

IMPLEMENTATION AND OPERATION OF INTEGRATED TRANSIT SERVICES

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In July 1974, the Board of Directors of the Orange County Transit District approved an 8-month study to plan the expansion and implementation of demand-responsive transportation (DRT) in Orange County. The plan selected and assigned priorities to those areas of the county with the greatest need for DRT service. The study outlined a short-range and medium-range expansion plan. The short range deals with implementation during the next 2 years, and the medium range deals with needs through 1980.

Significant aspects of the short-range effort include the processes for selection of the next areas to receive DRT service and the development of preliminary system designs for the selected areas. Area selection was directed by the following guidelines: serve those most in need, distribute OCTD services equitably, and use resources effectively.

Initially, 27 feasible DRT service areas were defined (Table 1). Area definition criteria, given below, restrict the number of possible ways of drawing boundaries and constrain the area and population size encompassed by the boundary.

1. Community service area boundaries should coincide with one of the following, listed in order of preference: city boundary, LARTS traffic zone, census tract, river, freeway, rail line, and major arterial.
2. Community service area should contain more than 8,000 but fewer than 32,000 households.
3. Community service areas should be greater than 6 but fewer than 22 miles² (57 km²) in size.
4. Community service areas should have at least 2 OCTD fixed routes serving the area and at least 20 one-way miles of service beyond their boundaries.

The second stage of the area selection process involved screening the 27 manually controlled areas to determine those most in need of additional service. A measure of the amount of existing and proposed fixed-route services in each area was selected and a cutoff value was established. Areas with less service than the cutoff value were considered for subsequent ranking, and areas with more service were not considered further.

Service was measured in terms of route-miles (km) per 10,000 persons. The value represents the amount of service that might reasonably be expected from a transit system in its early stages of development with the given land use patterns in the county. Simultaneously it permits enough areas to pass the criterion so that subsequent application of criteria corresponding to other guidelines is meaningful. Table 1 gives the service measure values of the feasible areas and identifies those areas selected as candidates for manually controlled DRT service.

The third stage of the selection process involved ranking the 8 candidate areas according to criteria indicative of the need for and effectiveness of public transportation

Table 1. Feasible demand-responsive transportation service areas.

Area	Population	Households	Area Size (miles ²)	Route-Miles per 10,000 Persons	Selected Candidate Area
Anaheim, Central	70,056	22,320	9.7	3.97	
Anaheim, East	51,562	16,974	10.3	5.62	
Anaheim, West	52,560	16,755	7.3	2.51	
Buena Park	56,766	16,081	10.0	2.15	X
Costa Mesa	78,454	25,723	16.0	4.79	
Cypress-La Palma	57,078	14,794	7.0	1.79	X
Fountain Valley	50,214	12,792	9.6	2.63	
Fullerton	85,578	26,764	21.7	2.89	
Garden Grove, East	80,399	23,268	9.4	3.22	
Garden Grove, West-Stanton	74,572	21,689	7.3	2.60	
Huntington Beach, East	70,029	20,514	13.6	2.30	X
Huntington Beach, West	77,725	22,338	10.1	1.70	X
Irvine	23,400	8,141	6.3	13.25	
Laguna Niguel-Laguna Beach-South Laguna-Moulton Ranch	33,220	10,395	12.8	5.30	
La Habra-Brea	65,975	19,182	11.2	2.09	X
Los Alamitos-Seal Beach-Rossmoor	38,715	13,769	10.6	6.54	
Mission Viejo-El Toro-Aegean Hills-Leisure World	66,176	11,798	15.8	2.78	
Newport Beach	53,276	21,985	14.6	7.30	
Orange, North-Peralta Hills-Villa Park	36,893	10,835	13.0	3.79	
Orange, South	57,516	17,087	9.6	2.10	X
Placentia-Yorba Linda-Other	54,985	13,739	21.2	4.64	
San Juan Capistrano-Dana Point-Capistrano Valley-San Clemente	45,950	12,516	13.7	4.87	
Santa Ana, North	68,649	20,883	10.2	4.66	
Santa Ana, Southeast	52,599	16,004	8.1	5.65	
Santa Ana, Southwest	51,974	15,875	8.1	2.73	
Tustin Foothills-Tustin	48,061	14,543	10.6	2.35	X
Westminster	69,583	17,566	10.7	2.01	X
Total	1,555,184	464,330	309.5		

Note: 1 mile² = 2.6 km².

Table 2. Ranking of selected candidate DRT service areas by 5 criteria.

Area	Young and Elderly			Households Without Automobile			Households With One Automobile			Route-Miles per 10,000 Persons			Daily Expected Patronage per 10,000 Persons			All Criteria		
	Per-cent	Per-centile Score	Rank	Per-cent	Per-centile Score	Rank	Per-cent	Per-centile Score	Rank	Num-ber	Per-centile Score	Rank	Num-ber	Per-centile Score	Rank	Total	Final	Rank
Orange, South	40.2	63.2	3	6.1	100.0	1	37.0	96.8	2	2.10	38.5	5	21.2	100.0	1	389.5	100.0	1
Huntington Beach, West	45.4	100.0	1	3.0	36.7	4	34.6	71.6	4	1.70	100.0	1	15.9	53.5	6	361.8	85.5	2
Buena Park	41.6	70.3	2	4.3	63.3	3	37.3	100.0	1	2.15	30.8	6	17.5	67.5	4	331.9	73.7	3
La Habra-Brea	38.9	49.2	6	4.4	65.3	2	33.2	56.8	6	2.09	40.0	4	18.1	72.8	3	284.1	55.1	4
Westminster	38.8	50.3	5	2.9	34.7	6	35.9	85.3	3	2.01	52.3	3	14.5	41.2	7	263.8	46.9	5
Huntington Beach, East	35.1	24.5	7	3.0	36.7	4	33.8	63.2	5	2.30	7.7	7	16.2	56.1	5	188.2	17.1	6
Tustin Foothills-Tustin	32.6	0.0	8	2.6	28.6	7	31.6	40.0	7	2.35	0.0	8	19.5	85.1	2	153.7	3.5	7
Cypress-La Palma	40.1	58.6	4	1.2	0.0	8	27.8	0.0	8	1.79	86.2	2	9.8	0.0	8	144.8	0.0	8

in each area. Five criteria or measures were used in the ranking process:

1. Percentage of area population under 16 and over 64 years of age,
2. Percentage of area households without an automobile,
3. Percentage of area households with only 1 automobile,
4. Expected DRT patronage per capita [patronage estimation is summarized in Appendix B of the report (1)], and
5. Miles of fixed-route service per capita.

All areas were first ranked according to each criterion by converting the 8 raw measures corresponding to a criterion into percentiles. This conversion assigned a 0 percentile score to the worst of the 8 candidates and 100 to the best. Those in between received percentile scores proportional to their measure. The 5 percentiles for each area were then summed to give an overall area measure that was then used in establishing rank. The results of applying the ranking criteria to the 8 candidate service areas are given in Table 2.

On the basis of purely technical considerations, service should be implemented in the selected areas according to their suitability. But because of a policy requiring each city to contribute one-third of the operating deficit, it was recommended that service be initiated in an entire municipality rather than in only a portion of a municipality.

Based on this consideration and the recognition of the obligation to keep the implementation sequence as similar as possible to the suitability ranking given in Table 2, the following implementation was recommended and approved:

1. Orange,
2. Huntington Beach,
3. Buena Park,
4. Brea,
5. Westminster,
6. Tustin, and
7. Cypress-La Palma.

The city of Fullerton was later added to the list to be implemented after Cypress-La Palma as funds and vehicles become available.

PRELIMINARY SYSTEM DESIGN

A countywide DRT fare of 50 cents cash was established. Three children 6 and under may ride free when accompanied by a fare-paying passenger. Some type of discount fare may be established to encourage daily commuters.

Service hours will initially be the same in each area, but subject to change according to the requirements for each individual service area: 7 a.m. to 7 p.m., Monday through Saturday.

Emphasis will be placed on integration of DRT with existing fixed-route services. Patrons will be encouraged to use DRT as a feeder to the fixed-route services; as DRT service expands, the fixed-route schedules will be developed into express services through each DRT service area.

In general, the number of vehicles required to provide DRT service depends on the area size, the level of service desired, and the demand rate (1, Appendix C). Table 3 gives the estimated patronage, fleet size, and vehicle hours for the DRT areas. In all, including the 7 vehicles currently operating in La Habra and the 20 vehicles for Fullerton, 107 vehicles will be required to implement the first phase of the expansion program.

Commuter service will be encouraged within and between service areas. Essentially, any concentrated employment center located in one service area that employs a minimum number of people residing in that area or in another DRT service area will be encouraged to contract with OCTD to provide commuter service for its employees. The DRT bus will pick up the employees at their homes (gather) if concentrations can

Table 3. Fleet size, vehicle use, and vehicle productivity in feasible and selected candidate DRT service areas.

Area	Expected Patronage		Expected Peak-Hour Demand	Fleet Size			Vehicle-Hours			Passengers per Vehicle-Hour
	Daily	Peak Hour		In Service	Spare	Total	Weekday	Saturday	Annual	
Anaheim, Central	1,606	146	93	9	2	11	100	60	29,210	16.1
Anaheim, East	1,212	110	70	9	2	11	100	60	29,210	12.1
Anaheim, West	1,097	100	64	7	2	9	78	47	22,724	14.1
Buena Park*	994	90	58	8	2	10	88	53	25,636	11.3
Costa Mesa	2,014	183	117	14	3	17	154	93	44,875	13.1
Cypress-La Palma*	588	51	33	5	1	6	56	34	16,328	10.0
Fountain Valley	686	62	40	7	2	9	78	47	22,724	8.8
Fullerton	2,063	188	120	16	4	20	176	106	51,272	11.7
Garden Grove, East	1,472	134	86	9	2	11	100	60	29,210	14.7
Garden Grove, West-Stanton	1,305	119	76	7	2	9	78	47	22,724	16.7
Huntington Beach, East*	1,134	103	66	10	2	12	110	66	32,032	10.3
Huntington Beach, West*	1,239	113	72	9	2	11	100	60	29,210	12.4
Irvine	529	48	31	5	1	6	56	34	16,328	9.4
Laguna Niguel-Laguna Beach-South Laguna-Moulton Ranch	807	73	47	9	2	11	100	60	29,210	8.1
La Habra-Brea*	1,193	108	69	9	2	11	100	60	29,210	11.9
Los Alamitos-Seal Beach-Rossmore	1,045	95	61	8	2	10	88	53	25,636	11.9
Mission Viejo-El Toro-Aegean Hills-Leisure World	883	80	51	10	2	12	110	66	32,032	8.0
Newport Beach	1,611	146	93	12	3	15	132	80	38,480	12.2
Orange, North-Peralta Hills-Villa Park	811	74	47	9	2	11	100	60	29,210	8.1
Orange, South*	1,222	111	71	8	2	10	88	53	25,636	13.9
Placentia-Yorba Linda-Other	973	88	56	13	3	16	144	87	41,984	6.8
San Juan Capistrano-Dana Point-Capistrano Valley-San Clemente	863	78	50	10	2	12	110	66	32,032	7.8
Santa Ana, North	1,875	170	109	10	2	12	110	66	32,032	17.0
Santa Ana, Southeast	1,260	115	74	8	2	10	88	53	25,636	14.3
Santa Ana, Southwest	1,361	124	79	12	3	15	132	80	38,480	10.3
Tustin Foothills-Tustin*	937	85	54	8	2	10	88	53	25,636	10.6
Westminster*	1,011	92	59	8	2	10	88	53	25,636	11.5
Total	31,761	2,886	1,846	249	58	307	2,752	1,657	802,313	11.5

*Selected candidate area.

Figure 1. Phasing of DRT expansion program.

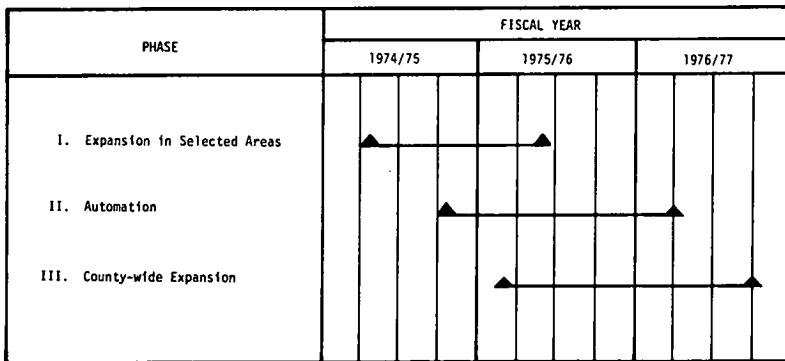
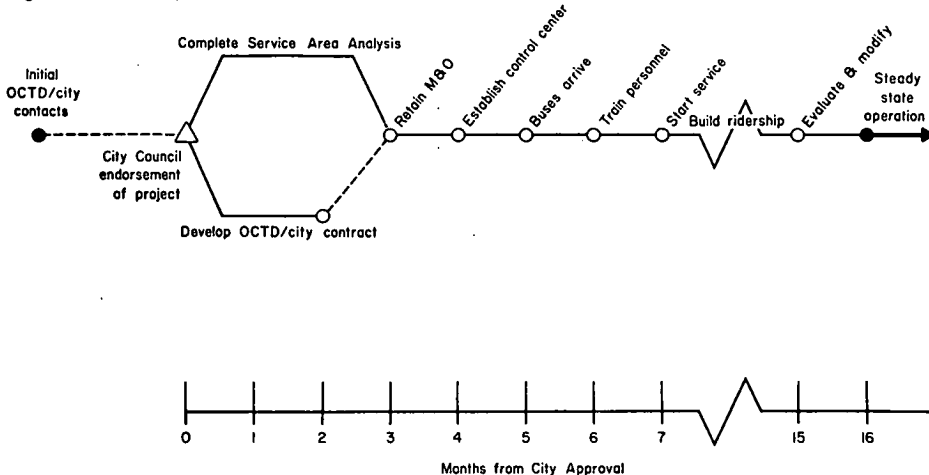


Figure 2. DRT implementation schedule.



be identified, take them by DRT express to the employment center, drop them off at several stops around the center (scatter), and thus provide a type of dual-mode service.

Park-and-ride is another alternative. Combined with DRT, people can move from one central location in the origin service area to the destination service area where they can be either scattered around the employment center or dropped off at a transfer point where another DRT bus picks them up and scatters them.

IMPLEMENTATION

The preliminary implementation schedule for DRT services in Orange County consists of 3 phases (Fig. 1): expansion in selected areas, automation, and countywide expansion. By June 1975, 107 DRT vehicles will be in service in various parts of the county. By April 1976, all of those vehicles and others are scheduled to be under computer control. By April 1977, DRT service is scheduled to be available to nearly every resident of Orange County. The implementation process requires a multitude of projects from designing equipment specifications to locating sites for the storage of vehicles and fuel.

Equipment

In May 1974, a \$1.6 million amendment to OCTD's capital grant was approved by the Urban Mass Transportation Administration for the purchase of equipment for the DRT expansion. After a careful review was made of a large assortment of transit-related equipment available on the market, specifications were drawn up covering vehicles, communications equipment, fare boxes, tow trucks, service trucks, supervisors' automobiles, shop equipment, control center furniture, and bus stop signs. Concurrently, the OCTD Board of Directors approved the expansion plan and authorized its implementation in July 1974.

Subsequently, requests for bids went out for the vehicles, communications equipment, and fare boxes. Equipment arrived in April 1975, the start-up date in the city of Orange, the initial site for DRT expansion.

Communications

The Orange County Communications Department provided OCTD with technical assistance in writing communication systems specifications, with installations, and in the maintenance of all communications equipment. The communications equipment consists of UHF base stations and 2-way mobile units with a multiplex channel capacity large enough to meet all present and anticipated future transit district requirements, including a future digital communications system and computerization. This system will use base station sites and microwave links, which are also part of the fixed-route system.

As implementation proceeds for the 8 sites, OCTD will initially use 2 mountain-top UHF base stations, 1 UHF base station located centrally at the Orange County Communications Department, 3 microwave terminals, and 1 microwave repeater. As expansion develops and as interference problems may increase, base stations and terminals located at the individual sites will be installed. Because the 8 sites will be sharing only 3 frequencies, squelch tone will be necessary. For future digital communications and computerized dispatching, the mountain-top equipment can again be used, for digital communications use less air time for all 8 sites than manual communications.

For smaller DRT systems, shared use of a public works or motor carrier frequency is an alternative to the application to the Federal Communications Commission for a separate frequency. At OCTD's existing DRT site in La Habra, the VHF frequency of the Department of Public Works is being shared with OCTD. As OCTD expands the service to other areas, the service in La Habra will be shifted to UHF.

Cities Involved

Each city involved in the expansion program must be contacted and involved in the preliminary planning. The cities involved have been asked to contribute one-third of the operating deficit of the system operating in the city. This will make expansion possible into more cities than if the district were to finance the systems exclusively. Figure 2 shows the schedule of implementation. Each city council must formally endorse the DRT service and agree to pay one-third of the operating deficit before system planning will begin. A service area analysis for each area will be undertaken to pinpoint specific characteristics of the area that may affect the service design. Trip patterns, employment, clusters of the young and elderly population, trip attractors, and other service area characteristics will be analyzed. Because of the flexibility of DRT, changes from the basic many-to-many service are possible and encouraged to accommodate unique features of each particular service area. This analysis will take place concurrently with negotiations with the cities and the managers and operators.

A contract with each city has been drawn up and designed according to each individual city's service needs. Basically the contract will outline the service to be provided by the district, a formula for the determination and payment of the one-third operating deficit subsidy by the city, and the in-kind services each city is responsible to provide.

As much as possible, the cities will be asked to provide the control center and furnishings, parking for the vehicles and visitors, storage for fuel, cooperation from its local public works department, and advertising and promotional assistance. OCTD will encourage fare subsidy contracts with the cities and with private employers.

Managers and Operators

Managers and operators for the individual service areas were selected by the OCTD Board of Directors in January 1974, when the La Habra operation contract was opened to competitive bidding for the second year. The first year's operator was maintained, and 3 of the other 4 bidders were chosen to operate subsequent DRT service areas to be implemented in the expansion. Each operator will be asked to manage and to operate 1 or more modules for a minimum of 1 year, after which the operation will be opened to a competitive bid each subsequent year.

Four or more operators will operate the 8 service areas to be implemented. Each one will operate service areas in a common computerized area to avoid duplication of control room space and supervisory personnel.

A standard contract with the operators has been drawn up and will be revised to include their particular needs and those of OCTD. Basically the contract outlines the type of service to be provided. Each operator will be given a fee partially fixed and partially incentive. There will be standards by which the quality and effectiveness of each operation can be measured. Maintenance of the equipment can be undertaken in 1 of 4 ways depending on the individual operator's capabilities, proximity of the service area to the OCTD maintenance facility, and services available in the local community.

1. All minor and major maintenance can be handled by OCTD. Mobile maintenance units can travel to the DRT sites to do on-site preventive maintenance. Major work can be done at the OCTD main facility.

2. Minor work can be handled by OCTD's mobile maintenance units, and major work can be done by the operator or a local dealer.

3. Minor work can be handled by the operator, and all major work can be done at OCTD's main facility.

4. The operator can lease OCTD's mobile maintenance units or hire the units and do all minor work. All major work can be done by a dealer.

Each operator will be required to fill out weekly fuel, passenger, and revenue summaries; monthly reports describing ridership, monthly occurrences, use of vehicles, service characteristics, mileage, costs, and revenues; and quarterly reports describ-

ing level of service, demand characteristics, trip patterns, peak-hour patterns, vehicle productivity, and other characteristics indicative of the level of service. All of these data can be obtained from the trip tickets filled out for each trip. Evaluation of each operator will be based on these reports and weekly supervision by a district employee. The district will analyze all costs, ridership, mileage, and vehicle-hour statistics in a detailed monthly cost analysis. The data of each service area will be normalized to provide a basis for comparative evaluations.

Training and Evaluation

The district will develop a training contract with a private firm for the training of the personnel for the first phase of the expansion. As funds become available for a county-wide expansion, OCTD will acquire its own training staff, who will maintain the constant and careful evaluation of each operation.

The training program will consist of careful aptitude and general intelligence testing of all applicants. Operating procedures manuals will be made available containing information in the areas of safety, management information, maintenance, and service operation. Each comprehensive 2-week training period will emphasize dispatching techniques, area familiarization and street layout, communications procedures, public relations, and simulation of actual service. Each site will be supervised during the initial service. Each operator will take full responsibility of his or her own operations on OCTD approval of the recommendation of the training supervisor.

The evaluation program will consist of a monthly overview of each operation and a detailed analysis of 1 day's operation taken from data from trip tickets, drivers' sheets, and revenue and passenger summaries. Dispatching techniques and driver safety habits will be carefully scrutinized to ensure the accurate pickup and delivery time estimations, the efficient routing of the vehicles, and the safety of passengers. The level of service will be analyzed by determining average wait and ride times and vehicle productivity. Data from each service area will be normalized to establish a comparative analysis among service areas. Normalization of data will be developed from each particular service area's individual characteristics (population, density, trip attractors, income levels).

A careful review of management will take place monthly. The attitudes of the drivers and the controllers are largely the product of positive or negative direction from the manager, and day-to-day operations usually reflect those attitudes. Operational efficiency can be effected by employee attitudes, especially in DRT, which has close public contact. This attitude can encourage or discourage potential patronage.

Marketing

Promotion of each individual DRT service is essential to its success. The district will work with each city to provide direct mail brochures, newspaper coverage, and visibility through bus signs and benches. Marketing representatives will be used to promote the service in major shopping and commercial centers. Private businesses will be contacted to help promote DRT service by distributing brochures and discount ticket books. Informing the public of this service but not overselling it is one of the most difficult tasks of system operation. An initial heavy demand for service that cannot be met can lower the level of service. A slow evolution to peak capacity is desirable; as they gain experience, operators are better able to handle rush hours. The most important element in the promotional campaign is the encouragement of DRT as a feeder into the fixed-route services.

CONCLUSION

The entire implementation process contains a multitude of tasks required in the prep-

aration of a steady-state operation of all 8 systems. At that time, a full-scale evaluation program will be undertaken. Up until that point, OCTD management will be preparing contracts, arranging control center sites, registering vehicles, overseeing training programs, and reviewing procedures for managers and operators. The development of OCTD's DRT system represents one part of an innovative and aggressive program to provide the public with new and better transportation service.

REFERENCES

1. Dial-A-Ride Expansion Plan for Orange County. DAVE Systems, Inc., and Orange County Transit District, June 1974.

Nigel H. M. Wilson and B. Trevor Higonet, Massachusetts Institute of Technology

For integrated DRT and conventional transit systems, the issue of control is considerably more important than for single-module DRT systems. On the one hand the control problems are more difficult, and on the other hand more capital-intensive solutions can be considered because of the large number of vehicles under control. Unfortunately, because of the limited number of existing systems, drawing conclusions based on actual operation is difficult, although such information will soon become available from Ann Arbor and Santa Clara, in particular. This paper reviews the major control functions required and presents the alternatives that have been or are being implemented or are realistic possibilities for the near future.

The control problem may be subdivided into information transfer and decision-making functions. Decision making is related to the operation of DRT vehicles, and information transfer is related to service requests and vehicle activities. To facilitate decision making requires an information base that is continually maintained by incoming and outgoing information flows. The nature and extent of these functions depend on the operational characteristics of the service. The range is from highly decentralized decision making with minimal information flows, such as in many of the Canadian systems, to the highly centralized system proposed for expansion in Rochester. In general, the greater the degree of decentralization is the less is the need for sophisticated and expensive equipment, but the more limited is the flexibility of the system and the service.

INFORMATION TRANSFER FUNCTION

The following information transfer functions can be identified: service request (from customer to control center), driver instructions (from control center to driver), and driver progress (from driver to control center).

Service Request

In general a customer may request service either from a low-volume (e.g., home) or high-volume (e.g., shopping center, transfer terminal) location. In both cases the mechanism used will be the telephone system—in the low-volume case, general purpose lines with a standard headset and in the high-volume case probably leased lines and possibly a special input device. At the present time no digital input service request device is in use. This innovation, which would require computer control, would decrease the number of telephone operators for large systems, but is unlikely to be widely available for several years.

For integrated systems another service request option is receiving the request from