and operators making decisions daily on whether to try DRT services in their areas.

The method we devised was to synthesize the substantial array of available literature on DRT services into a state-of-the-art document and to validate the document prior to its dissemination at a workshop where experts (operators of DRT services) and local transit operators and planners would comment (page by page) on the accuracy and relevancy of the material to their needs. The workshop was jointly sponsored by DOT's UMTA and Technology Sharing Program, which is a part of the Office of Research and Development Policy. The report and its revisions were prepared by the Technology Sharing Office at the Transportation Systems Center in Cambridge, Massachusetts. The response both to the workshop validation method and to the document was positive. I mention the document for 2 reasons: (a) The document provided a source for many of the statistics that I used to profile the operating DRT services, and (b), and more important, many will undoubtedly find the document a useful tool in developing a feel for the DRT concept and its status as an operating service. We are currently preparing a supplement to this overview document dealing with vehicles and their operation in DRT services. Copies are free and available on request.

SUMMARY

Many DRT systems are operating, and many systems are being implemented every year. Those who plan and implement systems should understand the markets DRT can serve, tailor system design to those markets, and understand the funding consequences of the level-of-service and market decisions. At the Department of Transportation, we must ensure that the best and latest information is available for people to use in making decisions and that they know where to get that information.

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Every successful DRT program starts with an effective planning effort. DRT systems that have had serious difficulties started with planning deficiencies such as inaccurate demand forecasting or absence of a long-range economic plan. This paper discusses some of the key elements of DRT planning and identifies some common pitfalls.

APPROACH TO PLANNING

For planning to have the necessary depth and quality, management must make a commitment to it. This means that the people who do the planning must realize that planning is vitally important and that the plans they produce will receive proper attention, including a detailed review and personal critique by management. A degree of formality, at least to the point of full documentation of the plans, is essential for both communication to management and later assignment of implementation responsibilities. For a new DRT system, the planning is from the ground up and covers initial concept through routine operations. There are 3 fundamental items for achieving this.

1. Work statements are descriptions of every task that must be performed to accomplish the program objectives. The scope of each task is defined so that each is a complete "package" of work to be performed by a person or group within a specific time period and budget. Thus, the completion of a task is indicative that a certain "value" has been earned. In many instances, the completion of a task is marked by production of a deliverable item. Some tasks are the carrying out of further planning functions such as supply and demand estimates or organization plans; those planning tasks are discussed later in this paper.
2. Schedules and the tasks of the work statement laid out chronologically into a logical sequence of events. The schedule may be presented in the form of a bar chart or as a task interrelationship network (similar to a PERT chart). The network permits a careful evaluation of the logical progression of events, i.e., that each item needed for subsequent tasks is generated in earlier tasks.
3. Budgets contain the costs (or applications of funds) to accomplish the tasks and a schedule for the expenditures. The costs are estimated from existing DRT data, site data, vendor information, and experience. The status of each task is indicated by the relation of funds or person-hours expended to date versus those budgeted.

The work statements, schedules, and budgets are the basic planning items of any program. Figure 7 shows how the plans can be exhibited throughout the duration of the program. Periodic management meetings, reviews, tracking, and control of the program can be aided in this way.

In addition to the 3 basic planning items, other key elements must be incorporated for effective implementation and control.

1. The plans should be arranged to fall into natural phases. Each phase is, in effect, a complete program with a distinct start and end. Management can review progress and status near the end of each phase and decide whether it is satisfactory and, if not, what to do about it. The phases are arranged so that the financial exposure of earlier phases is far less than the exposure of subsequent phases. Thus, if major changes or cancellation is desired, the losses incurred are minimized.
2. Resources that must be considered include personnel, sources of funding, facilities and equipment, management, and intangibles such as political support. Various options and alternatives are possible and should be considered. For example, sources of funding can be federal, state, or local sources, fare-box revenues, or advertising income.
3. Contingency plans should be prepared for each element of the plan. For example, it is theoretically feasible to implement a DRT system in about 4 to 5 months after contractual authorization is received. Experience has shown, however, that a slippage of from 4 to 8 weeks usually occurs for several reasons including unavoidable late delivery of equipment such as vehicles and radios or delays in funding. Some of the principal pitfalls are discussed in more detail later in this paper.
4. The program should be controlled on the basis of work accomplished (i.e., earned values), costs incurred, and schedule. All 3 are vital, but they must be viewed together to obtain an accurate picture of the status of the program and to identify any potential problems that may be developing. The cost versus schedule and milestone chart shown in Figure 7 is a convenient visual tool to accomplish this. Accountability by specific persons, groups, or organizations for each task must be clearly defined in writing for effective control.

DEMAND ESTIMATES

Estimates of what the ridership will be are often the least precise elements of DRT planning because of the large number of factors that affect demand and the general lack of sufficiently accurate forecasting tools. For example, some key variables that affect ridership are fare, reliability, service level, and marketing. Important parameters describing the site are population density, service area, age, income, automobile

Figure 7. Management control system.

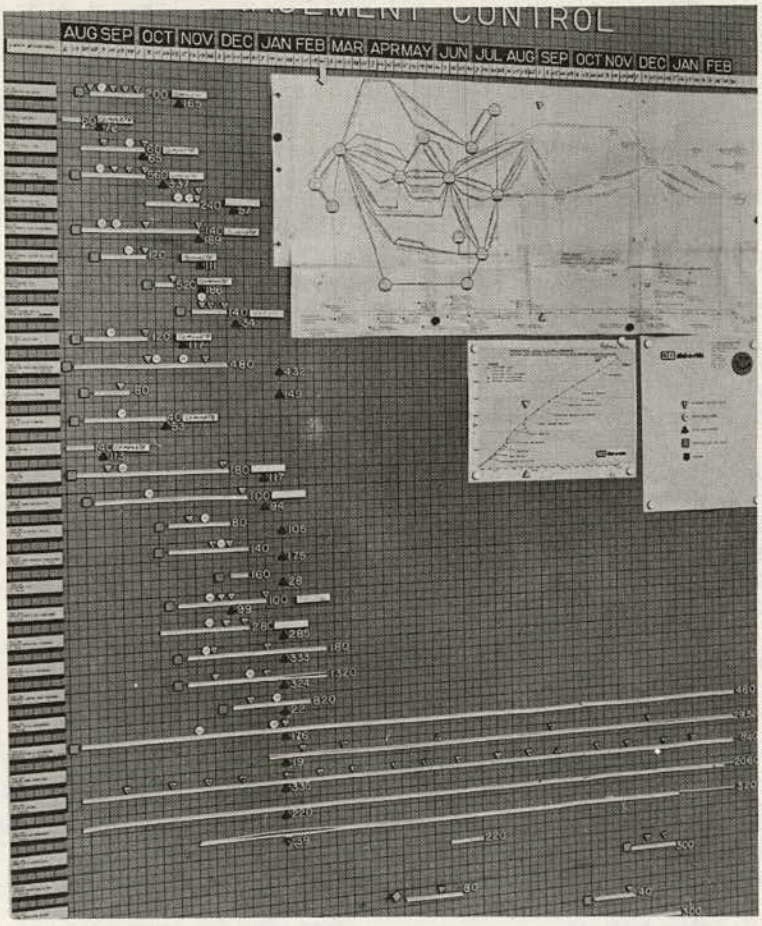

Figure 8. Demand forecast by sector model.

```
FARE = $0.50        SERVICE LEVEL = 4.5


DIAL-A-RIDE DAILY PATRONAGE:
  WORK INTERNAL   =    182.
  WORK EXTERNAL   =    319.
  OTHER INTERNAL  =   1057.
  OTHER EXTERNAL  =    201.
     TOTAL WORK   =    502.
     TOTAL OTHER  =   1258.
     TOTAL INT.   =   1239.
     TOTAL EXT.   =    520.
        TOTAL     =   1759.
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ownership, and external transit interfaces. Many other variables could be considered, but there is a practical limit to the complexity. Models have not yet been developed that consider all of these factors. Several worthwhile attempts, however, have been made to incorporate enough of the important factors to yield useful results (4).

A sector model has also been developed recently that accepts as input basic statistics usually available at any potential site such as service area, employment, students, and census data. If data on some details are not available, default values for the missing data are used. Modal-split factors as functions of fare and service are incorporated into the model. Outputs are in the form of internal and external work and nonwork DRT trips. One version of the sector model has been programmed to permit alternative operating conditions to be quickly explored; an example of the output is shown in Figure 8.

A word of caution is appropriate at this point. Simple extrapolation of ridership results from one DRT to another without a full consideration of subtle but important facets can lead to inappropriate system design and unsatisfactory operations. This has actually happened in regions where one or more DRT systems have been successful but other nearby implementations in the same city by the same people have run into ridership difficulties because of different ethnic and transit interface conditions.

SUPPLY ESTIMATES

DRT supply models are easier to develop and calibrate than demand models, and the results are more accurate. Some basic tools were developed at Massachusetts Institute of Technology (5) and have been calibrated from operating data at a number of sites. Input to supply models usually consists of the output ridership estimates from the demand model and service parameters such as hours of operation, types of DRT service, and level of service. An example of the prediction from a supply model in the form of a computer printout is shown in Figure 9.

Figure 9. Supply estimates.

DIAL-A-RIDE HOURLY PATRONAGE
BY TRIP TYPE AND PERIOD OF DAY
(ONE-WAY TRIPS/DAY)

	PERIOD OF DAY				
TRIP TYPE	7 AM-9 AM	9 AM-10 AM	10 AM-4 PM	4 PM-6 PM	6 PM-7 PM
INTERNAL	36.	56.	151.	74.	56.
EXTERNAL	64.	39.	29.	71.	39.
TOTAL	100.	95.	180.	145.	95.

DIAL-A-RIDE VEHICLES IN SERVICE
BY PERIOD OF DAY

	PERIOD OF DAY				
	7 AM-9 AM	9 AM-10 AM	10 AM-4 PM	4 PM-6 PM	6 PM-7 PM
VEHICLES	8	10	13	9	10

ANNUAL DIAL-A-RIDE PATRONAGE = 512349.
PEAK HOURLY PATRONAGE = 180.
PEAK VEHICLES IN SERVICE = 13
SPARE VEHICLES = 3
TOTAL FLEET SIZE = 16
ANNUAL VEHICLE-HOURS = 38438.
MEAN VEHICLE PRODUCTIVITY = 13.33

ECONOMIC PLANNING

The economics of DRT operations are determined primarily by the strategic objectives of the service and by personnel costs. The heart of the issue is the degree to which a DRT system is to meet the transit needs of those who cannot pay the actual costs of service but who urgently need some form of door-to-door transit versus the degree to which the operation should meet costs out of fare-box revenues. Those responsible for the program should tackle this issue at the earliest stage of planning, and clear-cut decisions should be well documented. Otherwise, the program will be plagued by lack of direction.

Cost of operating DRT is strongly dependent on the cost of labor, both direct and indirect, since DRT is labor intensive, accounting typically for more than 80 percent of total costs. Labor rates vary widely among locations, and both present rates and potential increases should be carefully evaluated during planning.

Total cost of DRT ranges from under $10 to more than $20 per vehicle-hour. Cost per trip varies from under $1 to more than $4. The lower costs usually occur in areas where the demand is high (e.g., where there is a significant commuter market) and where the labor rates are relatively low. The reverse usually applies for higher costs. No guidelines are available that will define simply what the costs will be for a new service. However, consideration of economic alternatives in the early stages of planning will permit choices to be made that could lead to costs at the low end of the ranges. If the alternatives are not explored, then higher costs could inadvertently become locked into the program.

Fares in most DRT systems are in the 25- to 50-cent range, a level at which recovery of costs from fare-box revenues cannot be achieved. (TSC and MITRE under UMTA contracts have investigated the economics of many of the existing DRT systems and have published the statistics in a number of reports.) A fare of $1 or more per trip is needed to achieve a breakeven point; this is evident from the profitable operation of shared-ride taxi services. However, this fare level is beyond the range established by the social objectives of most publicly financed DRT systems.

Planning the economic alternatives of operation involves the following: establishing the ranges of the variables acceptable from the viewpoint of the social objectives, using a demand model to determine ridership and revenues, using a supply model along with unit cost data to assess cost, and defining sources of subsidy. The process is iterative; i.e., with given variables of fare, level of service, type of service, labor rates, vehicle costs, and so on, the economics of operation are determined, and, if they are not acceptable, the process is repeated with new variables.

Start-up costs include procurement of vehicles, radios, control equipment, and other equipment and services to provide planning, design, and implementation. Capital grants for equipment can be obtained in many instances by a public organization on an 80 percent federal and 20 percent local basis from UMTA. Furthermore, highway funds can be diverted to provide the local share of the capital costs. The application for these funds usually requires a certain level of prior planning as defined in the UMTA guidelines. If a public organization contracts with a private operator, then it is expedient for the public organization to take advantage of the capital grants program and own the vehicles, leasing them at a nominal rate to the private operator.

Grants for operating subsidies are harder to obtain and are often not available unless the program qualifies in some special category. Furthermore, the grants are only to help to get the program started or to conduct research; long-term subsidies are not available. Some of the federal agencies that have made special DRT grants are the Department of Housing and Urban Development, UMTA, Department of Health, Education and Welfare, and Office of Economic Opportunity.

Operating subsidies are more often covered by local general funds, state sales and gasoline taxes, and property taxes. Operating subsidies for transit have been considered in the U.S. Congress, and citizens in many cities and counties voted in November 1974 on whether to raise local taxes for DRT.

TECHNOLOGY LEVEL

The level of technology needed for service requirements should be given careful consideration. Unnecessarily elaborate systems cause higher costs, are more complex to maintain, and may have a higher failure rate. In fact, some of the most successful DRT systems are the simplest.

Computer technology has been applied in a number of DRT and taxi operations (Haddonfield, Los Angeles, and Davenport), and other implementations are planned. A lesson that has been learned is that using a computer for DRT makes for a lot of complexity and that a good, simple manual operation is essential for backup while the computer system is being checked out. Another lesson is that manual control is adequate for DRT systems having about 20 vehicles.

Thus, it is doubtful that a new DRT system should use a computer. Rather, the initial operation should be controlled by a manual system that will be compatible with computer control. The initial manual operation gives personnel a chance to become familiar with DRT and makes them better qualified to direct and control the computer system when it is installed.

OPERATOR SELECTION

Selection of the organization that will operate the service (i.e., provide drivers, controllers, maintenance, supervision) is easy in some cases because there is only one choice. That is, an organization, either public or private, has a prerogative, obligation, or other special qualification to provide the transit service. In other cases where there are several alternatives, the selection of an operator may not be an easy process although it will often prove to be the most significant decision made in planning the program. A prudent approach to selection is, therefore, highly recommended. The only effective way to make a thorough evaluation of the alternatives and a wise selection of operator is by competitive bidding. A request for proposals should be issued to organizations who have expressed interest in or appear to be capable of doing the job. Any transportation company offering a passenger service in or near the intended service area should be included on the bid list; otherwise, the excluded company may protest the start of DRT service. Of particular importance in evaluating the proposals are the proposed operating costs, the qualifications of the personnel, and the operator's history of performance on similar programs.

A wide range of organizations have operated DRT systems, including transit districts, taxi companies, city employees, and management and operations companies. In fact, in Great Britian a new company called Dial-A-Ride, Ltd., was formed specifically to operate DRT systems. Where several DRT systems or modules are needed to cover the total service area, a particularly interesting concept is for the sponsor to contract the operations to several competing organizations (6). Periodically—once every year or two—the operation of each module is reviewed and, if found to be unsatisfactory, the operation can be put up for bid. This keeps all the operators trying to improve and helps to control costs by competition. Major equipment such as buses, radios, garages, and control centers should be owned by the sponsor; otherwise, the capital investments would have to be made by the operators, which would prohibit contracts lasting less than several years and would severely limit competition.

PERSONNEL

When a new DRT system is being implemented, qualified personnel will generally not be available and will have to be recruited and trained.

Drivers can become familiar with DRT procedures, public relations, geographic area, equipment usage, safety, and radio codes and discipline in about 2 weeks. After that, on-the-road experience is needed to learn the streets, house numbers (many houses are often unnumbered), and quick routes through congested traffic.

Drivers usually take 2 to 4 months to thoroughly learn the streets in a small DRT system and longer in large systems.

Controllers must have the ability to cope with the complex problems of DRT control. They must also be able to tolerate the tensions caused by the pressures of the job. Controllers can acquire basic manual skills in DRT procedures, area familiarization, radio codes and discipline, and scheduling and routing techniques in about 2 weeks. If a computer is used, an additional 2 weeks of training is needed. After this initial training, a controller can become fully proficient in about 6 months.

When an organization with existing work rules designed for some other job function implements DRT service, personnel policies, including work rules, should be reevaluated and changed to reflect the needs of DRT. Sometimes this is not possible because DRT personnel represents such a small percentage of the total work force that a separate set of DRT work rules is not feasible. Using existing rules can create both operating problems and added costs. For example, personnel in many organizations bid for the available jobs at certain times—often 4 times a year. The procedure includes listing all the jobs and having each person bid for his or her choice in order of seniority. If DRT jobs are bid with other jobs this way, inevitably new, untrained personnel will periodically replace trained personnel. It takes weeks of training plus months of experience before new personnel achieve full productivity. Therefore, if the turnover is large, as it has been in a number of existing DRT operations, extra staff must be considered in the staffing plans.

CONTINGENCY PLANNING AND PITFALLS

The art of planning lies in development of contingency plans. These are the fallback positions when things go wrong, as they always do to some extent. The following are some DRT pitfalls that should be included in the contingency planning.

Legal

If DRT is implemented in competition with other forms of transportation, legal issues may develop. Since DRT systems are different from other systems such as taxi, jitney, charter bus, or fixed-route bus, legislation enabling their operation is often required. This enabling legislation may be opposed by any transit organization that feels threatened. Allowances must be made for the time delays that may result, and purchase of major equipment should be scheduled to occur only after legal issues have been cleared.

Equipment

Modifications must often be made to standard equipment. Appropriate funds and time should be allocated to accomplish this. Furthermore, uncontrollable delays may be experienced in the manufacture of the equipment, and sufficient schedule slack should be planned for realistic delays. Public announcement of the start-of-service date should be made only after all essential equipment has been received.

Startup Overload

When a new system is started, most of the personnel know what to do, but perform slowly and inefficiently. Thus, at first they can handle only a limited ridership; later, their skills will develop so that they can handle several times the initial demand without difficulty. Advertising and formal inauguration should, if possible, be postponed until a few weeks after startup, and extra personnel should be on hand to help answer inquiries.

Radio License

If there is not a suitable existing license, then a new radio license must be obtained from the Federal Communications Commission. This is time-consuming and can easily get into procedural difficulties if it is not handled by experts.

Critical Paths

The 2 most common critical paths in DRT schedules are the vehicles (specification, bidding, procurement, checkout) and the radios (FCC license, radio manufacture, installation). Both of these paths need to be carefully monitored.

Service Mix

DRT includes a wide range of services (many-to-many, many-to-one, subscription, parcel delivery, shuttle, many-to-few, route deviation, and any mix of these). The mix of services should be chosen after careful consideration of the service objectives and economics. Often, choosing the right mix from the very large number of possible combinations is not immediately obvious, but the wrong mix will be costly and embarrassing to change after service has started.

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This paper discusses some aspects of implementing various DRT services, emphasizes funding at the state and federal levels, and reviews what several state transportation departments are doing with respect to DRT.

FUNDING

Identification of federal and state funds for DRT services is almost impossible for 2 reasons: Funding from state sources varies from state to state, and new federal legislation has not at this writing been signed and it is premature to estimate what programs the final legislation may affect.

In California, local funds are available through the state Transportation Development Act of 1971. In Michigan, funds from a special addition to the gasoline tax and some general funds are available for DRT services. Equally as important as having available funds is identifying the need for funds. At present, the tendency is to find a program to go with available funds, whether the program has high priority or not. What we really need to do is to establish the need for service and then work with state