FAIRTRAN: Operation of a Credit-Card Transit Fare System

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An Urban Mass Transportation Administration demonstration project has been implemented in the Lower Naugatuck Valley of Connecticut. The purpose of the demonstration was to provide a unified public transport service aimed primarily at the needs of health and social services and their clients. An entirely new fare system was devised to overcome problems in the pricing of multiple, coordinated service modes, to provide for accountability to third-party fare support sources, and to put into practice new ideas on fare equity and pricing. The fare system, FAIRTRAN, involves use of punch-coded credit cards specially issued for the project. Ride data are recorded on magnetic tape cassettes on board the vehicles and are processed remotely at a central computer; rides are billed monthly. An option, Fareshare, allows selective financial support of individual riders in contrast to shotgun subsidies now in practice. The demonstration has shown the system to be workable. Operational changes in hardware and software will be made in a second 3-year demonstration. As yet, fare system costs appear to be several times higher than conventional coin system costs, but benefits of data collection, elimination of coin handling (and out-of-pocket bias), pricing flexibility, and Fareshare have to be considered on balance.

Are present transit fares fair to either operators or users of transit? The search for fair transit fares is what first motivated the design of what is called the FAIRTRAN system. The specific context in which FAIRTRAN was developed, and is still developing, is the Valley Transit District (VTD) in Connecticut, where an Urban Mass Transportation Administration demonstration program has been in operation since late 1972.

In brief, FAIRTRAN contains several components and concepts that together constitute a complete revenue collecting and accounting system. Instead of cash, users use a wallet-sized, plastic, punch-coded credit card, the V-card. The five-digit punch code represents a user identity code. On board the transit vehicle is a service recorder or FAIRTRAN box (Figure 1), which generates and records data on rides. The driver may input geographic, modal, and other data into the box through push buttons or special punchcards. The user inserts the fact that he or she is taking a ride by means of his or her V-card. The box internally generates a time signal. These data are recorded together on a magnetic tape cassette. Because the user enters the card on entering and exiting, data are recorded for both ride ends.

The ride tapes from the box are then machine processed on a daily basis to recreate individual rides from the interleaved data strings. These rides are then priced according to a particular, and possibly complex, pricing formula. Rides of individual card holders are cumulatively stored over the monthly billing period. Each month, the accumulated charges are billed by mail to the user who makes a remittance (Figure 2). Currently only door-to-door trips are billed to individual users, but any of the modes would be listed with trip date, time, end zones, and price. In Figure 2, the customer price is lower than the total cost because of the Fareshare discount; the discounted amount will appear on another bill to the third party funding source that will indicate the same ride data listed by individual users. The FAIRTRAN information flow is shown in Figure 3.

Part of the pricing algorithm, but so important that it deserves special mention, is the Fareshare option. Fareshare is simply a means of allocating payment of a fare to multiple payors. However, it is only because of the nature of FAIRTRAN that it is possible to actually have separate entities participate in the payment of fares on a case-by-case basis. The significance of this should be seen in the instance of a service agency that might want to reimburse a client for trips to a service center. FAIRTRAN with Fareshare is the means whereby this can be accomplished with a high degree of accountability (for instance, geographic or time checks to see if a ride was indeed for a specified purpose), a high degree of specificity (perhaps the Fareshare is to be proportional to user income), and without a cash or pseudo-cash (ticket or pass) flow through the user. The features of accountability and selective subsidy have had the substantial benefit of attracting new money into the transit operation of VTD. Along with the UMTA demonstration, a U.S. Department of Health, Education, and Welfare demonstration is operating in the valley. HEW moneys have been devoted to funding agency use of VTD in a test of the integrated transport service concept. Without the Fareshare mechanism, it is doubtful that the HEW, or local agency,

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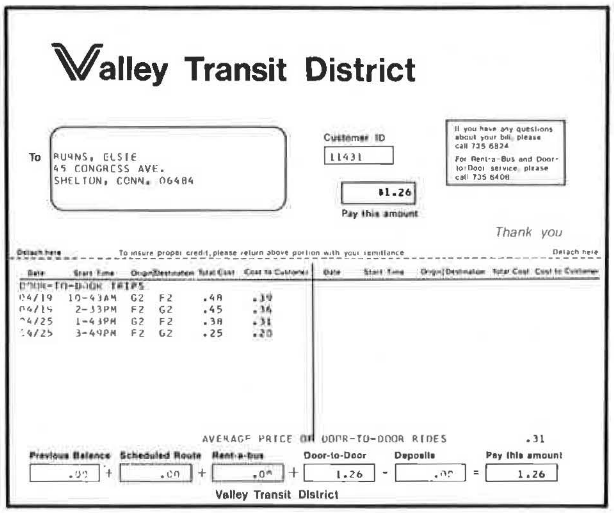
Figure 1. On-board FAIRTRAN service recorder.

Figure 2. User bill generated monthly by FAIRTRAN.



Valley Transit District

To BURNS, ELSIE
45 CONGRESS AVE.
SHELTON, CONN. 06484

Customer ID: 11431

$1.26
Pay this amount

If you have any questions about your bill, please call 735 6824
For Rent-a-Bus and Door-to-Door service, please call 735 6408

Thank you

Detach here — To insure proper credit, please return above portion with your remittance — Detach here

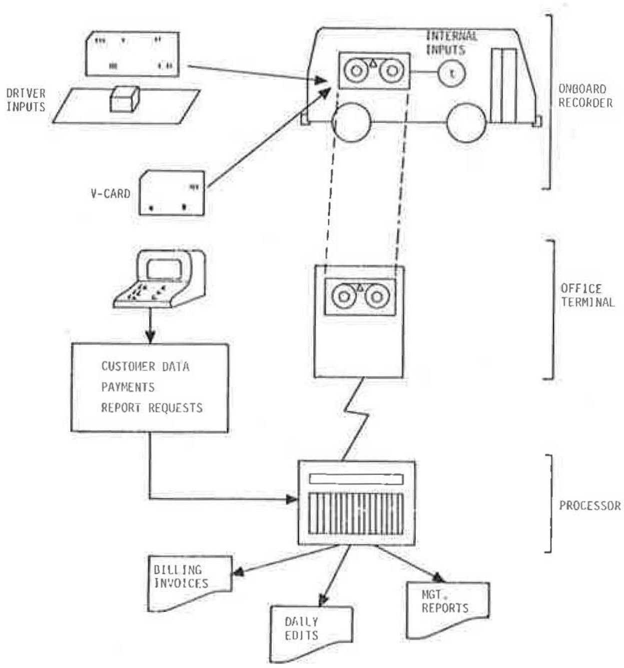
Date	Start Time	Origin/Destination		Total Cost	Cost to Customer
DOOR-TO-DOOR TRIPS					
04/19	10-43AM	G2	F2	.48	.39
04/19	2-33PM	F2	G2	.45	.36
04/25	1-43PM	G2	F2	.38	.31
04/25	3-49PM	F2	G2	.25	.20

AVERAGE PRICE OF DOOR-TO-DOOR RIDES .31

Previous Balance		Scheduled Route		Rent-a-bus		Door-to-Door		Deposits		Pay this amount
.00	+	.00	+	.00	+	1.26	-	.00	=	1.26

Valley Transit District

Figure 3. FAIRTRAN information flow.



money could be attracted into VTD. The significance of Fareshare as an alternative to present reduced fare programs will be discussed below.

VTD DEMONSTRATION

FAIRTRAN evolved integrally with the operational requirements of VTD. Although FAIRTRAN system and concepts are presumed to have further application beyond the VTD, a full understanding of FAIRTRAN requires some understanding of the goals of VTD.

The VTD demonstration operates in Connecticut in the Lower Naugatuck Valley region. This region is north of, and between, the cities of New Haven and Bridgeport in southwestern Connecticut. The region consists of four towns: Ansonia, Derby, Seymour, and Shelton, which constitute a Council of Governments. The region had a 1970 population of 73 700 and an area of 145 km^2 (56 $miles^2$). The UMTA demonstration began in July 1971 although vehicular operations began only during Christmas week 1972. FAIRTRAN itself became operational on March 26, 1973. With a 3-year extension starting July 1974, VTD became the first UMTA 6-year demonstration program.

The motivation for VTD came from the health and social service community of the valley in the 1960s. The VTD demonstration has always had the service of the elderly, handicapped, and other agency users as a prime objective. However, service to the general public has never been excluded.

The VTD demonstration was planned by RRC International. Sections of RRC involved in computer systems, electronics, and transport planning worked jointly on FAIRTRAN implementation. J. Woodhull, now with the Southern California Rapid Transit District, developed the original FAIRTRAN and service concepts. I served to develop the system and analyze its results. The two ideas of the multimode service, to achieve VTD goals and to pursue equitable fares, led to FAIRTRAN.

Four service mode concepts were first proposed for the VTD: shuttle (a fixed route), door-to-door (a demand service), hitch-a-ride (jitney service), and rent-a-bus (a charter or contract type of service). These multiple services would serve the needs of the general rider in the core area, the rider requiring door-to-door service over any part of the valley, those who could hail a demand vehicle, and groups or agencies. The two fare considerations arising from this mix of services were how to selectively charge different types of riders (particularly those allied with an agency versus the general public) and how to allocate and coordinate the mix of services through a price mechanism. In addition, the service mode concept changed in the course of the demonstration. The shuttle ran only briefly, up to the start of door-to-door service, and during the strike of the operators who previously drove the public transportation vehicle in the primary fixed-route corridor in the valley. However, a network of fixed routes is being established for the follow-up demonstration. Door-to-door service was never a dial-a-bus service, which is a long request time-lead service and requires high per-rider service subsidy. Distinguishing the subscription portion of door-to-door service from the "call-in" demand service became important. Hitch-a-ride never came to fruition because there were never enough vehicles (never more than six in service) to make hailed service practical. Rent-a-bus carries on as both the occasional rent-a-bus under FAIRTRAN fares and a regular contract service that is given for a lump-sum price billed through FAIRTRAN.

The other considerations leading to FAIRTRAN related to fare equity particularly in the demand service. The philosophy behind the FAIRTRAN fare algorithms is strictly opposed to the idea of flat fares. Although simplicity considerations, and indeed misguided equity and incentive considerations, have resulted in a trend toward flat fares, I think that flat fares have severe drawbacks.

The economic bases for transit pricing are muddled because, given that transit is increasingly a social service rather than an economic venture, pricing considers social costs and benefits that are poorly defined. It seems that social equity requires low fares, and, as long as fares are reasonably low, they can be flat. Economists have argued that average cost pricing is the only method feasible for fixed routes; this gives some credibility to the flat fare. However, the problems with flat fares are several. Even in fixed routes, it is entirely probable that the user perceives rides as being of different value for different distances. If there is any sort of conscious price comparison in modal choice, flat fares probably result in the loss of many potential short riders. On the other hand, there is a possibly excessive consumer surplus for long riders. Consider systems like AC Transit, which boast rides of over 161 km (100 miles) for the base fare, with transfers. In a radial system, longer rides tend to be taken by the more affluent in suburban areas, and, because of this, flat fares can in fact be an inequitable transfer of wealth. Flat fares, despite their touted simplicity, create the complexity of transfers. If each ride segment were priced in an incremental fashion, the rationale for transfers would be substantially reduced.

For demand service, the problems with flat fares are more severe. There is a marginal price associated with a demand service ride. Because demand service is very capacity limited (not by vehicle capacity but in terms of riders per time that can be served), serving one ride effectively means foregoing another ride. Each ride requires an increment of service capacity (vehicle-hours). If demand service is provided over a relatively small, homogeneous area, single-price service may not be too bad. However, in the VTD, transportation needs to serve a 145-km^2 (56-mile^2) area including farmland and dense core areas, and variable pricing was clearly necessary. (It is not to be inferred that pricing was the only problem in providing the demand service over that area.)

With the mix of services, service allocation and coordination were also a problem. What would be the transfer arrangements between a shuttle route and a demand vehicle? Could market mechanisms, rather than administrative restrictions, be used to allocate rides between demand and fixed-route services? The experience of the Santa Clara County District, which charged a flat $0.25 on both fixed-route and demand services and consequently overloaded the demand service while minimizing total passenger service, is instructive.

Clearly, Fareshare is an integral part of the FAIRTRAN pricing possibilities. The equity of lower fares for specific user groups, such as the poor, the elderly, and the handicapped, is only consistent with service allocation prices if the needy groups can selectively be charged proportionally less. There is a more fundamental benefit in the Fareshare approach to reduced fares. Currently, reduced or blanket-low fares have a hidden inequity. Fare reductions currently are financed out of the pool of transit funding moneys that could be used for better service. Better service, as is known, is more effective than price in determining transit use. This sacrifice of service for price is inequitable in that the fare reductions usually take no account of user income, which should be the only criterion of fare reduction qualifications, and therefore, the implicit transfer of income cannot be very equitable. But fare reductions act to benefit those already with service at the cost of those who could potentially have service. The benefits of lower fares in the case of diverted motorists or elderly riders are played up; however, the motorist still in his or her car or the poor person who must use a taxi because of poor service is entirely overlooked. It is reasonable to say that equity and benefit are maximized by the greatest selectivity in fare discount. This is one function of Fareshare that can grant specified discounts to individuals based on any detail of need data that can be collected and put in a data bank as part of the credit-card application process.

But Fareshare goes beyond this. Another major goal of VTD was to integrate existing moneys, other than transit funds, into the VTD operation. These moneys included those for previously fragmented agency-run transport services and moneys going to health and social services, for which a transport service component was implicit. As mentioned, it was largely because of Fareshare that a substantial HEW grant was obtained for the valley for use in VTD-provided transport. The present problem in fare reduction requirements for the elderly and handicapped, as in the UMTA Section 5 program, is that transit is being required to provide a social welfare function in income redistribution in conflict with its primary social function of providing a service. If there are reasons for providing this income redistribution through transit, it might be expected that individual agencies, with additional money, should provide this function through a process like Fareshare. It seems that sentiments for specific user groups have been more effective than the wider benefits of transit in getting public financing of transit. By specifically directing funds to various user groups, Fareshare might further use these sentiments for the sake of transit.

The specific fare structures used for VTD are basically three types. For the fixed-route services there is a time-based fare. A small, fixed, pickup charge is levied plus some constant rate times ride time. Because use of the fixed routes by coin is allowed, on a simple base fare plus zone charge, the FAIRTRAN fare is truncated to never exceed the coin fare. An additional fare feature is a group discount whereby the V-card user can make a multiple insertion for each rider in his party. A 10 percent fare discount is given to each rider after the first. Fareshare can be applied to any V-card user as a percentage discount from the calculated fare. In operation, the Fareshare discounts were primarily related to age, handicap, or need for medical service and ranged from 20 to 100 percent in some cases. These reduction criteria were generated by the HEW project and, it is admitted, partly ignore the Fareshare rationale.

The rent-a-bus mode has a time-dependent fare that includes both deadhead and user travel times for the entire bus. For groups without V-cards, rides can be billed on a special, driver-inserted punch card. The contract services sold for a prearranged lump sum will generally bypass the on-board recorder but are billed through the FAIRTRAN billing process. Fareshare could be applied to these modes also.

The door-to-door service developed the most complex pricing. In retrospect, the pricing may indeed have been too complex. A ride on the demand service had three price components: a predetermined charge dependent on which geographical zone the pickup was in, a charge for the particular zone-to-zone interchange of the trip, and another charge for the particular drop-off zone. There were 33 zones that were input to the FAIRTRAN box through the driver's push buttons. The pickup or drop-off charges were based on how outlying a zone was, that is, some estimation of the likelihood of having to go to that zone to serve another ride anyway. Outlying zones had higher charges than core zones since demand density was lower in the outskirts. The zone-to-zone charge came from a predefined matrix based on nominal direct service times between zones. This eliminated any user charges due to delay or diversion to serve other riders that would result from a direct time-based charge.

In addition to the three basic charges, there were three reduction factors. The popularity factor reduced the pickup or drop-off zone charges in proportion to the number of persons actually picked up or dropped off in a specified time interval. The occupancy reduction applied a discount to the zone-to-zone charge proportional to the time average of persons on board the vehicle. There were also the group ride and Fareshare reductions. Hitch-a-ride was charged as a modification of the demand service price, a fixed reduction was applied to the zone-to-zone charge, and a fixed nominal pickup and drop-off charge was made. However, the hitch rider had the option of specifying a drop-off rather than going where the bus might. A regular drop-off and ride charge was then assessed.

The form of the popularity and zone-to-zone reduction factors is of particular interest. The original form was $(k + a)/(k + x)$, but this was later changed to $(a/x) + k$, where a and k are constants and x is the parameter relating to popularity or occupancy. The actual reduction factors used could in fact be almost any form. The important thing to note is how the individual fare and the total vehicle revenue collected vary with x. As x increases (roughly more users per vehicle-hour), the reduction factor and the individual fare decrease. However, if the constant parameters are adjusted, the reduction factor can decrease less slowly than x increases. This means that, as use increases, individual fares decrease and total revenue increases—an incentive to both user and operator to increase use.

Note that, although the fixed and charter types of modes have, in principle, predictable fares, the demand service is not predictable. A user will not know a priori how much a ride will cost because the charge depends on ride decisions of others.

OPERATIONAL EXPERIENCE AND MODIFICATIONS

The FAIRTRAN system grew entirely with the demands and possibilities of the first VTD demonstration. Many difficulties have since been identified and are to be overcome, it is hoped, in the present demonstration phase.

By mid-1975, FAIRTRAN had processed over 50 000 rides for almost 4000 users. The overall reliability of the system, in terms of valid rides output for billing, has fluctuated but has increased to better than 95 percent of all rides. The problems of lost rides have come almost entirely from the farebox and its interfaces. Often the rider may forget to insert his or her card, usually on exit rather than entry. However, increased watchfulness of drivers and experience of riders have gradually decreased this. Unmatched rides (rides with a V-card insertion on only one end) can usually be recreated from dispatcher data anyway.

More serious problems have been in the use of the farebox mechanism. There is a leader on the tape cassette, and, when the cassette is emplaced, the leader is not always fully wound over, and data are lost. Sometimes the tape head is not shut, and data for a complete day are lost.

The power supply to the box has been very erratic: Sizable voltage pulses make power input conditioning difficult, low battery voltages may make the system inoperable, and extreme cold has sometimes produced spurious results if the electronics are not brought to a reasonable temperature. Since the data are generated in strips of multiple words, offsetting a digit by one place in a word because of some malfunction will throw off a whole data string. Because the clock in the box requires a constant power input, when the battery disconnects the time signal is often no longer synchronized. However, if human error and power input problems are discounted, the boxes have been highly reliable overall.

In the present system, a computer of a local industry is used to process the FAIRTRAN data and generate the bills. Because of an initial change in plans, the code of the box cassettes is incompatible with the computer code. Therefore, a conversion step of cassette magnetic tape to recoded paper tape must be made. This step has introduced error and inconvenience.

In credit card use, the default rate may well be questioned. At present there are about 4000 V-cards issued. The user group is somewhat select, primarily regular riders or persons associated with agencies. However, the default rate on payments has been only about 3 percent of gross receipts. This is surely not insignificant, but it probably compares favorably with skim and other losses in conventional fare systems. It can be argued that eliminating the out-of-pocket bias of transit fares through credit also generates more than an added 3 percent in revenue on a given system.

Fare transaction times were a consideration in FAIRTRAN design. It was hoped that the elimination of coin and ticket handling would reduce this transit delay component. Boarding times were measured as 4.8 s/person on a conventional transit system in Albany that uses a simple base plus zone fares. For FAIRTRAN, 4.08 s/person was the average for boarding times, and 4.2 s/person for alighting times. Unless the alighting V-card transaction can be conducted entirely before the bus stops (an unsafe practice) or in a two-stream arrangement, the two-transaction nature of FAIRTRAN can mean up to a doubling of fare-transaction time.

It is now believed that too much is asked of the drivers in operating FAIRTRAN. The driver not only must perform demand service duties, in particular, but must input zones, select other modal and special inputs, input special cards on occasion, and check V-card transactions. Particularly in larger systems, it is desirable to reduce the driver responsibilities. Removing cassette loading responsibilities from the drivers has already increased reliability.

User reaction to FAIRTRAN has been clear in distrust of the demand fares. There can be large variances in fare, even on the same ride, particularly because of the sharp cutoff of the popularity reduction factor (a 3-min interval). Two people riding subscription service the same way each morning could have fares varying by 50 percent or more if the time separation of their getting on or off exceeds the reduction time window by just a fraction. Because FAIRTRAN bills are itemized by ride, riders begin to suspect that the pricing is capricious. Therefore, the public seems to want determinant fares, and some people feel better about going back to cash fares entirely. However, public sentiment has not been adequately quantified on this matter yet.

Apart from the indeterminacy question, was the original demand price structure proper? It is now felt that having a predetermined, and somewhat arbitrary, set of endpoint and zone-to-zone charges is a shortcoming. Furthermore, popularity and occupancy reductions are somewhat redundant, eliminating dependency on geographic inputs to the box is desirable, and use of sharp popularity discount time windows is unwise. An entirely satisfactory pricing algorithm attempting to allocate marginal costs of demand service has not been devised; however, I have proposed an algorithm based on time-localized vehicle productivities measured as a productivity (riders served per time), in which riders are weighted by a nonsharp, decreasing time function centered on the subject users. That is, riders who board or alight later than the subject rider are worth less in the subject rider's discount. This endpoint-based pricing could be freed from geographic inputs. The presumption is that the real marginal cost is in serving the ride endpoints, not in the ride itself. Endpoints with low productivity are priced higher.

Data collection must also be cited as a major FAIRTRAN benefit. FAIRTRAN will give data on rider identity, any rider demographics that can be recorded as part of the V-card registration process, ride endpoint time, ride endpoint zones, and, by aggregation, any vehicle centered data derived from ride data. In the VTD demonstration however, these data for system management have not been used as much as possible. Because analysis programs have not been produced, except for the project final report, there has been no convenient way of using FAIRTRAN data for system analysis. In addition, the data were not oriented toward vehicle time as opposed to user time; therefore, important factors like overall vehicle productivity were not readily derivable.

The reduction factors in the demand pricing formula, which resulted in the fare indeterminacy, were conceived as user incentives; however, this is only true if riders can reasonably influence others to ride. Although this may occur in some long-term or fortuitous way, by and large people will feel randomly penalized by the occurrence of low-use rides with concomitant high fares, rather than feel rewarded by low fares on high-use rides.

Ultimately the real question for FAIRTRAN concerns system cost. Probably, the benefits of elimination of on-board cash transactions, fine fare structures, data collection, and Fareshare are apparent. But how much does this cost? As a demonstration, the costs developed are not necessarily indicative of larger scale operational costs. Also, although favorable rates on computer processing were obtained from the local industry that did VTD processing at or below cost, further savings might be obtained by in-house computing.

The major cost factors are on-board farebox hardware, terminal and keypunch personnel times, V-card distribution costs and customer entry costs, billing and mailing costs, and computer processing costs. Based on VTD experience, high and low cost functions in dollars per month, depending on various options, were derived for the steady-state system (after the initial surge of V-card applications). They were as follows:

$$\text{Low cost per month} = 110 + 0.201U + 0.012R + 30.49V \quad (1)$$

$$\text{High cost per month} = 178 + 0.354U + 0.040R + 30.49V \quad (2)$$

where U is the size of the active user pool, R is the rides per month, and V is vehicle fleet size. Based on experience, the minimum foreseeable per-ride cost for a debugged system now appears to be about $0.05/ride. The effects of economies of scale, in-house computing, and program refinement are yet to be definitely determined.

How does this compare with present costs? Based on a small sample of transit properties in Rochester, Albany, and St. Paul, fare collection and accounting costs were found to be remarkably uniform at $0.04/ride. It is then hard to reconcile the order-of-magnitude cost difference between FAIRTRAN and conventional systems on a per-ride basis. Note, however, that average fares on VTD were $0.86 compared to most conventional transit fares of $0.40 or less. Because FAIRTRAN is best suited for specialized, higher priced services, the fare collection cost as a percentage of fares is not so disparate, and the accounting of added FAIRTRAN benefits must certainly narrow the gap. Ultimately, the operator's evaluations of FAIRTRAN benefits and cost reductions would determine the operational feasibility of the system.

FUTURE DIRECTIONS

The next phase of the VTD demonstration will see a changed FAIRTRAN.

1. An in-house minicomputer for FAIRTRAN processing and demand bus dispatching will be purchased. This will reduce processing costs and greatly increase system accessibility.
2. Direct cassette-to-machine data transfer will be made possible.
3. Driver input of vehicle time-use data to the box will be limited, and dispatchers will input zonal data.
4. Reliability of the box will be improved through redesign and fail-safe features.
5. Fare structures will be modified, and demand fares will be determinant.
6. Data analysis programs will be produced to facilitate use of FAIRTRAN data in the management system.
7. Coin fare accounting will be incorporated into the system.
8. Fareshare will be modified to allow possible direct use of funds such as medicaid transport funds.

In summary, RRC developed and tested, in little more than 3 years, an entirely novel transit fare system, from concept to implementation. FAIRTRAN is already moving into a second generation. VTD has, however, been a small and specialized system. Whether FAIRTRAN can have application in larger or more general systems remains to be tested in further demonstrations.