OmniLink

Case Study of Successful Flex Route–Capable Intelligent Transportation System Implementation

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Potomac and Rappahannock Transportation Commission's OmniLink is an intelligent transportation system (ITS) assisted, hybrid public transportation service that permits flexible routing combined with the time points of conventional fixed-route services. OmniLink promotes mainstreaming of a significant portion of the disabled population eligible for paratransit under the Americans with Disabilities Act (ADA) while reducing the cost of accommodating these passengers. State-of-the-art ITS technology is used to accommodate passenger requests for off-route trips (route deviations). It gives an accept or reject decision to call-takers while the caller is on the phone; schedules all pickups and drop-offs; provides dispatcher oversight; conveys on-time performance and communicates all other relevant information between drivers and the control center; and incorporates passenger counting, navigation assistance to the operator, vehicle inspection documentation, and other utilities. The ITS package includes full post-processing capability to support service analysis and optimization. Initial service began in 1995, but full ITS functionality was achieved only in 2003 after the second procurement attempt. The identified monetary benefits exceed monetary costs by a wide margin. This success can be attributed to more mature technologies, a turnkey project contract model, and refined, firm specifications based on both practical and academic experience. ITS configurations similar to OmniLink's have the potential to solve several common bus transportation problems in lower-demand areas. Examples of benefits include forgoing or reducing ADA paratransit costs, substituting for large buses at night, serving pedestrian-unfriendly streets, and probing for demand in previously unserved areas.

Potomac and Rappahannock Transportation Commission (PRTC) serves Prince William and Stafford Counties and the cities of Manassas, Manassas Park, and Fredericksburg, Virginia. PRTC operates OmniRide and OmniLink bus services and Virginia Railway Express (VRE) commuter rail services. PRTC's primary market is weekday commuters to central Washington, D.C., the Pentagon, and other major traffic generators. The commission is also responsible for intracounty transit services. Whereas VRE serves all five PRTC jurisdictions, bus service is operated only in the eastern Prince William County and Manassas areas. Figure 1 is a system map of PRTC bus services.

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In the early 1990s, PRTC studied a proposed intracounty service area that had no regular transit service, only demand-responsive transportation provided by human service agencies. The gross density of eastern Prince William County was about 2,700 persons per square mile at the time of the original service design, with the overall service area having a density of less than three persons per acre (*1*). Development continues to expand into new areas. Most of the local bus service area was built up in the post–World War II style of numerous looping roads, cul-de-sacs, residential areas without sidewalks, and large arterials that can be difficult for pedestrians to cross.

At about the same time, the FTA had an Intelligent Transportation System (ITS) Operational Test Grant program. In 1993, PRTC planners submitted a proposal for one of these grants. The proposal called for an innovative service that could address the needs of riders eligible under the Americans with Disabilities Act (ADA) for complementary paratransit, as well as other unmet service needs. The FTA awarded PRTC a grant for procurement, testing, and evaluation of the ITS.

The study eventually resulted in what is now known as OmniLink. The service design principle is to create fixed time points, as with a conventional route; to locate other fixed stops between them sparingly; and to allow off-route pickups and drop-offs between all stops. The bus operator need not return to the route at the point at which the bus departed the route. The concept is shown schematically in Figure 2. Some slack is added to the schedule to facilitate deviations. If deviations are not made, the driver is instructed to slow down or to hold at time points.

The number of minutes of slack varies by route and time of day. On average, about 10 extra minutes are built in. When PRTC started, its rough rule of thumb was a 25% cushion between time points. This amount is adjusted based on ongoing operating statistics.

There are currently five such "flex routes" or "route-deviation services": two in the western Prince William/Manassas area and three in eastern Prince William County. The former operate hourly on weekdays. The latter three use a timed-transfer, or pulse system, at PRTC's Transit Center and operate on 45-min headways on weekdays (every 90 min on Saturdays). A map of one of the routes is shown in Figure 3. The deviation corridor is ¾ mi on both sides of each route. Buses 30 ft (9 m) long are used, to maneuver off the main arterials.

ITS PROCUREMENT: FIRST TRIAL

OmniLink services began in April 1995 using conventional manual dispatching and manual call-taking for off-route trip requests. In the beginning, reservations required 24-h notice because call-backs were needed to confirm pickup and drop-off times and locations. In

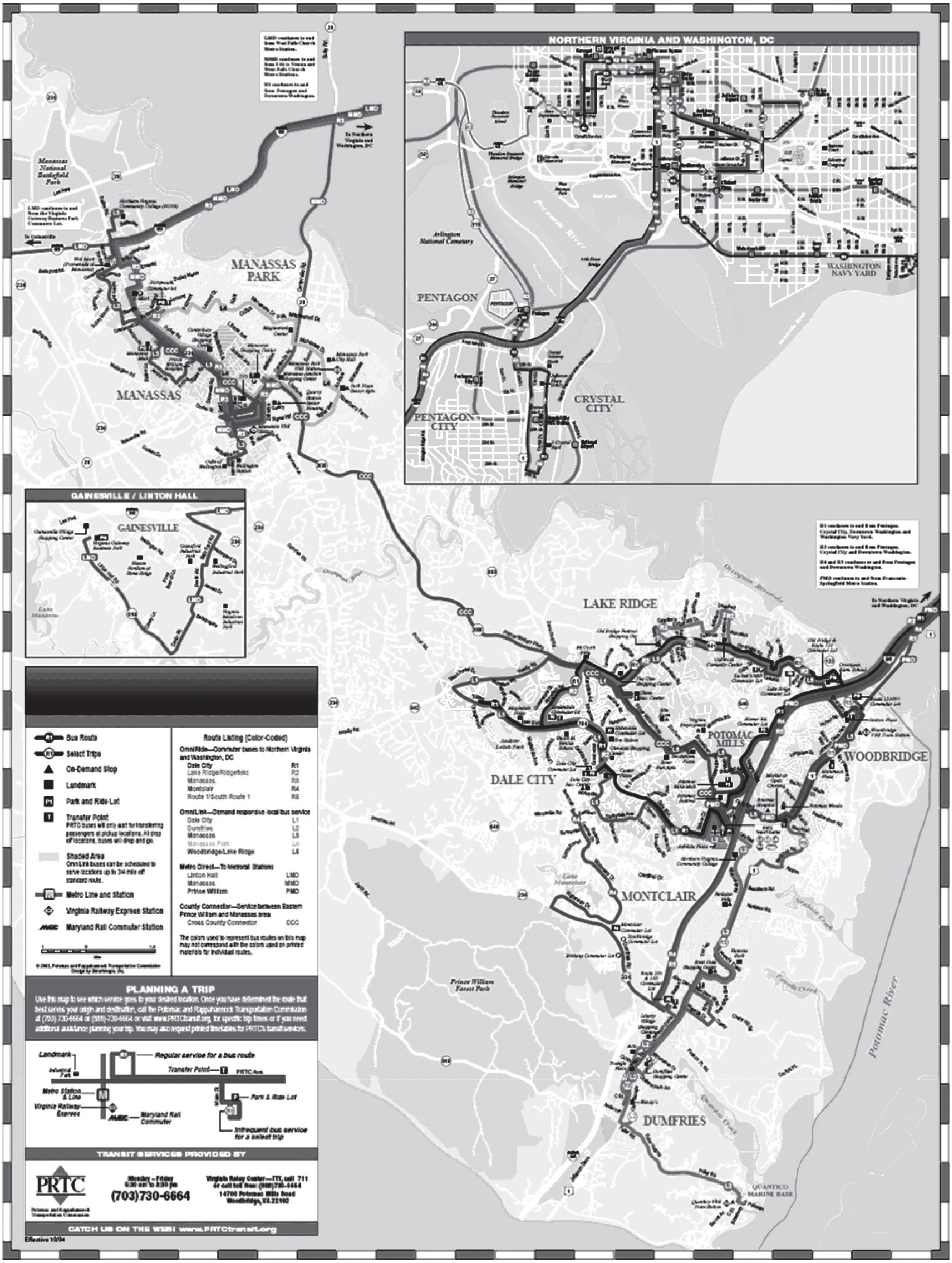

FIGURE 1 PRTC bus service system map.

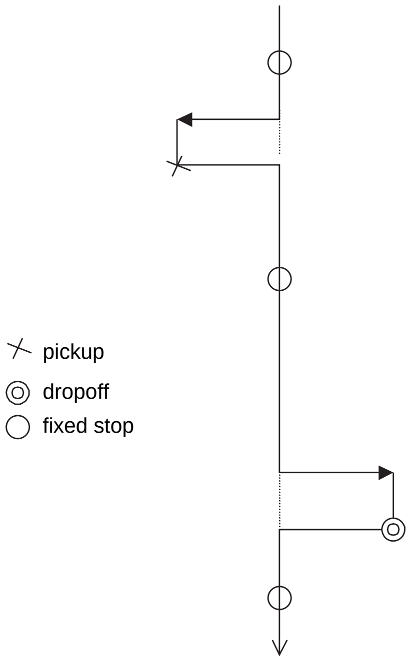

FIGURE 2 Flex-route concept.

late 1997 the first component of the ITS system, the flex-route call-taking and trip reservation system, was implemented. This system provided automated trip booking that allowed confirmation of times and locations while the caller was still on the phone and provided the means to routinely accommodate trip requests up to 2 h before departure time.

During this period, the true “high technology” elements of the ITS project were being developed and tested. The system was designed to perform several functions: assist both customer service agents and dispatchers with the acceptance or rejection decision process; provide the dispatcher with up-to-date location information for each vehicle via Global Positioning System equipment; and automatically update and transmit manifest information to drivers through a mobile data terminal (MDT).

The MDT performs several important functions, including relieving the bus operator and dispatcher of the burden of voice communication for routine information; relieving the operators of the need to update paper manifests by providing up-to-the-minute information; monitoring schedule adherence for the benefit of the operator; and transmitting the entire time and location record for each stopping event and each block of work performed by the vehicle to the data archives, for use in planning analysis and dispute resolution.

By mid-1998, full integration of the prototype ITS seemed imminent, but the system’s performance had never been fully satisfactory.

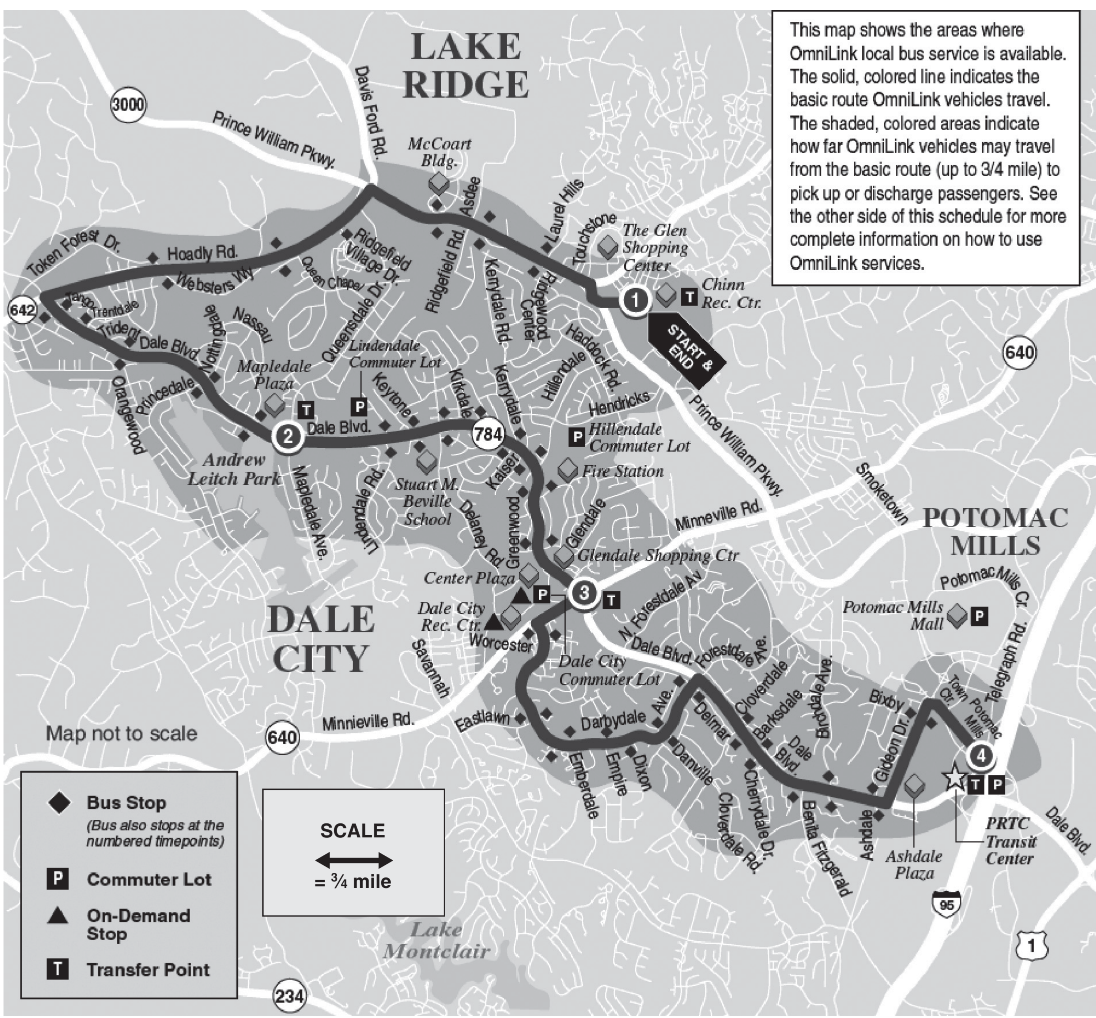

FIGURE 3 Sample route showing flex-route boundaries.

Several chronic problems existed, perhaps the most important of which was an unwieldy project management structure. The system design required significant refinement and fine tuning because of the first-time nature of its implementation. However, there was no clear way to assess the responsibility of individual contractors for making changes or meeting timelines; the firm hired by PRTC to manage the project was not connected contractually to the companies developing the systems. Another problem was that PRTC did not have access to a municipal radio system. An awkward private radio system was used for voice and data communication. In summer 1998, the radio service provider went out of business, and the operations department had no choice but to cease integration and testing efforts. At the same time PRTC—which contracts all transportation services—switched providers, and needed to focus significant attention on monitoring and improving on-street operations. This resulted in an approximately 3-year hiatus, during which there was little project advancement.

An evaluation of service improvements to the public, and of any benefits and cost savings to PRTC, was to have been conducted as part of the ITS Operational Test, once testing and implementation were complete for the first trial of ITS in revenue service. This evaluation had to be deferred because full functionality had not been achieved, but an independent evaluation of the partial system was conducted (*2*). The report of the partial evaluation gives further details about the ITS developed on the first trial and about the role the project management structure played in the outcome.

ITS PROCUREMENT: SECOND TRIAL

As a result of their several years of experience, PRTC had made great strides toward perfecting flex-route operations without the benefit of ITS. In 2001, PRTC was ready to prepare specifications and procure a new ITS system. But this time, there were several advantages. First, PRTC had a firm conception of how the system should function, so their technical consultants could prepare a precise performance specification. Second, the technology for computer-aided dispatching and automatic vehicle location (CAD/AVL) had matured. Third, and perhaps most important, was the use of a turnkey approach in which the technical management firm had subcontracts with the system development companies, eliminating many of the subcontractor coordination issues that arose in the first attempt.

The ITS that currently supports OmniLink was designed specifically for this precise application, but with the intention that it would not be an orphan system but would contain features of interest to other transit agencies. In this way, vendors would have an ongoing incentive to support and improve their components. Features include full CAD/AVL capability. All vehicles can be tracked on or off route, and warning flags can be generated automatically using dispatcher-selectable parameters. Vehicles that are *x* minutes behind or *y* minutes ahead of schedule at the last time point or off-route trip address, or are projected to be more than *z* minutes late, are typically selected. All vehicles also are equipped with a covert alarm. When an alarm is activated, it appears on the dispatcher screen and produces an audible siren until cleared. The polling rate for vehicle location is reduced to every few seconds, instead of every 60 s.

Customer service agents enter off-route trip requests into the scheduling software. Using the software, they can decide to accept, reject, or select alternatives for the requested trip while the customer is on the telephone line. Requests for cancellations made while the vehicle is on-route are readily accommodated, with the cancellation appearing on the updated manifest. On occasion, new requests are also accommodated in near real-time, but this requires discussion between the dispatcher and customer service agents. Customers who have a poor record of no-shows or cancellations can also be identified.

Bus operators, using a flat-panel, touch-screen computer display, exchange information with the control center on the latest generation of MDT. The MDT is particularly important for operating a flex-route system because schedule adherence must be monitored and the manifest is updated continually. The manifest on the MDT is updated automatically, with executed activities scrolling off the top of the screen and future activities entering the bottom. Figure 4 shows the types of activities transmitted to the manifest. At fixed stops, detection of arrival and departure is fully automatic within a user-definable range. Communications are often sent via predefined data messages (for example, "no-show"). At off-route trip locations, the operator must either push a button when departing or ask for permission to depart if there is a no-show. In this way the system operates similarly to many fully demand-responsive systems. Voice communications are possible when desired, but are usually minimal.

Log-on to the CAD/AVL system requires a user ID. At the beginning of the service day, a vehicle inspection check-off screen must be filled out before the first run can be started. There is an optional screen to enter passenger counts by type of fare and type of mobility device (if any). A sample screen is shown in Figure 5. This can be used on days designated for passenger-count sampling.

The importance of the capability for showing directional instructions on an electronic map was not understood during the trial of ITS procurement. Turnover of bus operators would prove to be high, and new operators tended to get lost frequently, significantly degrading on-time performance and system reliability. (This is no longer an issue at PRTC.) With the push of a button, a map can appear that orients the front of the bus toward the top of the screen. The recommended instructions on where to turn are then easy to follow.

Rare for a CAD/AVL system installed in North America, the PRTC system includes a postprocessing software package that can be used for service planning. Other agencies historically had to develop their own software at significant expense, or made limited use of their

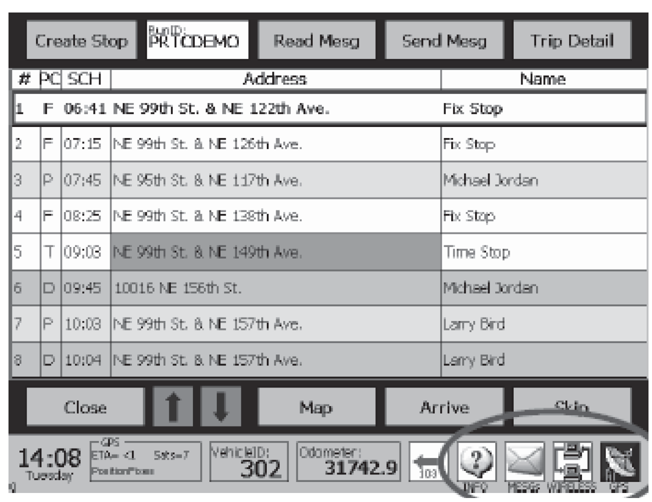

FIGURE 4 Features of flex-route manifest: first fixed-route stop (F); one pickup (P), off-route trip; one time point (T), fixed-route stop; one drop-off (D), off-route trip. The initial manifest configuration was for a maximum of 10 activities; the current configuration is for up to 20 activities.

FIGURE 5 Boarding and alighting count screen.

archived data. Using the PRTC software package, a transit planner without special programming or database expertise can request average and standard deviations of running times between time points, averages and standard deviations of passenger counts between segments, boarding and alighting counts, numbers and types of passengers needing mobility aids, and so on. This level of information, although desirable for any operation, is of particular value for flex services. The system can be used to optimize slack times and deviation acceptance rules, to select fixed stops, to identify bottlenecks that cause recurring delays, and to gather other data for planning route improvements.

The new CAD/AVL system has been in revenue service since March 2003. In the testing period and during the first months of operation, it experienced a few reliability problems, some caused by mechanical connections and excessive internal vibration. The MDT was located directly over the forward engine compartment in buses that have recently been retired. Now the engine is in the rear, and there are no longer problems with heat and vibration. The MDT is now almost always accessible and, on the basis of feedback from operators, it has been well accepted by all of them.

The communications system has needed changing again. With the phasing out of cellular digital package data by the incumbent phone company, the General Packet Radio Service system is now used for communications. In theory, only the modem within the MDT had to be changed, but the opportunity was taken to install an even more advanced processor and to separate the processor and modem from the MDT screen, thus eliminating the potential connection problems described earlier.

The Washington, D.C.–area transit agencies are in the process of installing a region-wide smart farebox system, and PRTC expects to take delivery of its boxes in 2006. Log-on to this device will be merged with the MDT. The farebox will receive locational information to append to its database, to analyze ridership patterns and eliminate bus operator duplication of data entry.

FINANCIAL PERFORMANCE

Figure 6 shows a daily ridership history for all five routes. It has had a steady upward trend. There were about 667,000 rides in FY 2005. On the basis of the results from the first half of the year, ridership will exceed 700,000 in FY 2006. The slight downward turn in FY 2004

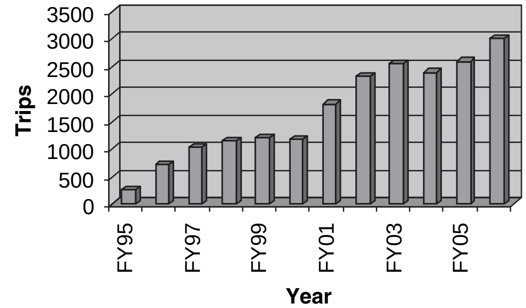

FIGURE 6 Ridership history of OmniLink (*3*).

was not due to any service deterioration related to ITS implementation. Rather, it was the result of a work stoppage by operators of an incoming contract management firm; a fare increase; and some data errors due to manual data processing difficulties, as the ITS-assisted service began without the postprocessing module in place. The substantial increase in patronage that took place in FY 2001 was due to expanded hours of operation. Before July 2000, service operated from 7:30 a.m. to 6:00 p.m.; beginning in July 2000, service expanded to 5:30 a.m. to 10:45 p.m., although headways were doubled for most additional hours.

The fare was increased from $0.75 to $1.00 in October 2003, and transfers were eliminated. Compensating somewhat was the institution of a $2.25 all-day pass. Also recently implemented was an additional charge of $1.00 for off-route trips. The double fare was not instituted to maximize revenue that can legally be collected under the ADA, as it does not apply to the elderly or the disabled. Rather, it was instituted to encourage able-bodied users to walk to a bus stop. While deviations were not being abused, both passengers and bus operators were frustrated by customers who could walk to the bus stop but chose to request that the bus come closer. Few complaints were received after the surcharge was implemented, and the change has had the desired effect of providing more off-route capability for those who need it most (elderly, disabled, those who truly have a long walk, etc.). Persons who are capable and feel secure doing so tend to walk to the nearest stop. In FY 2003 about 10.1% of riders requested deviations, and about 7.9% were actual riders. The difference was due to cancellations, no-shows, and the occasional rejected offer of accommodation. After the fare increase, the corresponding figures dropped to 8.1% and 6.5%. The route can be readjusted in accordance with demand, if deviations prove to be concentrated at particular locations.

As shown in Figure 7, this service has a respectable average productivity given the low density of the operating area and the long

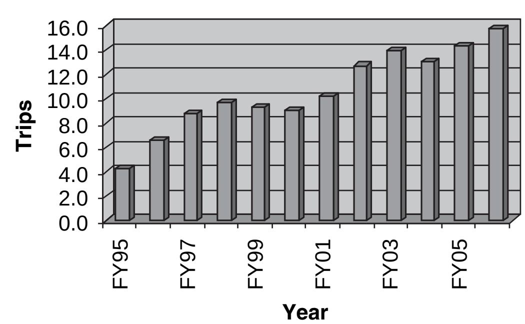

FIGURE 7 Productivity history of OmniLink (*3*).

headways. Average passengers per vehicle service hour across all five routes have ranged from 12 to 14 passengers per hour the past three fiscal years. As of the first half of FY 2006, the figure has climbed to more than 15 passengers per hour. The averages would no doubt be somewhat lower if the service operated on Sundays. It is interesting to note that productivity actually increased when service hours were expanded—an indication of how much latent demand existed. The productivity loss in FY 2004 is another manifestation of the strike and the fare increase, but it has recovered in the current fiscal year.

Due to demographics and operating environment, the three eastern routes perform significantly better than those to the west (17 passengers per hour versus eight for FY 2005). Specifically, the density is lower in the Manassas area. That area is also bisected by a major roadway with as many as nine through and turn lanes to cross, making it less pedestrian friendly and increasing running times for off-route service. Additionally, headways are longer at 1 h, even in the peak period, and they do not pulse as they do on the eastern side.

The OmniLink budget was approximately $3.5 million in FY 2005. The operating cost per hour for the current fleet of 30-ft-long midibuses is about $84 per revenue hour in FY 2006, and the farebox recovery ratio is about 12% (15% in the east and 7% in the west). But the cost cannot be compared directly with costs of other public agencies in the National Transit Database because OmniLink is a contracted operation. A few minor additional overhead and supply costs are borne by PRTC as joint costs with their other operations and therefore are not included in this estimate. Note also that the revenue hour cost is the same for all PRTC services, about 60% of which are commuter express trips with around 50% deadhead time.

BENEFIT-VERSUS-COST ANALYSIS

PRTC was awarded a one-time competitive grant from the FTA of approximately $1.3 million for the first trial of ITS procurement. It would not have been economical for PRTC to pay the entire ITS development cost itself, because the costs would have been spread over too small a fleet. However, the second trial was fully funded by PRTC and state of Virginia funds at an additional one-time capital cost of about $500,000. This was sufficient to develop the new system and equip 19 vehicles, plus spares, training equipment, and one dispatcher workstation.

It is not possible to do a precise cost-versus-benefit calculation for the implementation of the ITS-assisted version of OmniLink. PRTC is a moderate-size agency, in which IT support, maintenance, planning staff, and management all have multiple responsibilities among the various operations. The best estimate is that 20% of one person's time must be dedicated to administering the ITS, and 3 h of training are needed for new bus operators. The additional annual labor by electronics technicians and mechanics on board buses has not required additional staff. The best estimate for the value of time used by senior staff during the specification, procurement, and project oversight phases is a total of 1 person-year among several individuals, for a fully loaded one-time cost of $200,000. The consulting contracts for assistance in specification, procurement, and project oversight totaled $60,000. The CAD/AVL life is estimated at 12 years, or about the same as the buses. At a minimum allowable rate of return of 7%, the amortization is about $63,000 per year. Similarly, the senior staff costs can be amortized with the same interest rate and system life at $25,000 per year and the consultant costs at $7,500 per year. Added to these is the software and hardware service contract of about $25,000 per year.

The number of dispatchers is unchanged between fixed-route and flex-route operations. A case could be made that the cost of customer service agents should be included because they are not required for traditional fixed-route services. However, doing so would probably overstate the cost. First, most agencies need people to provide customer information. The ITS has improved the productivity of the customer service agents who take reservations to the degree that they can perform the customer information role as well. Second, should PRTC have chosen to provide pure demand-responsive ADA paratransit instead, it may well have had to hire customer service agents, or pay an additional fee to the contracted operating firm to provide it.

Balancing these liabilities is the obviation of the need for ADA paratransit. A close estimate of the ADA-eligible demand using pure demand-responsive paratransit would require a separate research effort, but a reasonable range can be estimated. Given a 2004 population in the OmniLink service area (Prince William County) of 336,000 persons (*4*), a low estimate of monthly demand would be 2,000 riders and a high estimate would be 4,000 riders per month. These compare with an average of about 4,375 off-route deviation requests per month based on the current request rate of roughly 7% (*3*) of all trips, but this also includes an uncertain, but relatively low number of able-bodied people. Based on the productivity of the adjacent demand-responsive services provided under contract to the Washington Metropolitan Area Transit Authority (WMATA) of about 1.5 riders per vehicle-hour and WMATA's corresponding fully allocated cost of $54 per contracted vehicle-hour (*5*), the avoided cost would range from $840,000 to $1.68 million per year.

Also contributing to the offset is the obviation of the need for manual passenger counts, travel time analyses, National Transit Database statistics, and other tasks performed automatically by the ITS. This is estimated to save about 1 person-year annually, at a fully loaded cost of $100,000.

The cost-versus-benefit accounting is summarized in Table 1. Based strictly on monetary costs versus benefits, the ITS far more than covers its expenses when all annualized costs and benefits are summed algebraically. The results are compelling, even when the minimal ADA-eligible demand is assumed. An additional $840,000 to $1.68 million per year added to $3.5 million would be a major increase in operating costs, almost 50% more if the higher demand is assumed. The results are also robust, because even major errors in cost assumptions would not close the gap between benefits and costs.

The nonmonetary benefits also must be added. There are significant benefits both to the agency and the ridership.

The quality of life of the bus operators, dispatchers, and customer service agents has improved at PRTC. This probably contributes to the lower turnover of staff once ITS became operational. OmniLink has also presented an image of PRTC as a progressive, technologically advanced transit agency to the community.

Certainly, those people who have been mainstreamed into society with this service, or who have otherwise needed the deviations, have benefited, although this cannot readily be translated into monetary terms. It does not appear that the extra time needed for the deviations has decreased satisfaction by the rest of the riders, either. PRTC performs random on-board surveys three times per year. The survey conducted in September 2005 resulted in 82% of riders rating overall service quality "excellent." The previous year, satisfaction was 72%. It should be noted that although this was about 1 year into ITS-assisted operations, the ITS cannot take all the credit. Driver stability had improved substantially following a new operating contract,

TABLE 1 PRTC's Estimated Annual Incremental Costs and Benefits

Incremental monetary costs (annualization factors $i = 7\%$, $n = 12$ years)	
Annualized CAD/AVL investment cost ($500,000)	$63,000
Annualized cost of senior staff time for specification, procurement, and oversight (1 person-year at $200,000)	$25,000
Annualized cost of consulting assistance	$7,500
Software and hardware maintenance contract	$25,000
Senior IT staff person (20% time)	$40,000
Operator training (3 h per year)	negligible
Vehicle onboard equipment maintenance (no extra staff)	negligible
Total	$160,500
Incremental monetary benefits	
No separate ADA paratransit (2000–4000 trips/month, 1.5 passengers/h, $54 per vehicle-h)	$840,000–$1,680,000
Reduction in planning staff (1 person-year)	$100,000
Total	$940,000–$1,780,000
Nonmonetary benefits	
To PRTC	
Increased satisfaction of staff (dispatchers, operators, and customer service agents)	
Progressive image of PRTC within community	
To the ridership	
Disabled riders mainstreamed into community	
Able-bodied riders receiving curb-to-curb service upon request	
Increased rider satisfaction (only partly attributable to flex-route concept)	

and new buses had just been introduced. The results before all these changes, in spring 2003, were a 58% rating. Over the same period, on-time performance "excellent" ratings improved from 36% to 48%, then to 60%.

It is fair in a cost–benefit evaluation to ask how this service would compare with a traditional service using shorter headways. The cost of service would not change because slack time is introduced. The service span on any particular route would remain the same regardless of whether traditional fixed-route or flex-route service is operated. Thus, the comparison should assume an equal operating budget under all options.

Ideally, if PRTC were big enough, one way to make a comparison would be to run two separate operations in two areas with similar characteristics. Without actual operating results from such a comparison, however, the evaluation would be based on speculation. PRTC could perhaps operate 35-min headways in an unreliable manner instead of 45 min, but this would require running nonclock headways and eliminating a pulsed scheduling system. On the other hand, 30-min headways to retain the pulsed schedule would require some type of service reduction, either truncation of all routes or elimination of one route. Either possibility would cause ridership losses that would offset increases attracted by shorter headways.

Local suburban bus services (i.e., not commuter or rail feeder) often have difficulty attracting choice riders. OmniLink ridership is probably inelastic to frequency, but clearly is sensitive to area coverage and service span, because people cannot ride a bus that does not come by. PRTC began with a budget sufficient for only 10.5 h per day and only expanded to 17 h in 2000. To pay for complementary pure demand-responsive service, PRTC might have had to lengthen headways from 45 min, instead of shortening them to 30 or 35 min. Thus, PRTC initially judged that route deviation was the least-bad alternative.

APPLICABILITY OF FLEX ROUTING TO OTHER LOCATIONS

Flex-route services might be applicable in any service area in which there is moderate demand (fewer than 20 passengers per hour) and where there are impediments to walking to fixed-route stops. This is, in fact, a common situation in many post–World War II U.S. suburbs. However, street layouts with only one entrance and exit point to the arterial on which the route is located might require a prohibitive deviation time. Thus, the entire proposed service area would need to be studied in detail. It should be noted that pure demand-responsive vehicles also lose excessive amounts of time in similar street layouts. Whereas PRTC uses 30-ft (9-m) long buses, the maximum allowable size elsewhere would depend on local community tolerance and the turn radius required to negotiate the streets involved.

Service area characteristics and community acceptance are important. If service already exists, so do service expectations. The disabled community might be wary of a new service, even one that promises to mainstream many people. Riders of existing fixed routes might be wary of services that are subject to delays from off-route excursions. During the planning of these services, outreach must include a discussion of tradeoffs, and how the potential advantages offset the potential disadvantages.

Flex-route service also can be used as a night replacement for large buses. Smaller buses probably can maintain the same average speed that large buses can during higher-demand periods, even with slack time introduced to accommodate deviations. This is due to less stopping during lower-demand periods and to the better maneuverability and acceleration of smaller buses (*6*). These capabilities might be particularly attractive on routes on which passengers express a reluctance to walk to and from fixed-route stops at night.

Finally, flex-route services show special promise as a device for probing demand. If there are areas where little or no service has been provided to date, service can be initiated based on the best estimate of where the fixed stops should be. As demand is revealed, high-demand deviation locations can become fixed stops. Should demand warrant, the route can evolve into a fixed route using large buses during high-demand periods. The smaller bus can be redeployed to explore another untested area.

See Koffman (*7*) for descriptions of other applications of route deviation at agencies across North America, and descriptions of other types of flexible services. Many of these applications could be enhanced with ITS of equal capability to that installed at PRTC.

LESSONS FOR OTHER AGENCIES

PRTC received significant federal grant funding that has enabled extensive research, development, and evaluation during the first round of project implementation. Although the first round was not fully successful, the lessons learned set the stage for subsequent success. Furthermore, PRTC had a few highly dedicated staff members who championed the overall project development. The tenacity to overcome many implementation challenges was an important component of PRTC's success.

Ultimately, this FTA ITS Operational Test Grant must be considered a success. As a result of one agency's pioneering effort, an ITS-assisted flex-route implementation will cost less to the next agency. The specifications for a CAD/AVL system that is field tested and reliable are now available as a starting point to follow-on transit agencies. Modifications to the specifications should be limited, as these can increase project risk and will require vendors to price using a risk premium.

The $500,000 capital investment in the second trial was reduced substantially from the first trial. There is every reason to expect that costs can be reduced substantially even further. With mass production, hardware costs will decrease. The system integration will be more straightforward at other agencies now that many questions requiring testing have been answered and open architecture hardware–software interfaces are becoming the norm. The largest uncertainty is in the future of the scheduling and call-taking software. As of this writing, there are at most two vendors in North America offering suitable software with flex-route capability.

It is best to include the postprocessing package in the initial specification. Once it has been developed for one agency, it makes sense for other agencies to order something similar. The costs to develop such a package in-house or to hire a third party to develop such a package would, no doubt, be much higher.

This paper mentioned that using a turnkey procurement was believed to be central to successful implementation. This needs some elaboration. The selected firm should have a project manager who acts as a single point of contact and who keeps abreast of all subcontractors' work. All timetables for achieving key milestones and for resolving action items should be reached in mutual consultation with agency staff. In this way, realistic rates of progress are maintained and tension is minimized. The contract with this firm should have a liquidated damages clause or some other incentive toward project completion. The contract should specify that all subcontractors also have an incentive structure. Although this requirement might appear to the prime subcontractor to be interference, the transit agency can reduce its risk substantially. Subcontractors have the potential to disrupt even the best-laid plans and intentions of a prime contractor. In the end, a transit agency should still allow for project delays with generous installation and testing schedules. There are always unforeseen delays, some of which may be beyond the control of either agency or contracting firm.

The entire CAD/AVL system combined with the hybrid scheduling software would qualify as a capital investment item rather than an operating expenditure. However, there will be ongoing maintenance and support costs. Whether it is necessary to hire additional staff for hardware maintenance and IT support will depend on the agency. An additional person was not required at PRTC, but it was necessary to raise the knowledge level required of the IT support staff and maintenance staff.

The total time involved in project management and development from staff during the specification, procurement, and implementation phases can be substantial. Allowances should be made in staff work responsibilities and annual staff budgets until the ITS becomes operational and used routinely.

PRTC was able to use a stand-alone system because it did not have separate paratransit and fixed-route divisions. However, many transit agencies have separate CAD/AVL systems in place. At agencies with existing demand-responsive CAD/AVL, the supporting IT infrastructure and software must be adapted to receive the full benefits of a flex-route system. Specifically, to make a decision between assigning a trip to a flex-route vehicle or to a pure demand-responsive vehicle, the scheduling and dispatching software for both services must share a rider database. (PRTC specified such a system but has not tested these capabilities because the agency does not operate a pure demand-responsive service.) This database should include disabled riders and any special needs they have, as well as other frequent requestors of off-route trips. Furthermore, dispatchers should be able to see all vehicles operating in a service area instead of having separate dispatching for demand-responsive and flex-route operations. These enhancements may, in fact, require acquisition of a combined software package from one vendor. However, such modifications to existing installations are less complicated than acquiring an entirely new CAD/AVL system.

The increased software complexity and compatibility issues raised by hybrid services have some offsetting benefits. Rather than maintaining two different types of dispatcher stations and on-board equipment for the fixed-route and demand-responsive services, the same software, spares, and maintenance practices would be usable for the entire fleet.

A flex-route service can be tried in a pilot area. But it would require a dedicated subfleet equipped with stand-alone on-board equipment and training of drivers assigned specifically to this service. The PRTC experience clearly shows that it would also require an outreach effort to users in the service area to explain the nature of this service. Flex routes cannot be tested on a casual basis; if the outreach is not adequate, then the true level of public interest and effectiveness will not be discovered.

PRTC did not have to worry about organizational divisions because it had no demand-responsive operations prior to OmniLink. But to use flex route to its full potential, there must be a blurring of the distinction between transit and paratransit. New productivity indicators that track performance of the combined, hybrid operations should be considered. These should be able to demonstrate to the agency that implements flex services whether any reduction in fixed-route productivity due to the deviations is compensated by lower paratransit costs or by better service to the public.

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