsibility for providing a high level of service rests with how well decisions are made, based on analyses of trip information. Awareness of characteristics of the service area, both geographically and demographically, is also critical. When are the peak periods of demand? Who rides? Where are they going? What is the effect of weather on demand? Should seasonal variations in ridership be considered? Such questions must be answered if the dial-a-ride system is to be a responsive and efficient operation.

A profile of demand is readily available from the record of the trip requests. This profile can be used by management to forecast demand and schedule labor and equipment. Variations in demand can be detected as trip requests exceed anticipated requests, and changes in operation can be broadcast to drivers so that the additional demand can be accommodated. Similarly, if demand is slack, drivers can be diverted to trip-generating areas where the presence of the bus often stimulates demand.

Dial-a-ride can provide information on trips (via tickets) and the characteristics of users and their desires (via communication with drivers). Fixed-route operations do not have the luxury of this information flow, nor are they able to modify operations as easily to accommodate change.

COMPUTER CONTROL

In a small system with less than 12 buses and approximately 50 demands/hour, receiving calls for service and scheduling and dispatching can be handled manually. But in a system of 15 or more buses and as many as 100 demands/hour, the decision-making capacity of the human mind can be exceeded.

Because of the economies of operating a large fleet from a single communication center, automated scheduling and dispatching techniques are attractive. Moreover, a well-refined computer program can make decisions with fewer errors; thus, the efficient use of person-hours and vehicles is maximized and a corresponding higher level of service to the user is provided.

The algorithms for such a system are being developed and tested at the Haddonfield, New Jersey, dial-a-ride demonstration project. But beyond its use in the scheduling and dispatching function, computerization can lead to a more efficient means of compiling and analyzing other system characteristics such as (a) real-time optimization of level-of-service variables (wait and ride time, vehicle productivity); (b) a storage-retrieval information format about fuel consumption, maintenance records, and other vehicle parameters; (c) vehicle-monitoring system in which the "vital signs" of vehicles can be monitored on an ongoing basis; and (d) a "vehicle locater" system tied to the dispatching processor for spontaneous interrogation of vehicle location and a consequent higher level of machine-made trip assignment.

In a single dial-a-ride module, these on-line monitoring characteristics are a luxury. However, when several dial-a-ride modules are integrated as a system, then computerized information files present an opportunity for real-time management of the transportation system.

The La Habra module was established as an experiment to determine costs of operations in Orange County and to enable the Transit District to adapt the techniques learned from the federal demonstration project in Haddonfield, New Jersey. The experiment has provided the district with considerable knowledge as well as operating records on which the costs of expansion can be estimated. During the next 4 years, a countywide dial-a-ride system will be developed incrementally to a fleet of 180 vehicles in 12 to 15 modules. A decision has not yet been made on computerized operation, but an opportunity exists to test in Orange County a medium-sized computerized dial-a-ride system that will integrate local dial-a-ride service with intercommunity bus routes operating on arterial highways. Operating statistics from each module could be interrogated from central control so that real-time management would be possible without interfering with the decentralized autonomy provided for the supervisors of each module. The control would exist through the records of the communications system rather than by personnel supervision. The following are key features of the integrated system:

1. Full integration of all transportation modes to maximize efficiency, provide a superior level of service, and demonstrate a fully integrated system of transit modes in a suburban area;
2. Door-to-door service anywhere in the developed area of the county for nearly a million people;
3. Innovative management by the Transit District of modules operated by both public and private organizations to maintain an incentive to provide a high level of service, to keep costs down, to ensure responsiveness to public needs, and to develop new techniques for controlling a highly refined transportation system;
4. New marketing strategies for increasing ridership of low mobility groups and for penetrating the automobile/commuter market;
5. More efficient use of existing rights-of-way and equipment to minimize costs and optimize present-day technologies;
6. "Transfer of technology" capabilities to develop dial-a-ride as a modular system that can be implemented in communities in need of transit services or new approaches to management and control; and
7. Reduction of pressing ecological and social problems such as excessive pollution, energy consumption, transportation network encroachment on land use, and low mobility of those without cars.

The foundation of the system would include 4 basic elements:

1. Community dial-a-ride services on 180 vehicles at 12 to 15 dial-a-ride nodes connected with the scheduled buses;
2. Intercommunity scheduled buses on both arterials and freeways, the latter stopping at park-ride lots, which will also be served by dial-a-ride;
3. Airport, heliport, commuter railroad, and other transportation modes integrated via the dial-a-ride mode; and
4. An information and control system using computers to provide real-time optimization, to automate dispatching to minimize passenger inconvenience, and to provide

management information for operations analyses and decision-making.

DECENTRALIZATION

Although a centralized system of communication and control is easily monitored, the inherent danger of a centrally controlled system of dial-a-ride modules is that the attributes of personal service that can be offered by transit are overlooked. To ensure that a close association develops between the operator and the patron requires that management of each module be decentralized.

The Orange County Transit District dial-a-ride program will be operated on a local community basis. Each dial-a-ride node will be independently operated, but its services will be integrated with contiguous dial-a-ride nodes and the fixed-route system. The involvement of the local community in dial-a-ride is critical to its success. These dial-a-ride modules can be operated for the district by local operators on a "franchise" basis. The district will provide the equipment, procedures, and supervision, and the local contractor will provide labor and facilities on a cost-plus-fee basis. Cab operators will be logical operating entities, for they have a labor pool and are familiar with the local area and with radio dispatching and scheduling techniques.

Another possibility for the locally based operator is city or interest group cooperatives. If labor can be trained on the job or be largely voluntary or locally subsidized, or all of these, the cost of operation to the district can be minimized to levels equal to or below that of the fixed-route operation.

By decentralizing control over labor and service while supervising and ensuring the overall integration of all dial-a-ride modules into a single, unified system, management can operate an efficient integrated transit system without the penalty of losing contact with the local community.

Module supervisors can operate a small system, maintain a close relation with drivers and dispatchers, and share the aspirations and feelings of staff. If the flow of information is as it should be, this feedback will flow upward for input into the management decision-making process. Another avenue for capturing the opinions of operators is through the resolution of problems that management perceives through comparisons of modules. District employees are freed from most labor-management conflicts and can place emphasis on correcting the causes of dissatisfaction rather than on relieving the symptoms.

A great many employees of large organizations are repelled by the idea that they can only be used to execute, within narrowly defined limits, the orders of management who alone can exercise judgment, imagination, and creativity (8). In transit the continuation of this philosophy has shut the door on a tremendous resource of human talent and alienated the operator on whom the success of public transit depends.

Communications technology can improve decentralization. It makes possible the designation of service areas and levels of performance that operators and management can agree to in advance. With the aid of the computer's storage and retrieval capabilities and the development of standardized formats of analysis, comparisons can be made of levels of service of various dial-a-ride nodes on a daily basis to determine segmental as well as systemwide efficiency. Deficiencies are readily apparent to operators when the modules are small and operators feel that they have a competitive interest in performance. Problems are often corrected through cooperation, and success is shared. Bonus payments can further aid learning through achievement.

Decentralized dial-a-ride modules stimulate communications between participants in the organization at the lowest level of heirarchy. If this communication network can emphasize the achievement of the performance goals established by top management, then a means of resolving the complex communications problems in large organizations is achieved. In this respect, dial-a-ride is as important a management technique as it is an innovation in public transit.

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