Intelligent Transportation Systems in 98 B-Line Rapid Bus Service: Advanced Technology at Work

Organization
TransLink (Greater Vancouver Transportation Commission)

Status
Started 2001, ongoing

Overview
TransLink's 98 B-Line between downtown Vancouver and Richmond, B.C., provides bus rapid transit service using intelligent transportation systems (ITS) technology and physical transit priority measures.

State-of-the-art ITS tools valued at $6.2 million are an integral part of the service. They increase service reliability, reduce travel times, and keep passengers informed and content. Automatic vehicle location systems, computerized monitoring of schedule adherence, sophisticated traffic signal priority and real-time "next bus" arrival information are all important parts of the 98 B-Line service.

An evaluation of the 98 B-Line that focused on its ITS components found that they led to annualized net benefits of $2.9 million, a 16% reduction in transit travel times, a 20% to 25% reduction in operating costs and similar reduction in vehicle capital cost, significant new transit ridership, and minimal disruption to corridor traffic operations.

The success of the 98 B-Line has prompted the addition of ITS tools to other existing B-Line services in the Vancouver area.

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Resources
- www.translink.bc.ca
- 98 B-Line Bus Rapid Transit Evaluation Study (www.translink.bc.ca/files/programs/its/98B_Eval_Final.pdf)
- 2005-2007 Three-Year Plan & Ten-Year Outlook (www.translink.bc.ca/files/3yr_plan_10yr_outlook.pdf)

Community context

The Greater Vancouver Regional District (GVRD) has a population of about 2 million people. TransLink (the Greater Vancouver Transportation Authority) is the agency responsible for area transit service and the major road network. Greater Vancouver's transit system includes over 1,200 buses, the SkyTrain light rail system, a commuter rail service and four passenger ferries. The transit system carries about 130 million passengers annually, trailing only Toronto and Montreal among Canadian metropolitan areas.

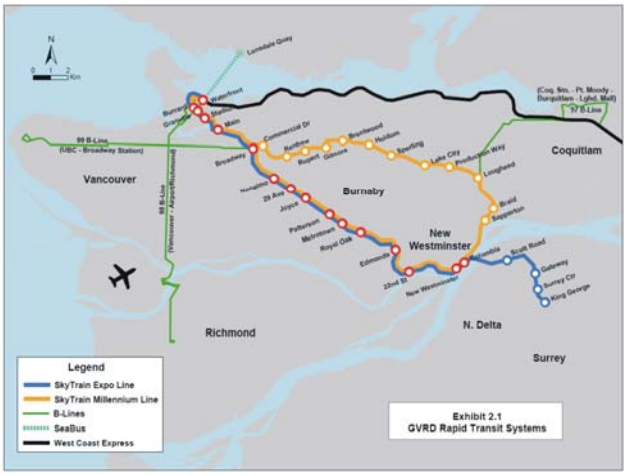
In 1998, TransLink started work on a new bus-based rapid transit service linking downtown Vancouver and the suburban community of Richmond. Downtown Vancouver is a major regional hub with dense employment (130,000 jobs) and residential uses. Further south, the hospital district is home to more than 40,000 jobs. Richmond is a growing urban centre with about 170,000 people and 100,000 jobs, including 30,000 in its central area. The 16-kilometre route also passes by the Vancouver International Airport, which has over 25,000 jobs and serves more than 15 million passengers each year.

TRANSLINK
Greater Vancouver Transportation Authority

Policy context

GVRD's Livable Region Strategic Plan calls for the development of new rapid transit services in five key corridors, accompanied by intensified development. Because SkyTrain (GVRD's longest-standing form of rapid transit) is very expensive to build, TransLink has chosen to start by developing a number of "rapid bus" transit lines, known as B-Lines.

Three B-Lines have been opened to date, including the 99 B-Line service from the University of British Columbia to Lougheed Mall in 1996, the 98 B-Line service from Richmond to downtown via the Airport in 2001, and the 97 B-Line service linking Coquitlam and Port Moody to the Millenium SkyTrain in 2002.



Location of 98 B-Line within Greater Vancouver's rapid transit network

98 B-Line route

Rationale and objectives

In their ongoing search for ways to make urban transportation networks more efficient and responsive, communities and service providers are increasingly looking to intelligent transportation systems (ITS) for assistance. ITS applications use computer and communications technologies to improve road and transit operations through tools such as automatic vehicle location, responsive traffic signal operations and advanced traveller information.

The 98 B-Line builds on TransLink's experience with the earlier 99 B-Line by applying intelligent transportation systems (ITS) to improve customer service. This B-Line service uses advanced technologies to reduce delays, increase service reliability and improve passenger information. It uses traffic signal priority and automatic vehicle location systems to reduce delay and increase reliability, and offers passengers real-time bus arrival information. This use of ITS reflects several key objectives:

- The desire for fast, frequent service
- The desire to improve customer service through reliability and convenience
- The desire to increase ridership
- The desire to operate more efficiently than traditional bus routes

Actions

The 98 B-Line is 16 kilometres long, with the distance between stations ranging from 400 metres to 2 kilometres. The service runs up to 22 hours a day, every day, with as many as 24 buses in concurrent operation running every 5 to 6 minutes in peak periods and 15 minutes in the evening. In 2002, about 18,000 passengers rode the line on an average weekday, with about 1,000 in the peak hour.

A number of transit priority measures permit B-Line buses to bypass chronic congestion locations and remain competitive with auto travel in terms of speed. There are exclusive median bus lanes on No. 3 Road in Richmond, queue jump lanes on bridge approaches at the Fraser River, exclusive curbside bus lanes in Vancouver, and traffic signals that give priority to B-Line buses when they are behind schedule.

The following paragraphs describe the 98 B-Line's ITS applications.

Transit management system. This system uses automatic vehicle location and schedule adherence monitoring to optimize the efficient use of buses. A differential global positioning system (GPS) provides accurate automatic vehicle location information. Each bus has a computer to carry schedule information and process GPS data, and bus operators can view their real-time schedule adherence on a mobile data terminal that also enables two-way messaging between buses and the control centre. Transit controllers can quickly identify and respond to changing traffic conditions and operational needs by communicating with drivers.

Traffic signal priority. Most of the signalized intersections (59 of 68) along the 98 B-Line can give priority to buses when they are behind schedule, by minimizing the need to stop or the duration of any red signals encountered. When alerted by the on-board computer, bus-mounted transponders send an infrared signal that requests priority from roadside traffic signal controllers. The location of buses around the intersection is detected precisely using both upstream and downstream detectors, to minimize undue delay to cross-street traffic. Signal priority is given to buses either in the form of an extended green signal or a truncated red signal.

Real-time passenger information. Real-time passenger information is provided to patrons both on-board buses and at stations. All 98 B-Line vehicles are equipped with dynamic message signs and speakers that announce the station being approached, as determined from real-time GSP information. At stations, dynamic message signs display a countdown timer that shows "next bus" arrival times for the next two B-Line vehicles approaching the station, based on real-time vehicle positions and speeds.

Real-time bus arrival display at station

Results

A comprehensive evaluation of the 98 B-Line for Transport Canada in 2003 identified its key results including benefits to users, operators and the community as a whole. These benefits can be considered to have arisen either partly or largely due to ITS measures. The following paragraphs review some notable results.

Travel time reductions. Average round-trip travel times in the 98 B-Line corridor have decreased from 100 to 84 minutes, largely due to fewer stops and higher travel speeds resulting from various measures including traffic signal priority. Aside from clearly benefiting riders, lower travel times also mean that about five fewer buses are needed to maintain scheduled frequencies, thereby reducing vehicle costs by $3.2 million and cutting annual operating costs by 20% (about $1.8 million).

Service reliability. Measures that give transit vehicles priority, especially at traffic signals, have substantially reduced variability in travel times. This greater reliability can reduce the need for layover times by at least 5%. Together, the automatic vehicle location and traffic signal priority measures are estimated to have reduced the number of required buses by one, implying a capital cost saving of $650,000 and annual operating cost savings of $360,000.

Modal shift. Increased speeds and reduced transit travel times have helped to create a substantial shift from auto use to transit use in the corridor. Surveys have found that 23% of 98 B-Line users previously made their trip by car, representing increased transit ridership of 1.2 million passengers (boosting net revenues by about $1.2 million) and reduced car use of about 8 million vehicle-kilometres per year. This modal shift can reduce traffic congestion, and is estimated to have reduced air emissions (including a 1,200-tonne drop in carbon dioxide emissions).

Customer satisfaction. User surveys have found strong satisfaction with the service, vehicles, shelters and passenger information. In the Richmond area in particular, community members have noted improved traffic flow and reduced accidents associated with the bus lanes on No. 3 Road.

Impacts on other traffic. Transit priority measures can have negative impacts on cross-traffic by disrupting signal phasing or "borrowing" green time. However, the sophisticated approach to signal priority for 98 B-Line operations has reduced cross-street capacity by amounts ranging from only 1% in Vancouver to 6% in Richmond. Capacity for traffic along the 98 B-Line route has increased, helping to offset any cross-street capacity reductions.

Benefit/cost ratio. An overall assessment of benefits and costs, considering user time and TransLink's costs and revenues, estimated that the project's benefit/cost ratio was about 1.3 and that benefits exceeded costs by 30% (about $2.9 million) on an annualized basis. This figure reflects 2002 ridership figures, and would grow in subsequent years as ridership increases.

Participants

TransLink. The 98 B-Line was implemented under the direction of the Engineering & Project Services Department, while the ITS Department was responsible for coordinating the ITS components. Coast Mountain Bus Company, the TransLink subsidiary that operates bus transit services, was also an important participant throughout planning and implementation.

City of Vancouver and City of Richmond. These municipalities own and operate the traffic signals and roads along the 98 B-Line route. They worked closely with TransLink to install traffic signal priority software and detectors at signalized intersections, and to coordinate traffic operations along the 98 B-Line route and adjacent roads.

Contractors. The project relied on vendors of the special systems used for traffic signal priority and automatic vehicle location, and on consultants who provided expert assistance in refining design concepts and resolving operational difficulties during the project's early phases.

Resources

The costs of 98 B-Line implementation totalled about $52 million for vehicles, land, stations, busway and maintenance garage construction, and the on-board transit management and traveller information systems.

The project's traffic signal priority system (i.e. in-vehicle transponders, roadside detectors, traffic signals and controllers, wiring and installation) cost $2.2 million.

The transit management system (i.e. acquisition, installation documentation and training related to the central and on-board automatic vehicle location systems) cost $4.0 million, including $2.8 million for the central system, $0.5 million for vehicle-mounted hardware in 28 buses, and $0.6 million for radio communications and project management.

Timeline

1997 to 1998. Preliminary design to evaluate alternative routes and select a preferred route and station locations

1999 to 2000. Detailed design of road and busway improvements, shelters, stations, traffic signal priority system and traveller information system

2000 to 2001. Land and vehicle acquisition, construction of roads, busways, shelters and stations, and implementation of traffic signal priority and real-time traveller information systems

August 2001. Start of service

Lessons learned

The evaluation of the 98 B-Line led to several conclusions and a set of guidelines for similar bus rapid transit systems, including:

- Transit priority measures are essential for maximum efficiency, and can achieve travel time reductions of 20% to 25% compared to local bus services.
- Transit priority systems can be designed to minimize transit delays while also minimizing negative impacts on other traffic (particularly cross-street traffic).
- Bus rapid transit services should be given a unique identity, which is supported when special features like real-time passenger information are highlighted in promotional materials.
- Real-time passenger information is a more valuable feature to customers when the time between arriving buses is more than just a few minutes, but the service is still appreciated even when bus arrivals are frequent.

A major challenge on this project was the coordination of stakeholders required to implement ITS systems with a scope that spanned roadway infrastructure, fleet infrastructure, communication systems, and traffic and transit operations.

Another major challenge experienced during implementation of the 98 B-Line project was the refinement and troubleshooting of the automatic vehicle location and traffic signal priority technologies. Project staff felt that the risks (in terms of project schedule and cost) associated with implementing new technologies on such a large scale could have been reduced through an initial smaller-scale pilot phase.

Next steps

The 98 B-Line evaluation identified several enhancement opportunities. Those related to the line's ITS components include:

- Future cooperation with the cities of Vancouver and Richmond to monitor, manage and refine traffic signal priority capabilities
- Development of enhanced traffic signal priority measures, such as unconditional traffic signal priority or the ability to insert a special phase for transit priority at multiphase intersections
- Enhancement of traffic signal priority software to better manage recovery (i.e. resynchronization of affected signals) after priority has been granted
- Evaluation of the operational transit management procedures, to ensure optimal use of the central system
- Tightening of the 98 B-Line schedule to take advantage of automatic vehicle location and traffic signal priority systems
- Examining the use of variable schedule adherence thresholds by bus occupancy, time of day, and direction (e.g. the schedule adherence threshold for full B-Line buses in the peak direction during rush hour could be specified more stringently than for empty buses at less busy times).

Based on the 98 B-Line success, TransLink's new 2005-2007 Three-Year Plan & Ten-Year Outlook includes provisions for implementing a new B-Line service in Surrey, a high-density urban setting, as well as adding transit signal priority and automatic vehicle location systems to the 99 and 97 B-Lines.

All images are courtesy TransLink
(source: 98 B-Line Bus Rapid Transit Evaluation Study)