ITE QUAD / IMSA BC JOINT CONFERENCE
VANCOUVER, BRITISH COLUMBIA
APRIL 2001

COMPENDIUM OF PAPERS

EMPIRE LANDMARK HOTEL

INTRODUCTION

The annual ITE Quad conference continues to grow into a major gathering of transportation professionals from the Cascadia region. It was not long ago that the Quad was a one day event featuring less than 10 speakers. This year, it is a two day event with more than 40 quality technical presentations and two to three parallel tracks. This year also features a partnership with our friends from IMSA - BC, and a major trade show.

Early in the process of planning this year's conference, the Organizing Committee recognized the growing stature of this conference and decided to prepare a compendium of papers. We also decided that the compendium will be a casual, "low-tech" affair, to reduce costs and increase the likelihood that the presenters will submit written papers. We also wanted the papers to be immediately accessible to the conference attendees during the conference. We therefore selected the binder format and imposed no paper formatting requirements.

We were very impressed that more than 30 written, high quality papers were submitted, making this compendium an excellent record of the conference and a valuable addition to your library. The Technical Committee wishes to sincerely thank all of the authors who took the time to prepare and submit their papers, and also all the presenters who couldn't submit a paper yet nevertheless submitted abstracts and gave presentations at the conference.

The technical program covers a diverse selection of topics and travel modes, ranging from strategic planning issues to detailed operational aspects of transportation. Several papers tackle the challenges of providing effective "transportation across borders", be they municipal, regional, or international. We are confident that you will find in these papers new and interesting ideas that may be of immediate benefit.

Thanks for attending, and enjoy the conference !!

Sany R. Zein, M.Eng., P.Eng.
Technical Committee Chair

CONFERENCE PLANNING COMMITTEE

The conference planning committee members wish to thank all the delegates for attending, all the exhibitors for supporting the trade show, and all the corporate sponsors of the conference. We hope you enjoy the conference as much as we enjoyed putting it together !

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TABLE OF CONTENTS

TABLE OF CONTENTS
continued

TABLE OF CONTENTS
continued

TABLE OF CONTENTS
continued

Introducing a Rapid Transit Line into an Established Community

by
Lon LaClaire, M.Eng, P.Eng.
Renate Ehm, P.Eng.

CITY OF VANCOUVER

ABSTRACT

Imagine that they have announced that a rapid transit line will be built through an established neighbourhood - your neighbourhood. This neighbourhood already has a rapid transit line that is seen as blight in the community and now they're going to build more! What do you do?

This is the story of how the Cedar Cottage neighbourhood in the City of Vancouver worked with the City and Provincial government agencies to integrate a new SkyTrain line into an established community. One of the biggest concerns was that fact that the alignment would pass right through a community that already had a rapid transit line running through it. The first SkyTrain line was built with haste and little consultation ... and it shows. The station and guideway created a less-than-desirable station precinct area and some bad associations with rapid transit overall. This report will walk you through the design development of the new SkyTrain line in Vancouver from the perspective of the local government.

BACKGROUND

Vancouver, with a population of over one-half million in a metropolitan region of two million, is the largest City in the Province of British Columbia, and the 3rd largest metropolitan area in Canada. In 1998, the Provincial Government granted authority over the region's transit service to the regional government to make transit and transportation service more responsive to the needs of local communities. Prior to 1998, *BC Transit* managed the region's transit system, a Provincial Crown Corporation.

TransLink, the new regional transportation authority, provides transit services across eighteen hundred square kilometers, using a variety of vehicles and passenger ferries. Transit carries more than 127 million passengers per year, or 11% of the region's transportation demands. About one-third of all trips made by transit, use SkyTrain, the region's rapid transit system, for all or part of their trips.

The Beginnings of Vancouver's Rapid Transit System

Planning for a light rail transit (LRT) system to connect New Westminster and Burnaby to downtown Vancouver was already underway when it was announced that Vancouver would host the 1986 World's Fair Exposition. The announcement accelerated the need for a rapid transit system, and in 1980, the Province of BC committed funding for an advanced light rail transit (ALRT) system for the Vancouver region, to be built by a former Ontario Crown corporation. The Urban Transportation Development Corporation of Toronto, created and funded by the Ontario government to develop new transit technologies, had developed and tested an ALRT. Expo '86 would bring world attention to Vancouver, and a Canadian state-of-the-art advanced light rail transit system. The Federal government contributed $60 million toward the the $854 million capital cost.

SkyTrain began operation in 1986, in time for Expo '86, Vancouver's gala world exposition. SkyTrain is a fully automated, driver-less light rail system running on its own guideway. It operates at headways of two to three minutes in the peak hours, and five minutes throughout the rest of the day. Cruising speed is

80km/hr and the system average speed is 44 km/hr. SkyTrain can transport up to 20,000 passengers per hour per direction. Eighty-two percent of the line is elevated; 6 percent is in a tunnel or below grade and 12 percent runs on the surface. The original 21km SkyTrain system had 15 stations. This line, now called the *Expo Line,* was expanded in three phases, adding 8km and five more stations.

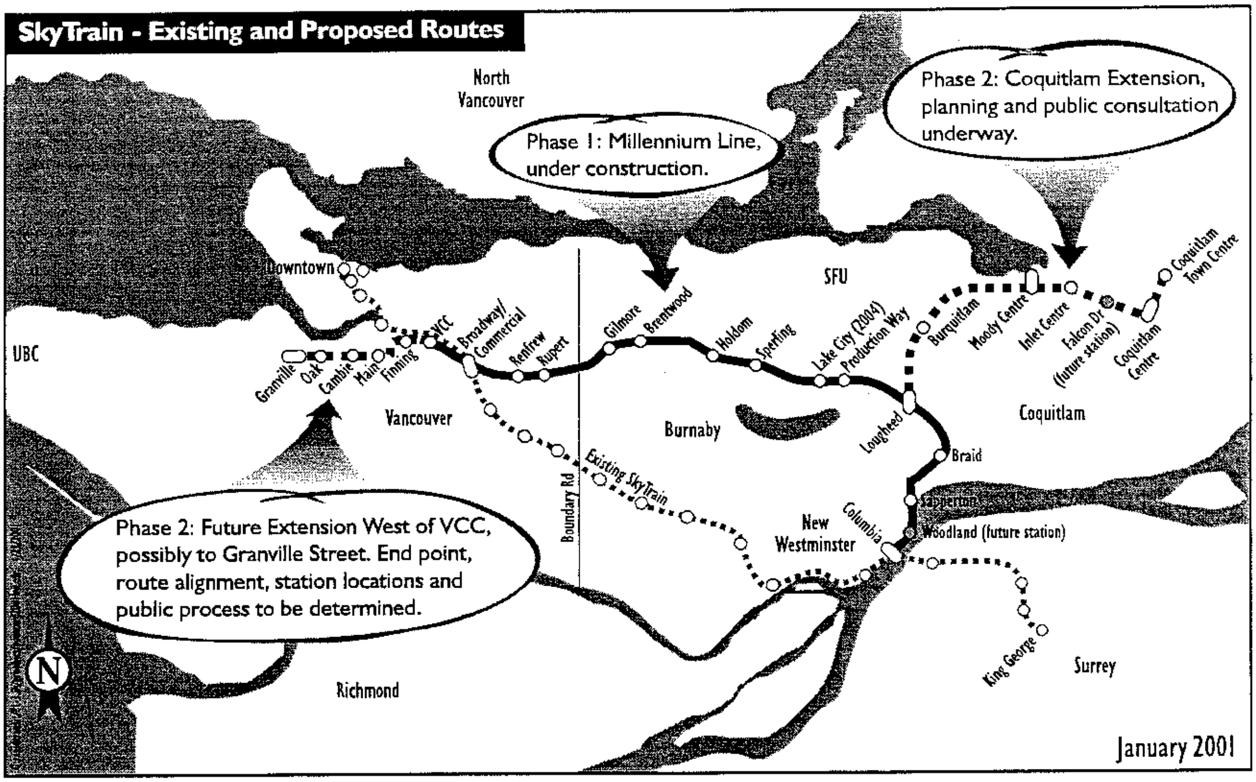

Figure 1: Existing SkyTrain (Expo Line) and planned rapid transit lines in Greater Vancouver.

The Cedar Cottage Neighbourhood Before SkyTrain

In the early 1980's, the area around Broadway and Commercial Drive had a thriving retail component centered on Commercial Drive. Buildings were primarily one-storey retail and service outlets with small frontages, awnings, and recessed entrances. Commercial Drive was largely a continuous pedestrian related retail area serving local shopping needs. The area also provided services that attracted a clientele from the greater community. A Safeway store on Broadway and three medical buildings drew people from outside the immediate community.

SkyTrain Comes to Cedar Cottage

Much controversy, emotion, and opposition surrounded the planning for the Broadway station and the elevated guideway in the adjacent communities of Kensington and Cedar Cottage. An early point of contention was the community's desire for a tunnel. Local residents and City Council favored a tunnel under Commercial Drive instead of the elevated guideway. About 23 homes containing 39 dwelling units, and 12 stores, were demolished to make way for the elevated guideway which runs in a lane immediately east of Commercial Drive. These homes provided low cost family accommodation and although new residential developments in the area would occur, they feared that new units would no longer be affordable. Homes that remained suffered from loss of privacy and views, shadowing, visual intrusion and increased noise.

It was suggested that BC Transit offer to purchase certain residential properties that would experience serious and un-mitigatable impacts as a result of the ALRT; however this was not done. Compensation to individual property owners to provide privacy screening or sound insulation building improvements was considered to be beyond the responsibility of BC Transit and the Provincial government. Assistance to properties was limited to those physically touched by the ALRT. Athough BC Transit did eventually respond to sustained pressure from staff and City Council on a number of impact reduction measures, they refused to respond to a number of adverse impacts identified by community residents, City staff and Council.

Upon opening, SkyTrain noise levels far exceeded those specified by the manufacturer, contributing further to the dissatisfaction in the community, and reinforcing the sentiment that BC Transit had little regard for the communities impacted by SkyTrain. In addition, the landscaping and screening provided consisted of sparsely planted trees and shurbs. As a transportation system, SkyTrain proved to be more popular than anticipated; however, as a neighbour, it proved more disruptive than planned.

Fourteen Years Pass

As anticipated, SkyTrain became a catalyst for new developments. Metrotown in Burnaby, Westminster Quay in New Westminster and Main Street and Joyce Station areas in Vancouver benefited from the accessibility and renewed interest generated by SkyTrain. Most areas around Vancouver's nine SkyTrain stations fared well with the exception of Broadway Station in Cedar Cottage.

The Broadway Station Area Plan sought to maintain the neighbourhood environment and housing opportunities for existing residents while permitting more people to live near the station on redeveloped properties. Rezoning and development of properties immediately north of the station, now referred to as the triangle site, was expected to be a catalyst and the focus for redevelopment of properties within a five to ten minute walk.

In 1990, a mixed-use development was approved that included two high rises: a thirteen storey residential tower of 72 units facing Broadway and a ten storey office building. About thirty shops on the ground level would ensure that pedestrian oriented uses continued to serve the local and new transient community. Parking for 400 vehicles was included in a multi-level, below-grade parking structure. Unfortunately, after several extensions to the development permit, the buildings were never constructed, and no redevelopment has occurred on this site.

The buildings that remained on the triangle site fell into disrepair. Some of the remaining businesses became negative influences on the neighbhourhood finding it easier and more lucrative to engage in criminal activities. A local pawn shop, dealing in stolen property, a market selling stolen cigarettes, an escort service, restaurants defying liquor laws and encouraging illegal activities drew a negative clientele to the area. High volumes of potential customers coupled with a small commercial core and surrounded by an accommodating residential area created an ideal environment for drug dealing. The result was a growing drug trade that today, seems entrenched in the neighbourhood and is perceived to be linked with SkyTrain.

PLANNING THE MILLENIUM LINE

In March1998, the Province of British Columbia established a Project Team to undertake a feasibility study of the proposed LRT "T-Line" (now referred to as the Millenium Line), connecting New Westminster, Coquitlam and Vancouver via the Lougheed/Broadway Corridor (figure 1). The study, expected to take 15 months, would identify a project plan, financial strategy and implementation options. A "go, no-go" decision would then be made on construction.

Expectations were for LRT as earlier studies of rapid transit technologies had recommended LRT over SkyTrain, largely on the basis of capital cost. Generally, there were two possible alignments for the conventional LRT through Vancouver East (figure 2):

1. at grade down the centre of Broadway for the entire route or
2. along the BNSF railway tracks

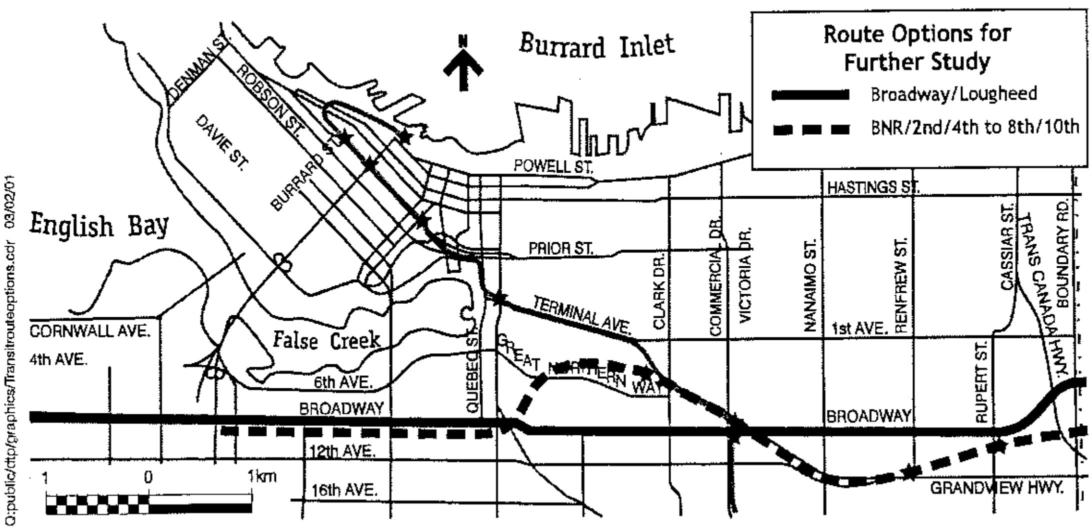

Figure 2: Two possible alignments for conventional LRT and the selected alignment for SkyTrain.

Up until June 1998, City staff worked with the neighbourhood under the assumption that they were planning for LRT. City staff encouraged residents to view the coming of LRT as an opportunity to correct the mistakes of the past and urged collaboration rather than confrontation in the planning process. The alignment selection process was favouring variations of option two (shown dashed in figure 2).

As planning progressed, demands for grade separation at major intersections increased. Following an update of the costs, the Provincial Government determined that the cost difference between LRT and SkyTrain was not as large as originally estimated. As a result, the Province, on June 24, 1998, announced their decision to proceed with an expansion to the SkyTrain system. Lower Mainland municipalities and the GVRD were surprised to hear of the change in technology from LRT to ALRT that included an accelerated time frame and revised priority for implementation. Sensing an urgency to "just get on with it", the Province accelerated the schedule for implementation by 5 years and adjusted the phasing such that the section with the fewest obstacles and complications was constructed first. More difficult sections would come later (figure 1).

The *Millennium Line* began construction in September 1999 and is expected to be operating in the second half of 2002. Project planning, design, and construction is coordinated by *Rapid Transit Project 2000 (RTP2000)*. This construction project will add 21 kilometers and include 12 stations, plus 2 future stations. Two further extensions are in various planning stages. An extension to Coquitlam's town center will add 11 kilometers and 6 stations and an extension into Vancouver's Uptown area will add another 4 kilometers and 5 stations (figure 1).

With SkyTrain technology, it was generally acepted that there was only one option for the alignment in East Vancouver: A variation of option 2 - elevated along the BNSF tracks, elevated or at grade in the Grandview Cut and in a tunnel under Broadway for all points west of Commercial Drive.

Generally, elevated guideways create the greatest impact on the adjacent land uses. However, east of the Slocan Street, the elevated guideway would pass through an industrial area of the City and therefore recieved little oposition. West of Slocan Street the guideway would pass through residential and commercial areas that would be sensitive to the visual and noise impacts of the guideway. Generally, tunneled guideways result in the least impact on the adjacent land uses. Therefore the tunneling west of Commercial Drive was considered to be an appropriate choice.

Vancouver Sets up a Rapid Transit Office

Once the dust had settled and it was clear that the SkyTrain system would be expanded, Vancouver City Council directed staff to work in collaboration with the Province's Rapid Transit Project2000 (RTP2000) Office. Given the accelerated schedule, it was crucial that staff be able to respond quickly to issues that arose and that there be a coordinating body to manage contacts with City Hall, on behalf of the RTP2000.

To address both these needs, the City established its own *Rapid Transit Office* (RTO) seconding staff from both the Planning and Engineering Departments and hiring a Project Manager with a legal background and volunteer experience as a member and Chair of the City's Planning Commission. An office was created and planning and engineering staff moved into one location. This proved invaluable to staff's ability to respond quickly to issues and to maintain a multi-disciplinary perspective.

City staff, building on the foundation of trust established in planning for LRT, worked hard to ensure that the community remained engaged and not turn their backs on planning yet another SkyTrain station. Anti-SkyTrain people were kept informed and a Broadway Working Group was established. Two key community objectives were:

- that the SkyTrain project make the community better; and,
- that the station be integrated into the community.

Guideway Aignment in the Grandview Cut

The *Grandview Cut* is the name given to a 1.2 km long trench that was excavated in the early 20th century to create a railway link between False Creek and the Fraser River. The trench needed to be dug to provide the gentle grades required by heavy rail service. The trench was bridged at seven locations to provide an uninterupted grid of major and minor roads. The shape and depth of the Cut is such that it would allow the new SkyTrain line to run below street level without the need to create a tunnel. Since its creation, the first stages of natural reforestion has taken place on the slopes of the Cut. This early stage sessesional forest is highly valued by the area residents as a de-facto nature reserve.

During the design development of the guideway, the designers were open to a number of options for locating the guideway within the Grandview Cut. In general, the options were a result of two variables:

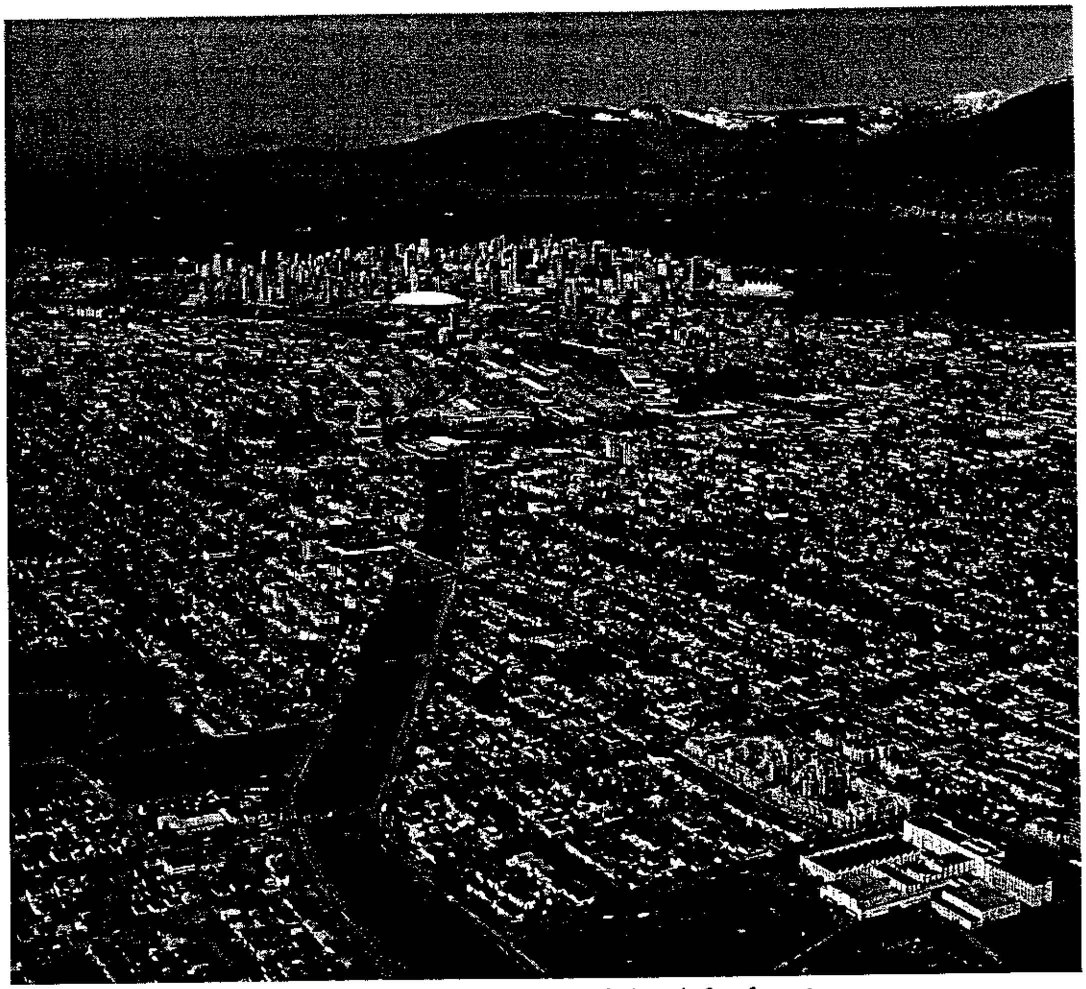

Figure 3: Image of Grandview Cut - the dark swath just left of centre.

elevated or set into the slope (at grade); and on the north side or on the south side of the Cut. Combinations of these two options created four options that were considered by City staff and taken out to the neighbourhood to determine their preferences (figure 4). The prefered alignment was *elevated* on the *northside* of the cut. *Elevated* because it was believed that this alignment would have the least impact on the vegetation in the Cut and on the *north side* to minimize the impact on the adjacent residents. Residents on the south side of the Cut are immediately adjacent while the north side residents are buffered by Grandview Highway North.

As the design for the alignment was further developed it was revealed that the slope of the cut had been poorly estimated and that only 200 m of the guideway had the potential to be elevated. The other 1000m would required massive disruption to the slope to create an elevated guideway. Further investigation revealed that elevating the guideway for this 200 m portion would have a greater impact on the area available for greenspace than the at-grade option. So it was decided to run the guideway at-grade for the entire length of the Cut on the northside. This was well received by the adjacent residents because it resulted in a guideway that was lower in the Cut and therefore less intrusive.

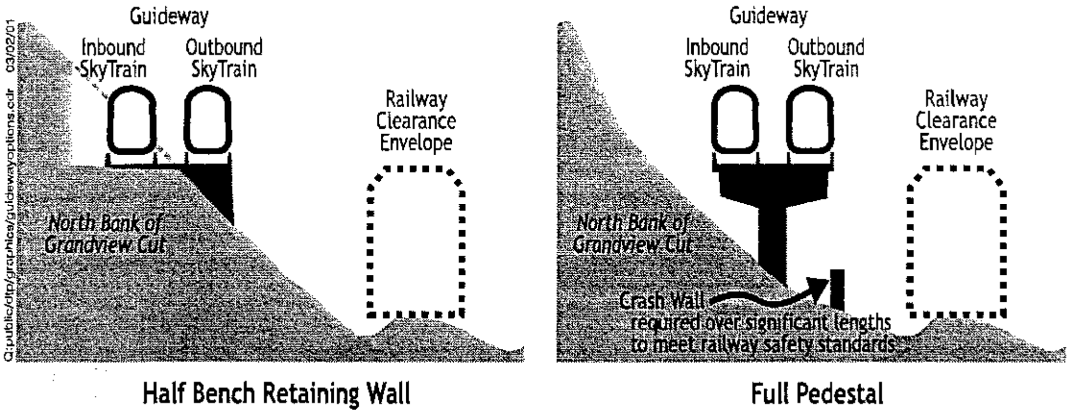

Figure 4: Some possible locations for the guideway in the Grandview Cut.

Station Location and Design

Transit stations are best located on existing bus route and at major destinations. In Vancouver elevated stations will be at Rupert and Renfrew Streets to connect with the existing bus routes on those streets. The station at Commercial Drive will connect with two major bus routes and the existing Broadway SkyTrain Station, making it the busiest and most important station on the Millenium Line.

Conventional LRT stations can be located at-grade, below grade, or above grade. At this specific location the new transit line must cross the existing SkyTrain line - i.e. the new line must pass over or under the existing line. Since the existing SkyTrain station is elevated, it would be impractical to 'super elevate' the new station. And since SkyTrain technology requires that stations be grade separated from other transportation modes, this determined that the new station would have to be located below street grade.

In addition, the new station was to be located near the point where the at-grade guideway in the 'Cut' was to head into a tunnel under Broadway. This created the following location options for the new station:

1. on the south side of the Cut,
2. on the north side of the Cut, and
3. in the tunnel under Broadway

An underground station near the intersection of Broadway and Commercial Drive was viewed as having the potential to become an un-welcoming public space with little oportunity for casual serveilance. The Grandview Cut station options had the potential to be lit by daylight and in full view of the public passing on the Commercial Drive and Broadway Bridges. Locating the station on the north side of the cut resulted in less impact on the adjacent land uses. For these reasons the community selected the north side.

To determine the *"big ideas"* for the station design, the City hosted a *Design Charette* in the neighbourhood community centre. Prominent architects worked in three teams with volunteers and specially selected City staff over two days to develop some conceptual design for the urban form around the station. The charette generated two *big ideas*:

1. The *neighbourhood centre* should be in a different location from the *transit centre* and
2. The station design and associated development should have a light touch on the Grandview Cut, respecting the valued greenspace and views.

These two big ideas conformed with the desires of the community.

Grandview Highway North to become a new Greenway/Bikeway

Grandview Highway North is the name of the street that parallels the Grandview Cut for its entire length. In the past, as the name implies, it was likely seen to be good candid for a future major street. As it happens, although it provided some convient connections for large trucks, it never evolved to become more than a local collector street. However, the extra wide right of way immediately adjacent to the guideway was seen as a huge opportunity to mitigate the impacts of the new SkyTrain line.

It was widely agreed that the Grandview Highway North right of way should be used to replace some of the natural vegetation that would be lost in the Cut due to the construction of the new SkyTrain guideway. This was also seen as an opportunity to create the Bikeway and Greenway routes that had long been planned by the City for this corridor.

The first step to implementing this vision was to remove Grandview Hwy North from the regional truck route system. This was a key element of the proposed Greenway/Bikeway. Eliminating trucks from Grandview Hwy North also facilitated the development of the new SkyTrain guideway, and the new Commercial Station. This required consultation with the trucking association and the adjacent neighbourhood and approval by both the Vancouver City Council and the regional transportation authority, TransLink. Fortunately the impact on adjacent truck routes was minimal.

However, simply removing trucks from the road in itself was not enough. The long straight stretches of GHN would continue to encourage high speed traffic. Traffic calming Grandview Highway North was essential to creating a more attractive Greenway/Bikeway and had solid community support. A traffic calming plan was developed by City staff with the area residents. At open houses and through surveys residents supported a proposal for a series of three full closures, two traffic circles, and one centre median to calm traffic on Grandview Highway North from Commercial Drive to Slocan Street. In locations where the street was to remain, it would be narrowed to provide more space for the Greenway/Bikeway elements.

COMMERCIAL STATION PRECINCT PLAN

The focus of the City's RTO was to build a City not simply to build a train. That meant integrating the new rapid transit line into the existing city fabric. The precinct plan identified elements needed to integrate transit and pedestrian movements with the new Commercial Station. These included

- new and widened sidewalks near the stations and bus stops,
- pedestrian bulges to reduced pedestrian crossing distances,
- new transit and pedestrian traffic signals,
- realigned streets to normalize odd intersection geometries,
- wider crosswalks,
- improved bus stopping locations, and
- new bus bulges to provide improved bus operations and pedestrian amenities near the station.

Various sources of funding will be used to complete this work including the street maintenance accounts and the Municipal Integration Fund, a Provincial/Regional cost-share program to help municipalities build the necessary infrastructure around new stations. In addition, local improvement funds could be made available where the local property owners want to contribute a portion of the cost of further enhancing what is being proposed.

Zoning Review

A retail consultant has been retained to provide advice on the nature of businesses that might best locate in the shopping area. Zoning will be examined to determine what changes could help attract and retain businesses and activities desired by the community. Design guidelines will be tailor-made to reflect the unique conditions of the Commercial Drive shopping area, defining it as a special place with a special character.

Vancouver's Amenity Package Agreement

While planning for SkyTrain was underway, the Province and TransLink continued to define a memorandum of agreement (Negotiators Agreement) to outline the basis upon which construction costs would be shared. Included in the Negotiators Agreement was TransLink's commitment to make best efforts to ensure that the RTP2000 gain access to municipal lands at no cost to RTP2000 and that the RTP2000 provide an amenity package, as part of the project budget, to the City of Vancouver.

This amenity package was provided in recognition that:

- the City contributed the Grandview Cut lands, which it had purchased in 1990 from the Burlington Northern Santa-Fe Railway for a substantial sum;
- the new station at Commercial Drive would be the busiest on the line;and,
- the neighbourhoods at Broadway and Commercial and along the Grandview Cut would be at the intersection of two regional SkyTrain lines and bear the brunt of the impact of SkyTrain infrastructure.

Amenities for the Broadway and Commercial station area include:

- Significant renovations to the existing Broadway Station;
- A contribution to the redevelopment of an adjacent site (CIBC); or if the site is not redeveloped, additional renovations to the Broadway Station;
- $200,000 towards a new home for a community police office;
- $60,000 for public art; and
- Design and construction of a 4.2 km Greenway/Bikeway along the guideway, valued at $4.6 million

In addition, the City of Vancouver and the RTP2000 mutually committed to work cooperatively to ensure that the construction of a multi-use development is completed on the triangle site at approximately the same time as the Ticket Hall. This development, by a private sector third party, would include retail use at street level with public access from both the street and the Ticket Hall, a landscaped public open space, and other landscaping to the street edge.

Development of the triangle site has a renewed sense of urgency since the property was purchased by the

RTP2000 and existing buildings demolished. Land not required for station purposes was made available for development of a multi-use, two and three-storey building. Wishes of the community were reflected in the site-specific zoning and design guidelines defined for the triangle site.

How Are We Doing?

Demolition of the buildings on the triangle site occurred in 1999. Vancouver, TransLink and the RTP2000 seized an early opportunity to make aesthetic and functional improvements to the site. The chain link fence surrounding the site is decorated with a community art project undertaken by the nearby Trout Lake Community Centre using materials donated by the RTP2000. Decorative lighting, purchased by the local Community Police Office, frames the fence and power was paid for by the City of Vancouver. Bus stops were consolidated to a more convenient location and large shelters were installed by TransLink. The sidewalk area was widened and lighting levels increased underneath the existing guideway. A local youth group was hired to provide regular litter pickup on and adjacent to the triangle site. Construction of the Commercial Station began in December 2000 and is expected to take one year. Renovations to the north entrance of the Broadway Station and the pedestrian overpass have yet to begin.

A third party developer recently submitted a development proposal for 1950 square metres of office and retail space housed in two building flanking the Commercial Station ticket hall: a one-storey retail unit and a two-storey retail and office building with retail on the ground floor. The City, with agreement from the community, waived its requirements for the provision for parking and loading spaces, to ensure the site would be economically viable and attractive as a development site. The community shows signs of optimism that the new SkyTrain station and development of the triangle site will benefit the neighbourhood and assist in sparking further improvements.

CONCLUSIONS

Overall our experience with this project has revealed three major conclusions that can be applied to most major projects.

1. Open, up-front, frequent communications with all stakeholders, especially residents, who often need continuous reassurace that their major issues will not be over-looked, is a necessity.
2. Close cooperation and commitment to the project at all levels of government and service agencies are required to maximize the benefits of the project for the public at large.
3. Mitigation and/or compensation, by way of off-setting area improvements, is required were residents and businesses will be directly impacted by the project.

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AREA TRANSIT PLANNING IN GREATER VANCOUVER – A NEW APPROACH TO COMMUNITY TRANSIT PLANNING

PREPARED BY:

Bill Lambert, M.P.I., M.P.A., MCIP
Program Manager
TransLink
William_lambert@translink.bc.ca
(604)453-4551

and

John Steiner, M.Sc.(Eng.), MCIP
Principal
Urban Systems Ltd.
Jsteiner@urban-systems.com
(604)273-8700

1.0 INTRODUCTION

Many communities throughout North America are struggling with optimizing their investments in transit services and facilities, while addressing the broad needs of many different transit riders and potential new target markets. This paper discusses a comprehensive and community based area transit planning approach used by the Greater Vancouver Transportation Authority- (termed TransLink) since 1999, to achieve these objectives. This approach is designed to work with municipalities and stakeholders through the Vancouver Region and consider all aspects of what is required to preserve and support investments in transit services and facilities. This approach can be used successfully by both large and small communities.

This paper outlines the following related to the area transit planning process:

- i) the context for developing area transit plans in Greater Vancouver;
- ii) the methods of public consultation and involvement of municipalities in the area planning process;
- iii) key factors contributing toward the success of transit service that are addressed through the area transit planning process;
- iv) how the performance of current services are measured;
- v) the approach used to develop candidate service concepts;
- vi) the critical steps in completing the area transit plan; and
- vii) key conclusions.

2.0 CONTEXT

TransLink was created in April 1999 by legislation and an agreement negotiated between the Greater Vancouver Regional District and the Province of British Columbia. A separate legal entity was created – Translink (formerly BC Transit-Vancouver Region). TransLink was given its own borrowing powers and financing tools including property taxes, hydro taxes, gasoline revenues, vehicle levies, rapid transit station benefiting area levies, roadway tolls and parking charges. TransLink has the authority to plan, finance and implement transit, roadway, transportation system demand, AirCare, bicycling policies and program investments in the Greater Vancouver area.

During public consultation leading to the creation of TransLink, there were many municipal and public requests for a radically different approach to developing and implementing transit service improvements. Stakeholders wanted a more holistic approach which considered the relationship of transit services to key land use and other transportation changes, and they stressed the need for much stronger community and municipal focus for TransLink's bus service planning and implementation. Towards this last point, it was commented that while the bus service operated reasonably well in providing service to and from the City of Vancouver, it was falling short in providing transportation within and between individual municipalities. As well, stakeholders wanted comprehensive and staged plans developed for these service improvements by employing bottom-up and broad consultation strategies which result in customer-focused service improvements.

To address the shortfalls of the service planning process, the TransLink Board strongly supported staffing and funding for the development of Area Transit Plans for all seven sub-regions of the GVRD between 1999 and 2003 using a new approach. As well, they committed to updating these Area Plans every three years.

In 1999/2000, three Area Transit Plans were completed and approved by the municipalities and the TransLink Board: Richmond; the South of Fraser River area (Cities of Surrey, White Rock and Langley Langley Township and District of Delta); and the North Shore area (City of North Vancouver, the Districts of North and West Vancouver, the Village of Lions Bay, and Bowen Island). In the fall of 2000, Area Plans were initiated in Burnaby-New Westminster and the

Northeast Sector (Cities of Coquitlam, Port Coquitlam and Port Moody, and the Villages of Belcarra and Anmore), and these plans are scheduled for completion in the fall of 2001. In the 2001/2002 period, starting in the fall of 2001, the two remaining plans will be completed for the City of Vancouver/UBC area and the Maple Ridge-Pitt Meadows area.

The Area Transit Plans are intended to have a strong community and municipal focus, while providing for an integrated regional transit system. To accomplish these objectives, each Plan is prepared in close consultation with the municipalities, residents and transit users of each sub-region. In particular, participation and input by municipalities is seen as an integral component in the development of the Plans. The Area Transit Plans form a key input to TransLink's annual Program Plan and budget, and longer-term operational and capital plans.

The overall context and policy direction for the Area Plans has been established in TransLink's Strategic Transportation Plan (STP) approved by the TransLink Board in April 2000. The STP establishes strategic actions and policies that TransLink will use to respond to transportation needs and to support the GVRD's Livable Region Strategic Plan over the next five years, which in turn guides regional growth and development. The STP proposes significantly increased expenditures for enhanced transit services, selective improvements to major and strategic roadway corridors required for transit and goods movement, and the implementation of a comprehensive transportation demand management strategy.

With respect to transit, the STP defines expenditure levels for transit and outlines the following specific targets for the transit system:

- Increase transit ridership by 29% by 2005, resulting in a market share of 12.5% of regional travel compared to 11.5% today.
- Provide more frequent and less crowded transit services through an increase in the bus fleet of 48%.
- Offer a much more responsive and flexible bus system better suited to different customer needs by providing a broader range of bus services:
  - Improved **City Bus** routes-the core of the bus system which operates throughout the Region and has frequent stops;
  - **B-Line** services which are high frequency (minimum 10 minute headways) with limited stops, using articulated vehicles and significant use of transit priority measures, and having integrated customer schedule information;
  - **Express Bus** providing long distance service using highway-type coaches to provide fast, comfortable service; and
  - **Community Shuttles** deploying 10-20 seat minibuses and shared-ride taxis operating on fixed or flexible routes and schedules.

The main objectives of each Area Transit Plan are to:

(i) Clearly identify existing travel and land use/development patterns from land use and transportation data, a regional Trip Diary survey and market research.

(ii) Prepare a report on the transit service performance and identify priorities for implementing changes to the following: services in corridors where ridership is growing quickly and additional resources are required; and under-performing services which require rationalization/elimination or changing the type of service (i.e. to Community Shuttle-minibus).

(iii) Identify short to medium-term (1-3 years) priorities for service improvements in a detailed plan which first focus on existing services that are overcrowded and with growing markets, and on services which are under-performing, **prior** to considering new local and regional services. Develop overall ridership objectives, identify primary and secondary markets, develop an overall service strategy, and develop service ridership and revenue projections. The plan must also identify transit supportive measures needed to not only address issues confronting existing services, but to make each new service concept operable and attractive to users.

(iv) Develop an implementation strategy for the preferred transit service improvements with recommend timing, routing, hours of operation, service levels, detailed infrastructure requirements and resources required, as well as estimated ridership and key markets. This strategy also establishes ridership performance and customer user satisfaction targets (see Appendix 1- Table 1 from the South of Fraser Plan as an example). The strategy also identifies specific actions required by TransLink, municipalities and other agencies to successfully implement and support the recommended transit service improvements.

3.0 STAKEHOLDER INVOLVEMENT

A key to the success of the Area Transit Plan process has been to use a bottom-up, community-based consultation program which employs a comprehensive range of innovative techniques to ensure the plan reflects the needs and interests of all the communities and stakeholders, and can be implemented successfully. Participants in the public consultation process include area residents, transit operating subsidiaries, existing and potential transit customers, and stakeholder groups. The following discussion highlights the public and agency consultation initiatives used in the Area Transit Plan process.

a) Public Consultation

The methods of public consultation include:

- ***Public Advisory Committee (PAC)-*** Public Advisory Committees are formed for the development of each area plan. Each PAC consists of eight to ten local members nominated by the municipal councils in the study area, as well TransLink and municipal staff. The PAC members can include representatives from the following key stakeholder groups: transit users; persons with disabilities; the business community; major ethnic communities; seniors; and students. Each PAC advises the Technical Advisory Committee and Project Manager on the form and content of the public consultation process, and reviews and provides comments on all the plan's key deliverables.
- ***Open Houses Workshops and Public Meetings-*** At key stages of the development of each area plan, open houses or workshops are held. During the early phases of the work, open houses at shopping centres or at community centres are held to present background information on the area planning process. These sessions provide information on the current transit system, and obtain feedback on opinions on issues and shortfalls with current transit service. During the later phases of the work, open houses and workshops are held at shopping centres or in community facilities as an interactive means of obtaining public input on preliminary service improvement options and on the draft plan.
- ***TransLink and Municipal Websites-*** TransLink and the municipalities use their web sites to actively solicit input during all stages of the plan preparation to determine key public issues and questions, and to provide areas for comments on key documents completed during the course of the plan preparation. Staff categorize this input and respond to it directly during the course of the work, to ensure that persons who provided input recognize that their comments were considered in the planning process.
- ***Market Research-*** TransLink uses market research as an accurate means of obtaining representative community feedback. In general, the market research is considered a statistical representation of community preferences and choices.

- ***Comments Forms-*** TransLink widely circulates comment forms to transit customers which provide valuable input.

- ***Focus Groups with Operating Companies-*** Two sets of focus groups are held at appropriate stages in the area plan with representatives from the operating bus companies.

- ***Stakeholder Meetings-*** Individual meetings are held with stakeholders groups such as educational institutions, seniors groups and business groups to solicit input.

b) Municipal Commitment

Considering that the transit services themselves are only part of the package needed to improve the success of transit, municipalities play an essential role in the development and implementation of the Area Transit Plans. They contribute toward the area transit planning process by:

i) participating on Technical and Public Advisory Committees, which advise on all the key plan documents and the public consultation process;
ii) regularly reporting to their councils on the progress of area plan process and work, and to obtain feedback;
iii) meeting with community stakeholders to get their input, and displaying plan materials in websites and at city halls;
iv) developing, funding and implementing specific transit supportive measures on municipal roadways (i.e. includes changes to traffic signals, traffic management measures, and measures such as bus lanes or queue jumpers) and for alternative modes;
v) supporting and funding other infrastructure requirements such as roadway geometric changes (i.e. changes to roadways such as corner cuts to enable service to be provided) and bus stops changes (i.e. additional shelters);
vi) developing and implementing municipal parking management strategies, including the role, location and cost of additional park and ride facilities; and
vii) developing and implementing community plan policies which support high density development in town centres and along specific corridors to increase transit ridership.

4.0 FACTORS OF SUCCESS

The demand for transit service is significantly influenced by a combination of factors, including the level and quality of transit service, land use patterns as well as the transportation system within the community. The municipal and regional partnership established through TransLink and the Area Transit Plan process provides the platform for effectively addressing the following factors critical to making transit a success.

- ***Transit service quality*** is the obvious determinant of transit success. Transit service must be attractive to generate ridership, and it must generate sufficient ridership to become cost-effective. The key contributors toward attractive transit service levels are coverage (amount of community within walking distance of transit), frequency of service and directness of routing between key destinations. The Area Transit Plan process provides the opportunity to consider a mix of transit services (such as B-Line, Express, City Bus (conventional) and/or Community Shuttle services) that may be used to best meet the needs of target customers.

- ***Land use patterns and socio-economic factors*** have a significant influence on the attractiveness of transit. Land use types, density and form can create a transit supportive community in which the target market is of a sufficient size for appropriate transit services. Socio-economic factors can influence whether riders are 'captive', in that they have no alternative to using transit, or 'choice', in that they have other transportation options but choose to use transit. In general, transit is most attractive to captive riders, including young people who cannot drive (such as students) and elderly persons, who may be unable to drive. Furthermore, transit use is typically higher in areas where automobile ownership is relatively low and where there are consequently more captive riders. While the Area Transit Plan process is not designed to assess alternative land use strategies and influence socio-economic characteristics of the community, it is important to clearly identify those areas with qualities that are more easily targeted by transit services and to which resources should be focussed.

- ***Transportation system-*** Roads provide accessibility and mobility for all travel modes. The road network layout and classification can affect the quality and attractiveness of community transit service. Some road network patterns can result in circuitous routing for transit vehicles, thereby reducing accessibility to some areas and dramatically increasing travel time and transit costs. The integration of other modes – particularly pedestrian and bicycle facilities – with transit service is also a key determinant of transit success. Transit access can be impeded by poor or inadequate facilities sidewalks, pathways and bikeways. The Area Transit Planning process provides the framework for addressing those elements of the transportation system that are needed to operate and enhance transit service.

- ***Transit supportive measures-*** Many transit facilities can be enhanced to improve transit travel time and to provide more user comfort and convenience. These measures would make transit more competitive with the private automobile to attract new riders and encourage existing riders to continue using transit. Within the Area Transit Plan, a range of transit supportive measures such as bus priority measures as well as safe, secure, and comfortable passenger waiting areas (such as larger bus shelters with adequate illumination, improved schedule information and emergency telephones) are examined.

  The Area Transit Plan is also designed to identify local strategies to support transit through policy incentives that encourage the use of non-automobile modes and discourage travel by single-occupant vehicle. The broad range of measures that can be applied to achieve these objectives is known as Transportation Demand Management (TDM).

- ***Travel patterns*** are influenced by the location of population and employment, and strongly affect the size of transit markets and the potential success of transit service. For the purposes of the Area Transit Plan, it is important to understand the current patterns of travel including: how much travel is occurring; why people travel; when people travel; where people travel; and how people travel. Combining these patterns with other factors of success provides the means of identifying the types of transit service that will capture key transit markets.

5.0 PERFORMANCE

Understanding the performance of existing transit services is a fundamental component of the area transit planning process. Combining this information with those features needed to make transit successful and public input can provide the foundation in which to:

- determine how well current services are working and some of the causes of poor service performance; and,
- identify potential new target markets for existing service modifications or for new services.

In cases where existing services are overcrowded or even underused, services may be adjusted by altering frequencies, routings and types of services. In very limited market areas, such as local service within a community, some services may even be eliminated in favour of providing more service to areas of higher potential transit ridership.

Historically, TransLink (BC Transit) largely relied on marketing research conducted for specific routes as well as regional trip diary surveys conducted every four years to identify and test many of the refinements to transit services. The formation of TransLink and initiation of the Area Transit Plan process provided the impetus for developing more comprehensive performance information to assess current and potential transit markets. The use of service ridership data and market research data in the development of service plans are briefly described below.

Ridership Surveys

Comprehensive ridership surveys have been conducted on many routes within those areas in which area transit plans have been prepared. The surveys may be used to define not only how *"effective"* a route is in attracting and serving existing and potential transit passengers, but also how *"efficient"* the route is in providing the service to an area. Although the surveys provide detailed profiles of ridership on each route for as many as six distinct periods of the day, the key measures of route effectiveness and efficiency considered within the area transit planning process include:

- ***Average maximum loads*** provide an indication of the typical passenger loads on each route during a given period in each direction. Rather than simply using the maximum loads at a given point in time however, moving averages – 30 minute during peak and 60 minute off-peak – have been used as an indication of usage. During periods where the average maximum loads are well beyond the seated capacity, strategies to enhance capacity of the route are generally examined. In areas where the average maximum loads are considered low – i.e., less than approximately 20 passengers – refinements to routing and / or the type of service are generally considered to improve performance and increase ridership.

- ***Average boards per service hour*** is a measure of how often passengers get on the bus during a given period of time. Routes where passengers are travelling relatively short distances typically have higher average boardings and are considered to be more effective. In many suburban areas with a feeder route from a SkyTrain or West Coast Express station for example, the average boardings are typically higher due to the short distance. In fact, the average boardings per service hour along a 'looping' route that is provided in many suburban communities can be overstated in the peak direction and very low on the return trip. In these cases, the boardings in the peak direction should be considered jointly with the return trip to provide a true indication of whole loop route's productivity.

- ***Revenue hours per platform hours or revenue kilometres per service hour*** are both measures of route efficiency. Revenue hours or kilometres refers to the time that the bus is on the route. Service hours include revenue hours plus layover time for a particular route. Platform hours include all service hour time in addition to the 'dead-head' time between the garage and start or end of the route. In general, inefficiencies on routes with the highest annual service hours are most problematic and the focus of the Area Transit Plan.

While new Service Design Guidelines (2001) are currently being developed for Greater Vancouver, each of the performance measures is compared to the average conditions within the area plan as well as areas of similar character. Although this comparative approach provides the relative performance of a particular route, opportunities to enhance service while improving performance is a principle goal of the planning process.

Market Research

TransLink has continued to undertake market research surveys of transit riders and non-riders to obtain insight into the overall satisfaction for particular routes. The Rider Satisfaction surveys examine relative ranking of each route in terms of frequency, directness, connections, reliability, overcrowdedness, safety as well as helpfulness of the operators. As part of the area transit planning process, additional market research surveys of existing and potential new transit riders is used to:

- determine the current transportation habits and socio-economic characteristics of existing and potential transit riders;
- understand the desirable target markets for existing transit to serve to increase ridership, and how to modify that service; and
- identify potential new markets for transit and general likelihood of success of specific services to appeal to these markets.

For example, in the Richmond Area Transit Plan, market research surveys were completed for existing and potential customers to test the potential ridership and market which would be generated by reducing the planned peak period frequency for the Richmond-Vancouver #98 B-Line" from 2-3 minutes to 4-5 minutes, and introducing two new peak period express services from Richmond to downtown Vancouver. The conclusions from this research were as follows:

- Customers would not distinguish between a 4-5 minute B-Line and a 2-3 minute B-Line service. There is no statistical difference between the appeal of these two options. As a result it appears that there would be no loss of ridership if TransLink introduced a 4-5 minute B-Line service; and

- Offering a 4-5 minute peak period B-Line service in combination with two new express routes (i.e. with no additional resources over the higher frequency 2-3 minute B-Line with no express routes) would potentially increase the overall market share from Richmond to Vancouver by 25%.

6.0 DEVELOPING SERVICE CONCEPTS

During the Area Transit Plan, many issues are identified through public input (based on market research and public events) as well as the technical analysis of transit service performance and the conditions that contribute toward making transit successful. The fundamental challenge is to not only identify the issues, but to determine which issues may be market opportunities in which to define and examine service concepts. In this regard, the planning process is clearly seen as an opportunity to confirm and redefine target markets as necessary, and to purposefully direct investments in transit, rather than attempting to solve all issues.

The service strategies developed through the Area Transit Plan are generally designed to address issues associated with existing services first, and then address new markets which are not currently served by transit. In this regard, the range of service concepts considered within the plan process fall within three broad categories as follows:

- service changes that address performance issues with existing services;
- changes to existing service or the introduction of new local and regional connections; and
- transit supportive strategies.

Based on recent experiences, the process for developing service concepts can vary significantly depending on the area and the range of issues that must be addressed. In those areas where the majority of issues and likely changes to services will largely consist of modifications to existing services – such as increasing frequency with minor routing adjustments – alternative service concepts may be developed. This will be done with the input received through the initial public consultation, market research as well as the technical analysis. In cases where the service changes may be more dramatic – such as significant route modifications, changes to the types of service, or consolidation of services – greater care must be taken in the development of service concepts to guide stakeholder interests through the process. The latter example requires a transparent process that engages public stakeholders in open discussion such as identified below:

- ***Identify market strengths and challenges*** in the local area for each key factor that affects the success of transit - land use and demographics, transportation system, travel patterns and transit supportive measures. Wherever possible, these strengths and challenges may be identified for sub-regions within the study area, and must be the primary factors in which to define market opportunities that should be maintained or enhanced. The ridership surveys also provide a means of distilling what is working and what needs to be changed in the various market areas.

- ***Select a range of potential market opportunities*** that may be considered within each area. At this stage of the process, the market opportunities need only be defined in terms of general statements to address existing service performance and/or to provide new connections between areas. For example, confirming the need to maintain attractive service levels between two areas may be identified as a market opportunity. Alternatively, travel within and between areas not currently well served by transit may also be identified as a new market opportunity for transit to examine within the Area Transit Plan. As part of this stage of review, locations and types of transit supportive measures should also be identified. Recognizing that all service changes and expansions must be phased over a five-year period, the process of defining target markets is also used to begin prioritization. In this regard, stakeholders may be asked to indicate relative priority of particular markets, without knowing the effectiveness of various strategies.

- ***Develop conceptual strategies*** that would best address the market opportunities. In some cases, there may be optional strategies to serve a particular market. For example, to maintain service in an area where ridership is low and the potential transit market is modest, community shuttle services may be considered as an alternative to modifying the routing and / or frequency of the conventional bus route. Conversely, in strong market areas for transit, the addition of new conventional services may be compared with a higher speed, limited stop fixed-route service strategy. In other words, the basic goal of this stage is to define the range of conceptual strategies that may be considered in addressing the specific market opportunities. The conceptual strategies should identify the type of service, general routing, the likely service frequency and travel time comparisons for each alternative.

7.0 DEVELOPING THE PLAN

In most transit and transportation strategies, the preferred concepts are usually selected through the evaluation process and translated directly into the final plan, with some direction on implementation. In this regard, there are typically no major refinements to the alternative concepts that are initially identified and evaluated. Within the Area Transit Plan process the factors that influence the success of each option are more complex. Therefore, a multi-stage evaluation and refinement process is used to examine service concepts and to develop the five-year strategy. The following discussion highlights the key stages of evaluation leading toward the development of the area transit plan.

- ***Market research***. Public input is probably one of the most significant factors in evaluating alternative service concepts. In this regard, market research provides a statistically meaningful assessment of public reactions to alternatives and the likelihood of success. At this stage of the process, market research can be effectively used to not only measure the potential success of each alternative concept, but to provide initial refinements to each concept that may be needed to enhance customer attraction. During the first round of Area Transit Plans completed in 1999/2000, market research of travel patterns and alternative service concepts were undertaken through telephone surveys. In the subsequent rounds of the area plans in 2000/2001, target customers are being asked about alternative service concepts through a mailout survey after an initial telephone survey. This provides respondents with an opportunity to clearly visualize the alternatives being considered and provide more informative feedback with the extra time compared to a telephone survey. The feedback from the market research may be used to screen out some conceptual alternatives from further review and/or to further refine concepts for subsequent evaluation.

- ***Technical evaluation***. The technical evaluation of alternative service concepts is needed to compare choices and to ensure that many of the goals for the transportation system are addressed. In total, alternative concepts are now compared using over twenty criteria. The following table highlights the categories of evaluation criteria used to evaluate service concepts.

Evaluation Criteria Categories	Description
Ridership	Provides a means of comparing the ridership of different options and ability to attract identified target markets.
Productivity	Compares the resources required to operate an option with the expected ridership.
Service Quality	Measures some of the major components of service quality including travel time, overcrowding and frequencies.
Community Support	Examines whether an option has received support from public.
Policy and Implementation considerations	Identifies opportunities and constraints associated with the implementation of an option.

Rather than weighting each criteria equally, the public has been asked to provide input on the relative importance of each factor prior to presenting the results of the evaluation.

- ***Public Consultation.*** Within the evaluation process, workshops and open houses are typically used to further assess service concepts. While this may not provide the most statistically reliable indication of public preferences, experience has shown this to be a valuable method of getting meaningful input on the concepts and identifying potential refinements that may be considered within the plan. Also including the public in the development process creates support of the final plan.

- ***Develop service strategy***. Once the preferred concepts are identified, the five-year area transit plan can be developed. The first step is to combine the preferred concepts into an integrated service strategy. In this regard, minor routing adjustments may be necessary for the overall plan to link the service improvements. The resource requirements for the entire area plan must also be identified, as well as performance targets (ridership and mode share) in which to ensure that measurable changes are achieved from the plan. Using the preliminary input on priorities as well as the results of the technical and marketing evaluation, the Area Transit Plan also identifies an implementation strategy which outlines the phasing of all new and modified services as well as any transit supportive measures. In this regard, the identification of regional and municipal responsibilities is also seen to be a critical element of the final Area Transit Plan and implementation strategy.

8.0 CONCLUSIONS

The Area Transit Plan process is designed as a holistic approach to improving transit service and ridership in Greater Vancouver. Although the success of the planning process is dependent on several factors, experience indicates that particular emphasis must be placed on the following:

- ***Community and agency involvement*** - The foundation of the Area Transit Plan process is a bottom-up, community-based approach to developing transit service throughout Greater Vancouver. Residents are engaged at various times of the study process and through a range of methods – from open houses and workshops through to the use of websites and customer surveys. Through the partnership created by TransLink, all area municipalities and the region work together on all technical and non-technical aspects of the plan.

- ***Address ALL service-related elements-*** The demand for transit is influenced by more that the service itself, albeit a fundamental component. The Area Transit Plan must provide the framework for evaluating the implications of other factors – such as land use patterns, transportation systems, transit supportive strategies – and identify the range of initiatives needed to enhance the success of transit in each area.

- ***Focus on those target markets where there is the greatest opportunity-*** The Area Transit Plan is not intended to address all issues and concerns. To be effective and supportive of customer needs, investments in transit must be selective and directed toward the specific market opportunities for the area. In this regard, each community is given an opportunity to identify strategies to best serve those key markets and choices on alternative approaches.

- ***Use market research to statistically gauge the support from the 'target' customers.*** The market research is imperative to statistically support the input provided by the public during the Area Transit Plan process and to gauge the significance of the support. Market research is used with the technical analysis to identify potential market opportunities that will enhance the success of transit and to assess support for alternative service concepts.

- ***Define 'targets' within the final plan to monitor and evaluate potential improvements-*** The Area Transit Plan should not be viewed as a static document, but rather a guide to the implementation of transit service and supportive measures over the next five years. As the implementation of specific services and supportive measures are realized, a monitoring program should be in place to measure success and identify any adjustments as required. In this regard, the measures of success should include route specific goals and objectives as well as system level performance targets. As well, the Area Transit Plans should be updated at appropriate time intervals (e.g. every three years) to respond to changing markets.

APPENDICES

APPENDIX 1-Example of Area Plan Resource Requirements and Monitoring Targets

	Current Service (2000)	2003 with South of Fraser Area Plan	% Change
Resources			
Annual Service Hours(buses only)	527,000	770,000	46%
Peak Buses	153	235	54%
Annual Total Cost-Buses Only ($ millions)*	$52.2	$73.7	41%
Annual Fare Revenue ($ millions)	$20.2	$25.7	27%
Performance Targets			
A.M. Peak Hour Ridership			
- From South of Fraser (origins)	8,600	10,940	27%
- From South of Fraser (*STP Target for 2005*)	--	*12,750*	48%
- To South of Fraser (destinations)	4,500	6,900	53%
- Total to/from South of Fraser	13,100	17,840	36%
• Annual Ridership to/from South of Fraser (millions)	13.2	16.8	27%
• Annual New Transit Trips (millions)**	--	3.5	
• Rides per Service Hour	25.0	21.8	-13%
• Cost per Ride	$3.95	$4.39	11%
• Cost per New Ride	--	$6.15	
• Cost Recovery	39%	35%	-10%
AM Peak Hour Transit Market Shares			
• *All trips to/from South of Fraser*	5.1%	6.4%	
• South of Fraser (originated from)	5.6%	7.0%	
• South of Fraser (destined to)	3.3%	4.8%	
• Trips within South of Fraser	3.6%	5.1%	
• South of Fraser to Downtown	69.2.%	71.6%	

Notes: * Total cost includes bus operating and debt service costs but excludes all SkyTrain service hours, operating costs and debt service.
** Net annual new transit trips attracted in GVRD as a whole

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Applications of Bus Rapid Transit in Europe

Graham N. Carey, P.E., AICP, ITE (Fellow)
BRT Project Engineer
Lane Transit District
P.O. Box 7070
Eugene, Oregon 97401
Phone: (541) 501-7558
Fax: (541) 682-7478
E-mail: graham.carey@ltd.lane.or.us

Abstract

Small- and medium-sized communities struggle with the challenge of providing efficient transit service that can attract choice riders by being competitive with the automobile. While many larger communities have turned to light rail systems as the solution to getting people out of their cars, smaller communities have neither the population base nor the financial resources to support these systems.

The Federal Transit Administration's Bus Rapid Transit Demonstration Program has focused attention on using bus transit technologies to enhance the performance of existing bus services to achieve the service quality traditionally devoted to more capital intensive transit solutions. Individual components of bus rapid transit (BRT)--effective applications of technology, flexible operations planning, effective intermodal facilities investments, and responsive customer interface--are not new and have been applied in European cities for a number of years. The transit agencies participating in the Bus Rapid Transit Consortium recently undertook a study tour of Europe to review new transit bus and transit system technologies that are currently developing bus rapid transit (BRT) systems.

This paper describes some of the innovative applications of bus-based techniques being applied in Europe.

1.0 INTRODUCTION

The quest for a competitive, low-cost, rubber-tired alternative to the automobile is not peculiar to North America. European cities have been grappling with the same issue for some time and have developed solutions that meet their needs. To investigative these projects, the Federal Transit Administration organized a 10-day tour of eight European cities: Trieste, Italy; Geneva, Switzerland; Lausanne, Switzerland; Lyon and Rouen, France; Essen, Germany; and London and Leeds, England.

The purpose of the tour was to review new transit bus and transit system technologies that are currently being developed for bus rapid transit (BRT) systems. These technologies included the latest vehicle propulsion and guidance technologies and also bus transit systems featuring dedicated lanes, level boarding, and signal priority.

This paper reviews two innovative buses and then describes five BRT-type systems.

This paper also provides a brief account of the technologies reviewed during the 10-day tour. A detailed account of the tour can be found in "European Scanning Tour" Federal Transit Administration, Draft Report, December 2000.

2.0 VEHICLES

During the study tour, two contemporary vehicle designs were reviewed. The first was the Neoplan N6121 articulated, low-floor vehicle and the second was the Irisbus CiViS.

2.1 Neoplan N6121 Articulated, Low-Floor Bus

The cities of Trieste and Lausanne had purchased the Neoplan N6121, 18-meter, dual-mode, articulated bus. This bus is available with a number of propulsion systems including diesel electric, hybrid electric, or as a dual-mode, propulsion system. The low-floor bus seated 55 passengers and had four curbside doors. Four 80-kilowatt wheel motors were packaged within the wheel hubs along with an 11:1 planetary gear set. Two wheel motors were packaged on the second axle and two were packaged on the third or trailer axle. In Trieste, electrical power was fed to the wheel motors either from the STREAM contact line embedded in the roadway (described below) or in an on-board battery pack. The battery pack allowed the bus to disconnect from the contact line if needed to travel around parked cars. The Lausanne vehicle utilizes two separate power sources such as catenary wires and a diesel generator connected to hub motors.

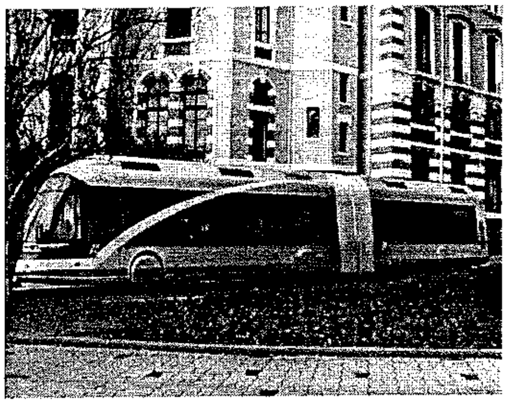
The bus also featured disc brakes that were packaged in board of the wheel motors. The trailer axle was located at the very rear of the vehicle. Its location and the use of wheel motors allowed for a true low-floor design from the front of the bus to the rear. The trailer axle was capable of steering, and the wheels were fitted with super single Michelin tires. This is the same bus model being purchased by Boston. The Boston bus will also be dual mode; however, its power sources will be catenary wires while operating in the tunnel and a diesel generator set operating outside the tunnel.

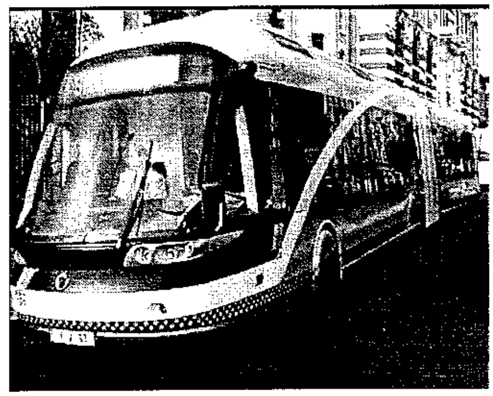
The diesel electric drive system consists of a diesel engine packaged above the rear axle. The engine in the Neoplan N6121 articulated model is a V-8 Mercedes diesel. The confined engine compartment limits the use of other engine configurations such as inline six cylinders. Attached to the diesel engine is a generator responsible for converting the mechanical power into electrical power, which is fed to the wheel motors.

The wheel motors and the packaging of the independent suspension enable the Neoplan N6121 to have a 100 percent low floor from the front of the bus to the rear. The rear axle is also packaged at the very rear of the bus eliminating two wheel-well housings from protruding into the passenger compartment. The rear axle is steered by an electronically controlled hydraulic cylinder; a controlling computer evaluates the signals of speed, driving angle, articulated angle, and logic links to calculate the desired steering angle. The rear steering axle improves the turning radius of the bus and can also be integrated with a guidance system to ease vehicle docking. At speeds above 40 kph, the steering mechanism on the rear axle is locked.

2.2 Irisbus CiViS

The CiViS and the Crystalis are available in 12-, 18-, and 18.5-meter (40 and 60 feet) lengths. The Crystalis is very similar to the CiViS except that the driver's console is positioned on the street side of the bus in a conventional location. With the CiViS model, the driver's console is centered between the curb side and street side of the bus. The nose of the Crystalis is also different--slightly flatter and less rail-like in its appearance. Both models have a 100 percent low floor and can be configured with various seating layouts. Large windows and skylights provide passengers with visibility to the outdoors.





A number of different drive systems are available. Electric trolley versions using catenary wires are available, as well as diesel electric, hybrid, dual mode, and natural gas electrics. On trolley bus versions, the catenary hardware, including the transformer, are roof mounted. A smaller diesel generator is packaged at the rear of the bus in the conventional engine compartment for limited off-wire capability. For diesel electric versions, the diesel engine is mounted transverse to the length of the bus, low and at the rear. The generator mounts to the curb side end of the engine. Motor controllers for each of the wheel motors are mounted under the floor behind the axle.

Four independent wheel motors propel the Irisbus CiViS and Crystalis models. The wheel motors are located on second and third axles. The axles use a drop center beam design. One of the main differences between the layout of the Irisbus and Neoplan models is the location of the rear axle on the trailer unit. Irisbus uses a more conventional drop center beam axle and locates it roughly 2.1 meters forward of the rear of the bus, similar to those on articulated buses found in the U.S. The rear axle does not steer and a conventional articulated hinge is used to attach the trailer unit to the main coach.

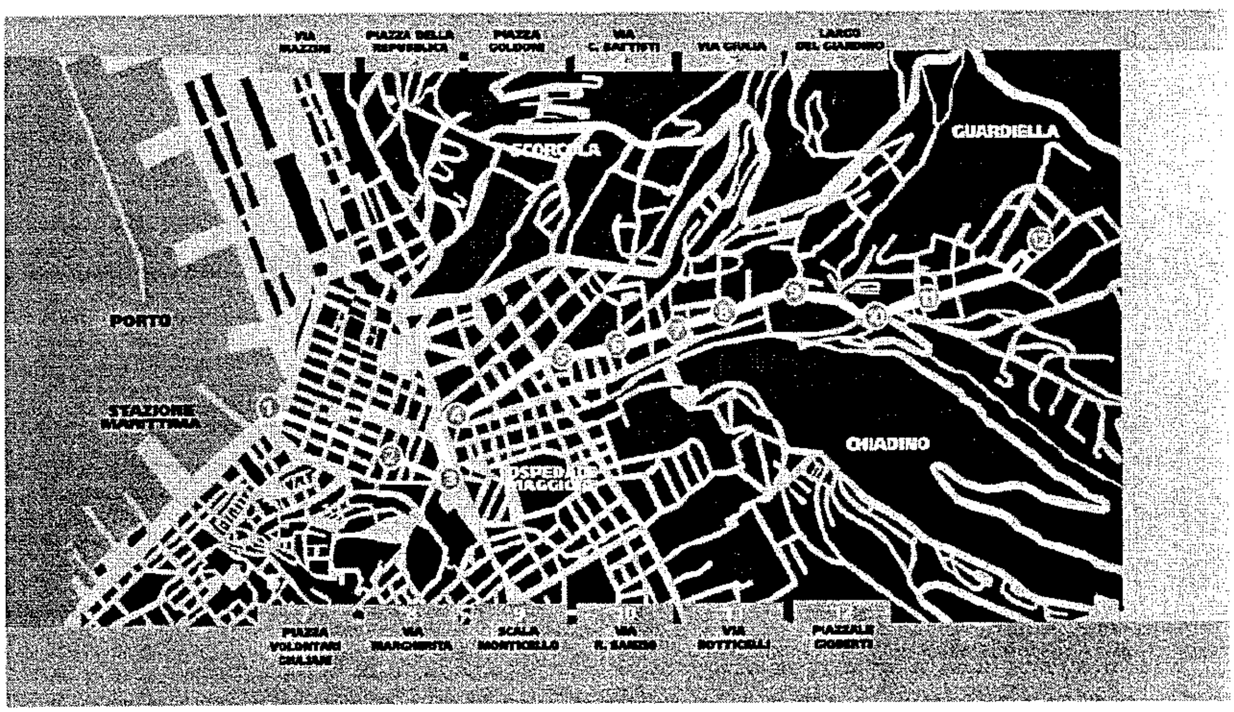
The CiViS bus also has an optical guidance feature available, which uses a node-mounted camera and image processing software to follow painted markings on the pavement. The system can guide the bus along the straightaway and through turns with minimal off-tracking movement--on the order of two to three inches. The roadway markings are normally in the center of the lane (preferred for optimum system operation) but can also be at the lane edge. The image processing technology used is very similar to that now in use for Lane Departure Warning in products for heavy trucks (soon to be available for cars).

In 1999, two French cities contracted with Irisbus to purchase the CiViS guided, rubber-tire, transit system and in July 2000 the Regional Transit Commission (RTC) of Clark County, Nevada, executed a memorandum of understanding to implement the CiViS system in Las Vegas, Nevada. The cities of Lyon and Grenoble in France have contracted for the unguided Crystalis electric trolley bus and dual-mode vehicles.

3.0 BRT SYSTEMS

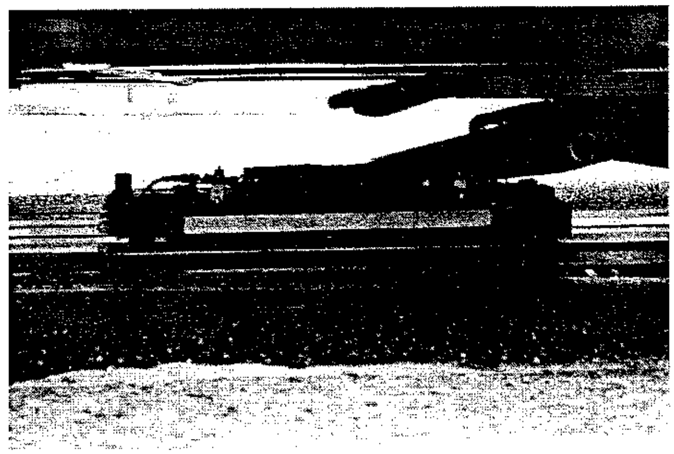
3.1 STREAM, Trieste, Italy

The population of Trieste is approximately 223,000. The STREAM system developed by Ansaldo Breda is being installed in downtown Trieste and will consist of a 3.3-kilometer loop when completed. The system will have twelve stops and will require two power supply substations. Three Neoplan buses will operate on the system--one 12-meter and two 18-meter articulated buses. The initial segment is due for completion in December 2000.



STREAM is an external, underground, power supply system. The contact line is embedded in the roadway, flush with the surface of the street. The magnetic current collector is located just aft of the front axle on the underside of the bus. In normal operating conditions, the vehicle collects traction power from the contact line. At bus stops it can charge onboard batteries. It can, however, disconnect immediately and automatically from the contact line for brief periods and continue using the on-board power source. The current collector under the vehicle has two sliding shoes that connect to the positive and negative conductors on the contact line by means of a magnetic pickup. Power is collected via direct contact with the conductor (distinct from some other roadway-power-electric-vehicle concepts prototyped in the U.S., which use less-efficient, inductive pickup). Vehicles can reconnect to the contact line at any point by simply lowering the current collector. Special reconnection stations are not required. These features give the vehicle the same operating flexibility as a bus.

STREAM Contact Line



Magnetic Current Collector

To install the contact line into the roadway, a trench measuring 30 centimeters deep and 60 centimeters wide is needed. The prefabricated box structure modules are rigid and waterproof, and contain the flexible power conductor or belt. Each module is between 3 and 6 meters long. Internal to the rigid box structure, the belt is divided into insulated metal segments about 48 centimeters long. The segments are connected to the power supply voltage by the magnetic force exerted by the pickup or current collector under the vehicle. This force raises the power belt, which normally rests on the bottom of the contact line modules, making contact with the metal plates above. The current collector under the vehicle has two sliding shoes that connect to the positive and negative conductors on the contact line by means of a magnetic pickup. The segment under the vehicle is connected to the traction supply as the bus passes over the line. Current is absorbed by the traction motor through the positive shoe returns through the secondary shoe to the negative pole formed by one of the non-energized contact line segments. The contact line is live only under stationary or moving buses. At all other points, the contact line is grounded and is completely harmless and hazard free. Infrastructure installation time is about 10 meters per day for a single crew.

Traction power is delivered by on-board AC/DC current converters, which receive AC voltage at 380 V and transform it to 560 Vdc. The converters are distributed along the line in special compact cabinets to reduce environmental impacts. Power can be tapped from existing low voltage cabins owned by the local power company or from special electric substations. Power requirements are 1 megawatt for every 3 kilometers. A key "plus" for this system is that it provides an alternative to overhead electric wires for cities that wish to reduce visual pollution and the other impacts of catenaries.

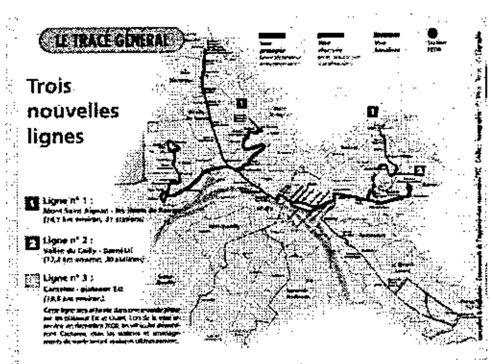
Another key plus is that the roadway contact line is installed in a trough shallow enough (35 centimeters) to typically not disturb utilities installed beneath the roadway.

STREAM cost was stated as approximately 2.5 times the cost of a catenary system. The group was told that new catenary systems are not practical and are not being allowed in Europe anymore, so STREAM is a solution in these cases.

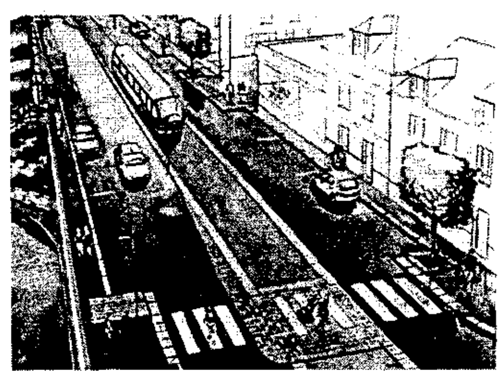
3.2 Rouen, France

The city of Rouen, population of 110,000 (with surrounding towns, the total increases to 395,000 residents), is currently constructing a BRT system referred to as TEOR.

The TEOR project consists of three overlapping lines totaling 24 kilometers. Sixty-five percent of the lanes will be dedicated to the BRT vehicles. The remaining 35 percent will be semi-dedicated (cars may cross the roadway) and shared roadway. The Rouen Transportation Authority has ordered 58 CiViS vehicles powered by diesel-electric powertrains. Optical guidance systems will be installed on all 58 vehicles and can be used continuously downtown and at stations in outlying areas. The TEOR system is expected to cost $165 million, which includes construction costs of stations, sidewalks, platforms, and trees. The BRT vehicles will operate up to 20 kilometers per hour with 2- to 3-minute headways. Bikes can be carried on the bus during non-peak service. A magnetic card reader is located at the entrance of the vehicle. The TEOR system consists of 40 stations with an average separation of 400 meters. TEOR road surface is tinted red.

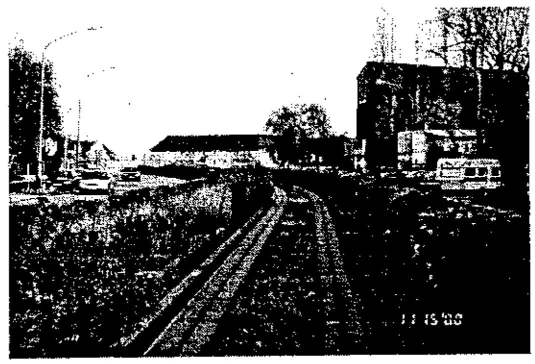


System Map


Busway

3.3 Essen, Germany

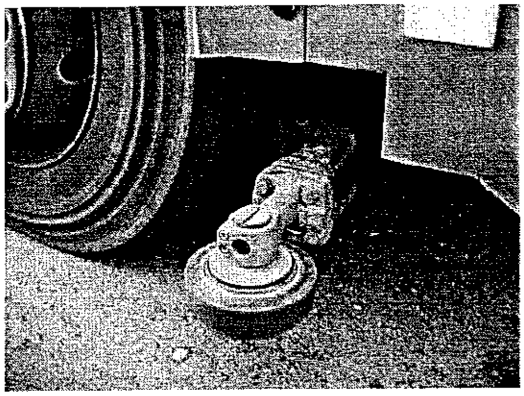
The first modern-day, mechanical, guided, bus system was constructed in Essen, Germany, in 1984. The guided bus lanes were constructed of two formed L-shaped concrete sections that lay parallel to one another at a distance slightly wider than the width of the bus. The bus guidance hardware consists of two small rubber wheels that attach to the bus steering system. The rubber wheels contact the vertical concrete section of the guideway with an interference fit of approximately 5 millimeters.

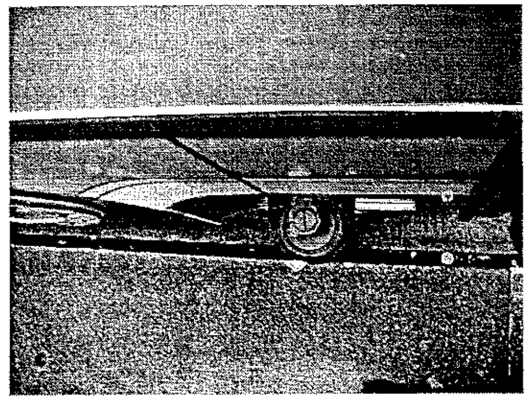


This guideway consists principally of sleepers on which the guideway elements with their integrated guide curbs are laid. The sleepers lie on two bore piles, which serve as the foundation. The length of the guideway elements is 10 meters, bent accordingly in the curves.

The sleepers, which support the guideway elements for both directions of travel, are laid at intervals of 3.33 meters. The sleepers are attached by means of spring clips as normally used to attach rails to sleepers. No special structural measures are required at the joints of the guideway elements as the gap area is completely covered by the running surface for the wheels. At the entry points, a continuous guideway with separate guide curbs made of hollow, tubular steel was selected instead of the standard guideway. This construction ensures simple maintenance and repair of the guide curbs as they do not form one unit with the guideway.

For mechanical track guidance, only a few components need to be fitted to the vehicle. The steering signals are transmitted via guide rollers located directly in front of the wheels. These are connected to the guide via a roller bracket. This guide arm then transmits the steering information to a modified stub axle. A rated break point in the roller bracket prevents damage being done to the steering mechanism in the event of a heavy impact. The wheel housings are slightly enlarged to ensure freedom of movement for the guide arm. The guide rollers protrude approximately 5 centimeters from the side of the vehicle, resulting in an overall vehicle width of 2.60 meters.

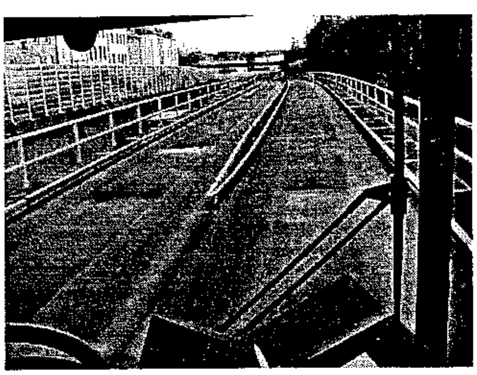

Guidewheel


Guidewheel at Curb

In addition to the guide rollers, distance rollers are required on the other axles of articulated vehicles. The purpose of these is to prevent contact between the rear axle and the guide curbs in bends with radii of less than 200 meters. The distance rollers are attached directly to the axle suspension by means of roller brackets. These distance rollers can be positioned either behind or in front of the wheel, depending on the axle construction. The position behind the wheel has proven to be considerably better than the one in front of the wheel. Here the distance rollers are better protected against damage from curbs and bumps in the normal road surface.

The rollers, both guide and distance, consist of a steel rim with a small, rubber tire mounted on bearings. The roller bearings are water tight to protect them against frost damage and water penetration.

For buses to enter the guided bus lane, the guide trough is widened from the normal 2.60 meters to 3.20 meters over a length of approximately 11 meters. The left-hand guide curb in the direction of travel is positioned further forward. When entering the guide trough, the driver steers his vehicle against this curb. The guided curbs have to be interrupted for crossroads and pedestrian crossings. For an interruption of less than 6 meters, the bus automatically drives in the guide trough without changing direction.


Guideway Entrance


Guideway Crossing

3.4 London Millennium Transit Electronic Guided Bus, England

The Millennium Transit M1 bus route was introduced to link London's Millennium Dome with the Charlton Tube station. Part of the route (1.3 kilometers of the 2.5 kilometer total length) utilizes a fully segregated busway with priority signalization at all intersections. The busway uses electronic guidance equipment and was designed as a technology independent alignment to permit future upgrades to a rail system. The bus fleet is low floor with advanced clean propulsion and an electronic guidance system for use on the busway.

The M1 route is a pilot project for contactless electronic guidance and has provided a considerable wealth of operating experience in the use of this new technology. The first task in the project was linking the characteristics of buses to the guidance system. Maximum accelerations initially set at 1.0 m/s/s (meters per second per second) lateral and 0.5 m/s/s vertical were found to be restrictive, slowing the buses significantly. In comparison to tram rail systems, these limits were found to be conservative, and the allowable limit for rate of change of steering angle was increased to allow quicker speeds around curves. However, this led to oscillations in the buses when running at normal operating speed in a direct line.

The guidance system consists of a set of cables buried in the trackway 30 centimeters apart, connected to frequency generators at each end of the busway. Antennas fitted to the bus detect the magnetic centerline of the signal and cause the power steering of the bus to steer towards the center line. The cables have experienced problems over time--displacing due to differential settlement and to nearby construction work. Cambered pavement also causes problems, as the guidance system affects the perception of the magnetic center line and sometimes causes the bus to dock at a platform with a larger gap than desired.

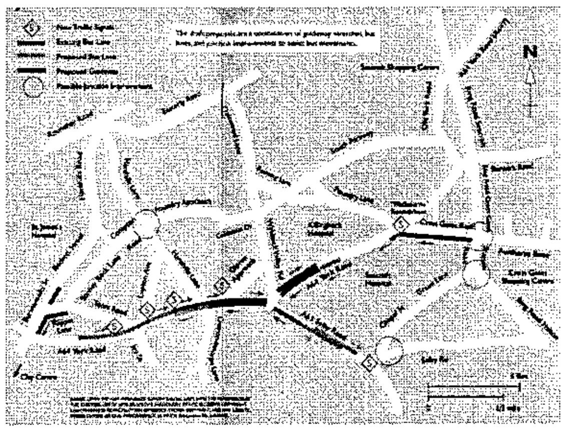
The guidance system also was designed to match the buses with boarding platforms, but this has been found to frequently only be possible for the front door due to vehicle design, while the vehicle has to slow considerably during the approach to the platform to permit precision docking.

Other issues included the use of a new paving type on the busway that has been found to be unsuitable, with pavement condition as well as vibration experienced by passengers, falling below that of standard asphalt roads. In addition, land taken for the installation of the busway was larger than expected due to the need for a fixed swept path in turns and required clearance between vehicles.

London Buses is undertaking a number of investigations into ways of improving the system. However, the testing highlighted significant problems with this particular approach to use of contactless guided technology. Solutions are being explored as there is continued interest in bringing this technology into operational service.

3.5 Leeds Superbus, England

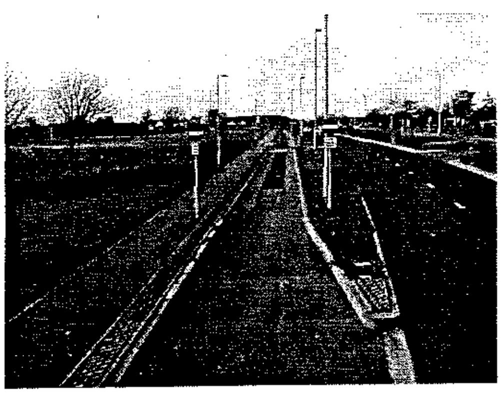
Leeds is one of the fastest growing cities in England with a population of approximately 750,000. Public bus service is provided by competitively bid contracts; the primary bus operator is FirstLeeds, a subsidiary of FirstGroup, which is the largest bus operator in Britain. FirstLeeds has approximately 500 buses and a staff of 1,200. As a high profile operator, FirstLeeds is positioning itself for increased growth, with 138 buses on order.



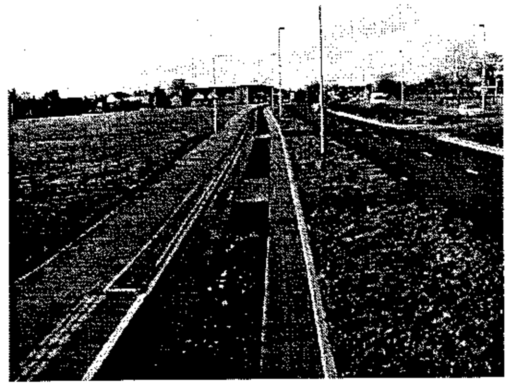
System Map

One of the leading transit projects in Leeds is the Superbus, a bus system utilizing a system of segregated guideways with mechanical guidance. The Superbus system includes five primary bus routes, all following a common alignment connecting the northern suburbs with the central business district. Superbus has been in operation since 1995 by FirstLeeds with ridership increasing by 75 percent in the first three years of service as a series of guideways and bus prioritization projects were completed. Ridership continues to grow at 2 to 3 percent a month as capacity and other improvements are made. Superbus has cut the previous 30-minute time down to 20 minutes, which is faster than car travel along the same alignment and attracts travelers from car use. The fleet uses 23 dedicated buses with a unique color scheme; these are rotated out to other services after three years. Both articulated and double-deck buses are used in service.

The guideways used by the bus are not contiguous but are instead built alongside existing roadways leading up to intersections where traffic queues develop. The buses use the guideways (up to 800 meters in length) to bypass congested traffic. In addition, as the bus drives along the guideway, a detector linked to the traffic signal changes the lights to stop other traffic and give the bus signal priority at the intersection. With a paved block system matching the axle width of the bus for a roadway, the guideways are physically limited to use by buses.



Guideway Entrance



Guideway

The guidance is a mechanical system designed by Scania and Volvo, which requires only six hours to install. Two horizontal wheels are attached ahead of the front wheels and are linked to the steering system. In the guideway, these wheels follow the curbs along each side of the segregated guideway, reducing necessary lane width. Entrances are funneled where the bus enters the guideway. In addition, the guidance also allows easy access at guideway bus stops where raised platforms facilitate passenger boarding and alighting.

The success of Superbus has pushed forward plans for more busways. The next service to be improved will be in East Leeds through the Quality Bus Initiative. Two of the major transit operators in West Yorkshire (FirstLeeds and Arriva Yorkshire) have agreed to pay half of the development costs ($7.5 million) of the guideways proposed. Over two kilometers of guideways will be built at some four key road stretches, connecting with existing and proposed bus lanes to speed travel. Cost of the guideways is approximately $1,500 per lane-meter, or $2.6 million for a two-lane, two-way, 1-kilometer stretch. The improvements in travel time and other level of service characteristics versus the project expenditure make the Superbus project one of the most efficient and effective transit improvements that Leeds has undertaken.

4.0 Conclusion

There are a number of exciting developments in "rubber-tired" transit in Europe in which North American transit can benefit. The perception that bus is a "poor relation" to the rail transit is not peculiar to North America. European transit operators have had to tackle the same issues and in response have developed attractive vehicles and innovative transit systems that warrant investigation.

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Transit Signal Priority along State Route 522

ITE "Quad" and IMSA B.C. Joint Conference and Trade Show

Vancouver British Columbia

Abstract

SR 522 is a state route that extends from Seattle to Monroe in the State of Washington. King County Metro Transit wanted to evaluate the benefits of transit signal priority (TSP) treatments along a portion of SR 522. In addition to the evaluation of TSP, the analysis also examined the expanded use of the eastbound transit-only lane during the AM and midday peak hours. This paper presents the methodology used for the analysis and a summary of the results.

Prepared by

Hicham F. Chatila, P.E., P.T.O.E.
The Transpo Group
11730 118th Avenue N.E., Suite 600
Kirkland, WA 98034-7120
425-821-3665 (Phone)
425-825-8434 (Fax)
Hichamc@thetranspogroup.com

Michael J. Swenson
The Transpo Group
11730 118th Avenue N.E., Suite 600
Kirkland, WA 98034-7120
425-821-3665 (Phone)
425-825-8434 (Fax)
Mikes@thetranspogroup.com

Introduction

As population densities increase in areas outside the Seattle CBD, transit ridership is also expected to grow. However, as congestion along the corridors in the area increase, the speed and reliability of transit routes operating along these key corridors are impacted. With the increased ridership, this corridor congestion contributes to an increase in overall person delay. King County Metro transit is working to improve transit speed and reliability.

Route SR 522 extends from the City of Seattle to City of Monroe, primarily on an east-west alignment between the two cities. King County Metro wanted to evaluate the benefits of potential TSP treatments along a portion of SR 522 located between the Cities of Lake Forest Park and Bothell. In total, the study addresses a 2.75 mile section of SR 522. Through the study area, SR 522 contains five general-purpose lanes as well as two transit only lanes. The transit lanes also serve as right-turn lanes for general-purpose traffic at the intersections. Currently, the westbound transit-only lane (into Seattle) is open 24-hours a day to transit. The eastbound transit lane is currently used in the PM peak period only. The following figure provides an overview of the study corridor and identifies locations for the signalized intersections.

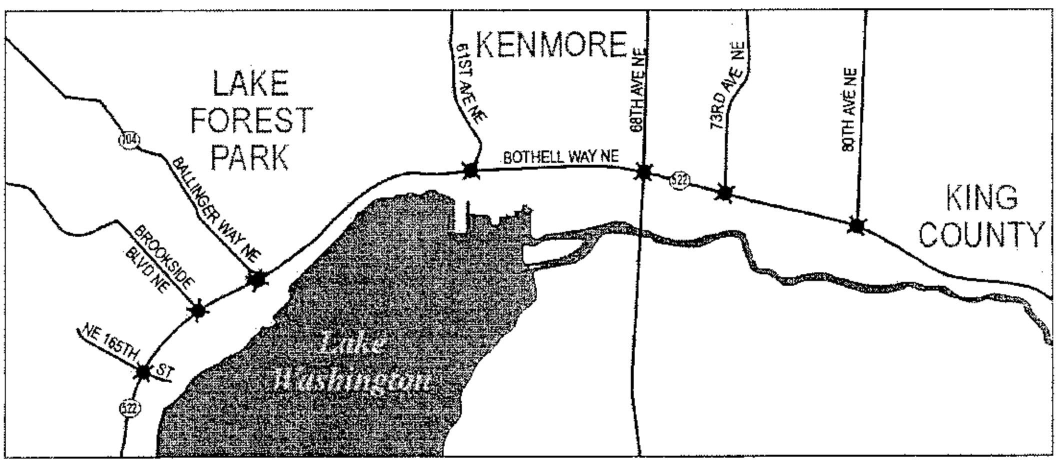

Figure 1. Study Corridor – Key Intersections

Seven signalized intersection are located within the study area. The Washington State Department of Transportation (WSDOT) is responsible for operating and maintaining the signals along this corridor. Due to the traffic volumes on the arterials intersecting SR 522, the synchronization of the corridor is challenging. WSDOT currently operates the signals along the corridor using two coordinated signal systems, with Ballinger Way the dividing line between the two systems. The cycle lengths along the corridor vary between 150 and 180, depending on the section of SR 522 and the peak hour. During the midday peak hour, all intersections operate with a 120 second cycle length.

The Burke-Gilman trail, part of the local trail system, is located along the northern edge of lake and parallels SR 522 on the south side of the road. Due to the location and popularity of the trail system there is a presence of both pedestrians and bicyclists along

SR 522. Many people travel to the trail from areas north of SR 522 and cross at the major intersections such as 68th Avenue NE and Ballinger Way NE. Land uses along the corridor include a mixture of retail, office, and residential developments. The location of several parks on the south side of SR 522 also creates a certain level of pedestrian traffic traveling north/south across SR 522.

King County Metro operates several routes along the corridor. Service levels vary between the peak hours. A total of nine routes operate along the corridor providing service between Bothell and Seattle and Woodinville and Seattle. The following table represents the transit vehicle activity near Ballinger Way NE. As shown in the table, the largest volume of transit activity occurs in the eastbound direction during the AM peak hour.

Table 1. SR 522 Transit Volumes

	Eastbound (to Bothell)	**Westbound (to Seattle)**
AM Peak Hour	100	77
Midday Peak Hour	6	6
PM Peak Hour	31	6

Transit Signal Priority and Transit Lane Evaluation/Methodology

This analysis focused on two primary areas. As outlined in the following paragraphs, the analysis included an evaluation of both TSP along the corridor as well as expanded use of the eastbound transit lane. As explained in the introduction, the eastbound transit lane is currently utilized during the PM peak hour only. The City currently limits the use of the transit lane due to noise impacts on adjacent residences. The analysis evaluated the benefits of expanding operations of the transit lane beyond the PM peak period to the AM and midday peaks as well. Although a detailed noise analysis was conducted in conjunction with the traffic analysis, the results have not been included in this paper. The analysis focused on the changes in travel times along the corridor for both general purpose and transit vehicles as a result of the expanded use of the transit lane in conjunction with the implementation of TSP.

In order to determine the benefits of Transit Signal Priority (TSP) and the expanded use of the transit lane, VISSIM was used to model both TSP as well as the transit lane operations. VISSIM is a microscopic simulation model capable of evaluating TSP and HOV lanes. The VISSIM model included all signalized intersections on SR 522 from NE 165th Street to 80th Avenue NE. Because of the proximity to SR 522, the intersections of 68th Avenue NE and NE 181st Street and NE 175th and 68th Avenue NE Street were also coded into the network. Signal phasing, splits, and offsets were based on existing signal timing plans provided by WSDOT. The timing plans used were downloaded from the controllers in the field. Traffic volumes through the corridor were based on recent peak hour turning movement counts conducted for the study area intersections at the start of the project.

Baseline VISSIM networks were developed for the AM and Midday peak hours. These peak periods were chosen since they included the transit lane restrictions during both peak periods. Once the existing (base) network was fully coded, travel times segments were calculated for the eastbound and westbound travel along SR 522. These travel times were then compared to the existing field measurements to assure that the model travel times were comparable to existing conditions.

The transit signal priority (TSP) logic in the VISSIM model emulates the signal logic of the intersection controllers. Depending on the phase served when the TSP call is received, the signal controller takes the appropriate action as described below.

If the TSP call is received at the controller when the transit phase is inactive, an early green is provided by switching to priority timing parameters for force-offs and maximum green times (set to 80% of normal split lengths) that shorten the green times for conflicting phases until the TSP phase is reached.

If the TSP call is received during the transit phase, a green extension occurs by stopping the local clock until check out or reaching a maximum green extension (set to 20% of cycle length). At that time the controller references the master clock to determine how far it is out of synchronization. It now begins to skip every 5th second until the local and master clock are back in synch. By setting the maximum green extension to 20% of the cycle length, the controller always returns to coordination within one cycle.

Several TSP scenarios were analyzed. The following matrix summarizes the combinations included in the travel time analysis.

Table 2. Analysis Scenario Summary Matrix

	Existing Scenario[1]		**Transit Lane Operations Scenario[2]**	
Peak Period	**w/o TSP**	**w/ TSP**	**w/o TSP**	**w/ TSP**
AM	x[3]	x	x	x
Midday	x	x	x	x

1. *Existing Scenario assumes eastbound use of transit lane during PM peak hour only along SR 522 east of the City of Lake Forest Park*
2. *Assumes eastbound use of transit lane through the City of Lake Forest Park*
3. *x - Scenario evaluated*

Travel time data through the corridor was collected for the existing baseline model. This information was compared to travel time runs conducted in the field. Travel time runs in the field were collected using a floating car methodology. In other words, travel times were recorded as a driver traveled between both ends of the study area while driving with the flow of traffic. The field runs are based on a single car making four runs in both directions. In order to get a range of results, the simulations were run five times with different seedings. These seedings control the hourly distribution pattern of the traffic being generated at the endpoints of the network. The multiple seedings produce a range of results that may better represent actual field conditions. The results of the travel time runs and model calibration are summarized in the following table. The percent difference was calculated by dividing the model data by the travel times found in the field.

Table 3. Model Calibration and Existing Travel Times

	Field Runs	Model Data	Percent Difference
AM Peak Hour			
WB (all)	400	420	6 %
EB (auto)	350	440	20 %
Midday Peak Hour			
WB (all)	330	355	7 %
EB (auto)	290	340	17 %

Analysis Results

The following table summarizes the results of the AM and midday peak hour travel time analysis. The results have been summarized for all scenarios, with and without TSP as well as with and without the expanded use of the transit lane. Since the expanded use of the transit lane only pertains to the eastbound direction, travel time data was collected for that direction only.

Table 4. Travel Time Analysis Results – eastbound between 165th and 80th

	Existing Conditions[1]			Expanded Use of Eastbound Transit Lane Scenario[2]		
Scenario	No TSP	With TSP	Percent Change	No TSP	With TSP	Percent Change
AM Peak						
Auto	439	445	+ 1%	444	437	- 2 %
Transit	621	577	- 7%	581	536	- 8 %
Midday Peak						
Auto	339	341	+ 1%	341	347	+ 2 %
Transit	588	573	- 3 %	548	508	- 7 %

1. Assumes the eastbound transit lane is not utlized by transit during the AM and midday peak hours.
2. Refers to the use of the eastbound transit lane by transit during the AM, PM, and midday peak hours.

AM Peak Hour Existing Conditions – With and Without TSP

As shown in the above figure, the travel times for autos stays fairly constant. A difference of approximately of one percent over 2.75 miles is considered a negligible change. Transit travel times could improve by approximately seven percent with the implementation of TSP.

AM Peak Hour Expanded Use of Transit Lane – With and Without TSP

Assuming the expanded use of the transit lane, the travel times for auto traffic is decreased by two percent. For transit vehicles the travel times could be expected to decrease by approximately eight percent with the implementation of TSP.

Midday Peak Hour Existing Conditions – With and Without TSP

As shown in the above table, the travel times for autos stay fairly constant. A difference of one percent over 2.75 miles is considered to be a negligible. Transit travel times could improve by approximately three percent with the implementation of TSP.

Midday Peak Hour Expanded Use of Transit Lane – With and Without TSP

Assuming the expanded use of the transit lane, travel times for auto traffic increased by two percent. Travel times for buses traveling along the corridor were shown to decrease by seven percent as compared to the transit lane with no TSP travel times.

Conclusions

The calibration and setup of the model was very important in this project. As noted in the text, the analysis focused primarily on the eastbound travel times and the impact that the implementation of TSP and the expanded use of the transit lane had on the general purpose and transit traffic. The eastbound travel times measured in the field were within 10 percent of the travel times collected from the model runs. Since traffic volumes themselves can vary on the order of +/- 10 percent, the model results were assumed to be valid for this analysis.

Given the location of the project, relative to a major pedestrian/bicycle path, pedestrian activity impacts signal operations at the intersections within the study area. Pedestrian information was important in the evaluation and was included in the model. Pedestrian volumes can impact the effectiveness of TSP, especially when pedestrian clearance phases are long.

Both policy-related directives as well as traffic flow impact the effectiveness of TSP. These influences should be reviewed while evaluating potential TSP applications at single intersections or along key corridors. The following summarizes several factors that were applicable to this project.

- **TSP strategies**. The specific TSP strategy helps define potential transit benefits and impacts on general-purpose traffic. Jurisdictions vary on what is an acceptable TSP implementation policy. This variation relates to questions such as: Is skipping a phase allowed? Can pedestrian phases be truncated? Should every bus be given priority or should priority be given to buses that are behind schedule and with high passenger occupancy? In addition, green extension and red truncation issues also impact the overall effectiveness of TSP. All these factors should be carefully evaluated before implementing TSP.

- **Pedestrians**. The presence of pedestrian phases could greatly impact the effectiveness of TSP. The number of pedestrian calls, the length of the crosswalks and the required clearance intervals greatly impacts the signal operations and TSP effectiveness.

- **Vehicle Queuing**. In many of the key corridors in the area, the curb lane serves as a business access and transit lane. In cases such as this, the transit lane will also accommodate right-turning vehicles at the intersections. The amount of traffic turning right and the associated queue lengths impact the effectiveness of TSP and overall signal operation. If high right-turn volumes exist, it may eliminate the benefit of TSP. The additional time allocated for transit may be used to process the right-turning vehicles. The expected back-of-queue should also be considered when locating the check-in detection.

Besides addressing the technical aspects of TSP, institutional issues should also be addressed. One of the local agencies along SR 522 route did not support the project because of a perceived noise issue due to the additional number of buses that would operate in the transit-only lane. Despite overall benefits that TSP could provide along the corridor, this agency was focused only on a single issue within its jurisdiction while ignoring the overall project benefit. A strong outreach program is highly recommended for TSP implementation.

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Planning the Coquitlam SkyTrain Line Extension

Ian Rokeby, P.Eng. Earth Tech (Canada) Inc., 300 – 4170 Still Creek Drive, Burnaby, BC V5C 6C6
Tel: (604) 473-8526 Fax: (604) 294-3647 e-mail: irokeby@earthtech.ca

Chris Mooi, MAIBC, Paul Merrick Architects, #1 Gaoler's Mews, Vancouver, BC V6B 4K7
Tel: (604) 683-4131 Fax: (604) 683-9313 e-mail: mooi@merrickarch.com

INTRODUCTION AND PROJECT BACKGROUND

In March 2000, the Provincial government and the Greater Vancouver Transportation Authority (TransLink) entered into an agreement to negotiate towards an alignment, station locations, and budget to complete an extension of the SkyTrain System from Lougheed Mall in Burnaby, through Port Moody to Coquitlam (the "PMC Line").

Rapid Transit Project 2000 Ltd. (RTP2000 Ltd.) has been incorporated to implement and complete both the Millennium Line and the PMC Line. All shares of Rapid Transit Project 2000 Ltd. are owned by the Province of British Columbia, and a Board of Directors comprised of a Chair, President and three Directors has been appointed.

In the summer of 1998 RTP2000 Ltd. commissioned Transurban, a consortium of Vancouver planning, urban design, and engineering professionals, to carry out a planning study of alternative route alignment options for the PMC Line. The team, led by Ray Spaxman of Spaxman Consulting Group, comprised senior representation from the following Vancouver firms:

- Paul Merrick Architects
- Arthur Andersen Consulting
- Earth Tech (Canada) Inc. (formerly Reid Crowther & Partners Ltd.)
- Spaxman Consulting Group
- Phillips Wuori Long
- GolderAssociates
- BKL Consultants
- Hotson Bakker Architects Ltd.

This team was charged with the planning, corridor selection, and some initial engineering input for the proposed Port Moody-Coquitlam (PMC) Line. This new 11.5 km extension to the SkyTrain system is proposed to join Lougheed Mall to Coquitlam Town Centre via Port Moody.

The PMC Line is considered a key initiative in support of the Liveable Region Strategic Plan (LRSP), linking two Town Centres (Port Moody, Coquitlam) in the Northeast Sector of the Burrard Peninsula which currently have a relatively poorly developed transit system. It is also viewed as a critical prerequisite to achieving the employment goals accepted by Coquitlam in support of the LRSP.

The proposed line traverses a number of established, relatively low density residential neighbourhoods, as well as the historic "Old Town" of Port Moody. It touches three separate municipalities along its length, each with its own vision of the role transit can play in future development. The proposed line also involves a number of significant design challenges, including steep grades (up to 10%), a 2 km tunnel necessitated by the escarpment separating Port Moody and Coquitlam, environmentally sensitive salmonid-bearing streams, poor soils, and the adjacent Canadian Pacific Railway mainline.

Project Objectives

The project sought to:

- Identify a range of feasible alignments and station locations within the previously identified corridor(s);
- Identify suitable responses to the various challenges presented by the project in the areas of planning, urban design, and engineering;
- Develop a concise description and conceptual level design information to support the preparation of comparative cost estimates and route selection decision-making;
- Prepare a structured assessment of the relative merits of the competing choices;
- Carry out sufficient public process work to gain an understanding of the key community issues along the line;
- Develop suitable design and mitigation strategies for major design issues along the competing alignments;
- Work with municipal staff and councils and TransLink to facilitate the development of constructive recommendations regarding route selection.

Development of Alignment Options

Previous work on this line had established the general corridor. However, in a number of key areas, there remained significant choices to be made, and further alignment development work was required throughout the line. In order to facilitate the evaluation of the various alignment options, schematic alignments were prepared for each, to a level of detail sufficient to describe major engineering and urban design issues. The major section divisions and the related alignment choices included:

- **North Road/Clarke Road**
    - The North Road portion of this section is on the municipal boundary between Coquitlam and Burnaby; both centreline and west side alignments were considered (east side options were precluded by proximity of high density residential development);
    - East side, centreline (overhead) or west side station location at/near Burquitlam Plaza.

- **Clarke/Port Moody Tunnel**
    - Portal Locations;
    - Alignments (Miller Ravine vs. Clarke Road).

- **Port Moody**
    - Alignment (CPR (north or south) vs. St. John's St.);
    - Urban design and station location issues, (Integration with existing Westcoast Express station).

- **Coquitlam Barnet/CP Rail/Guildford Drive**
    - Choice of alignment (Guildford Drive median, Barnet Highway north or south, or CP Rail north or south);
    - Station locations.

- **Pinetree Way**
    - Alignment (centre, east, west);
    - Station locations (Coquitlam Central, Lincoln Avenue, Coquitlam City Hall).

Figure 1 provides an overview of the alignment and major choices.

In initiating the planning level review of options, the Transurban team sought to generate a limited number of options which delineated the range of feasible solutions. By breaking the line into discrete physical pieces, the specific alignment and station location choices were rendered largely independent (i.e. the implications of a choice in one section did not impact the choice in a subsequent section). This permitted a simplified approach to the available choices, rather than having to consider the numerous permutations and combinations along the route.

Option Assessment

The terms of reference of this assignment did not extend to selecting a preferred alignment; rather it was desired to characterize the physical, engineering, cost and urban design implications of the available alternatives. This in turn would facilitate the elicitation of input from the various stakeholders on the relative desirability of the developed options. In order to provide this assessment, a set of 22 parameters was developed by the team, as follows:

- Guideway Alignment
- Stations
- Tunnel/Portal
- Property/Socio-Economic
- Geotechnical
- Noise
- Utilities
- Roads and Traffic
- Pedestrian Access
- Cyclist Access
- Vehicular Access and Parking
- Intermodal Connections
- Potential Walk-In Patronage
- Views
- Landscape
- Community Integration
- Development Opportunities
- Construction
- Operational Considerations
- Cost

For the purposes of documentation, the project corridor was split into 12 sections, each approximately one kilometre in length. Within each section, a separate presentation page was prepared for each competing alignment alternative, with a 1:5000 drawing showing existing topographic and cadastral mapping together with the proposed alignment option. Multiple station location options were all indicated on each sheet. Below the "strip mapping", a table was provided with one line for each of the 22 assessment parameters, in order to provide room for an option commentary. Many of these parameters only applied to stations, and where no stations were proposed for a particular sheet, this was noted.

In preparing the options commentary, considerable care was required to avoid pejorative language or value statements in the description of the options and their implications. This permitted the conclusions regarding the choices to be left to the public and elected officials, rather than technical personnel. Figure 2 provides a sample of the documentation ultimately prepared.

Consultation Process

As the material described above was prepared, it was shared with stakeholders through a series of open houses and meetings with neighbourhood associations, municipal staff and councils, and property owners. This permitted the gathering of opinion that ultimately shaped the options presented and facilitated the municipalities' recommendations regarding the alignment choices. For example, a number of original alignment options were deleted from further consideration, including:

- Miller Ravine, Port Moody (environmental sensitivity)
- St. John's Street, Port Moody (urban impact)
- Clarke Street, Port Moody (urban impact),
- CPR south side through Coquitlam (environmental sensitivity)
- Guildford Way (geometric constraints, proximity to residential development)
- "Switchback tunnel" under lower Clarke Road alignment (geometric and operational considerations).

In general, the public consultation process facilitated a vigorous public debate on the issues surrounding this project and improved the project considerably.

Municipal Recommendations to TransLink

In mid-2000, Burnaby, Coquitlam, and Port Moody submitted their recommendations regarding the alignment options to TransLink. These were generally adopted; where they were mutually exclusive, TransLink undertook to resolve the conflicts. In general, the alignment adopted by TransLink can be summarized as follows:

- North from Lougheed Town Centre Station on the centreline of North Road;
- Transition to the east side of Clarke Road to a station on the east side of Clarke Road at Burquitlam Plaza;
- Transition to the west side of Clarke Road near Como Lake Road;
- Decline to grade and tunnel portal located on west side of Clarke Road near Kemsley Avenue;

- Tunnel from Kemsley Avenue to approximately the intersection of Vintner and Douglas in Port Moody;
- At grade on the south side of the CPR tracks to the Ioco Road overpass;
- Under the south abutment of the Ioco Road overpass, becoming elevated and crossing to the north side of the CPR tracks;
- Along the north side of the CPR tracks to a station adjacent to the existing Coquitlam Central Westcoast Express station;
- North on Pinetree Way to a terminus in the vicinity of City Hall.

Subsequently additional work has been commissioned to resolve the details of the lower tunnel portal location, the Port Moody station locations, and the Pinetree Way alignment and station locations.

Next Steps

Rapid Transit Project 2000 Ltd. has commenced work on the preliminary design of the PMC Line. Significant progress has been made on resolving the remaining alignment choices and outlining the technical solutions to the project's varied challenges. The line could be open for revenue service as early as 2005.

A-1-5/7

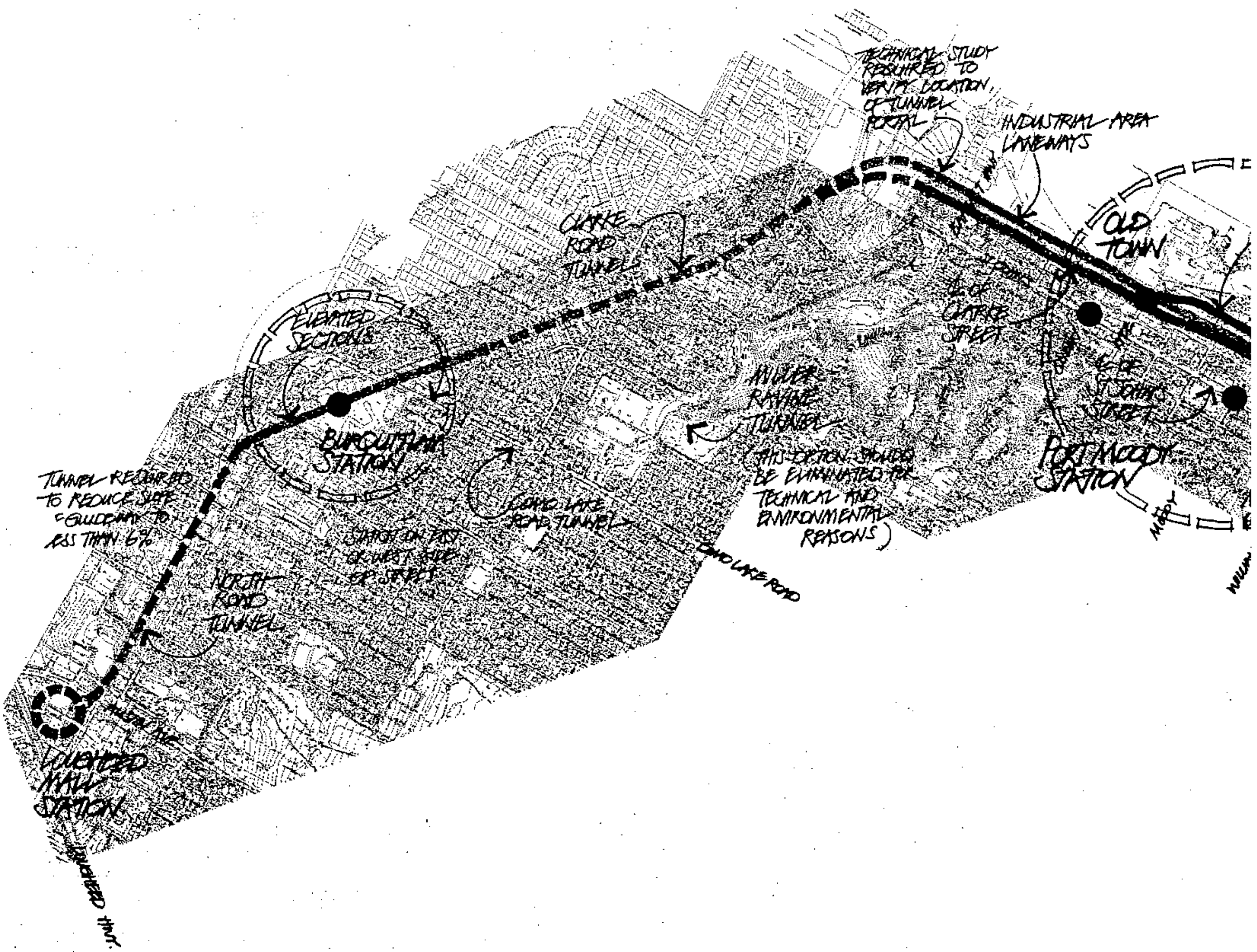


Figure 1a

A-1-5/

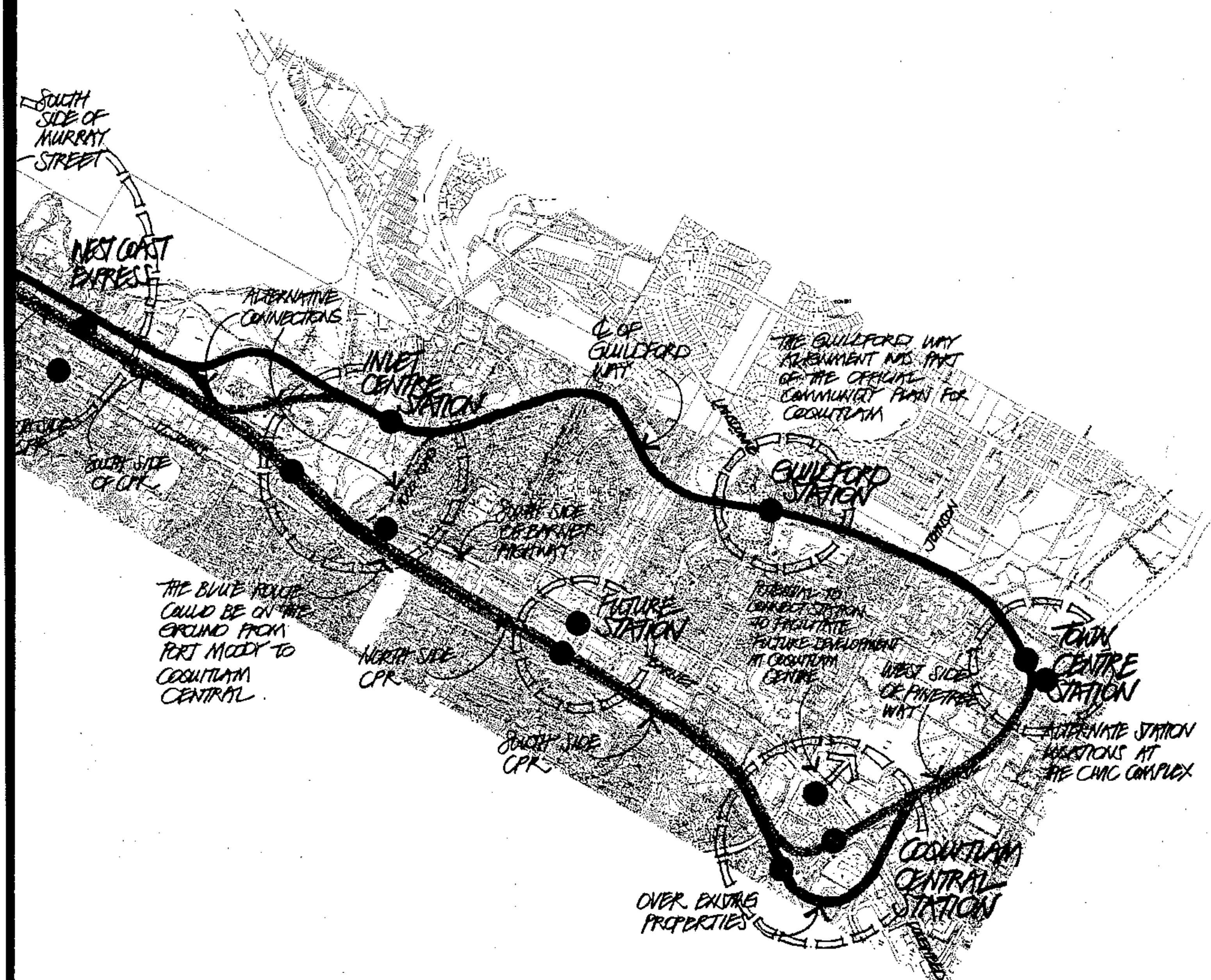
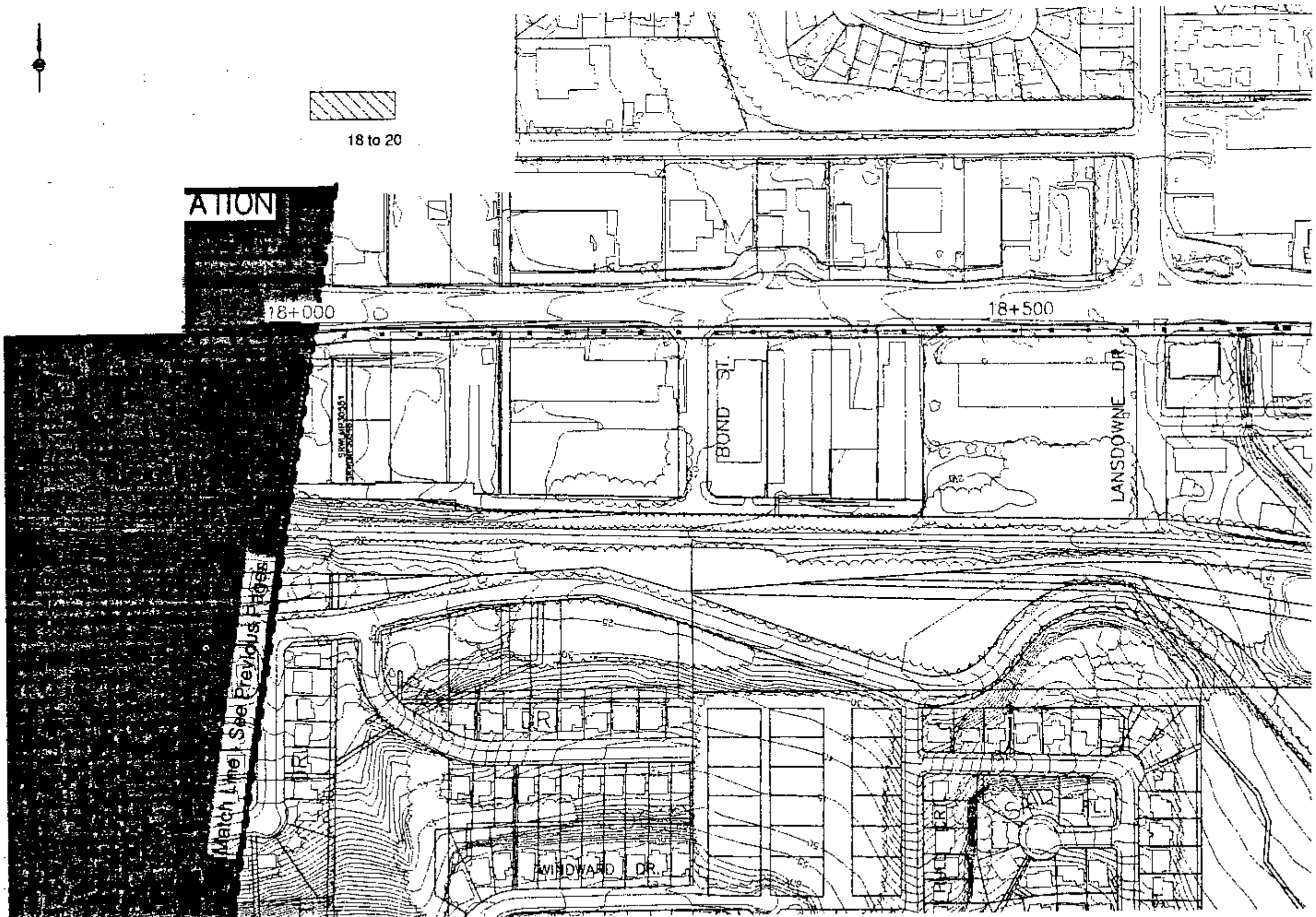


Figure 1b

A-1-5/9



1. Guideway Alignment	Elevated south side Barnet to Station A; alternate assumed under Johnson Street Overpass to elevated Station B; Specia
2. Station(s)	Station A on shorter route; Station B integrated with existing bus exchange
3. Tunnel/Portal	None
4. Property/Socio-economic	Station Option A has limited property impacts but affects access and visibility of 37 businesses west of Johnson Street; Sta
5. Geotechnical	Deep foundations needed over whole length
6. Geo-environmental	Many potential contamination sites exist in this section including, two metal manufacturing businesses, and many auto rep
7. Bio-environmental	18+630 Environmental Sensitive Area (ESA) Wildlife Habitat (WH) Scott Creek ravine Class A stream; 18+850 ESA WH H
8. Noise	Negligible noise impacts
9. Utilities	Possible costly conflict with sewer siphon crossing west of Bond Street, possible costly conflict with parallel 600mm storm
10. Roads and Traffic	Poor peak hour Level Of Service at Barnet/Pinetree; Best to route site traffic via existing West Coast Express access; His
11. Pedestrian Access	Pedestrian access between Station A and Coquitlam Centre would be best accommodated in bridge over Barnet; Station I
12. Cyclist Access	Proposed Johnson Street bike route is close but poor access from south; No east-west bike route identified; More design
13. Vehicular Access & Parking	Good access to both stations and to existing park-and-ride with potential to expand; No on-street parking; SkyTrain/West
14. Intermodal Connections	Intermodal connections to buses and West Coast Express; Station option B provides a direct connection to the existing tr
15. Potential Walk-in Patronage	Existing Rating: medium; Future Rating: high (excludes transfers from WCE)
16. Views and Privacy	Impact to south side industrial/commercial properties along Barnet
17. Landscape	Pedestrian improvements along south side Barnet Highway
18. Community Integration	Both stations contribute to creating a commuter node at Coquitlam Central; Impact to frontage properties on south side of
19. Development Opportunities	Excellent opportunity for new development along this route especially over West Coast Park and Ride lot and in the area
20. Construction	Piling noise disturbance duration is estimated to be 2 to 5 months
21. Operational Considerations	Station A is a shorter route, does not have "S" bends and is close to good ridership and service potential of Shopping Ce
22. Cost	Station A = $75 M; Station B = $80 M

TRANSURBAN

DEC 1999

Legend:
Elevated
Tunnel
At-Grade
Option

1:5000

0 100

Northeast

LOUGHEED •

Time: 4:35PM
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Figure 2a

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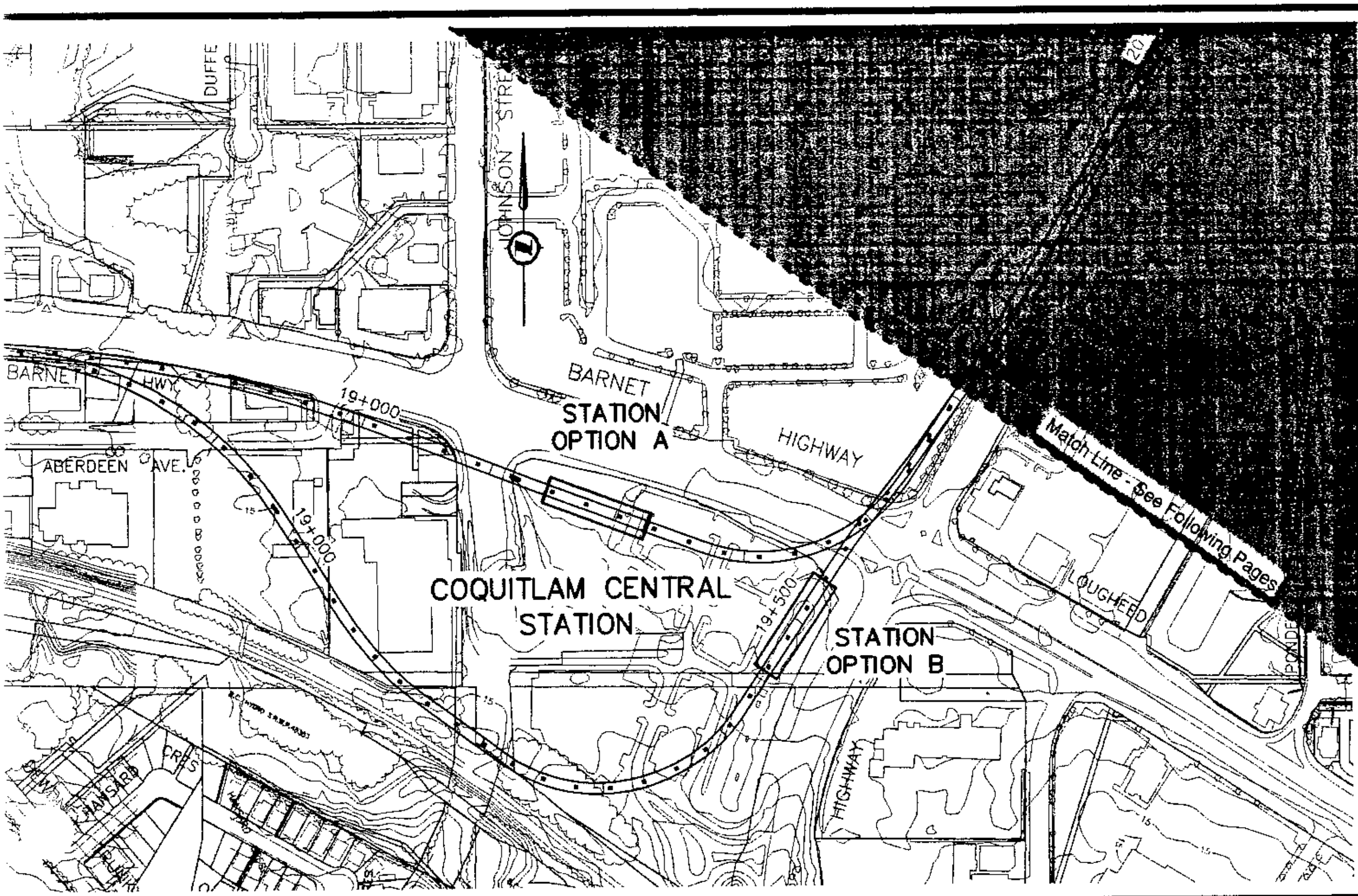


cture from Station "A" to cross Barnet Highway

Option B displaces 4 businesses and slightly disrupts 32

ops, with a concentration of them between 18+860 and 19+050
eek ravine Class A stream; Can be readily spanned; Special care needed around Scott/Hoy Creek at 19+100 to 19+300

possible costly conflict with BC Gas transmission crossing near Lansdowne need special care in design and construction
l data shows vehicular/pedestrian conflict at Barnet/Lougheed; Sight distance from cross streets south of Barnet may be affected
better connection to West Coast Express and pedestrians could circulate to surrounding area at grade via light controlled intersection
needed at next phase
Express access off Mariner, Barnet & Lougheed
exchange and a slightly more direct connection to the existing West Coast Express station than option A

t Highway; Station A integrates well to Coquitlam Centre if provided with a footbridge
f Station B

tor SkyTrain

RT MOODY • COQUITLAM

Evaluation Summary

SECTION EIGHT - Coquitlam South

OPTION 2 - South Side of Barnet *Sheet 19 of 24*

Figure 2b

The Pedestrian Pathway Prioritization (3P) Program

Kevin Chang, P.E. and Wally Archuleta, P.E. - King County Traffic Division

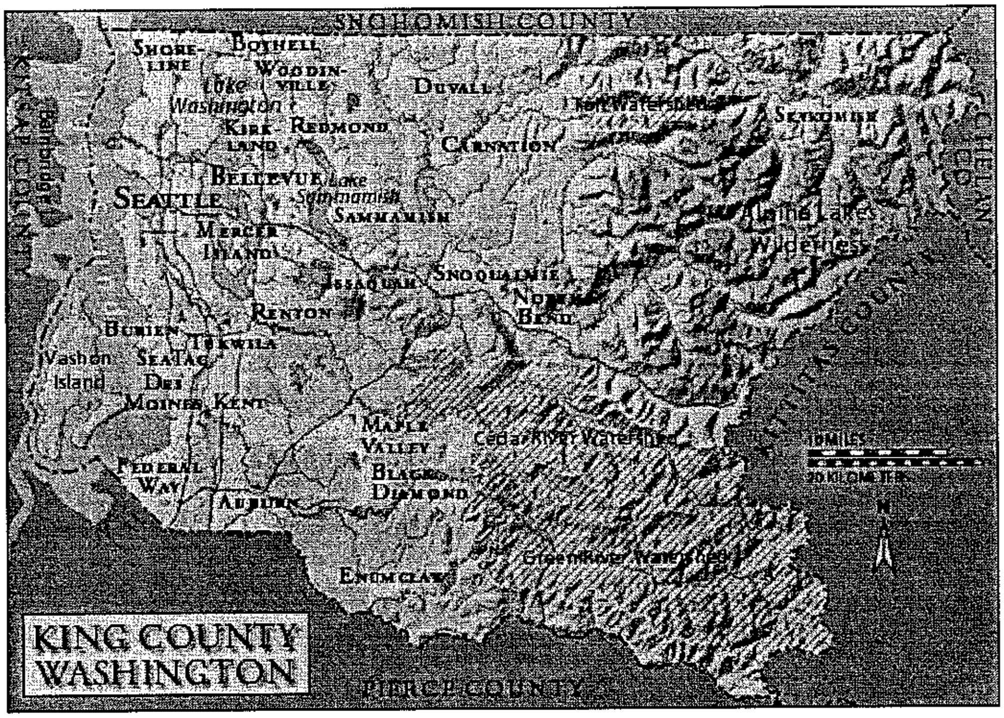
ABSTRACT

Pedestrian improvements have traditionally supplemented larger road construction and maintenance projects. Capital Improvement Programs, whose selection of transportation projects have been largely influenced by traffic capacity, level of service, and traffic safety thresholds, have tended to prioritize improvements which are most beneficial to vehicular roadway users. The non-motorized component of these projects, including pedestrian safety improvements and enhancements, have been effectively included to serve the purpose of satisfying local guidelines and policies.

Recognizing that there was a growing need to independently address the availability of non-motorized transportation facilities, King County established a separate countywide program, identified as the Pedestrian Pathway Prioritization (3P) Program, to focus entirely on pedestrian safety and mobility. In many cases, existing roadside pedestrian facilities had become inadequate to safely accommodate pedestrian usage in increasingly urban areas; changes in growth management policies and zoning regulations created a significant number of noticeable missing links between available pedestrian facilities elsewhere. To that extent, there became an inherent need to develop a process to determine which of these many locations would be given highest priority.

The Pedestrian Pathway Prioritization (3P) Program was established to serve as a tool for both planners and engineers to determine which project locations would serve as the best candidates for limited design and construction funding. The 3P Program utilized a four-step process conducted over the course of a calendar year. These four steps included: 1) candidate project identification, 2) preliminary screening and scoping, 3) project score determination, and 4) final analysis. Projects determined to be highest-priority were then further evaluated to ensure that local community needs were being adequately addressed.

KING COUNTY DEMOGRAPHICS



Population (1998) :	1,665,800 (total)
	408,000 (unincorporated)
Land :	2,134 square miles (total)
	1,787 square miles (unincorporated)

BACKGROUND

Funding for transportation improvements has typically favored larger capital projects. These projects include new highways, bridges, and roadway expansions. While these projects are attractive to the general public as a whole, they require significant design and construction budgets, and can quickly exhaust program funding. The reward, however, results from the cumulative benefits enjoyed by the commuting public after such enhancements are implemented.

Unfortunately, this heavy spending on selected projects can leave few crumbs for other transportation-related programs, including those focusing on the non-motorized traveling population. For these commuters who primarily walk or bike, non-motorized travel is often a choice or necessity based on the environment in which they live. These people include children, who may walk to their local elementary or middle school; the elderly, who may walk for exercise as part of a daily regimen; urban dwellers, who may utilize non-motorized transportation to avoid contending with on-street parking and traffic congestion; and the handicapped, who may rely on non-motorized facilities for daily travel. People who access public transit stops also represent part of this non-motorized population.

Admittedly, non-motorized travelers face added inherent danger, particularly when their travel is in close proximity to motor vehicles. Although each person's needs are different, certain high-risk pedestrians are clearly more susceptible than others. In this regard, safety control devices are installed for two purposes; these devices assist the motorized driver by delineating high pedestrian traffic areas while simultaneously warning the pedestrian from the dangers that exist. Specific safety control devices include, but are not limited to: signing, striping, overhead flashers, signals, sidewalk bulb-outs, and textured crosswalk crossings. Technological advancements are evidenced by other state-of-the-art devices, including in-pavement warning lights, although their actual effectiveness remains under close review at this early juncture.

When traffic operational devices fail to sufficiently address the problem at hand, implementing more permanent enhancements may be necessary. Specifically, as many localities have become increasingly urban in nature, existing roadside facilities are no longer adequate to safely serve increased pedestrian use. To distinguish roadway from walkway, new sidewalks, widened shoulders, and separated walkways are desired to provide pedestrians and, in some cases, bicyclists with the safest travel environment possible.

3P PROGRAM OVERVIEW

Planners and engineers alike benefit from a plethora of helpful criteria and methodology to substantiate and subsequently exercise all spending decisions. As political pressures may affect the selection of capital projects, and engineering judgment may vary from person to person, a credible evaluation process is necessary to justify funding decisions and establish a more standard platform from which decisions can be made.

Unfortunately, pedestrian improvements generally compete with other road improvements as projects are rated. In order to ensure that pedestrian safety projects extended beyond the role of mere supplemental enhancements to major capital improvement projects, King County dedicated funding to the Pedestrian Pathway Prioritization (3P) Program for the design and construction of pedestrian facilities. This program allowed the County to specifically target pedestrian walking areas in most need of improvement. With the evolution of changing design standards and County policy, this program has adapted accordingly since program inception. Today, the current state of practice contains four main steps:

- Identification of Candidate Locations,
- Preliminary Screening and Scoping,
- Determination of Priority Process Score, and
- Final Evaluation of Selected Locations.

Identification of Candidate Locations. Given the large geographical area encompassed by King County, program staff rely on a number of resources to identify locations where improvements are needed. Projects are regularly solicited from both interagency personnel and members of the general public. Businesses, community groups, and school district personnel also offer valuable insight for candidate locations. Further, press releases or public service announcements have shown to be very effective in generating responses. King County is also using Geographic Information System technology to map proposed project locations and pathway improvements and to assist in identifying missing links.

Preliminary Screening and Scoping. This stage of the process is conducted to ensure that the proposed project location is best suited for the 3P Program. For example, if an existing problem requires traffic control, staff from the Traffic Operations Unit will likely conduct a field investigation to determine possible solutions. If an existing walkway is affected by uprooting trees or poor drainage, County Maintenance forces will likely be contacted. When project locations are identified as school walkway routes, the School Pathway Program will be called upon to address this concern.

Determination of Priority Process Score. Once locations are identified, the viability, benefit, and impact of each project location is assessed. At this stage, a staff member field-checks potential locations to identify and eliminate those which are not significant safety hazards or which may be infeasible. Screening should ideally be done by one person to ensure consistency. Preliminary cost, environmental impact, and other permitting issues are noted at this point, and projects determined to be more appropriate for other capital programs are also identified. Project locations which pass this initial screening are then evaluated more comprehensively, and this criteria is discussed in greater detail in the next section.

The King County 3P Program heavily emphasizes land use and roadway characteristics, but other jurisdictions seeking to establish a similar program may value other factors. Depending on the goals of a particular jurisdiction, criteria may need to be adjusted accordingly. For example, a jurisdiction may be developing a pedestrian walkway network throughout the community; such a jurisdiction would likely consider a factor for missing links or connectivity.

Final Evaluation of Selected Locations. After projects are fully evaluated, those best meeting the criteria are considered for design and construction and prioritized. Since the criteria captures an array of widely diverse elements including financial cost, political feasibility, and environmental impact, engineering judgment is inherently needed to ensure that decisions make sense. When a highly-rated project is bypassed in favor of one rated lower, the reasons for doing so should be well-documented.

LESSONS LEARNED : PROJECT EVALUATION PROCESS

Given the multitude of possible pedestrian projects, it is beneficial to establish a methodology from which all locations can be evaluated. Development of such a standard is beneficial in the sense that the determination of projects then does not necessarily rely solely on engineering judgment. To that extent, previous studies conducted by other jurisdictions were referenced. Combined with field review, King County is in the process of developing its own set of evaluation standards to complement its specific program objectives. In the interim, the following observations are offered.

Pedestrian volume data is largely nonexistent. The most equitable way to prioritize projects would be to favor facilities where pedestrian volumes are highest. Unfortunately, collecting pedestrian volume data, aside from physically employing field staff to tally pedestrian volumes, can be costly, time-consuming, and labor intensive, particularly with both urban and rural landscapes involved. Unlike vehicular traffic, pedestrian travel is far less predictable as inclement weather, personal health, and availability of other travel modes can easily affect the decision-making for pedestrians. To remedy this issue, the capture of regional land use is synthesized to serve as a qualitative representation of pedestrian traffic and identify likely generators. Relative proximity to schools, parks, bus routes, businesses, community centers, retirement complexes, and other public facilities are all identified for consideration. King County is looking at using video technology to develop a sampling of pedestrian volumes in specific areas.

Establishing traffic volumes as a criterion does not apply in all cases. The safety of pedestrians faces increased danger as traffic volumes rise on the adjacent roadway, although pedestrians may take fewer precautions when traveling on low-volume roads. In areas where motorized traffic is restricted, favorably weighting a proposed project strictly on traffic volumes becomes impractical. In this regard, while traffic volumes on a grander scale could serve as a factor for project implementation, considering other roadway characteristics in aggregate may prove to be beneficial. These important roadway characteristics include posted speed of the roadway, number of travel lanes, outer lane width, existing shoulder width, shoulder surface, and horizontal and vertical sight distance.

The overall program can select projects based on either a proactive or reactive stance. Heavy vehicle and pedestrian interaction increases the likelihood for accidents. While reported incidents and accidents involving vehicles and pedestrians need to be taken into account, selected projects should not necessarily be chosen solely based on pedestrian accidents. In that regard, the 3P Program seeks to assume a proactive stance. Project locations with increased incidence for accidents should be further evaluated, but should not be given such heavy preference that other projects suffer.

Encourage other non-motorized methods of travel as part of an overall public outreach effort. The utility of a pedestrian project to complement other non-motorized users should always be considered. When feasible, if the project can be expanded to accommodate bicyclists, equestrians, and the disabled, additional consideration should certainly be given.

Project costs for design and construction and the time required for implementation deserve serious consideration. Since program funding is limited, projects that may be fast-tracked by County maintenance forces, avoid extended environmental impact reviews, and face narrow construction windows should be considered for priority status if the need is significant and the construction timeline achievable. Larger projects, which are likely to be more complex, would likely be better candidates for capital improvement program funding which target broader scoped projects by nature if 3P Program funding was not readily available.

Maintain program consistency, and make changes when warranted. With limited program funding, staff time and operating expenditures are placed at a premium. To minimize research and development efforts, the evaluation process would ideally stay relatively consistent over time, with interpretation of the evaluation criteria by different staff members viewed in a repeatable manner. For this to be possible, the importance of having a good prioritization process that is both comprehensive and reliable cannot be emphasized enough. These matters, taken in aggregate, serve as the tenets for the Pedestrian Pathway Prioritization Program.

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In-line Skate Experiment

Quad Conference

April, 2000

Vancouver, B.C.

Prepared by

CIVL 589 Class, Transportation Engineering, UBC

Presented by

Stella Chow, B.A.Sc

Joanne Ng, B.A.Sc

Vikki Ngan, B.A.Sc

Connie Tang, B.A.Sc

1.0 INTRODUCTION

The ever-increasing popularity of roller-blading (inline skating) as a form of recreation and more recently as a viable means of transportation has led to the need to analyse this mode of transportation further. Surprisingly, however, very little research has been done to quantify the performance characteristics of a group of inline skaters. Speed, flow and density relationships are needed to be developed in order to determine the performance measures of this type of travel mode and to develop "comfort" zones for service design guidelines. These are similar to the level of service (LOS) criteria used to assess roadway and pedestrian capacities.

As part of the requirements of the CIVL 589 class at the University of British Columbia, the class was required to prepare a methodology for an inline skate experiment. The purpose of the experiment was to determine the flow characteristics of inline skaters. In particular, the experiment was set up to calculate the speed, flow and density relationships of a group of inline skaters confined to a limited space. A track was designed and set up in order to control the experiment and to make observations. The speed of the skaters was used as the control variable where flow and density were measured as the skaters traveled around the track. The speed varied from a slow shuffling speed up to a maximum speed of close to 25 km/h. The optimum flow was assumed to be somewhere between 10 to 15 km/h. After the experiment was completed, the speed, flow and density were calculated using the video footage. From the results of the experiment the LOS for the in-line skaters was also determined.

2.0 METHODOLOGY

The location of the experiment was chosen to be the C2 Parking lot at UBC. This parking lot is quite large, relatively flat (1 - 2% grade) and could accommodate some parked vehicles and the inline skate experiment during off-peak parking hours.

A pre-experiment test run was performed to determine the dimensions of the inline skate track, as shown in the diagram below in **Figure 2.1**:

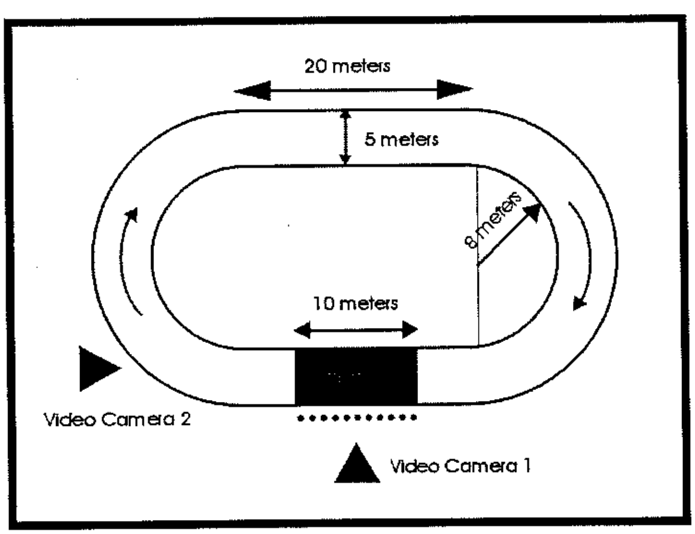

Figure 2.1 shows the track layout and the video camera locations within the C2 parking lot.

The "video section" was a 10 m long segment in the middle of one of the straight sections. Traffic cones and delineators were placed at 1 m intervals on either side of the "video section" to provide reference to indicate the position of each inline skater. One video recorder was set up in the middle of the video section and was used to video the side view of the in-line skaters' forward movements. The other camcorder was used to observe their lateral movements.

The followings outline the procedure of the Inline Skate Experiment:

1. A bicycle with a speedometer was used as the leading "vehicle" to set the specified speed for the in-line skaters.
2. Participants were instructed before the experiment to follow the bicycle and to skate as close together as possible while still maintaining enough space between them to feel comfortable and safe.
3. Two camcorders recorded the inline skaters' motions for the three laps within a 10 m long segment of the straight section, called the "video section".
4. In order to reduce the possibility that the in-line skaters would become "trained" for the speed, the speed trials were done in random order. The speed trials ranged from 5 km/hr to 20 km/hr, plus trials at jammed, slow walking, fast walking and fast as possible conditions.

3.0 RESULT & ANALYSIS

After the experiment was completed, three important parameters: traffic flow, concentration/density and space mean speed of each trial run are extracted from the video clips. These data are fitted against seven selected single regime models, and one two-regime model. The two-regime model is compared to a Pedestrian Model (Highway Capacity Manual, 1985)[3] and a Bicycle Model (Navin, 1992)[5]. A spacing-velocity relationship of inline skaters is also obtained from the experiment and the Level of Service (LOS) is determined for inline skaters from the relationship.

3.1 Single Regime Models

Single regime models assume that the data for congested and free flow conditions can be fitted to a single mathematical model (equation). There are seven traffic flow models from traditional traffic flow theory for vehicles (May 1990) that were used to fit the data from the inline skater experiment. These models are Greenshields Model, Drew Model, N-Power Curve Model, Greenberg Model, Underwood Model, May Model and Exponential Non-Linear Model.

The velocity-density curves were plotted for all seven models and a best-fit line equation was calculated for each model. Density, instead of concentration, was used for the single regime analysis because the width of the concentration measurement varied from the skating, walking, and jammed states (5 m, 2.5 m and 1.89 m respectively).

From the results, the best-fit model is the Greenberg Model because its R^2 value of 0.92 for the velocity-density curve is the highest among the seven models. However, the experimental data does not fit well against the flow-density of the Greenberg model. Therefore, a single-regime model does not reflect what was actually occurring for the inline skaters.

3.2 Two-Regime Models & Comparison

A two-regime model is used to fit the observed data in this section. In this model, the flow and density data are classified into two regimes. **Figure 3.1** and **Figure 3.2** below illustrate the speed-concentration and flow-concentration relationships using a two-regime model.

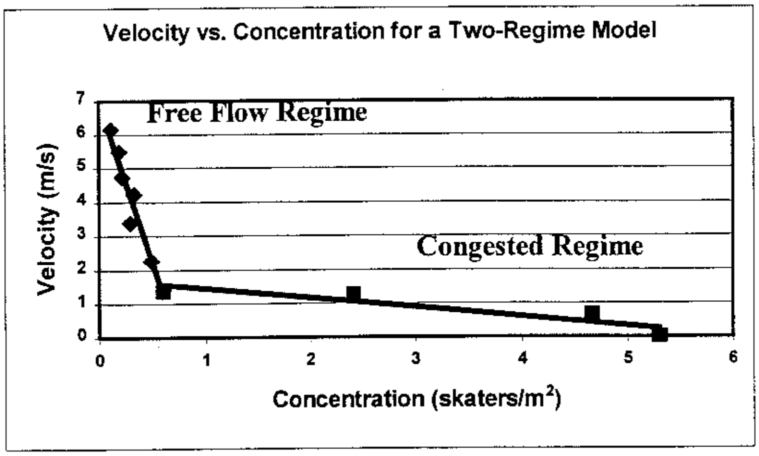

Figure 3.1 shows the velocity-concentration graph for a two-regime model. Both regimes exhibit linear relationships, thus Greenshield's Model best fit the data.

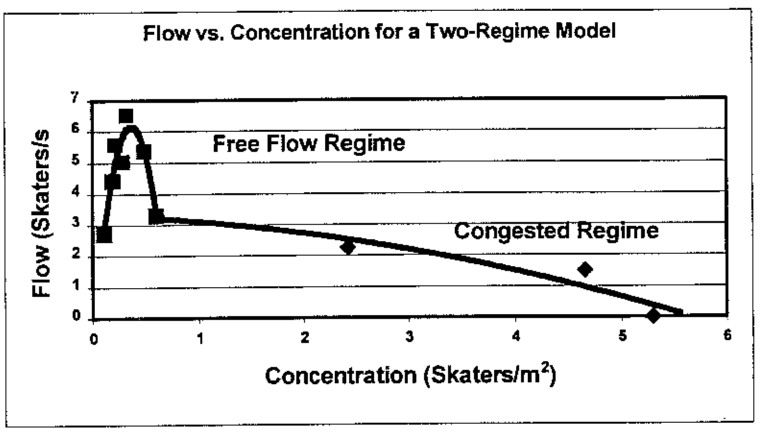

Figure 3.2 illustrates the flow-concentration graph for a two-regime model. The two regimes show parabolic curves.

The first regime, also referred to as the "Congested Regime", is observed from the jammed condition to 5 km/hr. This regime represents the shuffling mode of inline skaters, in which a very small amount of force is required to carry the forward momentum of skaters and the skaters can travel very close together because of the slight leg and arm movements needed at these slow speeds. The second regime, or the "Free Flow Regime", is observed for all other speeds above 5 km/hr. Beyond the speed of 5 km/hr, the skaters seem to "break-out" of the shuffling mode into a more regular skating motion. Considerable leg and arm movements are required to maintain their higher speed, thus more space is needed.

Inline skating is hypothesized as a mode between walking and biking. As a result, the two-regime model is compared with a Pedestrian Model (HCM, 1985)[4] and a Bicycle Model (Navin, 1992)[5] to illustrate the relationships between inline skating, walking and biking. **Figure 3.3** shows the comparison of the velocity-concentration relationships of these three modes.

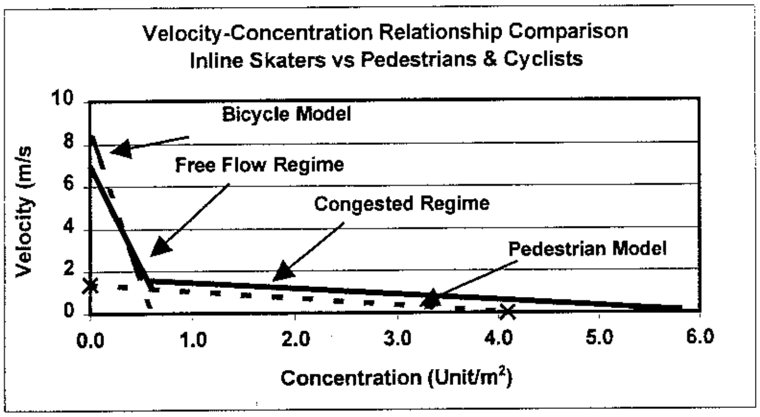

Figure 3.3 shows the velocity concentration comparison of inline skaters with pedestrians and cyclists.

The above comparison shows that the ***Congested Regime*** of inline skaters is almost parallel to the Pedestrian Model and is shifted a bit to the right. This means that at the same velocity, the concentration of inline skaters is higher than that of pedestrian, which can be explained by the fact that pedestrians need to have longer steps to increase their speed, whereas inline skaters barely need to move their feet once they start moving during the slow speeds. The ***Free Flow Regime*** of inline skaters is observed to have very similar slope with the Bicycle Model, which shows the similar traffic flow characteristics exhibited by the two modes.

Besides the velocity-concentration comparison, the flow-concentration relationship comparison is performed between inline skaters and cyclists is illustrated in **Figure 3.4** and the space-velocity comparison of inline skaters with pedestrians is shown in **Figure 3.5**.

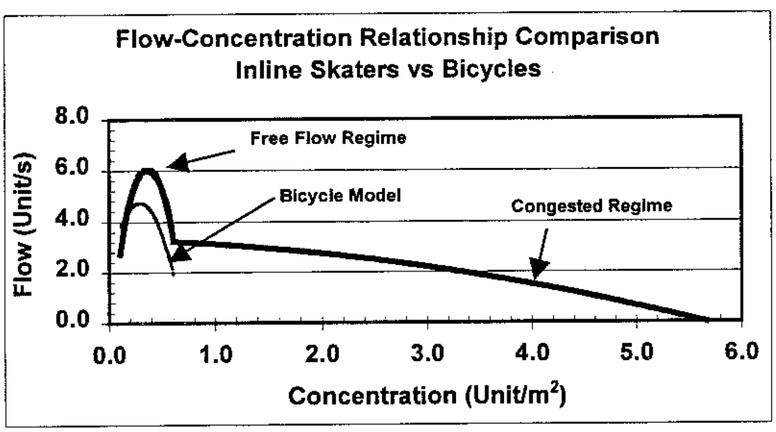

Figure 3.4 illustrates the flow concentration comparison between inline skaters and bicycles. Similar parabolic shapes are observed for the two modes, and bicycles have lower flow value because they are longer than the skaters and take them longer time to past a point.

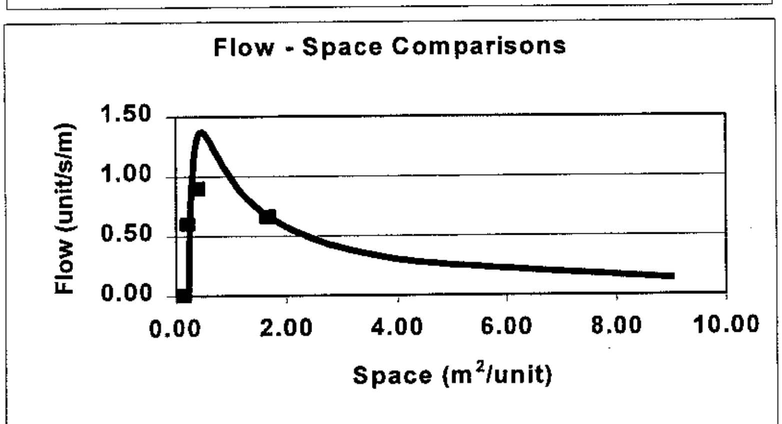

Figure 3.5 shows the flow-space comparison between the congested regime of inline skaters and pedestrians. The observed value (square data points) fit very well onto the pedestrian model (black curve).

3.3 Spacing of In-line Skaters & LOS

The concept of spacing and headway has also been used for pedestrians (Fruin, 1971)[3] and bicycle flow (Navin, 1992)[5] as a "measure of effectiveness" (MOE) of walkways and bikeways. For this experiment, the position of each inline skater and the relative distances (from centre to centre) between adjacent skaters were observed. **Figure 3.6** shows the average distance between skaters.

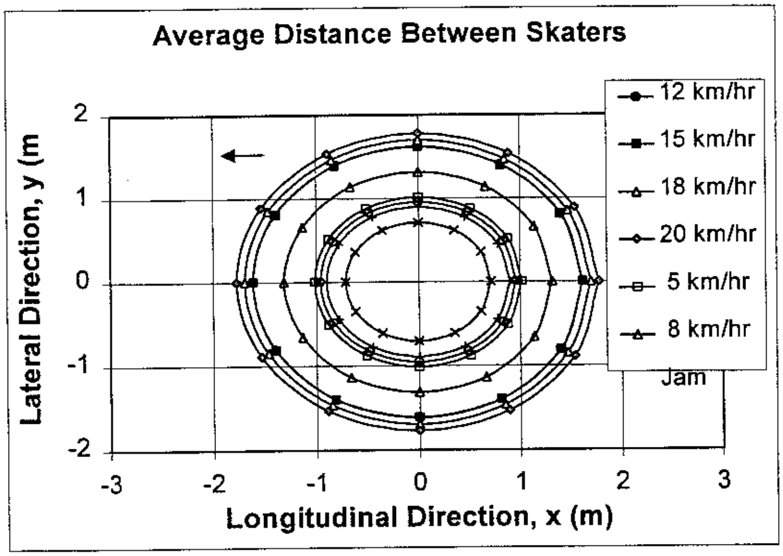

Figure 3.6 shows the average distance between skaters for each of the speed trials.

In **Figure 3.6**, a circular area is used to represent the area occupied by an inline skater at different speeds. As expected, the average distance between skaters increases as the operating speed increases. The average diameter of all speed trials for the experiment is found to be 0.95 meters (or 3.15 feet). This value is less than that obtained from two previous studies (Brown[6] and Birriel et al.[7]), which obtained an average lateral occupied width of inline skaters of 1.18 meters and 1.2 meters respectively.

The LOS for in-line skaters should follow the same approach used for determining the LOS for pedestrians and bicycles, which reflects riding comfort and the freedom to move laterally. The MOE used is the area occupied by the skater or the "space" around one skater, which is converted to a circular space as shown in **Figure 3.6**. The graph below, **Figure 3.7**, illustrates the relationship between this space and speed of inline skaters.

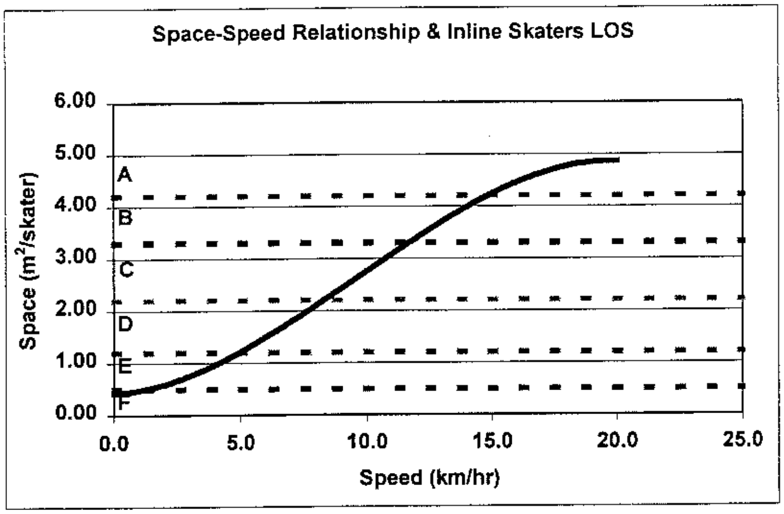

Figure 3.7 shows the space occupied by inline skaters at different speeds. The conditions from LOS A to LOS F are also illustrated on the graph.

The six LOS shown in **Figure 3.7** are derived using the LOS developed by Fruin (1971)[3] for pedestrians on walkways and by Navin (1992)[5] for bicycles. LOS F and E should be the same for pedestrians and inline skaters since both operate similarly under this range of space. However, since inline skaters need more operating space to achieve higher speeds (greater than walking speeds), LOS above D should reflect the greater space requirements.

The bicycle study (Navin, 1992)[5] used the concepts of zones to establish the LOS: collision zone (LOS E), comfort zone (LOS D) and circulation zone (LOS B). The comfort zone for skaters seems to correspond with speeds just beyond the normal walking speed (> 4 km/h), with a space of about 1.1 m^2 /skater from **Figure 3.7**. At the 12km/hr speed trial, the inline skaters appears to skate at a spacing that does not affect adjacent skaters and thus is selected as the lower limit of the circulation zone (LOS B).

Achieving and maintaining speeds of about 15 km/hr and higher requires a little more skill and experience from the inline skaters as observed from the experiment. This speed range could reflect an "expert" zone that in turn could correspond to LOS A. This is reasonable since "unskilled" inline skaters may not be able to maintain these higher speeds for long periods and on curved sections.

4.0 CONCLUSIONS

Unlike pedestrians and bicycles, inline skaters' traffic flow behaviour cannot be represented by a specific traffic flow model; instead the data fit very well against a two-regime model. This shows that inline skaters exhibit two very distinctive traffic flow characteristics: a **Congested Regime** (below 5 km/hr) and a **Free Flow Regime** (above 5 km/hr). The maximum capacity of inline skaters on a 5-meter wide path is about 6.3 skaters/s, which occurred at about 12 km/hr. The jammed density of inline skaters is observed to be 5.6 skaters/m^2, and the free flow speed is 6.9 m/s (or around 25 km/hr).

The comparison of the velocity-concentration and flow-concentration relationships of inline skaters with those for pedestrians and bicycles prove that congested flow regime of inline skaters acts similarly to pedestrian flow; whereas, the free flow regime is similar to bicycle flow.

However, in the congested regime, skaters can be more concentrated than pedestrians at a given velocity. In the free flow regime skaters have higher flow than cyclists.

Spaces occupied by inline skaters at different speeds are analyzed. The result shows that the space required by each inline skater increases as speed increases. The average lateral width of inline skaters for all the speed trials in the experiment is approximately 0.95 meters, which is found to be less than those from two previous studies with lateral widths of 1.8 and 2.0 meters respectively. LOS of inline skaters is also determined based on the comfort level criteria of the pedestrian and bicycle models.

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SkyTrain Kiss&Ride Traffic Operations Study
Vancouver, British Columbia

by Jo Fung, P.Eng.
and Floris van Weelderen, P.Eng.

Introduction

In November 1999, Rapid Transit Project 2000 Limited commissioned Bunt & Associates Engineering Ltd. to conduct a SkyTrain Kiss&Ride Traffic Operation Study for the proposed new Millenium Line SkyTrain stations, because there is no established methods for determining the number of Kiss&Ride parking spaces at SkyTrain stations. The purpose of this study was to develop a mathematical relationship between SkyTrain ridership and the number of Kiss&Ride spaces needed at a particular SkyTrain station.

This paper documents the methodology used to conduct the Kiss&Ride survey program at four selected existing SkyTrain stations, the findings of the survey, and the methodology used to estimate the number of Kiss&Ride spaces needed at SkyTrain stations.

Survey Methodology

The surveys were designed to measure two variables: the number of SkyTrain passengers that were boarding or alighting and the associated number of Kiss&Ride pick-ups or drop-offs. Surveyors were located in such a manner that they could count the inbound and outbound SkyTrain passengers at controlled accesses, i.e. escalators and elevators. Other surveyors counted the SkyTrain-related Kiss&Ride activities at existing Kiss&Ride facilities and any unofficial locations, i.e. Park&Ride lots.

Bunt & Associates collected the data on weekdays from 7:00 to 9:00 a.m. and from 4:00 to 6:00 p.m. at the following Skytrain Stations (see **Exhibit 1**).

- Surrey Central Station — Wednesday, October 20, 1999
- Edmonds Station — Thursday, October 21, 1999
- Royal Oak Station — Thursday, October 21, 1999
- King George Station — Tuesday, October 26, 1999

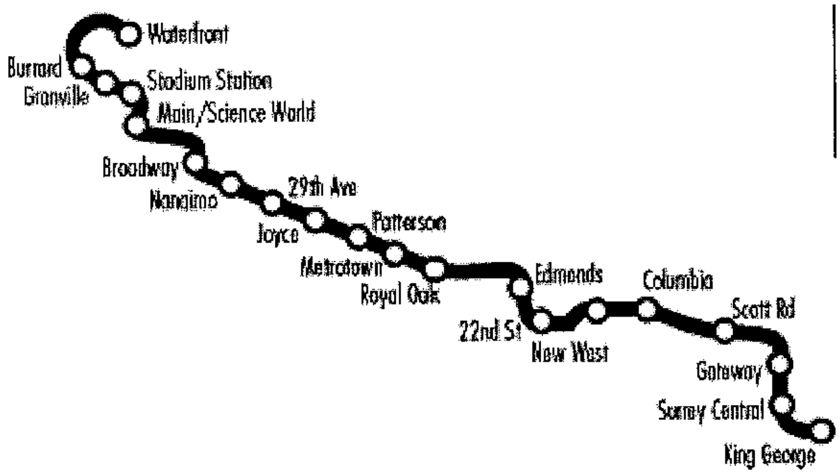

Exhibit 1: Existing SkyTrain Stations - Vancouver, BC, Canada

Survey Findings

As a part of the survey, the land uses surrounding each station were identified as well as the station's position within the existing SkyTrain network, the number of official and unofficial Kiss&Ride spaces, and the number of bus routes serving a particular station. The Royal Oak and Edmonds SkyTrain Stations are both located in the middle of the existing SkyTrain line and are adjacent to a mixture of residential and commercial land uses. Surrey Central Skytrain Station is adjacent to a regional bus exchange and community shopping/recreational centres. King George Station is located at the terminus of the SkyTrain route in Surrey.

The data collected during the survey was used to determine several mathematical relationships. These included the relationship between AM and PM peak hour SkyTrain ridership, how many SkyTrain passengers use the Kiss&Ride facilities, the average number of Kiss&Ride passengers per vehicles, and the number of vehicles that pick-up or drop off passengers at SkyTrain stations. **Table 1** summarizes the results of the SkyTrain Kiss&Ride survey. Due to the different characteristics exhibited by each station, use of a single system-wide factor to measure the relationship between Kiss&Ride spaces and SkyTrain ridership is not recommended. Instead, two sets of factors were developed for two types of stations – Small Community Stations and Town Centre Stations.

SkyTrain Kiss&Ride Traffic Operations Study (cont.)
Vancouver, British Columbia

Table 1: Kiss&Ride Survey Summary, October 1999

	Royal Oak Station		Edmonds Station		Surrey Central Station		King George Station		Average of Royal Oak and Edmonds		Average of all four Stations	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Boarding Passengers	497	383	945	469	957	498	1548	476	721	426	986.75	456.5
Alighting Passengers	583	326	516	866	407	1475	102	718	549.5	596	402	846.25
Total SkyTrain Ridership	1080	709	1461	1335	1364	1973	1650	1194	1270.5	1022	1388.75	1302.75
PM as % of AM Boarding Passengers		77%		50%		52%		31%		63%		52%
PM as % of AM Alighting Passengers		56%		168%		362%		704%		112%		323%
PM Peak Hour as % of AM Peak Hour		66%		91%		145%		72%		79%		94%
Drop-off Passengers	112	60	128	57	100	39	464	46	120	58.5	201	50.5
Pick-up Passengers	18	48	16	82	14	58	26	239	17	65	18.5	106.75
Total Kiss&Ride Passengers	130	108	144	139	114	97	490	285	137	123.5	219.5	157.25
Kiss&Ride Passengers as % of SkyTrain Riders	12%	15%	10%	10%	8%	5%	30%	24%	11%	12%	16%	12%
Drop-off Vehicles	108	46	119	52	93	31	445	41	113.5	49	191.25	42.5
Pick-up Vehicles	14	44	14	73	12	50	25	229	14	58.5	16.25	99
Total Kiss&Ride Vehicles	122	90	133	125	105	81	470	270	127.5	107.5	207.5	141.5
Pick-up Veh as % of Total Kiss&Ride Vehicles	11%	49%	11%	58%	11%	62%	5%	85%	11%	54%	10%	63%
PM as % of AM Peak Hour Pick-up Vehicles		43%		44%		33%		9%		43%		32%
PM as % of AM Peak Hour Drop-off Vehicles		314%		521%		417%		916%		418%		542%
PM as % of AM Peak Hour Total K&R Vehicles		74%		94%		77%		57%		84%		76%
Kiss&Ride Passenger Occupancy Rate*	1.07	1.20	1.08	1.11	1.09	1.20	1.04	1.06	1.07	1.16	1.07	1.14
Kiss&Ride Vehicles as % of SkyTrain Ridership	11%	13%	9%	9%	8%	4%	28%	23%	10%	11%	14%	12%
Official Kiss&Ride Spaces	5	5	22	22	6	6	48	48	13.5	13.5	20.25	20.25
Curbside Available Spaces	27	27	12	12	10	10	4	4	19.5	19.5	13.25	13.25
Total Available Spaces	32	32	34	34	16	16	52	52	33	33	33.5	33.5
Number of Bus Routes	2	2	5	5	21	21	8	8	3.5	3.5	9	9

*Does not include driver

Small Community Station

This type of station is located in the middle of the SkyTrain line and is adjacent to a mixture of residential and commercial/industrial land uses. Examples of small community stations are the Royal Oak and Edmonds Stations. As shown in Table 1, the PM Peak Hour SkyTrain ridership is between 66% to 91% of the AM Peak Hour SkyTrain ridership. The Kiss&Ride passenger occupancy rate varies between 1.07 to 1.08 passengers/vehicle (pass/veh) and 1.20 to 1.11 pass/veh during the AM and PM peak hours, respectively. Only about 11% of the vehicles coming to the Kiss&Ride are picking up passengers in the morning while between 49% to 58% of the vehicles are picking up passengers during the PM peak hour. The following factors are recommended for small community SkyTrain stations.

- PM Peak Hour Skytrain ridership is 85% of the AM Peak Hour Skytrain ridership.
- Kiss&Ride passengers comprises 10% of both the AM and PM peak hour SkyTrain ridership.
- The Kiss&Ride passenger occupancy rate is 1.05 pass/veh and 1.15 pass/veh in the AM and PM peak hours, respectively.
- The Pick-up Kiss&Ride vehicles comprise 15% and 50% of the total Kiss&Ride vehicles during the AM and PM peak hours, respectively.

Town Centre Station

On the other hand, a Town Centre Station is located in the middle of the SkyTrain line and is adjacent to a bus exchange and dense commercial land uses. An example of a Town Centre Station is Surrey Central. Table 1 shows that the PM Peak Hour SkyTrain ridership is 145% of the AM Peak Hour SkyTrain ridership. The Kiss&Ride passenger occupancy rate varies between 1.09 pass/veh and 1.20 pass/veh during the AM and PM peak hours, respectively. Only about 11% of the vehicles coming to the Kiss&Ride are picking up passengers in the morning while about 62% of the vehicles are picking up passengers during the PM peak hour. The following factors are recommended for town centre community SkyTrain stations.

- PM peak hour Skytrain ridership is 145% of the AM peak hour SkyTrain ridership.
- Kiss&Ride passengers comprise 10% and 5% of the AM and PM peak hour SkyTrain ridership, respectively.
- Kiss&Ride passenger occupancy rate is 1.05 pass/veh and 1.15 pass/veh in the AM and PM peak hours, respectively.
- The Pick-up Kiss&Ride vehicles comprise 15% and 65% of the total Kiss&Ride vehicles during the AM and PM peak hours, respectively.

Kiss&Ride Parking Spaces Calculations

The number of pick-up Kiss&Ride spaces required at a station during the AM peak hour was estimated as follows.

Formula	Units
1. K&R pass = SkyTrain ridership x %K&R pass	(pass)
2. K&R veh = K&R pass x K&R occupancy	(veh)
3. P/U veh = K&R veh x %P/U veh	(veh)
4. Total P/U veh-time = P/U veh x P/U time	(veh) x (time)
5. 90% Poisson Distribution P/U veh-time = Total veh-time x 1.5	(veh) x (time)
6. No. of K&R spaces = 90% Poisson Distr. P/U veh-time x 1 space/veh-time	(spaces)

This procedure is repeated for the pick-up activity during the PM peak hour as well as drop-off activity for both the AM and PM peak hour. The total number of Kiss&Ride spaces that should be provided is equal to the sum of the maximum number of pick-up and drop-off spaces that are required since the pick-up and drop-off Kiss&Ride zones should be separated. If there is not enough space available to separate the two activities, the maximum number of spaces that should be provided is equal to the peak Kiss&Ride (P/U and D/O) demand at any one time, i.e. AM or PM peak hour, whichever is greater.

Kiss&Ride drop off locations should be located as close as possible to the SkyTrain station entrance while the pick-up locations can be located further away, but no further than one street crossing. Kiss&Ride facilities should also be convenient for motorists. If the Kiss&Ride is inconvenient to use, i.e. out of the way, SkyTrain passengers will be dropped off or picked up at locations that are more convenient to the motorist.

The average drop-off time is assumed to be 1.0 minute per vehicle while the average pick-up time is 6.0 minutes per vehicle. The average drop-off time is less than the 2.0 minutes measured at the King George SkyTrain Station. This assumption accounts for the congestion occurring at the King George Kiss&Ride facility, which is not expected to occur at the Burnaby stations.[1] The 90% Poisson Distribution design factor accounts for the surges in the number of vehicles within the peak hour.

[1] *King George SkyTrain Station Kiss & Ride Traffic Operations Study* (Creative Transportation Solutions, September 19, 1999), p.11.

Table 2 shows how the number of vehicles dropping off or picking up passengers was estimated for the Royal Oak, Edmonds and Surrey Central stations. These results are consistent with the observations made by Bunt & Associates staff at the various Kiss&Ride facilities. Table 2 also summarizes the proposed Kiss&Ride spaces for Small Community and Town Centre Stations. Note that for the examples in Table 2, the observed PM ridership was used rather than an estimate based on the AM Peak Hour Skytrain ridership.

Recommendations

Based on the above findings, the following recommendations are made.

1. For Small Community Stations, use the following factors.
   - PM Peak Hour SkyTrain ridership is 85% of the AM Peak Hour SkyTrain ridership.
   - Kiss&Ride passengers comprises 10% of both the AM and PM peak hour SkyTrain ridership.
   - The Kiss&Ride passenger occupancy rate is 1.05 pass/veh and 1.15 pass/veh in the AM and PM peak hours, respectively.
   - The Pick-up Kiss&Ride vehicles comprise 15% and 50% of the total Kiss&Ride vehicles during the AM and PM peak hours, respectively.
2. For Town Centre Stations, use the following factors.
   - PM Peak Hour SkyTrain ridership is 145% of the AM Peak Hour SkyTrain ridership.
   - Kiss&Ride passengers comprise 10% and 5% of the AM and PM peak hour SkyTrain ridership, respectively.
   - Kiss&Ride passenger occupancy rate is 1.05 pass/veh and 1.15 pass/veh in the AM and PM peak hours, respectively.
   - The Pick-up Kiss&Ride vehicles comprise 15% and 65% of the total Kiss&Ride vehicles during the AM and PM peak hours, respectively.
3. The number of Kiss&Ride spaces needed at each SkyTrain station assumes that the average drop-off site time is 1.0 minute per vehicle while the average pick-up time is 6.0 minutes per vehicle. Furthermore, a 90% Poisson Distribution design factor of 1.5 should be applied.
4. When estimating the number of spaces, consideration should be given to the direction of predominant motorist travel in order to determine where pick-up and drop-off zones should be located, separately or together.

A-2-3/7

Table 2: SkyTrain Kiss&Ride Space Calculation Examples

	Small Community Stations				Town Centre Station	
	Royal Oak Station		Edmonds Station		Surrey Central Station	
	AM	PM	AM	PM	AM	PM
Boarding Passengers	497	383	945	469	957	498
Alighting Passengers	583	326	516	866	407	1475
SkyTrain Ridership	1080	709	1461	1335	1364	1973
PM Peak Hour as % of AM Peak Hour		<85%>		<85%>		<145%>
Kiss&Ride Passengers as % of SkyTrain Riders	10%	10%	10%	10%	10%	5%
Total Kiss&Ride Passengers	108	71	146	134	136	99
Kiss&Ride Passenger Occupancy Rate	1.05	1.15	1.05	1.15	1.05	1.15
Total Kiss&Ride Vehicles	103	62	139	116	130	86
Pick-up Vehicles as % of Kiss&Ride Vehicles	15%	50%	15%	50%	15%	65%
Pick-up Vehicles	15.4	30.8	20.9	58.0	19.5	55.8
Drop-off Vehicles	87.4	30.8	118.3	58.0	110.4	30.0
Pick-up Time	6.0	6.0	6.0	6.0	6.0	6.0
Pick-up Spaces *	2.3	4.6	3.1	8.7	2.9	8.4
Drop-off Time	1.0	1.0	1.0	1.0	1.0	1.0
Drop-off Spaces *	2.2	0.8	3.0	1.5	2.8	0.8
Estimated Kiss&Ride Spaces	**5**	**6**	**7**	**11**	**6**	**10**

* Includes 90% Poisson Distribution (1.5 factor)

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TRANSPORTATION DEMAND MANAGEMENT (TDM): STATE OF THE DEBATE

ABSTRACT

While most of the general public is not unhappy with the increased mobility afforded by private vehicles, and the current 'sprawl' pattern of development that seems to have accompanied it in most North American metropolitan areas – the infrastructure required to support it is increasingly no longer affordable. Many governments are choosing transportation demand management (TDM) policy strategies to manage growth - raising parking rates, charging tolls, and/or diverting scarce resources from road building to transit/alternative transportation improvements. This paper provides an assessment of Transportation Demand Management (TDM) policy in North American cities. Success is difficult to quantify and sustain on other than a site-focussed basis, due to a phenomenon labelled 'congestion homeostasis', whereby TDM gains seem to disappear relatively quickly. As such, researchers are split on the costs/benefits of TDM, due mainly to imprecision in modeling and monitoring programs. While the majority of discussion argues in support of TDM, the complexity and inter-related spatial-temporal factors renders a definitive, mathematical proof of TDM economic efficiency very difficult to prove on other than a simplistic basis. Based on current trends and NA practise, TDM appears to be losing the battle versus auto-dependence (ineffective?). Despite recent signs of life, transit mode splits for the most part are failing, and auto ownership/use trends are soaring. These suggest that personal exposure via auto-use is still worth the benefit. Folks drive due to lack of reasonable alternatives, improper pricing, wrong 'signals' – marginal cost, travel time, convenience; short term gain versus long-term pain. Will TDM ever work – yes under certain conditions. TDM is a worthwhile strategy given – political support, land-use density, convenient transit, and road/parking pricing. The effectiveness/economics of TDM - suggestions for further research - focus on the need for improved forecasts of TDM effectiveness via behavioural, activity-based (BAB) models. A conceptual BAB model is suggested based on current research in Canada, Japan, Holland, and the US. Expected model results are explored using exposure-reduction / life-cycle-cost comparisons of various TDM strategies.

© Gord Lovegrove, P.Eng., MBA, M.Eng.
Director of Transportation Planning
The University of British Columbia

INTRODUCTION

While most of the general public is not unhappy with the increased mobility afforded by private vehicles, and the current 'sprawl' pattern of development that seems to have accompanied it in most North American metropolitan areas – the infrastructure required to support it is increasingly no longer affordable. Land is being consumed in the US (statistics in Canada are similar) at triple the rate of household formation; automobile use is growing twice as fast as the population growth rate; and prime agricultural land, forests, and fragile lands encompassing natural habitats are decreasing at comparable reciprocal rates. As sprawl increases, transit system viability (i.e. cost recovery) is put at risk and auto-dependence (i.e. energy consumption) increases. The auto is fast, convenient, flexible, and comfortable relative to – transit, car/vanpooling, biking, walking, tele-commuting – hence, the auto mode is dominant, despite the costs - congestion delays, stress, road rage, high fixed/variable costs, pollution, collisions [1]. The situation is essentially a 'paradox of the commons', in which the interest of society is antithetical to that of many of its individual members.

Policy makers are pursuing a mix of supply and demand policies as growth management strategies. Many governments are choosing transportation demand management (TDM) policy solutions - raising parking rates, charging tolls, and/or diverting scarce resources from road building to transit/alternative transportation improvements2. The primary economic argument in support of TDM is the need to correct a market distortion3. The distortion has occurred because consumers are not taking into account the 'full' costs of their trips (e.g. economic impacts due to congestion delays/crop damage, health impacts due to air pollution/noise, safety impacts due to collisions/loss of life, etc.). Classic economic theory states that under-pricing results in over-consumption of a good, and a less than socially optimal market solution (i.e. social welfare is less than optimal). While critics agree there is a need to correct for these externalities[4], they suggest that TDM may not be the most efficient policy decision, especially given the lack of accurate, behavioural forecasting / analytical models. Road pricing has long been the favoured alternative of economists[5], but to date not enjoyed wide use.

LITERATURE REVIEW

TDM strategies typically include some combination of 'carrots' (incentives), 'sticks' (disincentives), land use planning, traffic management associations, and marketing programs. Research to date suggests that economic-based incentives are the most important and effective device at 'triggering' behavioural changes. In view of this finding, an assessment of TDM policy would entail an economics-based review methodology. There are several methods of policy assessment – Social Cost Benefit Analysis (SCBA), Cost Effectiveness (CE), and Multiple Account Evaluation (MAE) – that allow one to critique a policy decision in consistent, monetary and/or non-

[1] Literature from around the world shows overwhelming preference for vehicle use. In N.A. it appears that 90% plus (based on auto mode split) would like to drive; in Europe it is likely the same in terms of preferences, but high costs, denser development, and better transit have likely precluded this 'latent' demand.

[2] As the field of TDM researchers span across many disciplines and countries, the use of terms other than TDM needs to be acknowledged – sustainable transportation, road demand management, auto-dependence, transport control measures, co-ordinated urban transport strategy, ecological footprint, New Urbanism. There are slightly different perspectives behind these terms, perhaps reflecting locales and research disciplines in which they were coined. For example, the term 'auto-dependence' is commonly used by Australian researchers, and uses energy consumption / environmental focus to promote increased efficiency. Co-ordinated urban transport strategy is the term commonly used in Germany, to indicate a comprehensive program with many inter-related supporting policies.

[3] In a competitive market with no distortions, the price paid for inputs measures the lost value of output somewhere else in the economy (given distribution of income, tastes, no market distortions elsewhere, etc.)

[4] Verhoef (1994) notes that it is generally accepted that the source of externalities is typically to be found in the absence of property rights.

[5] Externalities create a split between marginal private cost (MPC) and marginal social cost (MSC), resulting in over-consumption. One of the earliest suggestions to improve traffic efficiency, road pricing, was proposed by Pigou in 1920, to improve the efficiency with which road space is allocated – Pigouvian taxes. While road users as a group would lose, society as a whole gains in social welfare (Button, 1994; Verhoef et al, 1995).

monetary economic terms.[6] Where quantification is possible, SCBA of costs/benefits is considered the best 'test for government'. Changes to transportation system policy directly impact standard of living on a personal level – social inter-actions, economic opportunities, and quality of life – and, aggregated across society, those changes also impact social welfare. The objective of policy assessments regarding the governance of transportation systems[7] is to assess whether or not the policy decision under review will result in an optimal (net) social benefit, relative to some alternative(s). If social welfare is optimized by the decision, it in effect promotes 'economic efficiency'. Typically, assessments rely on several assumptions regarding market mechanisms, including distributional effects[8], valuation methods[9], and consumer sovereignty[10].

The literature review found much controversy and speculation as to the definition, effectiveness and role of TDM, and the validity of TDM advocate claims. The boundaries of TDM seem to have expanded in the last decade – for example, in the 1980's and early 1990's TDM was one tool in a great congestion management toolbox. Now, TDM appears to be ***the*** toolbox within which most everything else fits, including ITS and road pricing. The scope of TDM has increased as new ideas and technologies develop. The most comprehensive lists of TDM strategies found are from Australia (Luk et al, 1998) and Canada (Litman, 1999; 2000), with over 40 measures specified.

TDM Critical success factors noted include:

- integrated land use (density/jobs-services-housing mix)/transportation planning[11],
- parking charges and other financial incentives and disincentives that make SOV-alternatives less expensive and more convenient than driving alone;

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[6] Whereas SCBA provides a monetary estimate of benefits versus costs, CE and MAE do not. Without a 'bottom line', however, it is difficult to assess the merit of the policy choices, that is, whether it (or any of its alternatives) should be adopted. In the absence of quantification, cost effectiveness is often used (Chan, 1997, page 734, (147)).

[7] There are other methods and objectives of policy assessments (e.g. profit maximization), depending on whether the decision under review is dealing with public policy or private matters. Typically TDM is implemented area-wide by government agencies (e.g. regional transit system). Even if a TDM program is part of a corporate site-focused program, the literature typically portrays it as providing benefits beyond the corporation (e.g. air quality, traffic congestion), and not a 'for-profit' program. This evaluation of TDM will include consideration of gains and losses beyond just those included in private 'for-profit' decisions – benefits and costs external to the corporation and/or users directly involved - SCBA.

[8] Maximizing net benefits as the objective ignores distributional effects; the winners could compensate the losers and still be better off than if the project had never happened. This reflects the Hicks Kaldor decision criterion – benefits exceed costs, winners could compensate losers – which is commonly used in view of its democratic or 'majority rule' underlying principle. Other decision rules are used, such as the Pareto criterion – some win, with no losers – or, Unanimity – all must win, no losers. Both of the latter provide veto power to anyone who loses, and doesn't reflect current political practise.

[9] The distribution of income, consumer tastes (preferences), technology, resource endowments and their ownership, information, competitive market are all a given. This assumption permits aggregation of consumer preferences into a market demand curve, and, the aggregation of producer costs into a market supply curve. It also permits use of the demand curve as a measure of social value (17).

[10] Consumer sovereignty is maintained; there is no provision for imposed or dictatorial objectives which are contrary to those that are collectively demanded. In terms of TDM, government is intervening to correct market distortions; consumers are still given the choice of how, when, where to travel, but costs/supply have been adjusted to reflect 'true' or 'full' costs of production and/or remediation of impacts. Also, there is a need to recognize that, despite convention, money is not always an effective proxy for the 'collective will' of the people/market. For example, who speaks for future generations which would like to have access to/enjoyment of activities (e.g. parks, wildlife) which may be destroyed by current generations?

[11] Kenworthy and Laube (1999) have done extensive research of the interaction between land use, parking, and travel demand/patterns across 46 major global metropolitan areas. They have correlated interactions between various land use – transportation descriptors using linear, power, logarithmic, and exponential equations. Of 168 correlations between 21 transportation and energy variables and 8 key urban form variables, only 13 (less than 8%) are not significant at the 95% confidence interval. They suggest that land use (and in particular density) is a critical factor affecting travel patterns. Some specific conclusions drawn are as follows (11):

- As urban density increases - auto-dependance, parking provision, and congestion decrease, with a corresponding increase in transit use and traffic safety.
- Parking strategies will only be successful if used in concert with other strategies
- While density is the key indicator for vehicular transport, mixed use land-use is the key indicator for non-motorized transport (NMT); neighbourhoods with corner stores within 100 metres of home promote NMT (see also 36)
- The well developed rail transit systems in European and wealthy Asian cities allows transit speeds to *exceed* that of the car.
- There are key differences between Canada and the US in per capita car use and energy use (Canadians use less), and in urban densit and transit use (much higher in Canada).
- Constant travel time budgets, transportation infrastructure, and urban form are key descriptors in the level of access (mobility) of a city.
- Average home-work trip distance is related to density – 8 kilometres in Asia, 10 in Europe, 11 in Canada, 13 in Australia, and 15 in the US, and, is increasing worldwide

- integration of individual TDM measures into a 'system' complete with supporting policy context and implementation plan that make SOV-alternatives as or more convenient than driving alone[12]; and,
- psychological incentives through marketing and stakeholder consultation and buy-in – sites, sponsors, users – on the problem, and the solution.
- Short term – carpool/transit [reasonable alternative], toll / parking charges [road pricing, economic incentives], monitor/control closely [site specific]
- Long term – land use [i.e. dense, mixed (service, residential, jobs), calmed], political will [community support], monitoring [needs, success, adaptation]

The **barriers**, both within and between each level of society[13], are related to that of unclear and competing (versus integrated) objectives (e.g. a focus on enhancing mobility and safety may ignore the environment), and insufficient feedback mechanisms (e.g. consequences of decisions). The feedback necessary is faced with time and spatial constraints – improved mobility reaps immediate rewards (less travel time and/or cost for the participant); improved safety reaps longer term rewards AND potential immediate penalties (less claims and/or complaints for the sponsors, but participants may have increased travel time if speed reduced); protected environment reaps only long term rewards and is not perceived by present society. In other words, "safe mobility is immediately rewarded and environmental disregard is not immediately punished". Research by several psychologists suggest that there is a great deal of awareness and a 'latent' guilt or desire to do more to help solve the problem, so much so that some aggressive TDM marketing programs have inadvertently created PR 'backlashes' as this latent guilt turns into frustration and anger.

- Expectations: Accurate / realistic monitoring / forecasts to confirm 'success'
- Politics: External costs are not communicated temporally, or spatially, or personally
- Temporal: Safe mobility is immediately rewarded and environmental disregard is not immediately punished
- Spatial: Tragedy of the commons; low density, sprawling land use

Wootton (1998, Pucher (1998), May et al (2000) have done a review of TDM efforts / results in the UK and Germany, respectively in relation to other EC members and the US. Past auto trip reduction policies in the UK focused just on improved auto-alternatives have been ineffective, despite public support for TDM. New objectives in Britain are focused on using road pricing/fuel taxes, safety programs, and integrated land use/transportation planning.[14] Pucher (1998), and May et al (2000) hold out Germany as a vision that North American TDM policies could achieve. In many respects – geography (topography, weather), auto ownership and use, socio-economics – Germany is similar to the US and Canada. Despite some of the highest personal income, car ownership and VKT rates in the world, Germany has been able to stabilise the auto mode split, while increasing transit/bicycle use (30 - 40% of all travel in Europe is by walking and bicycling, 15 – 25% by transit). Case studies of several urban areas conclude that overall mobility levels can be maintained, while limiting car use in central areas and residential neighbourhoods. Similar to Britain, the focus on German TDM programs has not been to try to restrict the already high auto ownership rates. Instead, their aim has been to restrict car use in those areas where it does the most damage, namely in downtown cores, while improving auto-alternatives. The prevailing differences from

[12] This policy context includes legislative mandates at the regional TDM level (e.g. Growth Management Strategy in BC), transportation management associations (i.e. employer/community groups) at the corridor level (e.g. Cambie Corridor Consortium in the GVRD), and, senior corporate 'champion' and dictum at the site level (e.g. UBC Strategic Transportation Plan).(26)

[13] These conflicts occur at several levels in society's use of the transportation system: participants (drivers, passengers, bicyclists, pedestrians, non-travellers), sponsors (government, developers, funding agencies), managers (planning, design, operation, marketing professionals). The decisions made at each level all suffer from lack of full information, and as a result rational decision making is not possible and significant decision biases result. (Brown, 1992)

[14] Research on car ownership shows it is closely related to their cost relative to income, and rate of growth is related to growth in the economy. Saturation is forecast at 400 to 600 cars per 1,000 people. Trip making is also closely related to car ownership – when the first car is bought, trips will double, with roughly half formerly made by transit transferred to the car; bike/walking trips will also decline slightly.

North America relate to land use and rail transit policies - average trip distance (i.e. much shorter in Germany), railway mode split (i.e. much higher inter-city use in Germany), and urban land use control (e.g. higher density, use of central car-free zones in German cities). Despite successes to date, the heavy investments in rail transit has put the German government under an acknowledged heavy financial debt burden, putting the sustainability of its TDM program in doubt unless road pricing/tolls are employed. This underlies the concern with promoting transit as the cornerstone of an effective TDM program –the cost per passenger-kilometre to expand and run an effective system, especially in low-density North American markets. This may be possible in the long term in North American cities if major land use changes (i.e. increased density, jobs-home mix, support services) are implemented.

Researchers have observed that statistically deaths are correlated with auto dependence[15] and traffic exposure[16]. Cities utilising TDM policies - high transit (e.g. Tokyo, Hong Kong) and bicycle use (e.g. Amsterdam) - have lower fatality rates than expected[17]. Improving traffic safety and its inter-relationship with TDM is important because the economic and social costs due to pain, grief, loss of property, injury, and deaths is one of if not the major costs associated with increasing mobility (Sayed, 1995).

Navin (1999) and others have found a fundamental relationship that links traffic safety risks (i.e. exposure) with land use and transportation planning, of the general form:

Risk = Exposure x Probability (Event) x Consequence of an Event

Economic assessments - There are still many questions regarding TDM, whether it is 'successful', whether / how much it increases social welfare, and many different foci, due to the relatively 'young' field

- TDM programs focused on a specific site can be monitored and appear successful in the short term, but success may wain over time
- TDM programs focused on corridors / regions have had mixed results world-wide (e.g. Europe versus North America), generally few successes in North America
- Supply (e.g. more roads) / Demand (e.g. TDM) side solutions don't matter, as induced traffic / latent demand will restore congestion levels to the way they were before the 'improvement', sort of like 'risk homeostasis' – how do we change public level of congestion tolerance?
- North Americans (esp. US) are set in their ways (i.e. auto dependent, suburbanites, large lots), and will not change, so whatever is planned should NOT reduce service levels to the auto; just improve the alternatives so long as they don't interfere with the auto drivers
- Auto versus transit travel time – light rail 'wins' if and only if it provides a direct route, integrated at origin and destination, but high costs require high density
- Newman & Kenworthy (1999) provide comprehensive data on land use, auto dependence, expenditures, energy use, and sustainability from 38 global cities.

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[15] Newman & Kenworthy (1999) define auto-dependence in several economic, social, and environmental ways. In general, an auto-dependent city is one in which "use of an automobile is not so much a choice but a necessity." Key indicators include: low density (< 10 to 20 people per hectare), separated land uses, arterial grid and cul-de-sac based, decentralised via suburbs, and relatively low transit provision and mode split.

[16] Navin & DeLeur (1999) define traffic exposure as "a measure to quantify the "exposure" of road users to potential hazards"

[17] In North America and Europe gains have been made in the biking / walking mode split, but it is doubtful that walking/biking will ever achieve more than a 5 or 10% mode split due to various barriers, including increasing trip distance (current average bicycle trip distance in the US is 2 miles), and greying population trends. 40% of all trips in the US are less than 2 miles (57). Average trip distance may be the key reason mode splits are higher in Europe, where trip lengths average less than 1.3 miles. Research by Shafizadeh and Niemeier, 1997, suggests that separate bike paths will encourage longer bike trips, which may be a long term strategy to overcome this barriers. In certain locales across the US, Canada, and Europe, bike mode split is 25% or more (e.g. Davis, UBC, Netherlands, Germany). The relatively low cost to support these modes together with the potential to realize benefits (including to other road users) of removing up to 25% of road users out of vehicles,

Composition of Travel Costs – Internal & External

	Verhoef (1997)		Litman (1999)		Province of BC (1993)	
	Estimate	Ratios	Estimate	Ratios	Estimate	Ratios
Noise	0.2	0.2/0.2 = 1	0.8	1	515	5
Air	0.4	2	4.8	6		
Collisions	1.5	7	3.5	4	397	4
Congestion	2.0	2.0/0.2 = 10	4.2	5	97	1

Activity-Based Models

The ability to forecast rates of exposure and, hence, the economic benefits of TDM, however, have been hampered by lack of suitable TDM modelling capability. The essence of TDM is to change consumer / traveller behaviour; therefore, forecasts of the impact of various TDM policies must be built on the time-space demand for travel, which is primarily a demand derived from the desire for social and/or economic interactions[18]. In view of this need, and with improved technology and computers, there is a movement from trip-based to activity-based travel forecasting models. They define trips (by individuals versus conventionally aggregated by the four-step trip-based model) as linked elements within a *tour*, and take into account the demand for activity participation, inter-relationships among trips, and interactions among household members. Early validation results look promising regarding activity and destination choice, but an assignment has yet to be done.

Researchers commonly refer to the space-time tour concept used in activity-based models as the Hagerstrand prism, viewing travel as a need derived from the need to pursue activities distributed over time and space. The equation defining the area reachable over the course of a day (i.e. Potential Action Space or Reach) given by Dijst and Vidakovic (2000) is:

$$\{4 (x - \tfrac{1}{2} L)^2 / [(t_r (T - L/V) + L/V) v]^2\} + \{y^2 / [[t_r (T - L/V) + L/v) V]^2 - (\tfrac{1}{2} L)^2]\} \leq 1$$

where:
T = available time interval — V = travel speed
L = distance between bases (i.e. home, work, relatives, friends)
t_r = travel time ratio — x, y, v = co-ordinates of points on or within the elipse

A related concept is the travel time ratio, which may allow one to calibrate the model. It is observed that for certain activity types (e.g. mandatory, optional), the time spent travelling is a fixed proportion of the time spent on the activity. This relationship holds across similar activity types, and may provide the key to optimize the spatial planning of communities. This travel time ratio relationship will allow a more integrated approach to planning, influencing, and/or forecasting the distribution and mix of different activity places, and more efficient use of facilities. Dijst and Vidakovic (2000) define it in the following equation:

$$t_r = T_t / (T_t + T_s)$$

where:
t_r = travel time ratio = 0.4 – 0.5 mandatory, 0.2 – 0.3 for discretionary
T_s = stay time — T_t = travel time

is why extensive efforts and research are underway world-wide to at least maintain current bike/walk/tele-commute mode splits (if not increase them).

[18] One could argue that every desired interaction has at least an implicit value that could be monetarized, and, therefore, all desired travel has some form of value.

Emphasis has shifted from evaluating long-term investment-based capital improvement strategies to understanding travel behaviour responses to shorter-term congestion management policies (e.g. flex-work weeks, tele-commuting, congestion pricing) (Bhat and Koppelman, 1999). For example, a new highway when opened (i.e. t = 0) may have low congestion and reduce congestion on adjacent facilities, but within months (t = 4 months) is just as congested as before. While some may be attributed to background growth, the phenomena of **congestion homeostasis** may be at work.

The ability to conduct social cost-benefit analysis (SCBA) – including all costs and benefits, internal AND external, and their distribution – must be improved and strengthened; current models are both inaccurate and incomplete. For example, peak period road pricing and/or HOV lane improvements would have little impact in corridors where commuters make many stops during the commute (i.e. the use of linked trips is increasing), and not even use the main corridor. A behavioural (i.e. activity-based) model would pick this up, whereas a conventional (i.e. trip-based model) would over-predict the mode shift to HOV lane use.

Simply put, we need better modelling of TDM so we can improve our prediction accuracy (confidence level?), and decision making ability. Improved predictions will allow us to more realistically predict the return on our TDM program investments – SOV reduction, collision reduction, congestion delays reduction. Better prediction tools will allow us to better predict costs and benefits, for TDM program analysis BEFORE deciding on how, and whether or not to implement it. Some elements will be more successful than others, depending on the subject market (geography, socio-economics, demographics, etc.)

A conceptual model is suggested based on current research in Canada, Japan, Holland, and the US. Activity-based models begin with the individual, and construct his or her 'tour' of activities over the course of an 'average' 24 hour day. The need and desire to participate in activities (socio-economic interactions) is a basic human need. The resulting travel, as such, is a derived demand, derived from the need to pursue these activities distributed in time and space. The person goes out on tours, participating in various activities each day. Decisions regarding activities, travel modes, and route choices are made based on random utility theory[19], and depend on travel time (cost) to get there, how long (cost) the activity takes, how much time is left in the day, etc. There are mandatory / life sustaining (e.g. work), and optional / discretionary (e.g. eat-out) activities. An 'average' day is calibrated and forecast using previously collected travel diary information (see Lawton and Pas, 1996). An individual's activity-travel patterns are assumed to vary randomly from day to day, with certain probability. Aggregation of many individual tours provides forecast trip demand on individual routes. Each of the core elements is described below.

The daily activity-travel pattern of an individual, i, is composed of a series of activities and trips, as follows:

$$[\mathbf{X_i, T_i, L_i, M_i, W_i}] = [X_{io}, X_{i1}, \ldots, X_{in}; T_{io}, T_{i1}, \ldots, T_{in}; L_{io}, L_{i1}, \ldots, L_{in}; M_{io}, M_{i1}, \ldots, M_{in}, W_{io}, W_{i1}, \ldots, W_{in}]$$

Where

X_{ij} = the **type** of the j-th activity (or a bundle of activities) pursued by individual i (excluding travel),
T_{ij} = the **duration** of the j-th activity pursued by individual i
L_{ij} = the **location** of the j-th activity pursued by individual i,
M_{ij} = the **mode of travel** used to reach the of the j-th activity,
W_{ij} = the **route choice** to get to the j-th activity pursued by individual i, and
n = the **number of activities** involved in individual i's daily activity-travel pattern

[19] Ben-Akiva and Bierlaire (1999) note that models based strictly on travellers choosing according to micro-economic or utility theory have serious practical limitations. The complexity of human behavior, together with the near impossible task of having complete information with which to make a decision, strongly supports an argument for introducing uncertainty and probability into the decision process. Hence the multinomial logit probability models, etc., used in activity-based modelling.

Aggregated Model Outputs

Time	**Link Volumes (AADT, v/c) (LoS, delays)**			**Mode Use (X-reference by link)**			**Activity Location (duration, trip length)**				**Exposure (veh-km-ca)**	**Comp Var ($)**
	l1	l2	...	SOV	HOV	Bus	A1	A2	A3	...		
00 - 01												
01 - 02												
. . .												
23 - 24												
Totals:											Σ Veh-km-ca	Σ all trips

Once the model has produced a forecast of tours, we can then assess the exposure in terms of vehicle-kilometres per capita. This gives another method of evaluating model output in terms of risk assessment of both travel costs and traffic safety (i.e. integrated). It utilises vehicle kilometres, mode splits, time of days, etc. from outputs and translates into a range of social costs – at an expected confidence level. The road safety planning model (Navin et al, 1999) in its simplest form is shown as:

Safety Risk = Exposure (E) x P (event) x Consequences (C)

We add to and expand this equation to recognise the inter-relationship between exposure and land use, as follows:

Expected Cost (Risk) of Travel = [E] x [P] x [C]

where:

[E] = Matrix of outputs (i.e. exposure performance measures) from the activity model = vehicle-kilometres/ca/day, aggregated across the day, and across all modes / all users / all tours

[P] = Vector of probabilities of expected impacts from exposure:

- **Socio-economic:**
  - health (respiratory, stress, mortality),
  - safety (collisions, fatalities, injuries, property damage),
  - economic (cost of living, infrastructure, GRP, competitiveness),
  - social (satisfaction, quality of life, equity, political)
- **Spatial:**
  - environment (air, noise, water, wildlife),
  - mobility (accessibility, barriers)
- **Temporal:**
  - sustainability (program durability, losses to future generations)
- **others** identified in specific case model development

[C] = Vector of costs (consequences) corresponding to each impact

A search was made for working activity-based models, on which to base projections for the above activity model. An early model by Bowman at MIT was not available for loan. Documentation on the two most prominent activity models – Prism-Constrained Activity-Travel Simulator (Kitamura and Fujii, 1998), and the Comprehensive Activity-Travel Generation for Workers (CATGW, Bhat and Singh, 1999) – suggest promising but very preliminary validation results. Documentation detailing analyses, route assignments, and future TDM forecasts has not been found, although there are said to be working Dutch activity-based models.

In the absence of quantifiable social cost-benefit analysis data and precision TDM forecasting tools, expected model results are explored via cost effectiveness, and expected impact on performance measures (i.e. exposure reduction). A cost effectiveness review has been conducted, modified from Navin et al (1998), assuming the following TDM / exposure reduction strategies:

Socio-Economic:

RP, Road Pricing (tolls, variable insurance, gas tax, property tax)
P, Parking (supply, price, preferential, location, enforcement)

Spatial:

NMT (walk / bike – lighting, pathways, inter-modal, end-of-trip facilities)
HOV (carpools, vanpools, ridematching)
T, Transit (bus, para-transit)
RT, Rapid Transit (light rail, heavy rail)
LU, Land Use (parking supply, politics, regulations, density, mix)
ITS (tolls, traffic management, smart cards, vehicles)
ME, Marketing / Education (drivers, bicycles, children)
WA, Working Arrangements (flex-hours, tele-commuting/study)

Temporal:

INT, 'Integrated TDM' (e.g. U-Pass, land use, transit, parking)

An 'exposure-reduction' / 'life cycle cost' grid was created. The effectiveness evaluation criteria incorporate previously noted TDM 'barrier' and 'success' factors found in the literature review. Life-cycle costs have been derived using standard engineering economics / net present value methods, based on actual or estimated costs from several sources. Conclusions from the analysis:

- Strategies focused on Land Use and Integration would be most cost effective
- Flexible work arrangements have the greatest exposure-reduction potential, subject to lowering of implementation costs
- Non-motorized travel modes are surprisingly cost effective, but need further research to confirm, and to encourage their acceptance / popularity as bona fide travel modes
- Road pricing, parking charges, and other economic 'sticks' are low cost and theoretically effective, but lack support unless part of an integrated package
- ITS is expensive, but could be used in a supportive role to enhance TDM strategy
- The most cost effective strategies – integrated TDM, Land Use, NMT,

Further research is needed in the following areas:

- Value of Travel Time Savings
  - variance over time of day, size of savings
  - travel time / activity duration ratios
- Congestion Homeostasis
  - does it exist and can it be predicted
- Exposure Reduction
  - integrated modelling approach, quantifiable relationship
- Activity-based working model
  - development, calibration, forecasts

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ICBC Road Sense

AN ANALYTICAL FRAMEWORK FOR SAFER TRANSPORTATION NETWORK PLANNING

KELVIN ROBERTS: MANAGER, SAFETY CONSCIOUS PLANNING
INSURANCE CORPORATION OF BRITISH COLUMBIA

ABSTRACT

ICBC is implementing a Safety Conscious Planning (SCP) program to facilitate that road safety is treated as an explicit priority in land use and transportation planning projects, with a view to establishing inherently safe transportation systems. As the science of SCP is in the early stages of evolution, it was necessary to develop an analytical framework as a basis for undertaking the initial SCP work. This framework is essentially a comprehensive checklist of planning parameters that can be considered to promote inherent safety, at all levels of planning and stages of the planning process. Although "best practices" are being compiled, there is still a significant amount of research and development required before truly informed decisions can be made. ICBC has established a solid foundation for SCP practice and will be approaching other agencies to partner in taking these practices to the next level of sophistication.

INTRODUCTION

- There is increasing consideration being given to how road safety can proactively be incorporated into the urban land use and transportation planning process, with a view to preventing "unsafe" situations from arising in the first place.

- The Insurance Corporation of British Columbia (ICBC) initiated its Safety Conscious Planning (SCP) program in 1997, with the objective of ***making safety an explicit priority in urban planning processes.***

- As the science of "safer planning" is still in the early stages of evolution, there were no "off-the-shelf" processes, techniques or tools that could be applied. One of the first activities of the program was thus to develop an analytical framework for guiding the initial SCP work. This framework reflected available research findings and fundamental road safety and planning principles.

- It is emphasized that, although the science of safety planning is largely undeveloped, there is some basic working knowledge which can be exploited to begin impacting day-to-day planning decisions.

- ICBC subsequently entered into a partnership with SWOV (the Dutch Road Safety Institute) to develop processes and tools for SCP (or "Sustainable Safety", as it is known in The Netherlands). The analytical framework has evolved to a point that it is now being applied in a wide range of planning applications in BC.

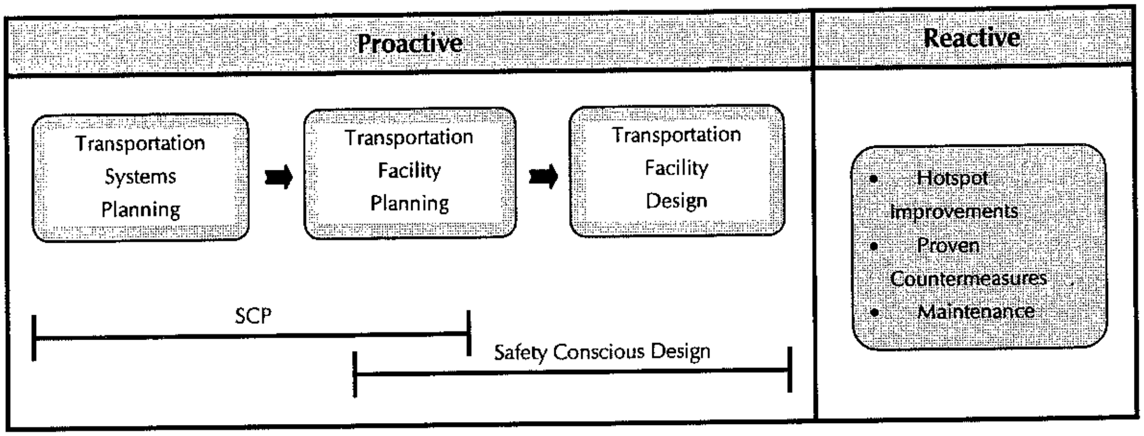
CONTEXT OF SCP

- The scope of what "safety planning" initiatives should include are:

  1. ***Programming safety improvements*** to address roadway "hotspots".
  2. Implementing ***multi-disciplinary road safety programs*** i.e. integrating engineering, enforcement and education activities.
  3. Reflecting road safety considerations as a ***key decision-making parameter*** in the evaluation of project options.
  4. Establishing ***inherently safe transportation networks.***

- SCP addresses only the last of these considerations. The other activities would also have significant safety benefits, and should be incorporated in an overall safety planning strategy.

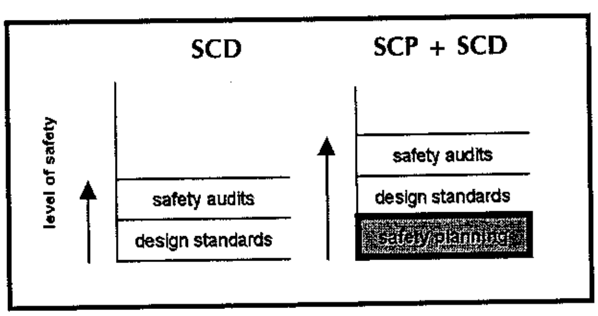
- The context of SCP within the overall infrastructure delivery and management process is illustrated below:



- The ***reactive approach*** addresses situations which have already proven to be crash prone, through "hotspot" improvements, proven countermeasures, e.g. roadside barriers and improved maintenance procedures.

- ***Proactive initiatives***, directed at preventing such unsafe situations from arising, can address ***system and facility*** level projects, and can be applied in ***planning and design*** activities.

- Although SCP and Safety Conscious Design (SCD) are identified as separate initiatives, they are supportive of one another in terms of establishing an inherently safe transportation system. SCP essentially provides a safer foundation upon which design activities can be undertaken.



SCOPE OF SCP

- SCP works on the basis that there is ***no acceptable or threshold level of "safety"*** which planners can target. All opportunities to reduce the frequency and severity of collisions should be systematically pursued, regardless of the current levels of safety. (This differs from the approach used for "mobility" planning, which is directed at achieving a target level of service). These opportunities include:

All Levels of Planning

- There are several levels of planning processes and decisions relevant to SCP:

    - ***Regional:*** e.g. growth strategies, major network plans
    - ***Municipal:*** e.g. Official Community Plans, zoning bylaws, multi-modal transportation plans
    - ***Local Area:*** e.g. neighbourhood plans, sector land use plans
    - ***Site:*** e.g. site plans, subdivision applications, site impact studies

- Decisions made at the higher levels influence the direction of subsequent stages of planning and decision making. Higher level planning also has an impact on the amount of travel (traffic volumes and distances travelled).

- The specifics of safety planning are ***formulated at the more detailed levels of planning.***

All Stages of the Planning Process

- Some examples of how safety can be explicitly addressed in each stage of the planning process are:

    - ***Existing Conditions:*** SCP requires a clear understanding of the existing road safety situation, mainly through collision statistics.

    - ***Problem Identification and Definition:*** Detailed road safety diagnostic techniques are required to identify areas in which there is potential to improve inherent safety.

    - ***Policy Direction***: Transportation safety policies should be developed to provide direction to the safety component of a plan.

- ***Measures:*** Guidelines for generating safer options, and quantitative techniques for evaluating the relative safety impacts of these options, would assist in establishing safer "building blocks" for a plan.

- ***Implementation Strategy:*** For a safety conscious approach, the implementation strategy should reflect road safety priorities.

Land Use and All Modes of Transportation

- SCP should be reflected in ***land use planning*** decisions and processes, e.g to influence urban form, mix and density of use.

- SCP is an integral part of ***transportation planning for all modes*** of travel, to influence the amount of travel, the mix of transportation modes and traffic patterns.

- Of particular relevance to SCP are ***Transportation Demand Management (TDM) initiatives.*** The positive impacts of reducing exposure must be reinforced with strategies for addressing the safety aspects of integrating alternative modes.

- SCP also addresses the planning aspects of ***road form, intersections and access***, as the decisions on these can significantly impact the extent of traffic friction and conflicts in the transportation network, and the predictability of the driving task.

- Another SCP focus, is working with road designers in providing a ***road form compatible with its function***. This facilitates the establishment of functional transportation networks.

- The planning of ***route and speed management*** measures (traffic calming) are important for establishing inherently safe networks.

THE BASIC APPROACH

- An important consideration in the development of the analytical framework is the ***quantifying of the safety impacts*** of proposed plans or measures. In ideal terms, the availability of reliable collision prediction models will facilitate:

    - the formulation of ***"optimal" planning recommendations***, in terms of safety benefits from transportation decisions and / or infrastructure investments

   ◦ the ability to ***influence decision-makers***, by informing them of the potential safety consequences of their decisions.

- However, as there are a limited number of crash prediction models currently available, the analytical process will need to be more ***qualitative-based in the formative stage*** of the program.

- Although crash prediction will be the focus for research and development activities, it is envisioned that, at least for the ***next 5 to 10 years***, the SCP process will still have a significant qualitative component.

- In the absence of support of quantitative analytical techniques, planning recommendations will reflect the ***judgement processes of practitioners*** and the current knowledge base. The effectiveness of a judgemental base is in turn dependent on the ***skills and interests*** of these practitioners.

- The challenge in developing an analytical framework at this stage is how to achieve ***informed and consistent judgement***. This is not only important for optimizing road safety investments, but also for maintaining the credibility of the SCP process.

- The following three principles were applied in the establishment of such an analytical process:

   1 Develop a ***comprehensive approach***, that provides practitioners with diagnostic prompts relating to all potential safety contributors, at each stage of the planning process.

   2 Provide a ***systematic process*** that leads practitioners step-by-step through this comprehensive approach. At each step, the practitioner may be required to make some judgements. This is not intended to be a 'black box' approach.

   3 Provide as much ***quantitative support*** as possible, through inclusion of state-of-the-art crash prediction models. Where these are not available, provide links to the best available ***knowledge*** on each of the subject areas.

(These principles are being embraced in the development of an electronic planning tool – ***Safer-TNP*** (Safer Transportation Network Planning).

- The need for the comprehensive approach is emphasized by the situation that:
    - There is ***no single dominant*** area of effectiveness for SCP.
    - SCP relies on the need to influence the safety level of ***many "small" safety contributors***, the aggregation of which will provide quantum safety improvements.
    - These safety contributors are distributed through the ***wide range of subject areas*** included in the scope of SCP.

SAFETY GOALS AND OBJECTIVES

- The first step in the development of the analytical framework was to define the primary goals of SCP, which are to:
    - ***Reduce exposure*** to collisions, through reduced automobile travel
    - ***Reduce the risk*** of collisions occurring, for travel that does take place;
    - ***Reduce the consequences*** for collisions that do occur.
- For each safety goal, several land use and transportation planning objectives are identified:

Safety Goals	*Planning Objectives*
Minimize Exposure	• provide a compact ***urban form*** • provide an efficient ***network*** • promote the use of ***alternative modes*** (safely)
Minimize Risk	• establish a ***functional*** network • manage ***conflicts*** at intersections • manage ***friction*** between intersections • promote ***predictability*** of the driving task
Minimize Consequences	• reduce ***speeds*** at high risk locations • protect ***vulnerable road users*** • provide a forgiving ***roadside*** • establish an efficient ***emergency response system***

THE SUBJECT AREAS

- The scope of SCP, and the range of potential safety contributors, cover the activities of a number of "planning disciplines", or specialist areas. These subject areas are (acronym ***PLANFAIR***):

  - Policy framework
  - Land use
  - Alternative modes (walking, cycling and transit)
  - Road Network
  - Road Form
  - Access
  - Intersections
  - Route planning.

- Each of these subject areas can be addressed at all levels of planning and at all stages of the planning process. Furthermore, in order to achieve the quantum improvements to the inherent safety of the transportation system, attention is required to addressing issues associated with all subject areas (i.e. the comprehensive approach).

Policy Framework

- The directions for land use and transportation systems are established through plans and policies, which become the basis for establishing community priorities, and through which community commitment to safety may be formalized.

- The key elements that can contribute toward an overall recognition of safety include:

  - Safety goals and objectives, including crash reduction targets;
  - Commitment to integrating safety within all stages of planning,

- The policy framework can provide an effective foundation for ensuring that safety becomes an inherent part of the planning process.

Land Use

- Land use shape provides the foundation for all travel patterns. There is significant leverage for influencing land use planning decisions in a direction which promotes inherent road safety e.g:

    - efficient land use shape;
    - land use to promote alternative modes;
    - coverage of amenities;
    - compatible land use mix;
    - relative location of generators and the need for dangerous crossings.

- The majority of the decisions would reflect multi-criteria urban planning objectives. It is important that the safety implications of these become one of the explicit planning priorities.

Alternative Modes

- There is an increasing number of initiatives aimed at promoting the use of alternative modes. Although this does lead to reduced exposure, such initiatives can also have negative safety impacts, e.g due to

    - the differential speeds of the modes, and consequent traffic friction;
    - the different sizes and levels of vulnerability of pedestrians and cyclists.

- SCP activities should include:

    - land use orientated to encouraging the use of alternative modes;
    - providing safe and convenient facilities for pedestrians, bicycles and transit;
    - protecting vulnerable road users.

Road Network

- The shape of the road network, i.e spatial layout and functional classification, are important considerations in establishing inherent safety.

- Establishing an efficient network is one of the primary planning considerations in this subject area. An important objective is to plan that the shortest and safest routes coincide.

- As much as possible, the different trip types, (i.e. through, distribution and local) should be separated, promoting the concept of mono-functionality. This simplifies the driving task, with all drivers on a road having similar expectations, and there being reduced friction between longer distance / faster flowing traffic and the shorter distance / slower moving and turning traffic.

Road Form

- The main parameter of road form is the cross-sections. SCP is directed at:

  - providing a road form compatible with the function of the road, and that this function be recognized by drivers (i.e. "self-explaining"/consistent road form)
  - providing safe features and standards
  - accommodating alternative modes

- The objective of predictable roads is that the drivers recognize the road class, and therefore understand the driver behaviour expected of them, and what to expect of other drivers.

Intersections

- The majority of collisions on a road network occur at intersections. The safety of intersections reflects a number of considerations:

  - the location of individual intersections, e.g. relating to sight distance;
  - the proximity of, and potential interference between adjacent intersections, including signal coordination and signing requirements;
  - the frequency of intersections and its impact on the driving task;
  - the configuration and form of intersections, including grade separation, T-junctions, roundabouts;
  - traffic patterns, in terms of volumes, mix and turning proportions;
  - intersection control and geometric design.

- A further SCP consideration is to provide an intersection form which is compatible with function of intersecting roads

Within an established network, there is limited potential to influence the network / planning level considerations relating to intersections. However, there are still opportunities to:

- undertake planning of new and developing sections of roads;
- influence traffic patterns;
- modify intersection configurations.

Route Planning

- The safety considerations arising from this subject include:
  - the availability of efficient routes
  - that the shortest and safest routes coincide
  - preventing shortcuts through residential areas

- Within a developed network, there are often constraints in achieving idealized network shapes and road forms. The primary tactic to deal with this reality is to introduce management measures that encourage the use of certain roads and discourage the use of less desirable routes and roadways, e.g:
  - signing recommended routes;
  - introducing physical measures to discourage or prevent the use of undesirable routes;
  - improving mobility on desired routes, and slowing down traffic on other routes.

CONCLUSIONS

- The vision for SCP is one in which:
  - All planning organizations routinely consider safety as an explicit planning priority in all planning projects.
  - All planning organizations (public and private sector) have:
    - ⇒ some practitioners trained in state-of-the-art safety techniques;
    - ⇒ access to state-of-the-art safety planning tools.
  - Decision-makers are informed about the quantitative safety implications of all planning decisions, and reflect these in their decision-making.

- The analytical framework developed for SCP is essentially a comprehensive checklist of planning parameters that can be considered to promote inherent safety, at all levels of planning and stages of the planning process.

- Although "best practices" related to each of these subject areas are being compiled, there is still a significant amount of research and development required before truly informed decisions can be made. ICBC has established a solid foundation for SCP practice and will be approaching other agencies to partner in taking this practices to the next level of sophistication

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Traffic Calming For Small Communities

Abstract

Although traffic calming has proven effective in addressing speeding, short-cutting and traffic safety problems in large urban areas, traffic calming measures are rarely used in small communities. This is partly because traffic problems are not widespread in small communities, and partly because municipal staff often have little or no experience with traffic calming. Traffic calming can be as effective in small communities as it is in larger communities, but a different approach is needed. This paper describes how traffic calming can be applied in small communities, in a manner which is sensitive to the expectations of residents and businesses, within a community's financial capabilities.

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Richard Drdul, P.Eng., PTOE
Community Transportation Planner
Urban Systems Ltd.
Vancouver, BC

Traffic Calming For Small Communities

Although traffic calming has proven to be an effective means of addressing traffic concerns in large urban areas, traffic calming measures are rarely used in small communities. This is partly because speeding, short-cutting and traffic safety problems are not as widespread in small communities, and partly because transportation engineers and other municipal staff in small communities have little or no experience with traffic calming.

The good news is that traffic calming can be as effective in small communities as it is in larger communities. However, a "big city" approach to traffic calming doesn't always work in a small community. This paper describes how traffic calming can be applied in small communities, in a manner which is sensitive to the expectations of residents and businesses, within a community's financial capabilities.

Neighbourhood Streets

Neighbourhood streets are where traffic calming is most commonly applied, to address problems with speeding, short-cutting and conflicts between road users. In larger communities, traffic calming is typically applied to whole neighbourhoods, where most streets have traffic problems. Restrictive traffic calming devices are often used, to prevent traffic from entering a neighbourhood. In small communities, on the other hand, traffic problems tend to be isolated to a specific location or street within a neighbourhood. Restrictive devices are not appropriate and should be avoided in favour of non-restrictive traffic calming solutions. The most appropriate traffic calming devices for small communities include:

- **Speed humps** are the most effective form of speed control, and are the most commonly used traffic calming device. They are inexpensive to construct, and unlike many other traffic calming devices, can be used on roads with open shoulders (no curbs). Speed humps will generally not divert much traffic from a short-cutting route.

- **A raised crosswalk** is essentially a speed hump combined with a crosswalk. These are best used near schools and playgrounds, and can be used on roads without curbs.

- **Curb extensions** should be used at crosswalks (and can be used in combination with a raised crosswalk) and at intersections where speeding and pedestrian safety is a concern.

- **Median islands** can be used at crosswalks and intersections to improve pedestrian safety, to increase stop sign compliance and to slow vehicles travelling through the intersection.

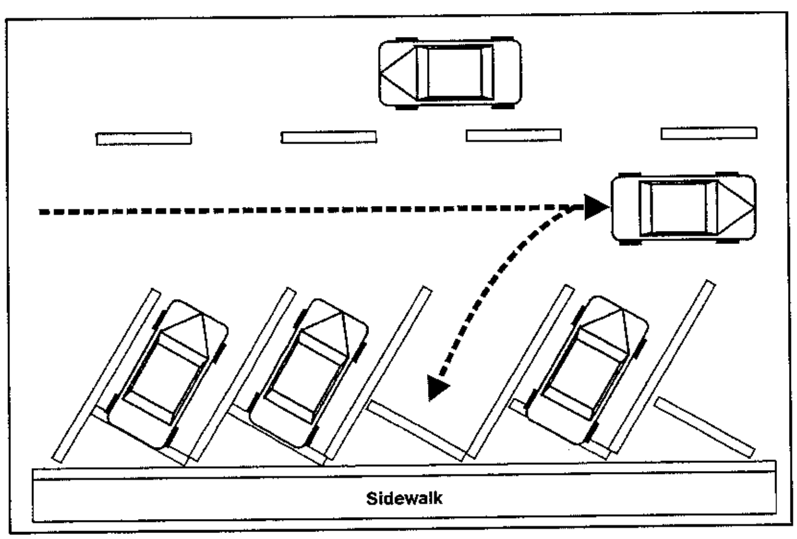
- **Traffic circles** should only be used on roads with curbs (if necessary, short sections of curb can be constructed on all corners of an intersection). If traffic circles are used in a small community, they should be installed in several locations rather than just one or two isolated locations, so that residents and visitors become familiar with them. Otherwise, they can become a source of frequent complaints and traffic problems.

Downtown Revitalization

Many small communities undertake revitalization projects to improve and enhance their downtown areas. These projects provide an ideal opportunity for traffic calming, with benefits of reduced vehicle speeds, increased pedestrian safety and greater economic vitality in the downtown area. Opportunities for traffic calming as part of downtown revitalization projects include:

- **Parking** is one of the most effective means of traffic calming on downtown streets. Parking slows traffic, particularly where turnover is high. On-street parking also provides a buffer between pedestrians on the sidewalk and moving traffic, thereby enhancing the pedestrian environment. In general, parallel parking is preferred. If angle parking is used, stalls should be oriented so that motorists must back in, as illustrated in Figure 1. This minimizes the potential for conflicts when exiting the parking stall.

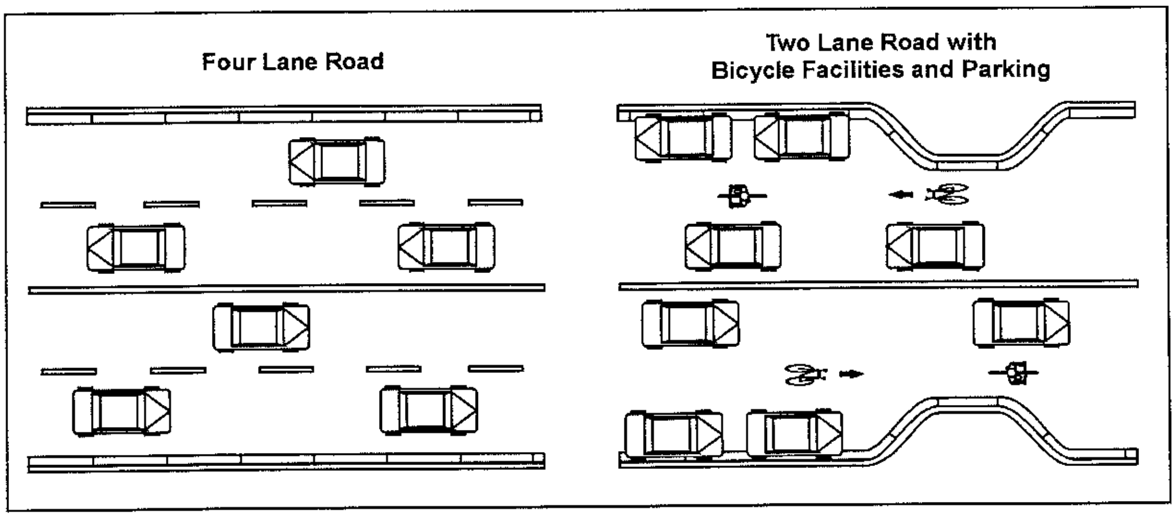
Figure 1 — Back-In Angle Parking



- **Curb extensions** can be used at intersections, crosswalks and bus stops on streets with parking. Typically, the curb is extended into the roadway a distance equal to the width of the parking lane (2.0 m or more), so that the new curb is aligned with parked vehicles. The primary benefits of curb extensions are improved safety for pedestrians, reduced speeds of turning vehicles, and additional opportunities for street furniture and landscaping.

- **Two-lane roads.** In many cities, four-lane and even five-lane roadways have been converted to two-lane roadways, with turn lanes, space for bicycles and parking added to the road, as illustrated in Figure 2. The primary benefit of this change is reduced vehicle speeds. With a four-lane road, motorists can change lanes to pass slower vehicles, and many motorists exceed the posted speed limit. On a two-lane road, motorists must travel at the speed of the slowest vehicle. An additional benefit reported in several downtown areas where roads have been reduced to two lanes is higher store occupancies and increased sales.

Figure 2 — Roadway Reconfigured From Four To Two Lanes



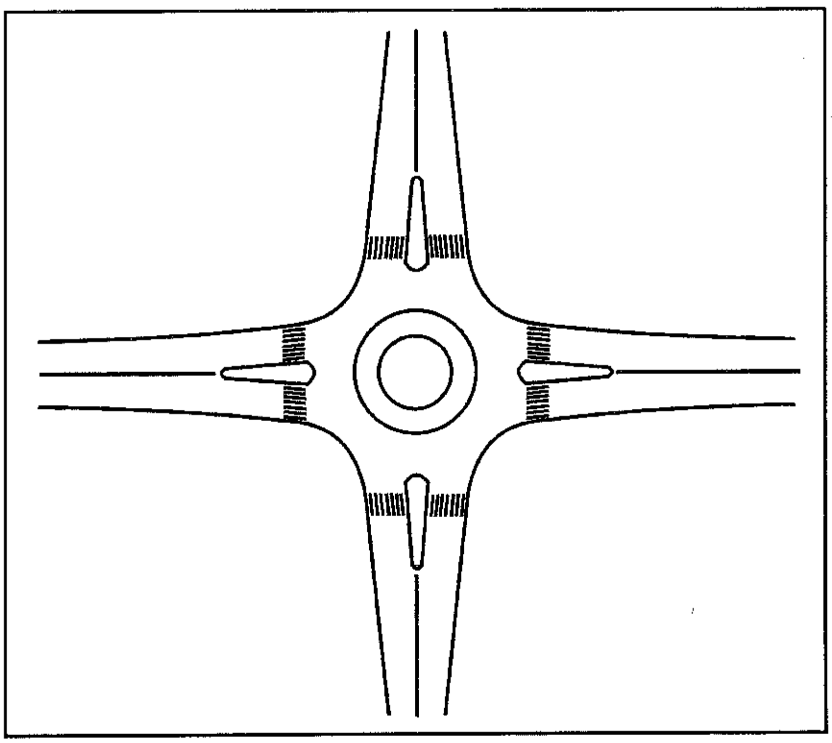
Highways

Many small communities are bisected by major highways. This creates a problem, where motorists travelling at high speeds between communities fail to slow sufficiently when entering a community. Means of addressing speeding and safety concerns on highways through small communities include:

- **Gateways.** This approach describes a range of techniques used to highlight the entrance to a community, where the transition occurs from high-speed rural highway to low-speed urban roadway. Examples of gateway techniques include signs and other roadside structures, street trees and landscaping, medians, narrowed roadways and modern roundabouts.

- **Modern roundabouts** are an alternative to signalized intersections. Roundabouts force vehicles to slow approaching and travelling through an intersection. Roundabouts can also reduce crashes by as much as 85%. Single lane roundabouts (such as illustrated in Figure 3) are as safe or safer for cyclists and pedestrians than conventional intersections. Multi-lane roundabouts are a different matter, however, as they involve higher traffic volumes and more complex movements, and consequently should be not be considered as a traffic calming technique.

Figure 3 — Modern Roundabout



Cost-Effective Design

For small communities, a significant challenge is implementing traffic calming at a cost the community can afford. Costs of traffic calming can be minimized — without compromising the effectiveness or aesthetics of the devices — by using the following techniques:

- **Temporary devices.** Where possible, traffic calming devices such as curb extensions and median islands should first be constructed on a temporary basis to ensure that they are effective, before funds are spent on permanent construction. Flexible rubber barriers (used in parking lots) can be bent to shape and pinned to the road surface to inexpensively create temporary devices.

- **Precast concrete** objects can be used to construct some traffic calming devices. For example, short sections of large-diameter concrete pipe can be partially buried on the corners of intersections where traffic circles are constructed, as an inexpensive alternative to constructing curb and gutter.

- **Cast in place concrete**. Curb extensions, median islands and traffic circles are best constructed by pouring concrete onto the road surface (with pins to attach the concrete to the road). Asphalt can be removed from the centre of the device and the area filled with soil and landscaped.

A-4-4 / 1

ICBC Road Sense

ICBC's School Road Safety Planning Project

Elizabeth Heinz: Manager, Provincial Programs
Insurance Corporation of British Columbia

Kelvin Roberts: Manager, Safety Conscious Planning
Insurance Corporation of British Columbia

ABSTRACT:

ICBC considers the road safety of students to be an important issue. It has developed a process and a supporting CD-ROM, called ***Safer School Travel***, for assisting Parent Advisory Committees in preparing School Road Safety Plans. These plans are comprehensive, addressing all modes of transport, and include holistic engineering, enforcement and education strategies. The road safety planning process requires extensive consultation with all affected stakeholders, and reflects the understanding that, because of the limitations in children's road safety skills, special attention is needed to help them cope in all traffic conditions.

Background

Children are vulnerable road users. Whether they are walking, cycling or travelling as passengers in vehicles, special attention needs to be given to their road safety.

Children perceive traffic differently to adults. There are twenty-six judgement skills needed to cross a street safely. These skills are not fully developed in children, for example:

- The ability to estimate whether there is sufficient time to safely cross the road, especially in high speed, high volume traffic environments.
- Their field of vision is not fully matured and is in fact one-third narrower than that of an adult.

Furthermore, since children are short in stature, and have lower eye levels than adults, obstructions such as parked cars and newspaper stands can obstruct their field of vision. Younger children attending kindergarten and elementary school are particularly at risk.

Historically (and still today), many school site decisions were based on the cost of land and urban planning factors. Safety was not a primary factor or even a conscious consideration.

These same schools are now centered in increasingly populated areas with higher traffic volumes, complex traffic patterns and the diverse transportation infrastructure required to accommodate evolving community needs. Yet, there are limited initiatives which meet the needs of children having to navigate their way to and from school in this more complex environment.

As in other areas, potential traffic crashes and injuries involving school children are therefore important issues for British Columbians. ICBC has been requested by communities in the province to lead the response in minimizing the risks associated with school travel.

Contributing to the Solution

One of ICBC's important road safety goals has always been to reduce the risk of traffic crashes and injuries for children travelling to and from schools. We would like to facilitate that every school in BC develops a School Road Safety Plan tailored to their unique situation and requirements.

To that end, ICBC is developing an approach to help planners consider road safety before selecting a site and building a new school, and has developed a CD-ROM (***Safer School Travel***) to help prepare the School Road Safety Plans, and address the road safety issues that have evolved around existing schools.

Safer School Travel has been developed to assist Parent Advisory Committees (PACs) in preparing these plans. The tool bridges the knowledge gap between practitioners and the lay person. In turn, the parents become informed safety champions with their newly acquired insight into safety issues and measures.

The tool promotes a realistic and balanced approach between providing for the safety of children and maintaining the mobility of vehicles. The scope of a School Road Safety Plan includes all modes of transportation, vehicle reduction initiatives and engineering, education and enforcement measures.

The CD-ROM includes:

- An ***audio-visual presentation*** on the philosophy of School Road Safety Plans
- ***Information papers*** on topics such as Children in Traffic and the Way to Go program (a program to encourage less auto travel for school trips)
- Guidelines on undertaking ***community road safety initiatives***, i.e crossing guards, Speed Watch, parent parking patrol and walking school buses
- Guidelines on ***engineering measures*** for pedestrians, bicycles, transit and cars
- A guided ***step-by-step planning process***, with training material, for the individuals developing the School Road Safety Plan

Who should prepare a School Road Safety Plan?

An effective road safety plan requires the cooperation of a number of stakeholders, each having unique and important roles to play. These include:

- **School boards** - who formulate school transportation policies and whose personnel are responsible for the school's operation and maintenance
- **Principals and teachers** – who manage the school, and communicate with parents and children
- **Parents** - who, under the coordination of the Parent Advisory Committees, are active participants in the development of a road safety plan, and can supervise and assist children at risky locations
- **Children** – who can assist in collecting and providing information
- **Urban planners** - who plan school sites and surrounding land use activities
- **Engineers** - who plan road infrastructure and traffic management
- **Police** – who are responsible for traffic enforcement, and provide road safety education to children.

Although it is generally assumed that Parent Advisory Committees will lead the school road safety planning process, the ***Safer School Travel (SST)*** approach is flexible in this regard. The planning activities are managed by a committee established for this purpose. In addition to the chair of this committee, there are three other key participants:

- the ***SST operator***, generally a PAC member trained by ICBC in the use of the ***SST*** software
- the ***SST specialist***, an ICBC representative providing support at important junctures of the project, and on an as-and-when-required basis
- the ***technical specialist***, generally the local government traffic engineer.

The Scope of a School Road Safety Plan:

The extent of the road safety plan should consider all road safety issues between home and school. Generally, the physical planning area focuses on the geographic area within which students walk or cycle to school.

The plan develops safety strategies for all modes, including pedestrians, cyclists, private vehicles, transit and school bus passengers. It also includes measures to influence the behaviour and actions of children and motorists travelling to and from the school, as well as those travelling past the school.

A holistic approach is adopted, including:

- **Engineering** – planning of school sites, provision and maintenance of traffic management and transportation infrastructure
- **Education** – the road safety culture and skills of children and parents
- **Enforcement** – police initiatives to achieve compliance with traffic regulations.

An additional and important strategy unique to School Road Safety Plans, is the supervisory and assistance roles that parents can play in situations in which other approaches do not adequately provide for the road safety of students. These include initiatives such as:

- Crossing guards
- Walking school buses
- Parent Parking Patrol
- Speed Watch

Five Principles for preparing a School Road Safety Plan:

1. ***Establish effective participation and consultation with a broad range of stakeholders***:

   By building on the knowledge and skills of all stakeholders, the plan will not only be more effective, but will also have a greater likelihood of being endorsed and supported by the parents, children and community.

2. ***Acquire a comprehensive understanding of the school's road safety parameters:***

   Each school is unique and there is no "one-size-fits-all" road safety plan. A detailed understanding should be developed on:

   - Existing transportation infrastructure and facilities
   - Choice of, and reason for choosing transportation modes, for travelling to and from school
   - Volumes and routes of pedestrians, cyclists and bus passengers
   - Vehicle traffic patterns
   - Adult and child safety perceptions, crash statistics.

3. ***Take advantage of experience gained in other school safety initiatives:***

   Learn from others and avoid reinventing the wheel. Even though each school is unique, there is valuable information to be gleaned from how other schools have approached their safety issues. (ICBC is compiling information in this regard)

4. ***Understand the unique considerations of how children perceive traffic situations:***

   Children can be impulsive and unpredictable, and have limited perception and judgement capabilities. These characteristics must be taken into consideration when creating a School Road Safety Plan, e.g:

   - Do not accept marginally safe situations - build in spare "capacity" for safety into the plan
   - Plan, as far as possible, that the shortest and safest routes coincide
   - Supervise and assist children if safety cannot be adequately provided for.

5. ***Balance the needs of mobility of traffic and the safety of children***:

   A realistic and balanced approach, which caters for a broad range of stakeholders and road users, is required.

A-4-4/6

School Road Safety Accords

An important and innovative approach to encourage commitment of stakeholders to the plan, is the formulation of School Road Safety Accords. These are "social agreements" which spell out the roles and responsibilities of each stakeholder in the implementation and ongoing operations of the School Road Safety Plan. Of particular importance is the sustainability of the plan, and ensuring that responsibilities are carried forward to incoming Parent Advisory Committees.

Pilot Projects

There are seven elementary and middle schools in British Columbia who are currently testing the ***Safer School Travel*** CD-ROM, as they develop their School Road Safety Plans. The schools were selected for their diverse characteristics including geography, urban/rural locations, student population size, etc. The only requirement was that they have an active and committed Parent Advisory Committee (PAC) willing to undertake the project.

The pilots started in November 2000 and will conclude June 2001. At that stage, the planning process and the software will be reviewed and refined. It is intended to commence broad-based implementation of School Road Safety Plans during the 2001 / 2002 school year.

Conclusion

The pilot project experience to date has been very encouraging. The process and software is proving to be effective in identifying safety issues and formulating associated responses.

We are finding that an adequate number of parents are willing to actively participate in the school road safety planning process, and that they become road safety champions in their own right. This spin-off effect supports other ICBC's other strategies, namely raising awareness of road safety issues and encouraging communities to start taking some accountability for their own road safety.

A-5 - 1 / 1

ITE Quad Conference
May 4,5 2001
Vancouver, B.C.

TransLink's Regional Cycling Program

Abstract:

The Greater Vancouver Transportation Authority adopted a Strategic Plan in April 2000 which calls for the provision of new cycling facilities and a gradual increase in cycling. This paper will discuss the approach that TransLink has taken to define a regional role for supporting cycling as a viable transportation mode, and it will outline programs underway to achieve safer cycling and a higher number of cycling trips.

Paper submitted by:

Helen Cook
Program Manager, Alternative Transportation
TransLink

March 8, 2001

A-5-1/2

2001 ITE Quad Conference
May 4,5
Vancouver, B.C

TransLink's Regional Cycling Program

1. Introduction

The 2001 ITE conference theme of "Transportation Across Borders" is intended to focus on the challenges of delivering transportation solutions across municipal, regional, and international borders, within increasingly complex and constantly changing circumstances. These arbitrary political borders represent vested institutional interests as well as physical borders; all of which can present barriers to cycling in the Vancouver Regional District.

In recent years some progress has been made on improving cycling conditions, however, in general the regional transportation system is not well adapted to cycling. Roads and bridges do not accommodate cyclists very well, end-of-trip facilities (such as racks, bike lockers and change rooms) are not common, fear of traffic is a deterrent to many and there are few educational and promotional programs to encourage people to cycle safely.

The Greater Vancouver Transportation Authority adopted a Strategic Plan in April 2000 which calls for the provision of new cycling facilities. This paper will discuss the approach that TransLink has taken to define a regional role for supporting cycling as a viable transportation mode, and it will outline programs underway to achieve safer cycling and a higher number of cycling trips.

2. Regional Plan Context

TransLink's primary goal in developing a regional bicycle plan is to *encourage increased use of bicycles as a transportation mode.* The strategy for achieving this is goal to invest in cost-effective bicycle facilities in an integrated network of routes as well as programs that encourage people to cycle rather than drive. To be successful, the development of a comprehensive bicycle network for the region will depend on partnerships. TransLink does not have the resources or the mandate to deliver all facets of a cycling network. The first five years of TransLink's cycling strategy will complement the efforts of the local and provincial governments and will focus on priority infrastructure, services and programs that will increase bicycle trips in the region.

In order to achieve maximum use of bicycle facilities, capital investments and programs should consider of all types of cyclists. As described below, market research conducted in the region confirms that a combination of safe and attractively engineered bicycle facilities as well as information and education about the benefits of cycling will encourage more trips by bicycle.

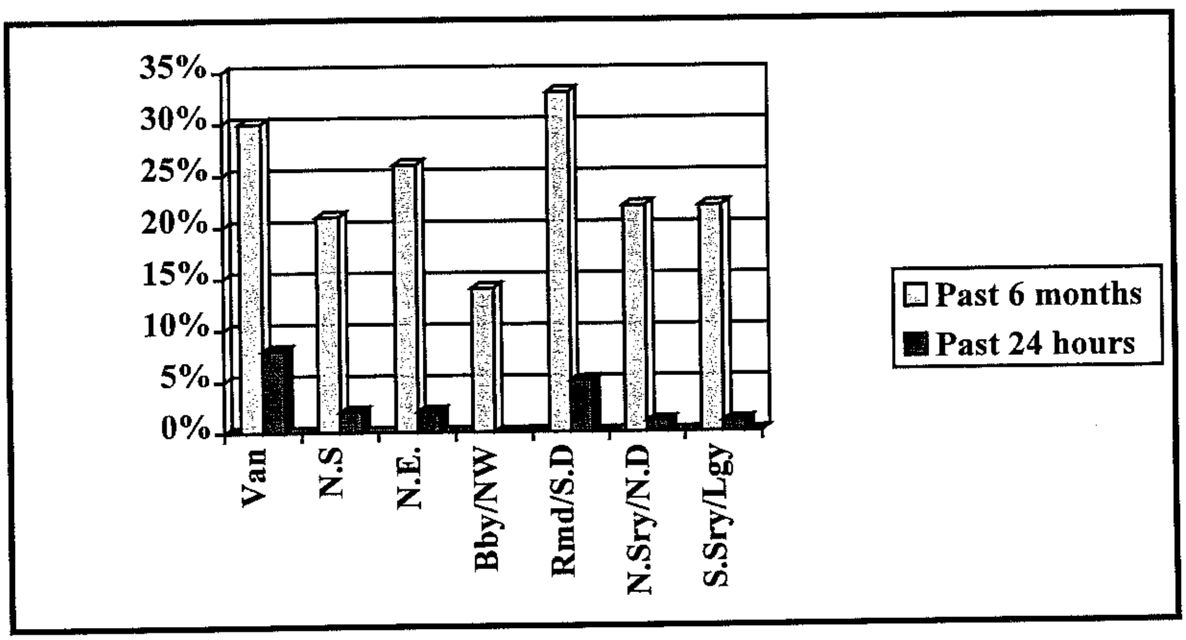
3. Bicycle Travel Characteristics

There is no such thing as a "typical" cyclist. People ride bicycles for a wide variety of reasons — to commute to work or school, for shopping, for entertainment, for social reasons and for recreation. Cyclists' skill levels and fitness vary widely, as does their comfort and willingness to ride in traffic, across challenging terrain, or during inclement weather. Some cyclists can ride long distances at relatively high speeds, whereas other cyclists are only willing to ride a few kilometres.

The most recent data available about cyclists in the lower mainland is from a telephone survey conducted for TransLink in December 2000. This survey collected basic travel data for 600 cyclists and 583 drivers, as well as attitudinal data.

Mode share of bicycle trips is low region wide, however there are pockets of higher usage. Not surprisingly, the urban core generates a higher percentage of trips, where there are more designated bicycle paths and shorter travel distances. As illustrated, the challenge to increase the daily mode share is to motivate infrequent cyclists to use their bicycle more often.

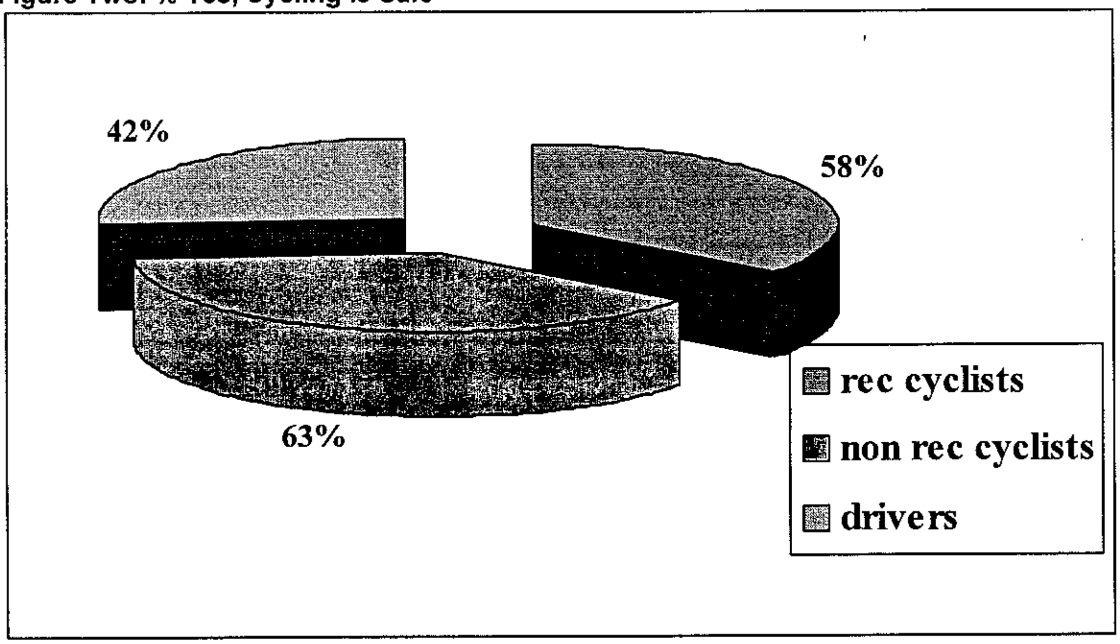
Figure One: Use of Bicycle for any trip purpose



A-5-1/4

Discussions with regular cyclists offer informal advice about what facilities are preferred and what challenges there are to safety. There is much anecdotal evidence to suggest that lower mainland residents think cycling is unsafe, and the survey results generally support this sentiment. But the variation in opinion between drivers (42%) and non-recreational cyclists (63%) is interesting, since both are frequent road users. Further analysis of this data set may reveal if notions of safety are linked with cycle frequency and with level of experience, as well as age, and location.

Figure Two: % Yes, Cycling is Safe



Municipalities, TransLink and the provincial Cycling Network Program invest a significant amount annually in new bicycle facilities to improve safety, and to make cycling more attractive. It is assumed that given a choice, a cyclist will prefer to ride on a street with designated bicycle priority, either a lane or shared space, or a "greenway" either on or off street. This makes intuitive sense, yet the question remains whether or not the bike facility is well located relative dominant travel patterns, or whether it is designed effectively. Cyclists were asked what facilities were part TransLink posed some questions to find out what routes they were using on a regular basis.

As shown below, non-recreational and recreational cyclists frequently mention riding along streets with parked cars, and all other types of cycling facilities are less often used. This is partially a function of the lack of facilities, and a lack of appropriately located facilities. The data also confirms that recreational cyclist make more use of off street facilities either bicycle paths or shared use paths.

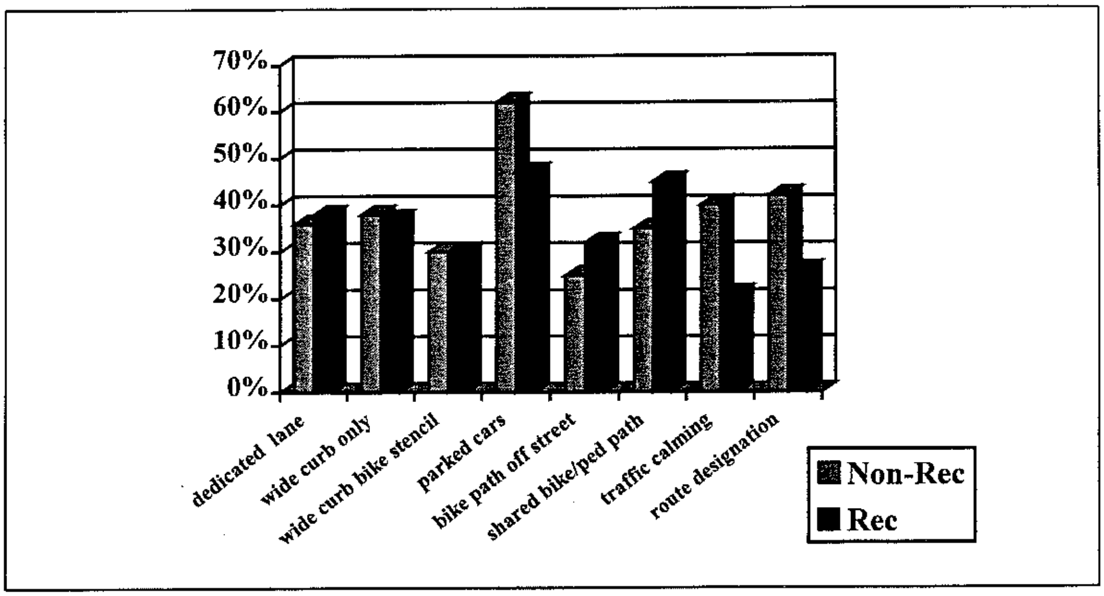
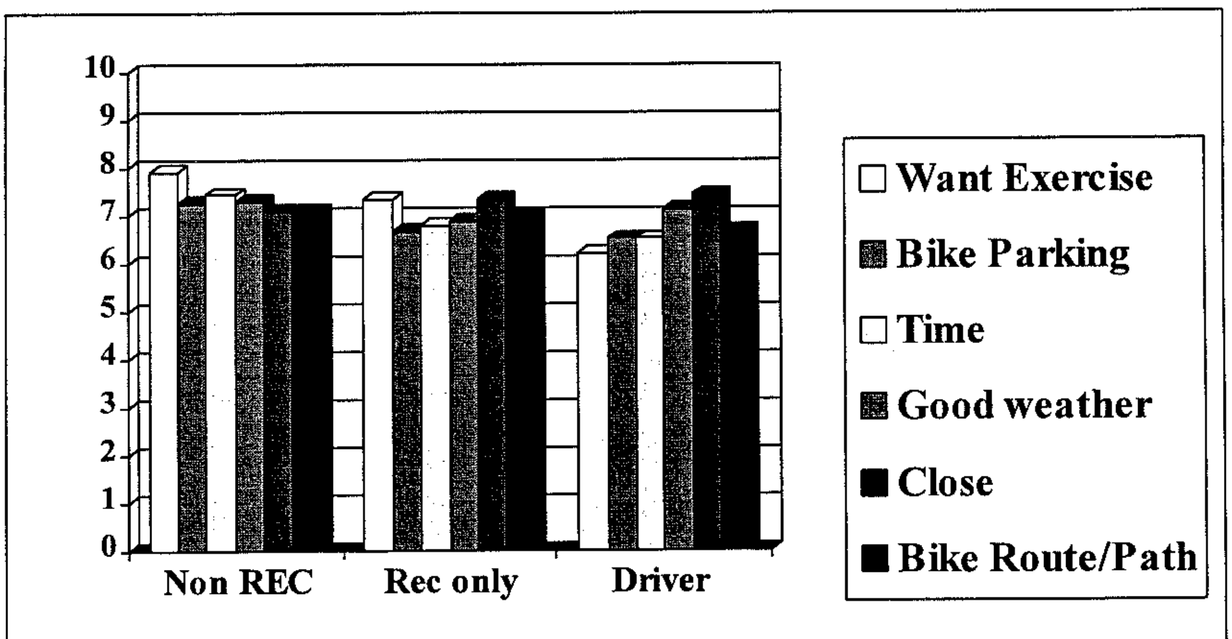


Figure Three: Use of Bike Facility by Type

4.0 Why Ride?

TransLink recognizes that the greatest potential for increasing bicycle use exists among occasional cyclists and non-cyclists, rather than among existing committed cyclists who already travel by bicycle on a regular basis. As indicated by Figure 4 Recreational and Non-Recreational cyclists both rank exercise as a key motivator, but other factors such as time, weather and distance are valued differently.

Figure Four: How Important would each factor be in influencing you to ride more often?
Each group has different priorities. For example of the fourteen factors rated on a scale of one to ten, Non Recreational cyclists rated "having a bike route or path" as the sixth



most important factor. Recreational Cyclists and Drivers rated the same factor as the third most important factor to influence them to ride more often. These factors combined with the information that only 30-40% of cyclists report using a bicycle facility as part of their journey support the strategy of building more cycling facilities.

5. The TransLink Program

The year 2001 marks the first full year of TransLink's Bicycle Program, and it will be focused on initiatives that improve bicycle facilities and promote cycling in general.

5.1 Capital Investment

The largest resource allocation is to capital funding for municipal bicycle projects. The $1 million fund has been shared among 16 municipalities who had specific projects to improve cycling in their community. The projects vary in cost and significance from the addition of signage and pavement markings to the construction of a pedestrian/cycle overpass, to the completion of a bikeway along Kent Avenue. All projects will improve safety and bring further attention to the presence of cyclists on roadways.

5.2 Inter Modal Links

TransLink will continue to facilitate inter-modal travel as a means of extending the maximum distance for cycling in combination with transit for a portion of the trip. Establishing a regional bicycle network with connections to regional rail and bus transit services will help to increase bicycle use and transit use. To achieve this, TransLink will make all transit services bicycle accessible by:

- providing bike racks on all buses in the region as early as possible;
- expanding rack and secure bike locker facilities at potential key transit nodes; and
- working towards accommodating bikes on SkyTrain.

There is much work to be done in terms determining the priorities for building and expanding the bicycle network with municipalities. This is an institutional challenge, as TransLink is merely the co-ordinating role among the many communities. Through the Bicycle Working Group advisory committee, municipalities will participate in a discussion of priorities for funding future network improvements.

5.3 Promotion and Education

To achieve noticeable increases in bicycle use, TransLink will also dedicate resources to improving information and education about cycling. For 2001, the emphasis will be on updating the regional inventory of facilities and producing a map for distribution to the public. In addition, there will be funding for promotional events such as Bike Month. The survey data gathered in 2000 will be used to guide the development of promotional campaigns with a variety of messages regarding safety and the benefits of cycling.

6.0 Future Prospects

At this stage, it is not possible to accurately estimate the cost of a regional bicycle network — more work needs to be done by municipalities and TransLink to confirm routes and determine what capital expenditures will be required. However, it is possible to develop an order of magnitude cost estimate. Costs for the improvements to regional bicycle routes were estimated assuming four different levels of improvements which would be required, as summarised below in Table 1.

Table 1
Cost Assumptions
(property and utility costs not included)

Level of Improvement		Examples	Cost per km
1	No improvements	Signage	$2,000
2	Minor improvements	Unsignalized crossings Modify lane markings	$50,000
3	Moderate improvements	Signalised/unsignalised crossings Wide curb lanes, paved shoulders Widen multi-use pathway	$150,000
4	Major improvements	Bicycle lanes New multi-use pathway Bridge	$300,000

The total estimated cost to build a regional cycle network is $50 million, shown below in Table 2. If costs for municipal facilities are cost-shared by TransLink at 50%, the estimated cost to TransLink to implement the Regional Bicycle Plan would be $29 million which includes $21 million to be cost shared with municipalities.

Table 2
Estimated Regional Bicycle Plan Costs

TransLink facilities	Bridges	$1,100,000
	BC Parkway	$5,000,000
	Secure parking at transit facilities	$500,000
	Bicycle racks on buses	$1,000,000
	Awareness and education programs (over 10 years)	$500,000
Municipal facilities	Bicycle routes	$42,200,000
	Secure parking at major regional destinations	$200,000
Total		**$50,500,000**

A-5-1/8

7.0 Conclusion

TransLink resources for cycling are limited to the activity level of a single staff person working with consultants and external agencies to build awareness, motivation and improve facilities. As the program becomes more structured, it is more likely that funding will be available for "joint-venture" projects with municipalities in areas of high priority to improve safety and to meet local travel demand.

The profile of the Bicycle Program at TransLink tends to be overshadowed by the larger transit component and the Major Road Network planning, however, this situation only mirrors that which exists in most municipalities. The opportunity to present information about the program at multi disciplinary engineering conferences is one method to send the message that cycling may be a small component of the transportation, but it could be much more significant given adequate funding and attention from all transportation engineers.

A-5-2/1

SAFER BICYCLE AND PEDESTRIAN PLANNING

Kelvin Roberts: Manager, Safety Conscious Planning
Insurance Corporation of British Columbia

ABSTRACT

There are increasing political pressures to promote walking and cycling as alternatives to the single occupant vehicle. The resulting modal shifts would have environmental benefits and potentially reduce exposure, or amount of travel. However, unless properly planned, increased cycling and walking can lead to a higher frequency of collisions and increased collision consequences for vulnerable road users. ICBC is, as part of its Safety Conscious Planning program, developing a range of initiatives to assist transportation planners in the safe accommodation of cyclists and pedestrians. This paper describes the scope of these initiatives. The conclusion is that the current safer planning techniques for vulnerable road users have limitations, and that joint research and development programs could provide the resources required to bridge the related knowledge gaps.

INTRODUCTION

- There are increasing political pressures on transportation planners to promote walking and cycling as alternative transportation modes to the single occupant vehicle. This is mainly driven by sustainable transportation objectives.

- Although the use of alternative modes does result in less overall travel, and hence reduced exposure to potential collisions, not all initiatives aimed at promoting walking and cycling lead to net road safety benefits.

- Unless adequate road space and safe crossing opportunities are provided, the mixing of higher speed vehicles with lower speed bicycles / pedestrians leads to increased traffic friction and conflicts, which can result in increased collision frequency. Because of the vulnerability of cyclists / pedestrians, this can also lead to increased collision severity.

- ICBC has adopted a safety advocacy role in Transportation Demand Management-related initiatives, including bicycle and pedestrian projects. In principle, ICBC supports trip reduction projects that also adequately cater for potential safety impacts. In this regard, ICBC is also serving as the "facilitator of best practices", as it relates to the planning of bicycle and pedestrian facilities.

- This paper describes some of ICBC's initiatives in promoting safer bicycle and pedestrian planning.

SOME BASIC PRINCIPLES

- ICBC has adopted the following basic principles in guiding its approach to the development of safer bicycle and pedestrian planning initiatives:

  - Transportation planning projects should reflect a ***balanced multi-modal perspective***, leading to informed decision-making on the road safety considerations for all transportation modes (not only for cyclists and pedestrians).

  - All roads (with a few legal exceptions) are potential bicycle and pedestrian facilities. ***Primary planning issues*** are the level of facility that should be provided on every road, and what the implementation priorities should be.

- There are a variety of ***"market segments"*** of cyclists and pedestrians that need to be accommodated, including different age groups, levels of mobility, age and trip purpose. These various stakeholders often have different infrastructure needs.

- Where appropriate, a ***holistic road safety approach*** should be adopted. This could include the consideration of engineering, enforcement and education measures.

■ An important reality is that safer pedestrian and bicycle planning are evolving sciences. There are no "cookie-cutter" approaches for planning the provision of the "safest" facilities. Often, flair and experience are required to optimize safety, especially in the more complex situations. This also emphasizes the importance for practitioners to stay abreast of the latest available knowledge in this subject area.

PEDESTRIAN / BICYCLE MASTER PLANNING

■ Pedestrian and bicycle master planning initiatives are mainly directed at answering two basic questions:

1. What ***level of facility*** should be provided on every link of the network?
2. What is the ***implementation priority*** of each of these facilities?

In general, only the higher order road classes are considered, as cycling and walking can normally be accommodated under mixed traffic conditions on local roads.

■ The alternative facility types that can be considered include:

For Pedestrians	For Bicycles
Sidewalks both sides	Bicycle paths
Sidewalks one side	Bicycle lanes
Shoulders	Wide curb lanes
On-street	Mixed traffic

Within each of these categories, different levels of facilities can be provided, reflecting, for example, degree of separation from vehicle traffic and the width of the facility.

- The decision on which facility to provide requires the consideration of techniques such as bicycle and pedestrian ***level of service models***. Such models reflect the perceived safety of cyclists and pedestrians using different levels and types of facilities. Although these models are not wholly reliable safety predictors, they do provide a consistent and quantitative basis for evaluating optional facilities.

- The second planning issue, namely implementation priority, requires both a ***prioritized needs assessment*** and ***benefit-cost evaluation***. The needs assessment includes the consideration of the following parameters for each network segment:

  - existing and latent demand
  - local road safety concerns
  - bicycle / pedestrian level of service
  - "desirability" of the facility (to encourage increased use)
  - network contribution e.g. continuity, consistency and connectivity.

- With the exception of the level of service, all these parameters are assessed on a qualitative basis by a focus group of local users and practitioners. The focus group also weights the relative importance of each parameter. An overall weighted rating is then developed for each segment, which is applied as the indicator for the needs assessment priority.

- The benefit-cost proxy that is applied in the prioritization process is the extent to which the bicycle / pedestrian level of service is improved, divided by the cost of achieving this improvement.

- In addition to addressing these primaryissues, the following ancilliary considerations are also addressed in bicycle / pedestrian master planning:

  - modal integration
  - destination facilities
  - engineering and enforcement initiatives
  - maintenance policies
  - intersection and crossing facilities.

POLICY ISSUES

- From the experience gained in ICBC's initial bicycle / pedestrian planning activities, a number of policy issues have been identified, the content of which could have significant impacts on the outcome and effectiveness of the planning activities. These include:

  - ***Target level of service***, i.e. when is the type and level of facility adequate, or at what stage do pedestrian / cycling operations become an issue? In ideal terms, it is useful to have some target or threshold values to direct planning activities.
  - Deciding between the use of ***bicycle lanes or wide curb lanes***.
  - The adoption and application of ***geometric standards***, for example how to deal with situations in which full standards cannot be achieved, but a small "sub-standard" improvement could yield significant safety benefits over the existing situation
  - How to deal with trade-offs between providing for bicycles and pedestrians, and ***impacts on the mobility and safety of vehicles***. This could arise, for example, when the vehicle travel lanes are removed or narrowed, or route and speed management measures are introduced.
  - What constitutes ***effective maintenance*** of bicycle / pedestrian facilities, e.g. for snow and ice, sweeping, pavement, signing and vegetation.

- Although interim approaches have been adopted for most of the above issues, it is recognized that significant more thought, and probably research, are still required. This will be one of the short term focus areas in ICBC's bicycle / pedestrian planning activities.

SAFETY REVIEWS

- Safety review ("audit") procedures are being developed for identifying and filtering out safety issues relating to the provision of cyclist and pedestrian infrastructure. These can be undertaken for a range of applications:

  - from area wide to facility levels of detail
  - addressing existing in-situ conditions and proposed facilities
  - at different planning and design stages
  - along road segments or at intersections / crossings.

- The logistics for undertaking the bicycle / pedestrian safety reviews will be addressed as part of ICBC's comprehensive approach to conducting road safety audits. During 2001, guidelines for application in these reviews will be developed and piloted. It is also intended to conduct training courses

EMPOWERING PRACTITIONERS

- In general, transportation planners / engineers have not had intensive training in safer pedestrian and bicycle planning practices. Notwithstanding, they are still expected to make technical recommendations on how best to accommodate vulnerable road users such as cyclists and pedestrians.

- B.C practitioners have indicated that one of ICBC's primary roles in this subject area should be that of empowering practitioners in the application of state-of-art knowledge. ICBC has developed a multi-facetted approach in responding to this issue:

  - conducting training courses and seminars
  - arranging conferences
  - facilitating discussion groups
  - developing a best practice web site
  - developing analytical tools.

- Significant progress has been made in developing and piloting the ***Safer Bicycle Planning*** CD-ROM, which include training material and a step-by-step application tool to assist in bicycle master planning.

CONCLUSIONS

- Unless properly planned, initiatives to promote increased cycling and walking can lead to a higher frequency of collisions and increased collision consequences for vulnerable road users.

- Regardless of safety considerations, pedestrians and bicycles will continue to be promoted. ICBC understands and supports such initiatives, and has adopted a safety advocate role to promote the safer accommodation of these vulnerable road users.

- Transportation planning projects should reflect a balanced multi-modal perspective, leading to informed decision-making on road safety considerations for all transportation modes (not only for cyclists and pedestrians).

- A number of policy issues have been identified, the content of which could have significant impacts on the outcome and effectiveness of the planning activities. Although ICBC has developed interim approaches for most of the issues, it is recognized that significantly more thought, and probably research, are still required.

- An important reality is that safer pedestrian and bicycle planning are evolving sciences. There are no "cookie-cutter" approaches for planning the provision of the "safest" facilities. An important strategy to achieve safer bicycle and pedestrian planning is one of empowering practitioners in the application of evolving state-of-art knowledge.

- There is still a lot of knowledge to be gained on safer planning techniques for vulnerable road users. ICBC is promoting joint research and development programs as a means of generating the resources required to bridge the knowledge gaps.

A-5-2/8

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A-5-3 | 1

The Right Way To Build Bicycle Facilities

Abstract

National bicycle design guidelines provide good, basic guidance for the design of bicycle facilities. However, these guidelines do not address many important aspects of bicycle facility design. This paper supplements current design guidelines by providing guidance for key design issues — those which directly affect the form, function and success of a project. Designers can use the information in this paper in combination with national and local bicycle facility design guidelines to confidently design, construct and maintain bicycle facilities, in a manner which minimizes costs, minimizes potential liability, and maximizes the effectiveness of the bicycle facilities.

ITE Quad 2001 Conference
April, 2001
Vancouver, BC

Richard Drdul, P.Eng., PTOE
Community Transportation Planner
Urban Systems Ltd.
Vancouver, BC

The Right Way To Build Bicycle Facilities

The public wants bicycle facilities. People want safe places to ride for recreation and to travel to work or to the store. Municipal Councils know this, and as a result transportation engineers are being asked to design and maintain bicycle facilities. Many professionals have little or no experience with bicycles, however, and may not feel prepared nor qualified to tackle a bicycle facility design. Or worse, they may go ahead and design a bicycle facility that appears to meet current guidelines, but in fact contains many problems.

Bicycle facility design guidelines prepared by the Transportation Association of Canada (TAC) and by AASHTO in the U.S. provide a good starting point, but do not address many important aspects of bicycle facility design. This paper is intended to complement TAC and AASHTO guidelines by providing guidance for key design issues — those which directly affect the form, function and success of a project. It is not intended that this paper be a comprehensive review of bicycle design standards — designers should refer to appropriate guides and design documents for more detailed information. Rather, the intent is to enable transportation engineers to confidently design, construct and maintain bicycle facilities, in a manner which minimizes costs, minimizes potential liability, and maximizes the effectiveness of the bicycle facilities.

Types of Bicycle Facilities

There are five types of bicycle facilities commonly used in urban areas:

- Shared routes generally follow local streets, rather than collector or arterial roads. Because traffic volumes and speeds on these streets are low, cyclists and motorists can safely share the road without the need for dedicated space for bicycles.
- Marked wide curb lanes (MWCL's) are used on collector and arterial roads where it is desirable to provide space for bicycles. The additional lane width provides sufficient space for an automobile to safely overtake a cyclist without crossing into the adjacent or oncoming traffic lane.
- Bicycle lanes (BL's) are separate travel lanes designated for the exclusive use of bicycles. In most cases, they are located at the right side of the road.
- Paved shoulders are used by cyclists on roads without curbs, typically on highways and roads in rural areas.
- Multi-use pathways are off-street facilities used by a variety of users — cyclists, pedestrians, disabled persons, in-line skaters, equestrians, people with pets and people pushing strollers.

It is important to select the right type of bicycle facility for the circumstances. A common mistake is to implement bicycle lanes in conditions where they are not appropriate, and which are better-suited to marked wide curb lanes. In extreme cases, the result of this mistake is bicycle lanes of sub-standard width, unnecessary removal of on-street parking, and conflicts at intersections. **Table 1** provides a summary of appropriate conditions for each of the four types of on-street facilities.

Table 1 — Applicability of On-Street Bicycle Facilities

	Shared Routes	Marked Wide Curb Lanes
Appropriate Conditions	• Local streets • Posted speed 50 km/h or less • Low traffic volumes • With or without on-street parking • With or without traffic calming	• Arterial and collector roads with curbs • Posted speed 50 km/h • Moderate traffic volumes • Frequent turning vehicles • Frequent stopping buses • On-street parking
Examples	• Local streets in grid or redundant street network • Parallel to major road corridors	• CBD roads • Arterial road in commercial area with parking • Two-lane arterial road with low to moderate volumes

	Bicycle Lanes	Paved Shoulders
Appropriate Conditions	• Arterial roads with curbs • Posted speed 60 km/h or more • High traffic volumes • Few turning vehicles • Few stopping buses • No on-street parking	• Arterial and collector roads without curbs • Posted speed 50 km/h or more • Moderate to high traffic volumes • With or without bus stops • No on-street parking • Separate sidewalk for pedestrians
Examples	• Suburban arterial road with access management, bus bays and no parking • Urban highway • Bridge	• Rural highway • Urban arterial road without curbs

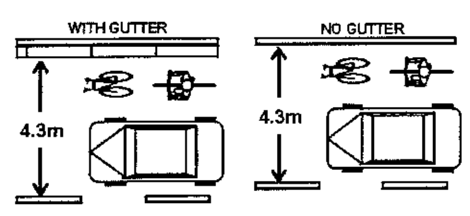
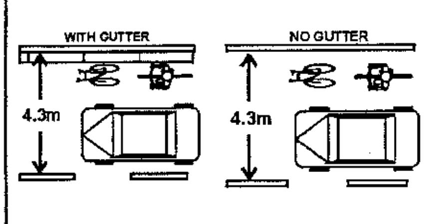
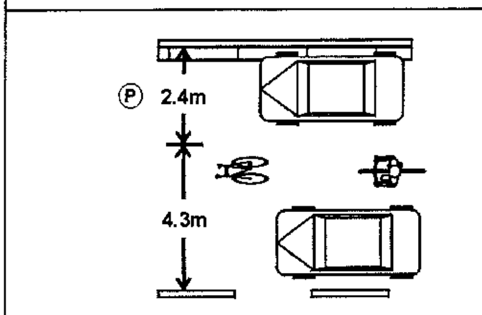
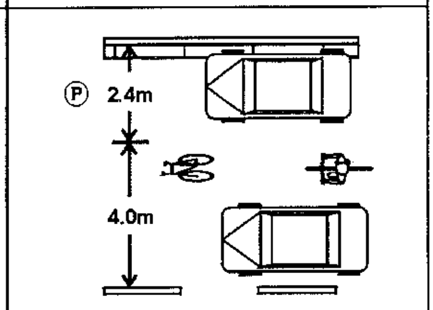
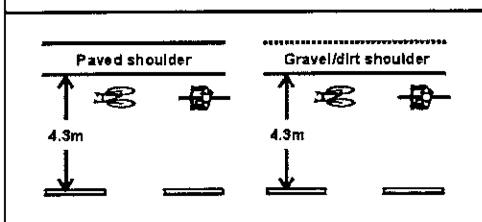
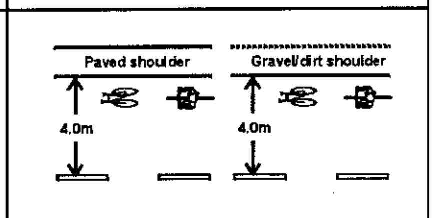
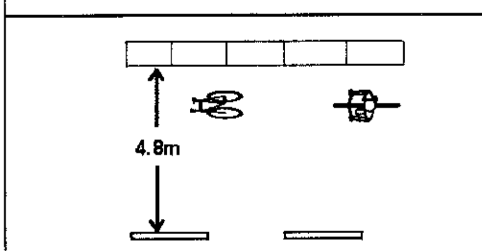
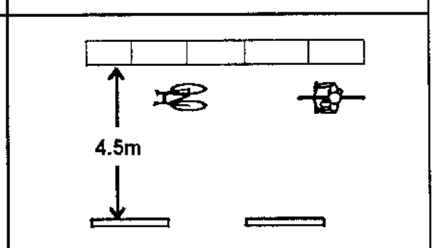
Marked Wide Curb Lanes

As described above, marked wide curb lanes are appropriate for many arterial and collector roads, and offer the best opportunity for retrofitting existing roadways with bicycle facilities. National guidelines suggest that an appropriate width for MWCL's is 4.3 m, but provide little additional guidance as to how MWCL's should be implemented in various conditions.

The most important point regarding MWCL's is that the specified width should not include the width of the gutter, which typically is 0.3 to 0.5 m wide. On most roads, the gutter represents a hazard to cyclists due to an uneven joint between the asphalt road and the concrete gutter, and due to accumulated debris in the gutter. Consequently, cyclists do not consider the gutter usable road space, and ride some distance away from the gutter.

Often it is not possible to achieve a 4.3 m width for a MWCL in a retrofit situation. **Figure 1** illustrates the full recommended MWCL width for different road conditions, and a reduced minimum width for retrofit situations. It is important to note that any widening of the travel lane benefits cyclists, and should be pursued where possible. However, only in cases where the width meets the minimum guidelines illustrated in **Figure 1** should the lane be marked with bicycle symbols.

Figure 1 — Guidelines for Marked Wide Curb Lanes

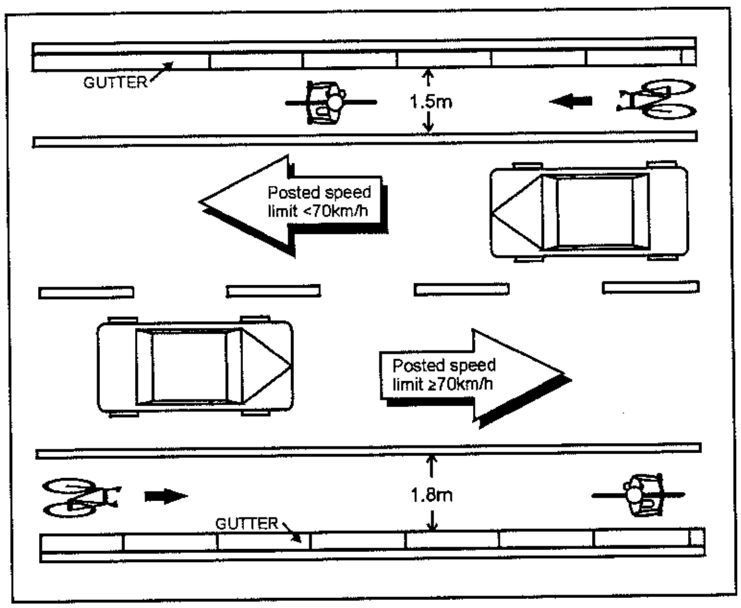
Recommended Widths	Applications	Minimum Widths
	Curb (with or with-out gutter)	
	On-street parking	
	No curb	
	Barrier (e.g. No-post, wall or railings)	
No extra space required for bicycles	Left turn lanes, right turn lanes, auxillary lanes	

Bicycle Lanes

As with MWCL's, the width of a bicycle lane should not include the width of the gutter. A key design consideration is how wide the bicycle lane should be. The minimum width of a bicycle lane is 1.5 m, as illustrated in **Figure 2**. On roads with posted speeds of 70 km/h or more, bicycle lanes should be at least 1.8 m wide.

The other challenge in designing bicycle lanes is correctly orienting bicycle lanes approaching and through intersections. Bicycle lanes should always be oriented to accommodate through travel — cyclists turning right or left will leave the bicycle lane to use the appropriate turn lane. At intersections with unusual configurations, it is often advisable to continue the bicycle lane through the intersection using dashed lines, to guide cyclists and to alert motorists to the presence of bicycles.

Figure 2 — Bicycle lane widths



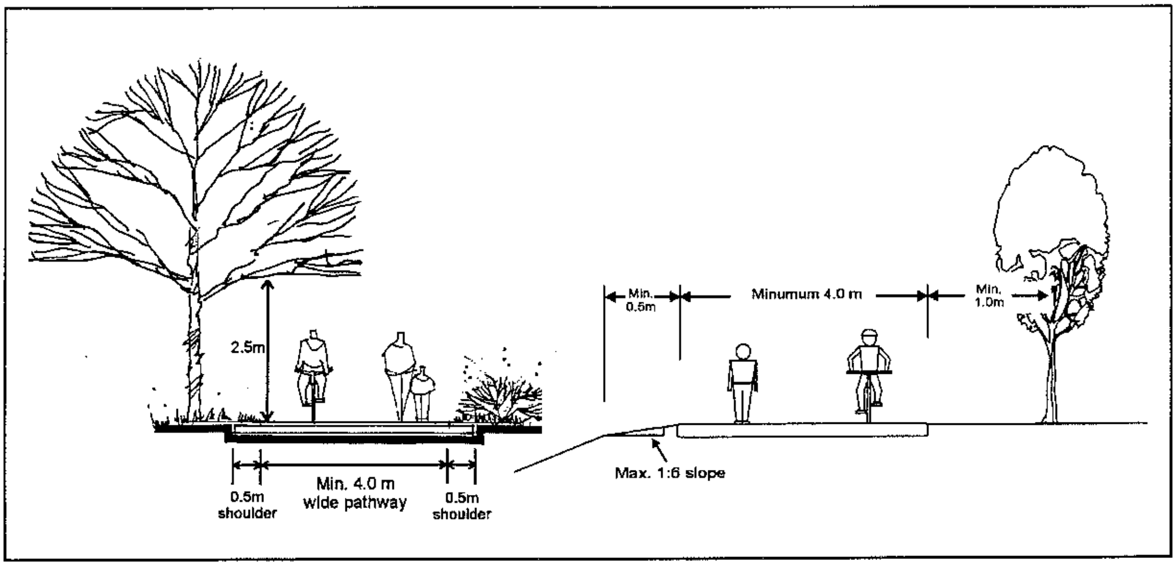
Off-Street Pathways

It is far more difficult to design an off-street pathway than it is to design an on-street bicycle facility. However, few designers realize this, and as a result many important design considerations are often overlooked.

All pathways, even those built solely for bicycles, will attract pedestrians, runners, wheelchair users, people with strollers, in-line skaters, equestrians, dogs and other animals.

The primary design challenge is accommodating all of these users, whose speeds may range from less than 4 km/h to over 50 km/h. This is best accomplished by ensuring that the pathway is wide enough. As illustrated in **Figure 3**, the minimum recommended pathway width is 4.0 m. This might appear to be far wider than necessary, but most agencies have found that on all but the lest-used pathways, anything less than 4.0 m is too narrow. Some agencies have widened pathways to as much as 7.0 m.

Figure 3 — Multi-Use Pathway Dimensions



Other key pathway design considerations include:

- Maximum uphill grades should not exceed 3% for sustained sections, or 5% for more than 30 m, or 10% for more than 15 m.
- Sight distances should be determined based on minimum design speeds of 35 km/h for pathways on level ground, and 50 km/h for pathways with grades of more than 3%. The corresponding minimum horizontal curve radii are 35 m and 80 m, respectively.
- The vertical clearance to tree branches and other objects should be a minimum of 2.5 m above the pathway surface. In underpasses and under structures more than 2.0 m in length, the minimum vertical clearance should be 3.0 m.
- Horizontal clearance should be 1.0 m to any object more than 150 mm in height, and a minimum clearance of 0.5 m should be provided to the top of a side slope.
- Side slopes should not be steeper than 1:6, or else a safety railing should be used.
- Safety railings should be 1.4 m high, with a 200 mm rub rail centred at a 1.0 m height to prevent the ends of handlebars from catching on vertical supports.

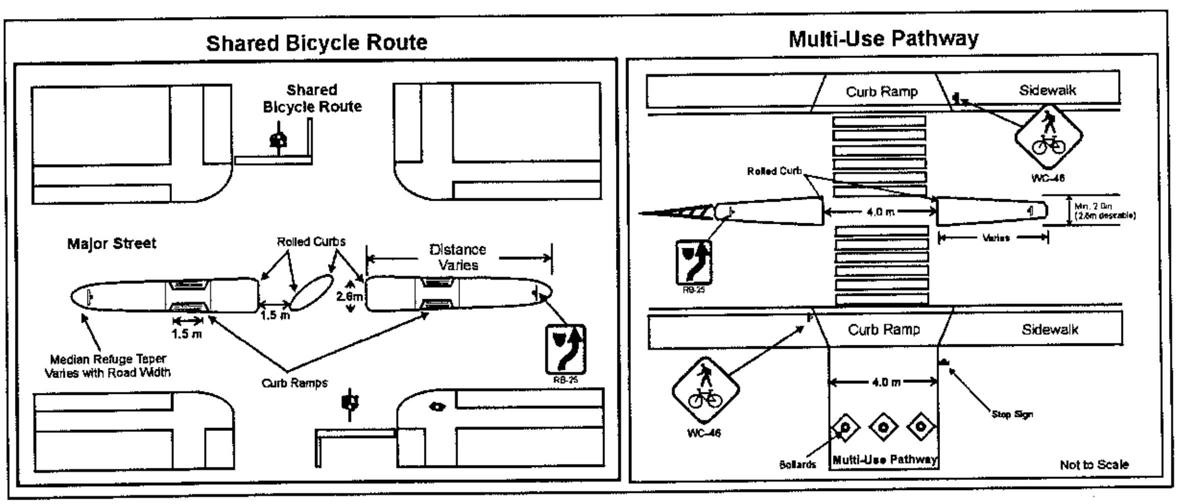
- Bicycle baffles or gates should not be used at pathway access points. Instead, bollards should be used in odd numbers (one, three or five).

Crossings

Where pathways and bicycle routes on local streets intersect arterial and major collector roads, it is typically necessary and desirable to provide some form of crossing to assist cyclists, pedestrians and others in crossing major roads, and to minimize potential conflicts with motor vehicles.

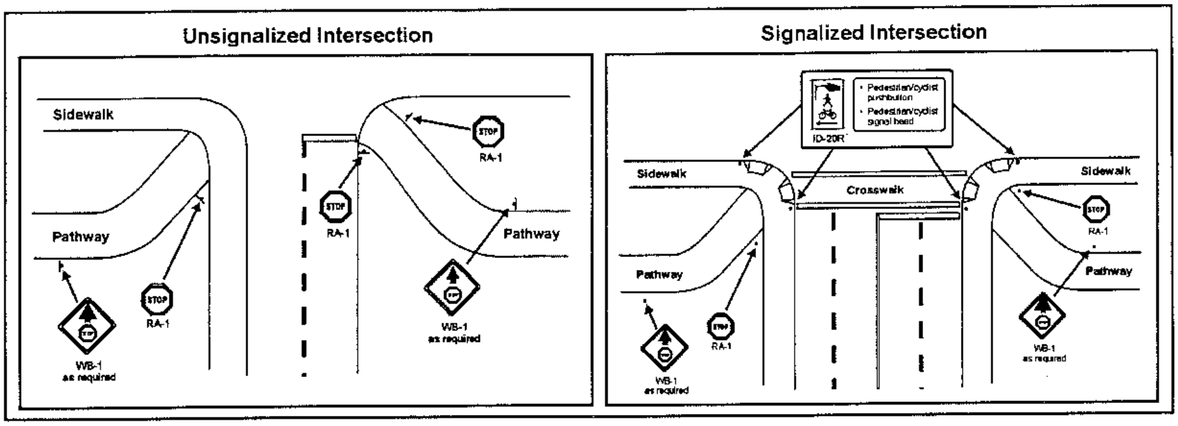
Raised median islands enable cyclists to cross one direction of traffic at a time, rather than having to wait for a gap in both directions of traffic flow. This reduces delays to cyclists, and increases safety for cyclists by increasing the visibility of the crossing to motorists. Raised median island crossings are illustrated in **Figure 4**.

Figure 4 — Raised Median Island Crossings



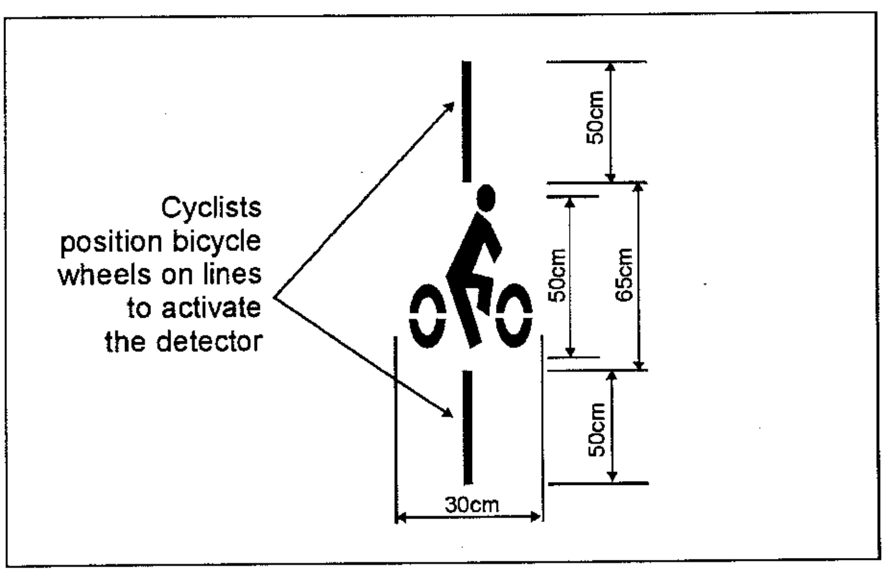
Where pathways are located parallel to a roadway, crossings should be located as close to an intersection as possible. **Figure 5** illustrates how pathways should be oriented at unsignalized and signalized intersections in order to maximize the visibility of approaching pathway users to motorists.

Figure 5 — Parallel Pathway Intersections



Traffic signals can be activated by either a cyclist push-button located adjacent the curb (supplementing the pedestrian pushbuttons), or by an in-pavement loop detector. Where a loop detectors exists, it should be marked as illustrated in **Figure 6** with a symbol identifying the "hot-spot" where cyclists can situate their bicycles to activate the signal.

Figure 6 — Loop Detector Pavement Marking



A-5-3/9

Signs and Pavement Markings

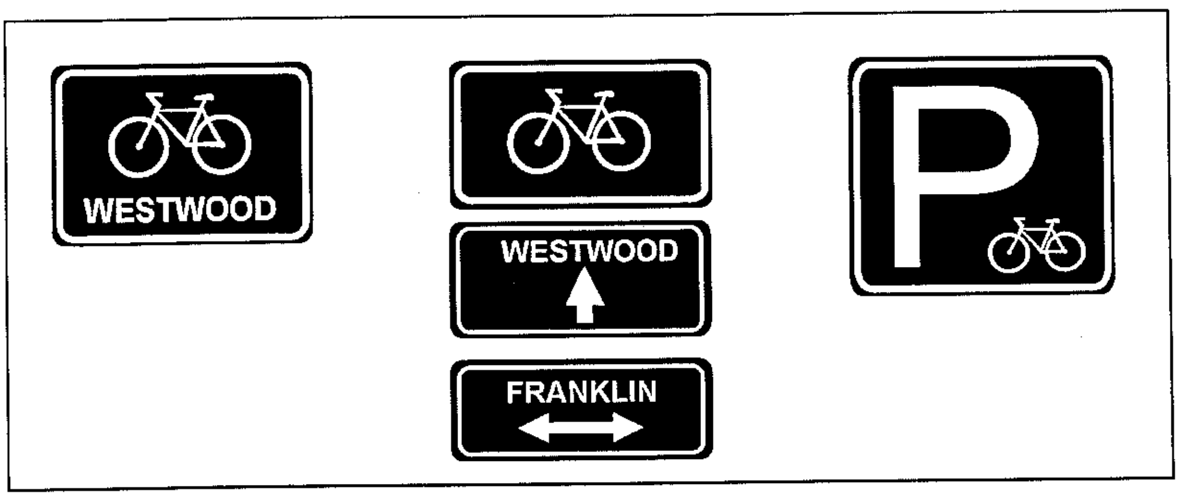
Signs and pavement markings should be installed along bicycle routes in a consistent manner to maximize clarity and safety, and avoid confusion for motorists and cyclists. Many designers consider regulatory signs, but overlook the need for warning signs and particularly guide signs.

Warning signs should be used in the following situations:

- To identify hazardous conditions, including temporary hazards. This is particularly important, as bicycles are more susceptible to poor road conditions than motor vehicles.
- In locations where an on-street bicycle facility narrows or ends.
- In advance of grades exceeding 10% for more than 15 m, or exceeding 5% for more than 30 m.
- To advise motorists of bicycle crossings.

Guide signs should be used to indicate continuation of bicycle routes, to identify intersections with other bicycle routes, and to identify major destinations and bicycle parking locations. Examples of guide signs are included in Figure 6.

Figure 6 — Guide Signs



Maintenance

Unfortunately, many jurisdictions overlook the maintenance needs associated with bicycle facilities, particularly bicycle lanes and off-street pathways. Not only does this discourage cycling, but it also creates a significant liability concern for municipalities. A bicycle program should incorporate a regular maintenance program, including:

- **Sweeping** is the most common maintenance need. Bicycle lanes and multi-use pathways should be regularly swept of debris in order to minimize the potential for slippage and punctured tires, and to maintain visibility of pavement markings.

- **Repainting of pavement markings** should be undertaken periodically to maintain visibility and clarity. Additionally, bicycle route signage should be inspected regularly to ensure that signs have not been damaged, removed, obscured or oriented incorrectly.

- **Pruning.** For multi-use pathways, the periodic pruning of adjacent vegetation is required to maintain the clear width of the pathway, as well as sight distances. Pruning of vegetation is also important for maintaining visibility at intersections along on-street bicycle routes.

- **Pavement repair.** Regular inspection and repair activities should be undertaken as needed to eliminate cracks, potholes, bumps and other surface irregularities.

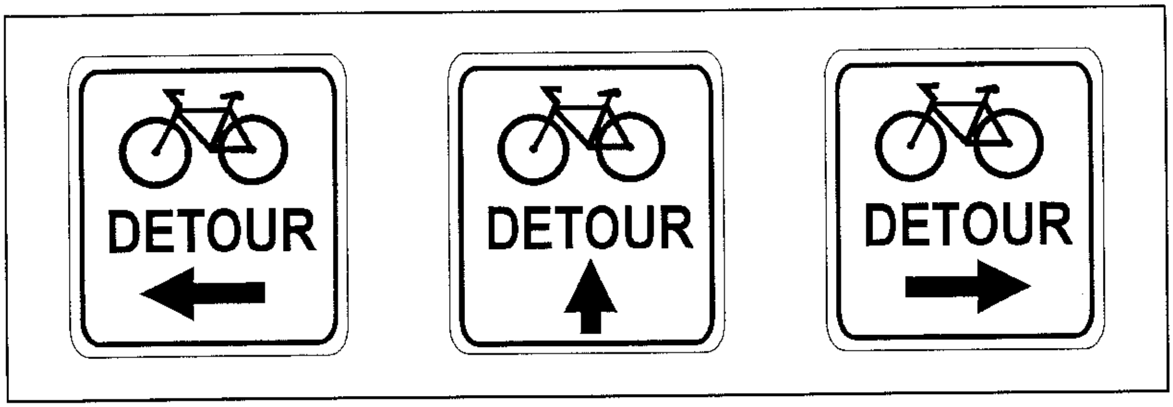
- **Pavement overlays** on bicycle routes should be inspected to ensure that no ridges or cracks are left in the area where cyclists ride.

- **Drainage facilities** along bicycle routes should be periodically inspected to ensure that they are properly diverting storm water, and that ponding is not occurring. The elevation of catchbasins should be within 10 mm of the pavement surface, and any change in elevation should occur over a 300 mm distance.

- **Snow removal** should be undertaken on primary bicycle routes and pathways — in the same manner as primary traffic routes are cleared of snow — to permit cycling in winter.

- **Accommodating cyclists during road construction**. During road construction projects, roadways are often narrowed and space for bicycles eliminated, or warning signs and other objects are placed at the side of the road, obstructing cyclists. As with motor vehicles, convenient detours must be provided for cyclists. Examples of bicycle detour signage are illustrated in **Figure 7**.

Figure 7 — Bicycle Detour Signs



A-5-3/12

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Bike Lane Facility on an HOV Direct Access Interchange:

Prepared by:

Thomas F. McDonald, P.E.
Sr. Transportation Engineer
David Evans and Associates, Inc.
415 – 118th Avenue SE
Bellevue, WA 98005-3518
425.519.6500

Eric Widstrand, P.E.
Senior Traffic Engineer
David Evans and Associates, Inc.
415 – 118th Avenue SE
Bellevue, WA 98005-3518
425.519.6500

David Godfrey
Transportation Engineering Manager
City of Kirkland Public Works Department
123 Fifth Avenue
Kirkland, WA 98033-6189
425.828.1214

Michael Dornfeld
Bicycle and Pedestrian Program
Washington State Department of Transportation
PO Box 47393
Olympia, WA 98504-7393
360.705.7258

ABSTRACT:

The project proposes to construct an HOV direct access connection from I-405 to a new bridge structure over I-405 in the City of Kirkland, Washington. The new connection will provide in-line flyer stops for transit moving north/south on I-405. It will also provide connections to an existing 500+ park-and-ride lot on one side and a separate transit center on the other side of the freeway. The new bridge over I-405 is proposed to carry six 12-foot lanes, two 5-foot bike lanes, and up to 20-foot sidewalks for pedestrian access to the park-and-ride lot and transit center. The six-lane facility connects a three-lane roadway (one lane in each direction with a left turn lane) on each side of the freeway.

The issue examined in this paper is how bicycle facilities are combined with HOV direct access, transit flyer stops, local transit and pedestrian facilities on a structure 500 feet long and which has three signalized intersections.

March 2001

Background

The Kirkland HOV Direct Access project was originally identified in the Puget Sound HOV Pre-Design Study lead by the Washington State Department of Transportation in the mid to late 1990's. Its purpose was to provide inside lane HOV access to and from the I-405 freeway in the Totem Lake area of Kirkland. A major benefit of providing this connection was speed and reliability for HOV and transit using the HOV lanes on I-405. In 1996, the voters approved the creation of a Regional Transit Authority, now called Sound Transit, to provide funding for design and implementation of regional mass transit that included commuter rail, light rail, and express bus services. Regional Express, Sound Transit's bus service, is providing the funding for the design and construction of the facilities now in preliminary engineering.

A portion of this project overlaps with local plans. In 1995, the City of Kirkland's Non-Motorized Transportation Plan was adopted by the City Council. This Plan identified a connection across I-405 at NE 128th Street as a high priority for both pedestrian and bicycle travel. In 1996, a project to construct a bicycle and pedestrian bridge was placed on the Capital Improvement Program (CIP) to be funded in 1999. It was eventually moved to the unfunded portion of subsequent CIPs with the hope of funding the project through grants.

Project Description

The proposed project is located between the NE 124th Street interchange to the south, and NE 132nd Street to the north (see Figure 1). NE 124th Street is a heavily congested crossing and interchange with I-405 having no sidewalks or bicycle accommodation. Conflicts between bicycles and vehicles at the freeway interchange are perceived to be a problem by the community. NE 132nd Street is a two lane street crossing under I-405 with 5 feet wide sidewalks on both sides. No additional width is provided for bicycle lanes. The width of NE 132nd Street is constrained by pier columns for I-405. The fact that neither NE 124th Street nor NE 132nd Street could serve as a viable alternative for bicycle travel gave rise to the City project at NE 128th Street mentioned earlier. This also led the project team to attempt to bring the City's proposed bike and pedestrian crossing to the HOV direct access facility and bridge NE 128th Street.

Initial assessment of the direct access project included consideration of over 15 potential locations during a two-day design alternative brainstorming meeting. Other locations considered for direct access included both NE 124th Street and NE 132nd Street. Through subsequent levels of screening, NE 128th Street was found to be the preferred location to provide HOV direct access to and from the freeway. The benefits of this location include connections to an existing park-and-ride, employment in the immediate area, including the expanding Evergreen Hospital and Totem Lake Mall, and an opportunity to provide additional general purpose (GP) capacity over I-405 to relieve NE 124th Street and NE 132nd Street. Additional GP capacity to the overcrossing brought the proposed width of the overcrossing from 4 to 6 lanes.

A-5-4/3

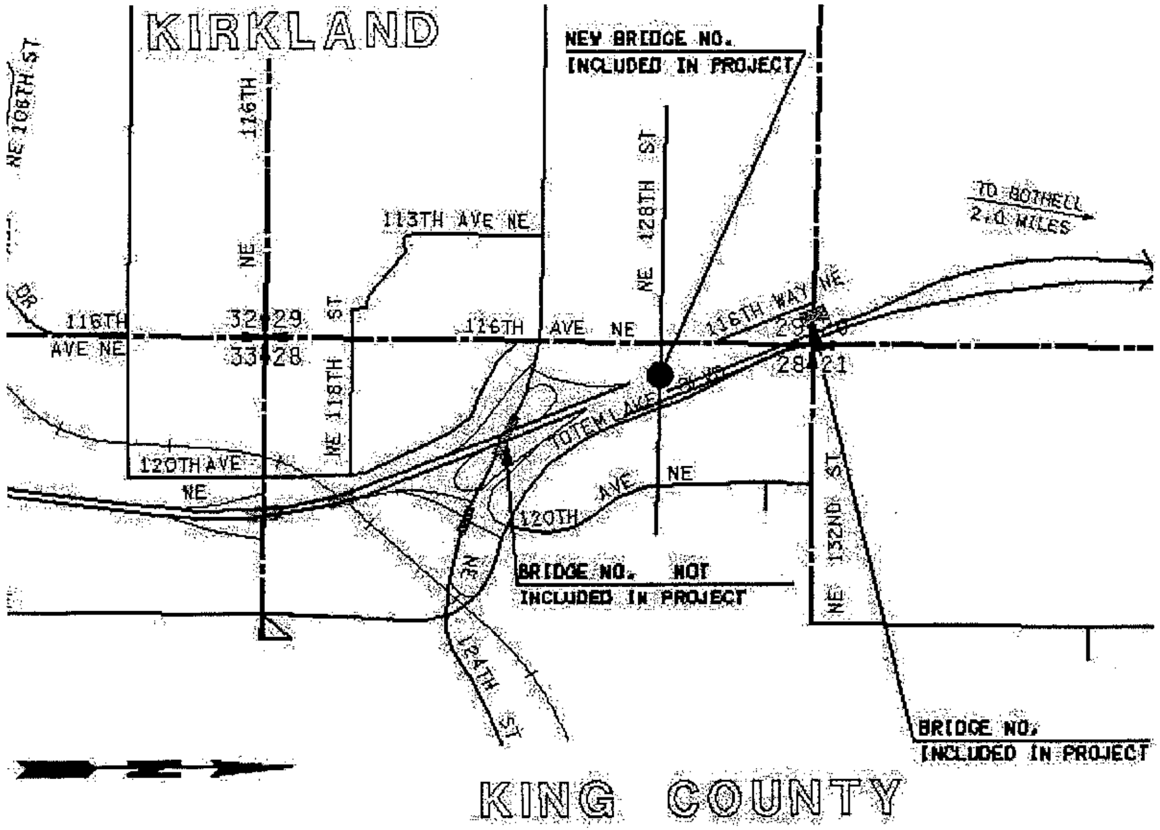

Figure 1 – Vicinity Map

During the early stages of the Sound Transit work in Kirkland, citizens and elected officials made it clear that they were interested in keeping a strong non-motorized connection across the new HOV facility. As the NE 128th Street location emerged, that desire was translated into a request for bike lanes.

The proposed HOV direct access connection provides both transit and HOV access to and from the northbound and southbound lanes. For express transit operations that operate along I-405, in-line transit stations are included. This allows transit to stop on the ramps to drop and pick up passengers, travel though the intersection and continue back onto I-405. Travel time is saved by transit that does not have to exit the freeway system to pick up passengers. Local transit will operate from a proposed transit center located east of I-405, or from the park-and-ride on the west side. Additionally, transit stops are provided on the overcrossing to bring local routes closer for transfer between regional and local service.

After the project is constructed, there will be three signalized intersections located within 500 feet of each other. A signal will control the ramps to the freeway and a signal will be located at the north-south streets at each end of the bridge. The new direct access ramps signals will operate with split phasing. 116th Avenue NE to the west is signalized, and Totem Lake Boulevard to the east is signalized; both of these also operate on a split phasing. The 2005 volumes for right turn movements, those that will affect the through movement for bicyclist the most are shown in Figure 2.

Options for Accommodating Bicycle Travel

One option to accommodate bicycles was widen to the outside lane, not provide a striped bike lane. With local transit service stopping in the lane to drop/pick up passengers, the bicyclist would have to move around the bus, and possibly into conflict with cars trying to change lanes to pass the buses. Additionally, vehicles make right turns onto the direct access ramps (transit and HOV) and the right lane on each respective end becomes a "right turn only" lane. This arrangement would require that a great deal of caution be exercised by both motorists and cyclists to avoid one another's turning movements.

The City of Kirkland, Washington State Department of Transportation, and a representative of King County Metro Transit looked at three options for providing a striped bike lane instead of a widened outside lane. These alternatives are represented in Figures 2, 3 and 4, respectively.

Alternative 1 (Figure 3) provides a striped bike lane on the curb edge of the outer travel lane. A bicyclist traveling along NE 128th Street along the outside edge of the road approaching the proposed bridge crossing continues on the outside edge across the structure. The advantages of this alternative are normal driver expectations that cyclists are to their right, and remain on the right side of the travel lane. A disadvantage of this alternative is the right turning movement conflicts at the direct access ramps and the following street intersection, where the outer lane becomes a "right turn only" lane.

Alternative 2 (Figure 4) provides a striped bike lane between the outside through/right turn lane and the middle through lane. A cyclist traveling along NE 128th Street along the outside edge of road approaching the proposed bridge crossing will continue onto the bridge in their own lane with right turning traffic on their right. The advantages of this alternative are the removal of right turning vehicle conflicts with bicycles at both the direct access ramps and the following intersection, and the lane continuity for the cyclist as they cross the bridge. A disadvantage of this alternative is that driver's expectations may be violated with a bike lane between vehicle travel lanes.

A-5-4/5

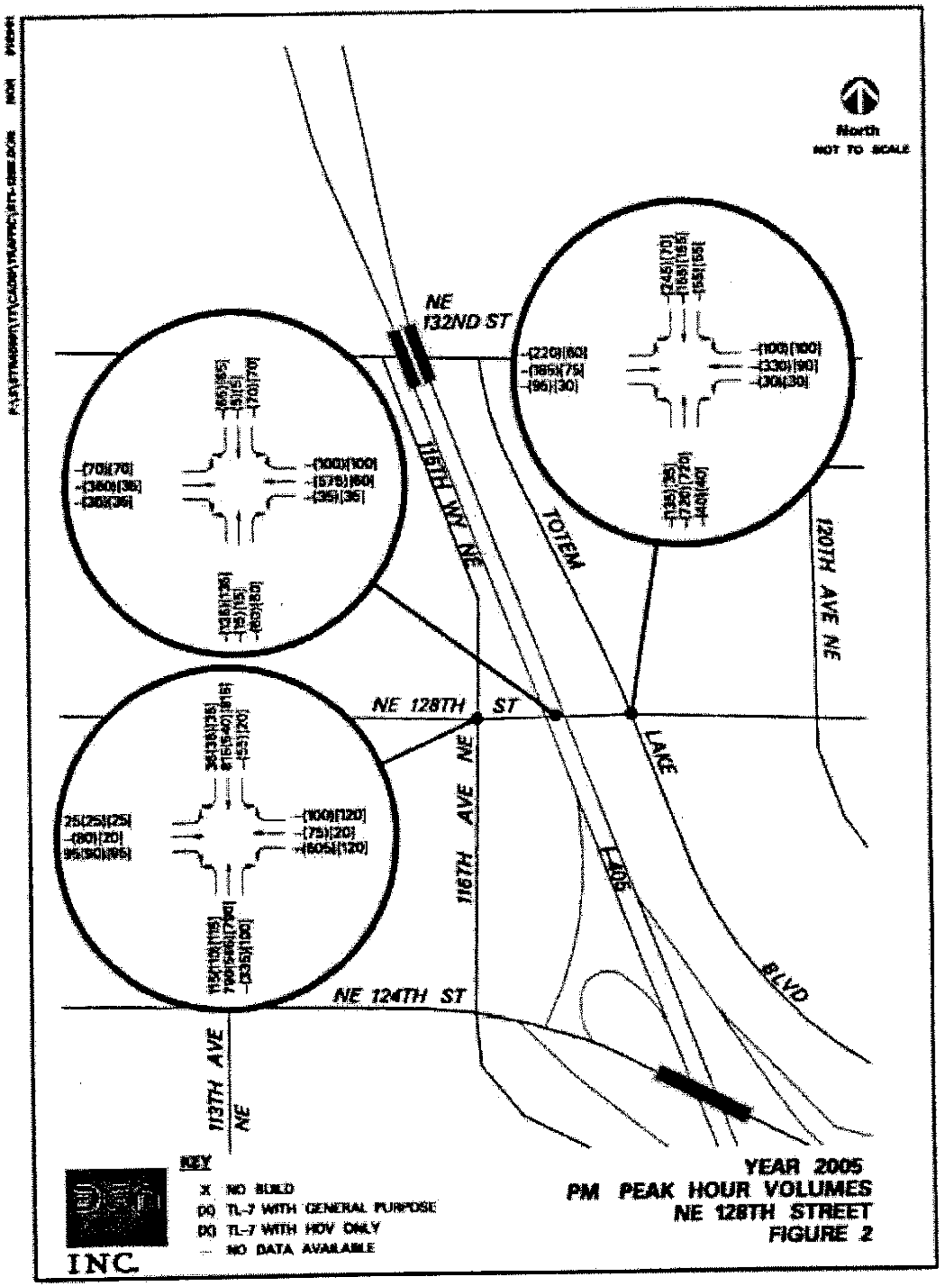

Figure 2 – 2005 PM Peak Hour Volumes

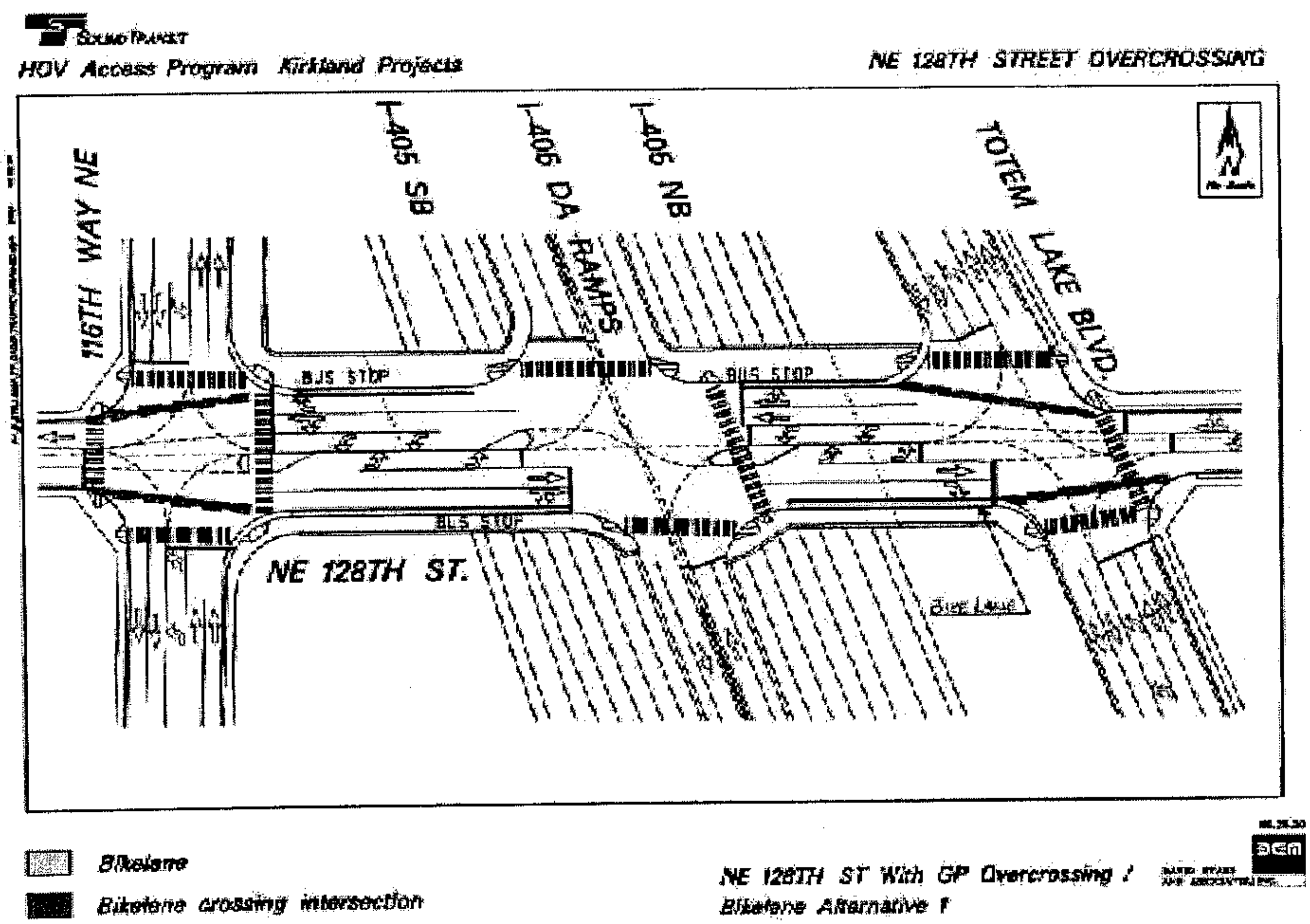

Figure 3 – Alternative 1

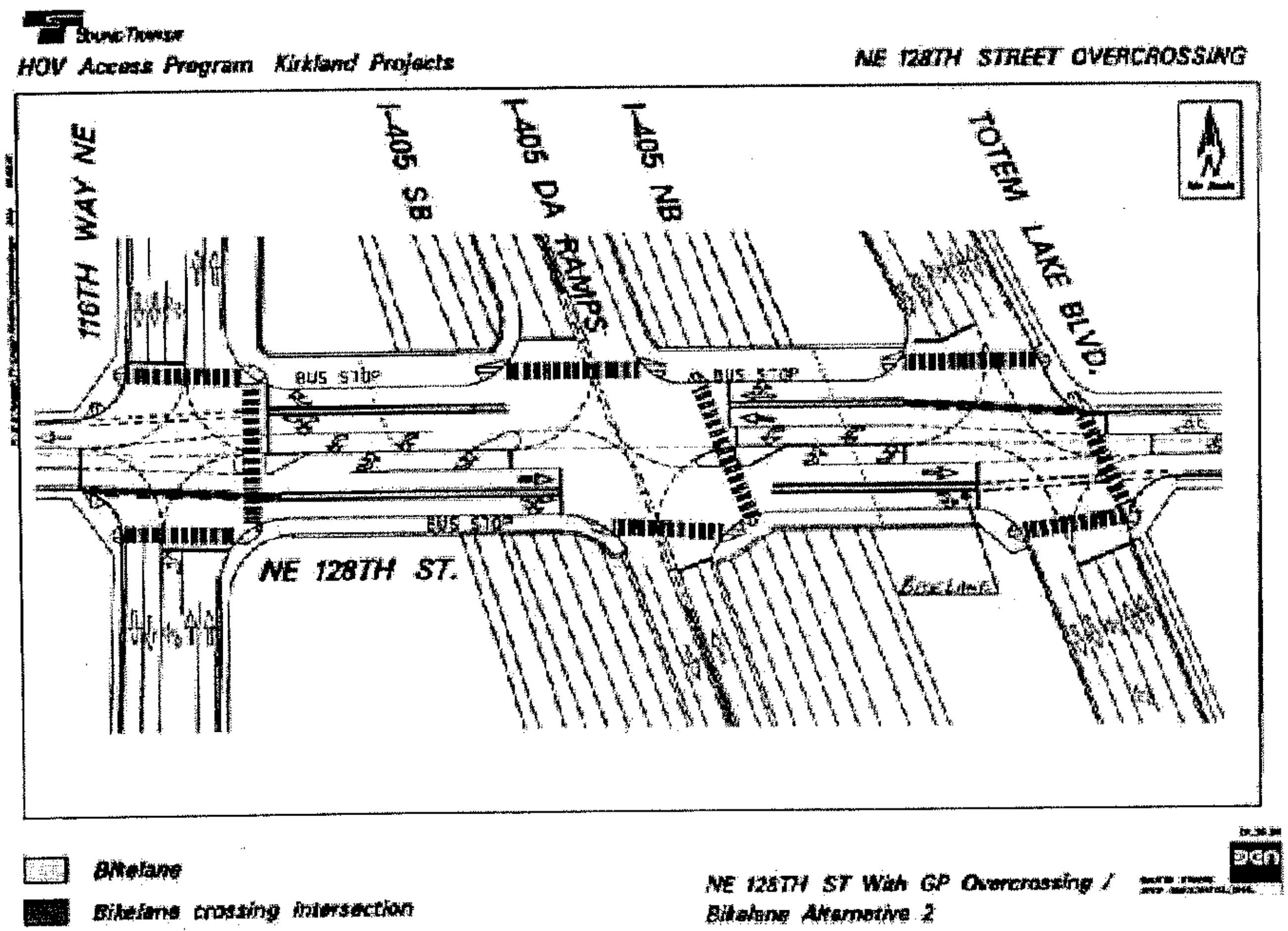

Figure 4 – Alternative 2

A-5-4/7

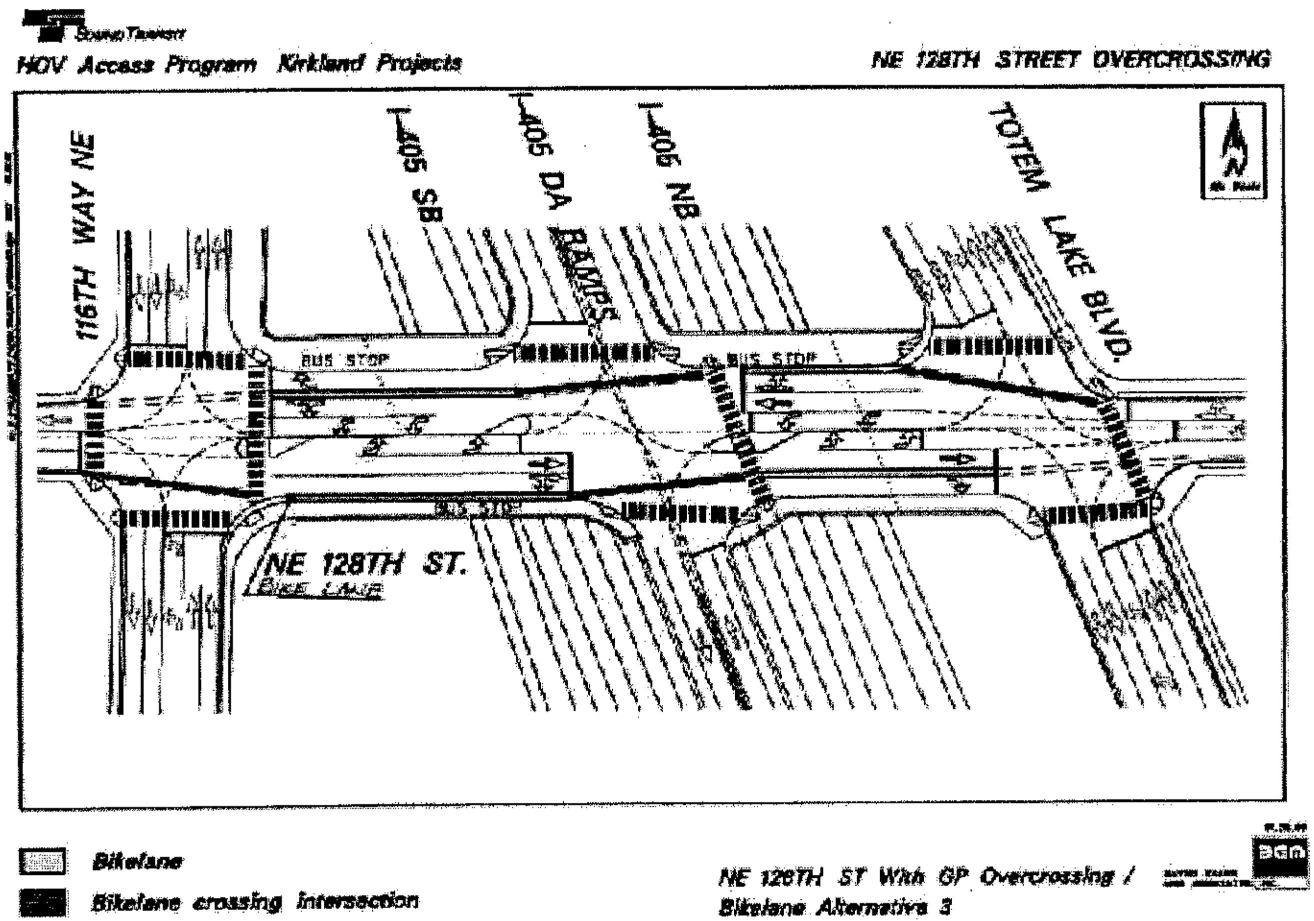

Figure 5 – Alternative 3

A-5-4/8

In Alternative 3 (Figure 5), a striped bike lane is on the outside for half of the bridge, before it transitions to a location between through lanes after the direct access intersection. The advantage of this option is that the cyclist is kept to the right for a portion of the bridge where the outside lane can make a right turn or travel through the direct access intersection. The disadvantage of this option is it introduces additional bicycle lane change movements that create potential conflict and confusion for both bicycle rider and vehicle driver unfamiliar with this location.

The City of Kirkland had requested that blue pavement marking be used to denote the bike lanes. This idea was later dropped pending more information on work being done by the City of Portland, and the WSDOT's reluctance to experiment at this particular location.

Conclusion

Alternative 2 is being carried forward as the preferred alternative. The main reasons for this was continuity across the bridge. The bicycle rider's expectation approaching the bridge structure was a visible lane relative in-line of sight to their approach lane. Once on the overcrossing the bicyclist did not need to negotiate additional maneuvers or lane changes. Additionally, all the right turning vehicle traffic was on the right side of bicyclist, eliminating the right turn conflict. Additional signing will be used to warn both vehicle traffic and bicyclists of the lane designation to help reduce the chance for confusion.

A-5-4 / 10

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Paper Title: Target Zero, a strategic plan for highway safety--the implementation stage

Author and Affiliation: Sandra Pedigo-Marshall,
Traffic Program Planner, Washington State Department of Transportation Traffic Operations Office

Abstract: Washington State is a leader in traffic safety. In the past 10 years, our state noted its lowest annual fatalities rates since record keeping began almost a century ago. Target Zero, a strategic plan for highway safety, represents a collaborative push toward eliminating deaths and disabling injuries on our state and local highways. Target Zero identifies 12 emphasis areas and supports the implementation of over 65 action strategies.

What is Target Zero?

On July 22, 1999, Washington Traffic Safety Commissioners endorsed the development of a statewide strategic plan for highway safety called Target Zero. The Commissioners also identified a statewide planning committee made up of people with differing interests, skills and experiences in traffic safety.

Since that time, Target Zero Steering Committee members developed a vision statement, identified 12 emphasis areas, held nine subcommittee meetings, and created over 60 action strategies focused on traffic safety.

Target Zero represents a collaborative push toward eliminating deaths and disabling injuries on our state and local highways. The statewide plan provides measurable "traffic safety" goals and action strategies as a foundation for the development of new traffic safety projects and programs.

Who are the Target Zero Partners?

The Target Zero Steering Committee serves as statewide partners providing insight and ongoing dialogue throughout the planning process. The following partnerships represent state, local, and private traffic safety interests:

Department of Health
Washington State Department of Transportation
Office of Superintendent of Public Instruction
Department of Social and Health Services
Washington State Patrol
Staff for the House Legislative Transportation Committee
Washington Traffic Safety Commission
Association of Washington Cities
Local DUI Traffic Safety Task Force
Washington Trucking Association
AAA of Washington
Department of Licensing
Spokane County Engineers

The Steering Committee creates a statewide vision!

During the first Target Zero meeting, Committee members created the following statewide vision to realize, in year 2030, zero deaths and disabling injuries on our roads and highways:

We envision a safe and efficient surface transportation system with no deaths or disabling injuries.

What does the Steering Committee recommend?

Washington State will work to improve the safety of all roads and highways by focusing on the following 12 emphasis areas and key objectives:

Age Extremes • Identify those most at risk and develop specific crash reduction programs.

Aggressive Drivers • Determine the frequency of road crashes related to aggressive driving and develop appropriate countermeasures.

Bicycle Safety • Develop programs and implement laws to make the roads safer for bicyclists.

Data and Technology • Require better programs for the collection and distribution of statewide traffic collision data.

Emergency Response • Set appropriate response times and training for emergency services.

Impaired Drivers • Discourage this as socially acceptable behavior.

Large Trucks • Increase enforcement and education, and encourage safe interaction between cars and large trucks.

Pedestrian Safety • Collaborate to design better pedestrian facilities.

Road Environment • Identify and maintain the overall quality and safety standards of the road, especially in high accident locations.

Safety Restraints • Focus on the proper use of child safety restraints, and increasing Washington's seat belt use.

Sleepy Drivers • Develop a better understanding of driving while fatigued and awareness of its dangers, and implement appropriate educational and engineering programs.

Work Zones • Develop programs to ensure the overall safety of motorists and road workers.

How can we get to Zero?

The Target Zero vision is for a safe and efficient traffic system with no deaths or disabling injuries by the year 2030! How can we get to zero?

Committee members looked at the following trends and historical information:

- In 1910 there were 21 fatalities on our state roads. But with fewer vehicles on the road, the fatality rate was over 64 deaths per 100 million vehicles miles traveled.
- In 1945 the fatality rate was just over 12 deaths per 100 million vehicles miles traveled.
- In 1999, with millions of vehicles miles traveled each day, the fatality rate is down to 1.2 deaths per 100 million vehicles miles traveled.

With safer vehicles, safer roads, and safer operators, the death rate can be reduced to zero.

What will it take?

Target Zero represents a collaborative effort push for no deaths and disabling injuries. Stakeholders have begun the process of identifying action strategies and developing performance measures. Grant programs and strategic plans have adopted the Target Zero vision statement and philosophy of "no deaths and disabling injuries." The following activities have begun:

- Stakeholder ownership of Target Zero
- Dedicating resources to implement Target Zero strategies
- Interagency and cross-jurisdiction collaboration in traffic safety
- Funding available to support Target Zero efforts

Target Zero will Save Lives!

Approximately 9,000 lives can be saved by the year 2030.

B-1-4/1

rWeather

Real-time Statewide Road & Weather Information Network

by

William W. Brown
WSDOT RWIS Project Manager

(206) 616-9183

Guy Coss
Washington State Governor Fellow

Bill Legg
Assistant ATB Program Manager

(206) 543-3332

Amy O'Brien
Information Specialist

(206) 685-2644

Washington State Transportation Center (TRAC)
&
Washington State Department of Transportation
Advanced Technology Branch

University District Building
1107 NE 45th Street, Suite 535
Seattle, Washington 98105
FAX: (206) 685-0767

ABSTRACT

The Washington State Department of Transportation (WSDOT) has begun the RWeather Program to collect and disseminate real-time and predictive statewide road and weather information. The program is being accomplished in two phases. In phase I, WSDOT is gathering all available data and developing better ways to more accurately predict detailed weather conditions. These high-resolution weather forecasts are then being integrated with information from road condition models developed for use in Washington State.

SUMMARY

Adverse weather conditions have a profound effect on the safety and efficiency of urban and rural travel throughout the United States. Whatever the weather—snow, ice, flooding, fog, dust, wind, or tornadoes—commercial vehicle operators, long distance travelers, transit operators, commuters, and others are directly affected. The end result is decreased visibility, vehicle stability, and surface friction, causing delays, incidents, and reduced pavement level of service. According to the U.S. Department of Transportation, approximately a third of all inter-urban road accidents occur during bad weather.

In addition, the economic costs of adverse weather to the nation are great, both in direct maintenance costs and indirect costs caused by roadway accidents and decreased roadway efficiency. The cost of snow and ice control in the U.S. and Canada alone is estimated to exceed $2 billion annually. According to studies, state and local governments could save as much as 10 percent, or $200 million, by making use of accurate real-time and short-term predictions of localized snow and ice conditions (1). Analysts have estimated that a 1-day highway shutdown caused by snow costs a metropolitan area between $15 and $76 million in lost salaries, sales, and taxes. Add to this cost such as higher insurance rates for drivers and liability suits against the state, and the price of adverse weather grows even higher. Costs are also associated with the impact that inclement weather has on the ability for businesses to receive or deliver inventories. Increased application of "just in time" inventorying systems means that companies need accurate real-time and predictive road and weather data, as well as improved snow and ice operations, to ensure that they have enough inventory to operate.

These problems suggest that a comprehensive, real-time or predictive system of collecting and disseminating statewide road and weather information would be extremely useful, with the potential to save lives and money. Various state and federal agencies have begun to investigate the development of such comprehensive systems, called road and weather information systems (RWIS). These RWIS are much broader in scope than the remote sensor roadway or runway information systems that many maintenance personnel are familiar with.

Washington State weather includes a mix of vastly different conditions, from the mountain passes to the coast, from the urban areas of the west side to the rural areas of the east side. The Washington State Department of Transportation (WSDOT) has embarked on the development of a comprehensive program for collecting and disseminating road and weather condition forecasts.

To respond to needs for road and weather information across the state, WSDOT has begun development of RWeather. This RWIS-based system includes ways to collect road data and weather condition forecasts and to prepare this information for use by WSDOT maintenance departments, as well as for advanced traveler information systems to aid the public.

Making use of atmospheric and road condition forecasts could reduce the cost of WSDOT's winter maintenance budget for snow and ice control, as well as other weather events. These localized reports need to be more than the general area reports available from weather services, the media, and even the National Weather Service (NWS). Maintenance supervisors need to have detailed reports on which stretch of roadway will receive ice or snow, how much snow will accumulate, and when the problem will occur so that specific resource decisions can be made.

This same set of collected road and weather data can also be used to address the safety and decision-making needs of travelers. Localized weather information for travelers could help decrease the adverse impacts that weather conditions have on roadway safety. According to a traveler needs survey conducted by the Western Transportation Institute (8), the majority of respondents said that they "predominantly worried about road conditions like ice and snow." Importantly, snow and ice storms are not the only weather related problems that highway departments and travelers need to know about. Any event that leads to reduced visibility, reduced traction, and/or debris over the road surface, such as wind and dust storms, flooding, and others, are of concern.

As citizens gain more access to existing and developing information technologies, they expect government agencies to provide them with access to a greater depth of information than ever before. In Washington State, comparisons are already being made to other states' levels of service, and demand is increasing for a statewide road and weather information system. On the national front, significant efforts are under way to develop such road and weather information systems. The RWeather project is working in conjunction with these groups reviewing their development efforts and coordinating with them where feasible.

The RWeather project is paid for by a $1.25 million grant from the U.S. Department of Transportation Federal Highway Administration (FHWA) and $312,500 from WSDOT. Bill W. Brown, Transportation Engineer with WSDOT's Advanced Technology Branch, is the RWeather project manager.

B-1-4/4

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B-2-5/1

The Setting of Speed Limits Along Fraser Highway in Surrey, British Columbia

by

Mr. Kanny Chow, B.A.Sc., G.D. Hamilton Associates

Submitted for the 2001 ITE Quad Conference, April 5-7

Abstract

The City of Surrey recently initiated a study along Fraser Highway to review and possibly change the current posted speed limits. The study considered various existing physical and vehicle speed characteristics, and the safety risk associated with inappropriate vehicle speeds. In addition, comments collected from the City, the RCMP detachment in Surrey, and the public were reviewed. Based on an extensive literature review, several different methods of determining an appropriate posted speed limit were found, studied, and evaluated for their relevance. Using these speed limit setting methods and the collected input, an appropriate speed limit along Fraser Highway within the City of Surrey was determined.

Introduction

The City of Surrey recently initiated a study along Fraser Highway to review and possibly change the current posted speed limits. Hamilton Associates completed the study. This paper reviews the methodology, findings, and results of the study. The study considered existing physical and vehicle speed characteristics, vehicle travel efficiency, and the safety risk associated with inappropriate vehicle speeds. In addition, comments collected from the City, the RCMP detachment in Surrey, and the public were reviewed.

Study Corridor

The study corridor includes Fraser Highway in the City between 168th Street to the west and 194th Street at the City of Langley border to the east, as shown in FIGURE 1. The length of the study corridor is approximately 6.7 kilometres. The corridor is in primarily rural and low density suburban areas, and connects the City of Langley to the east and the Fleetwood urban area to the west. The corridor typically provides one travel lane and a paved shoulder in both directions. The section east of 192nd Street provides two travel lanes in each direction. There are also several sections where two lanes are provided.

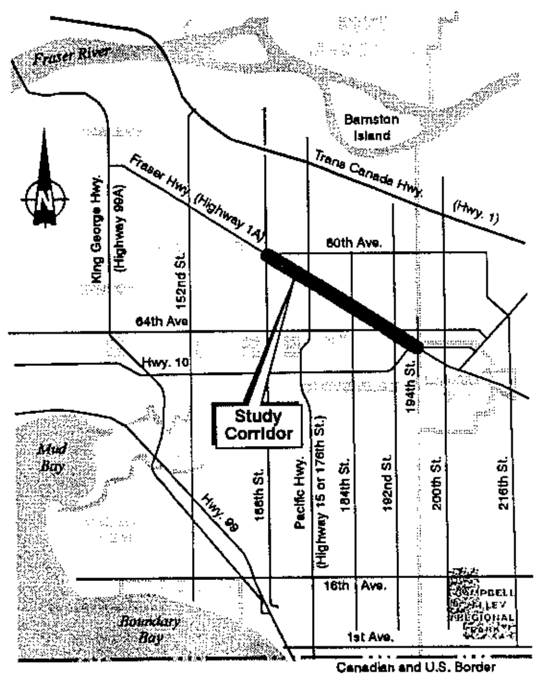

FIGURE 1 STUDY CORRIDOR

There are five fully signalized intersections at 168th Street, 176th Street, 184th Street, 64th Avenue, and 194th Street. Most signalized intersection approaches provide advanced warning flashers. Other intersections are two-way STOP-controlled, with Fraser Highway forming the major street for all unsignalized intersections.

The existing posted speed limits along the study corridor are shown in FIGURE 2, and ranges between 50 kilometres per hour and 80 kilometres per hour. The speed limits at each end of the corridor are lower than the middle section due to their proximity to urban areas immediately outside of the study area (the City of Langley to the east and Fleetwood to the west). An advisory speed limit of 60 kilometres per hour is placed in the westbound direction near 180th Street due to horizontal curves. The posting of four posted speed limits within the 6.7 kilometre study section is considered to be a frequent change in speed limits, and may result in poor expectancy and compliance at speed zones with lower posted speed limits.

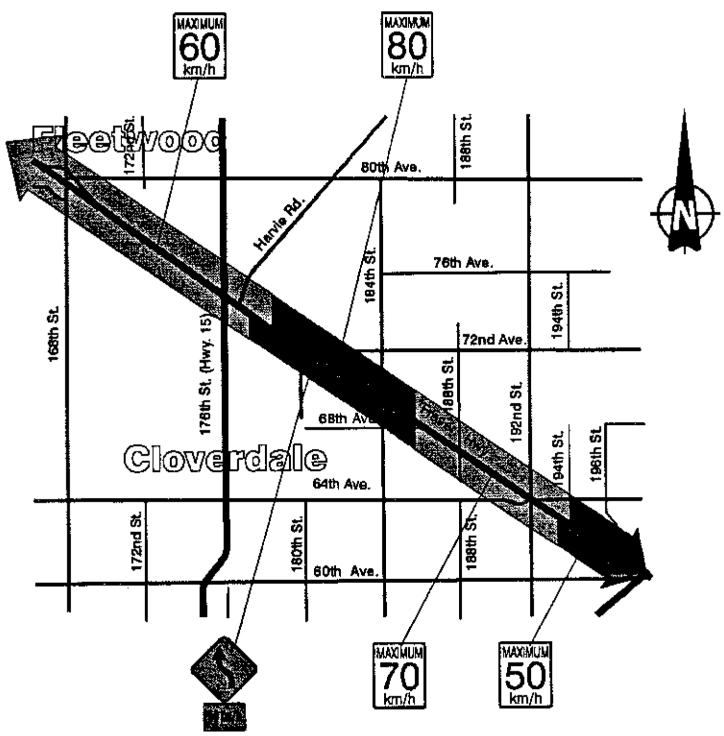

FIGURE 2 EXISTING POSTED SPEED LIMITS

To determine appropriate speed limits along the corridor, the following procedures were followed:

- Review of local current speed limit practices and methods;
- Review of public and City concerns;
- Review of existing corridor physical characteristics;
- Review of the vehicle classification and speed characteristics; and,
- Analysis the collision characteristics.

Review of Local Current Speed Limit Practices and Methods

The setting of posted speed limits has been well documented in literature. However, the setting of speed limits has never been confined to any one reliable method. A literature review indicates that there are several different methods, each with different theories as to the appropriateness of the desired speed. However, the methods generally agree on these two points.

- With some exceptions, the posted speed limit should not exceed the design speed of the roadway (defined as the maximum safe speed that can be maintained over a specified section of road when conditions are favourable that the design features of the road govern, typically up to a maximum of 120 kilometres per hour for two-lane roads).
- The posted speed limit should be set at a "reasonable" speed that generally meets the expectation of the driver.

Based on a literature review, the most commonly used methods of establishing a posted speed limit were:

- Statutory Limits;
- 85th Percentile Speeds;
- Pace Speeds; and,
- Expert System Approach.

Statutory Limits

The method of establishing posted speed limits by law was one of the first approaches to managing vehicle speed. Using this method, a maximum posted speed limit along a section of roadway is determined by the roadway classification or adjacent land use, and is usually set by a government or road authority. Based on a literature review, the following statutory limits applicable to the corridor are generally accepted by road authorities, and used for arterials and highways.

- Suburban undivided arterials with medium density commercial and/or residential land use - 50 to 80 kilometres per hour
- Suburban undivided arterials with low density commercial and/or residential land use - 50 to 90 kilometres per hour
- Rural undivided highways - 70 to 130 kilometres per hour

In general, the greater the level of urban development, the lower the accepted statutory speed limits.

This method provides a general guideline as to typical appropriate posted speed limits for a given roadway. The method also attempts to meet the driver expectancy for roadways of a given classification or function. However, site-specific roadway characteristics may make the statutory speed limit unsuitable or even undesirable. It is generally agreed that while statutory speed limits are a suitable starting point, a comparison to other methods is required to determine the most appropriate posted speed limit along a section.

85th Percentile Speeds

The 85th percentile speed method is one of the most popular techniques in determining the posted speed limit. Because it is based on actual measurements of vehicle speeds along the roadway, the method is site-specific and usually considered suitable for that section of roadway. Studies have also shown that the 85th percentile speed roughly coincides with the upper bound of a speed range for which the collision rate is the lowest. The method also corresponds with most police methods of issuing violation tickets to drivers who are in the upper 15 percent of vehicle speeds, thus establishing a desirable connection between the posted speed limit and vehicle speed enforcement.

The most often-documented concern with using the 85th percentile speed method is that it may be inappropriate for a particular road. This is especially true along roadways where driveways and pedestrians are common. For example, an 85th percentile speed along a wide residential street may be 65 kilometres per hour, but because of the residential land use and road classification, a posted speed limit approaching the 85th percentile speed would be inappropriate. In similar situations, other factors and roadway characteristics should be considered in determining the posted speed limit.

Pace Speed

The pace speed method uses the upper limit of a 15 kilometres per hour speed range that has the largest number of vehicles. In Canadian practice, these ranges are typically incremented at every five kilometres per hour. The main difference between the pace and the 85th percentile speed methods is that the pace speed identifies the speed range that the largest group of vehicles travels at, whereas the 85th percentile speed denotes a speed demarcation. As a result, the main application of using the pace speed range method is in situations where there is a wide distribution of vehicle speeds. The pace speed method results in a recommended posted speed that is closer to the most common vehicle speed.

Although there are roadways where the pace speeds and 85th percentile speeds are dissimilar, studies into limits set by the pace speeds have found that they are generally similar to the 85th percentile speed of the same roadway. For this reason, many of the advantages common to the 85th percentile speed method are applicable to the pace speed method.

Expert System Approach

The expert system approach is based on a structured set of logical arguments that simulates the decisions made by an "expert" in selecting a posted speed limit. Because the approach follows a specific set of procedures, the expert system may be in the form of a computer program. Examples of expert system approaches include VLIMITS, NLIMITS, and QLIMITS, which were developed specifically for Australian road characteristics, as well as a speed limit logic flow chart developed by the Township of Langley. The University of British Columbia (UBC) has also developed an expert system computer program called Speed Limit Advisor (SLA) that uses similar arguments used the Australian programs.

The expert system approach technique usually begins by entering information about the study roadway. The information inputs may include geometric features, environmental characteristics, roadway and roadside factors, special activities or other land use factors, and vehicle speed characteristics. The decision tree underlying the expert system is usually developed by knowledgeable and experienced engineers, and is based on suggested speed limits for certain road or traffic characteristics. Based on the inputted values and characteristics, an appropriate posted speed limit is generated.

The use of an expert system approach consolidates the decisions that determine an appropriate speed limit. However, the literature review generally indicates that the program output should not be automatically adopted as the posted speed limit. It is generally suggested that such systems be used as a guideline to a speed limit, and that the generated results only assist and advise those that make the final decision.

Additional Considerations

The literature review has noted other considerations in the determination of appropriate speed limits.

- Road surface characteristics, such as shoulder and roadside characteristics, grade, alignment, and sight distance should be reviewed, especially if a high speed limit may result in potentially unsafe situations.
- Future or potential roadside development, as well as potential road classification changes should be considered.
- The collision history of the roadway should be reviewed to determine whether the current posted speed limits may be contributing to significantly high collision rates.
- It is highly desirable to have uniform posted speed limits to improve driver expectancy and to reduce vehicle speed variances.
- Municipalities and road authorities sometimes post speed limits lower than the design speed to provide some margin-for-error. This is usually at least 10 kilometres per hour lower than the design speed.

Suggested Methodology

Based on the literature review, the use of statutory limits, 85th percentile speeds, pace speeds, and expert system approach are reasonable methods to determine posted speed limits. It is suggested that all the methods be compared with each other and used as a guideline to set appropriate speed limits along Fraser Highway. The existing design speeds and the collision characteristics along the corridor are also considered in the methodology. Based on the results of these methods, an appropriate recommended posted speed limit can be established.

Review of Public and City Concerns

Based on the comments received from the City, the local RCMP detachment, and the public, the following concerns are cited.

- The RCMP and the City said that vehicle speeds in the 50 and 60 kilometres per hour speed zones were higher than the posted speed limits.
- The RCMP noted that in the urban areas to the east (Langley City) and to the west (Fleetwood), vehicles continued driving at high speeds after driving through the corridor.
- Residents complained that the posted speed limit of 80 kilometres per hour was too fast for the section between 176th Street and 184th Street.

Review of Existing Corridor Physical Characteristics

The following significant findings were determined.

- Sections near 168th Street, 176th Street, and 64th Avenue had vertical grades exceeding 5 percent. The resulting vertical curves were estimated to have a design speed of approximately 80 kilometres or less.
- The study section is relatively straight with two significant horizontal curves near 180th Street. It was estimated that the horizontal curves had a design speed of approximately 70 kilometres per hour in the westbound direction and 80 kilometres in the eastbound direction for both ideal and wet road surface conditions. As shown in FIGURE 2, an advisory speed limit of 60 kilometres per hour is posted at the horizontal curves in the westbound direction.
- Throughout most of the corridor, there are roadside ditches and sloped embankments. Barriers separating vehicles and the ditches are notably absent.
- The section between 184th Street and 64th Avenue had a driveway density of approximately 25 driveways per kilometre, which is higher than similar roadways through the City.

Review of the Vehicle Classification and Speed Characteristics

Vehicle classifications and speeds were recorded in both directions near 168th Street, 184th Street, and 196th Street during the midday and afternoon periods. The results indicate that passenger vehicles, vans, and pick-up trucks comprise the highest proportion of vehicle types for all vehicles at 61, 16, and 13 percent respectively. Light trucks and heavy trucks consisted of approximately 8 percent of the total vehicle traffic. The distribution of vehicle classifications was found to be similar at all three locations. The vehicle classification proportions are typical of an arterial roadway designated as a truck route.

As mentioned, the 85th percentile and pace speeds are typically used to establish posted speed limits. These speeds, as well as the median speeds and standard deviations were determined for the four sites, and are summarized in TABLE 1.

TABLE 1 SUMMARY OF VEHICLE SPEED CHARACTERISTICS BY LOCATION AND DIRECTION

DIRECTION	SURVEY LOCATION	POSTED SPEED LIMIT (kilometres per hour)	SAMPLE SIZE	VEHICLE SPEED CHARACTERISTICS (kilometres per hour)			
				Median Speed	85th Percentile Speed	Pace Speed	Standard Deviation
Eastbound	Near 168th Street	60	200	72	78	85	6.2
	Near 176th Street	60	55	71	74	80	5.7
	Near 184th Street	80	200	70	75	80	6.3
	Near 196th Street	50	200	64	72	75	6.3
Westbound	Near 168th Street	60	200	76	85	90	7.4
	Near 176th Street	80	50	74	81	85	6.4
	Near 184th Street	80	200	70	76	80	7.6
	Near 196th Street	70	200	69	78	80	7.7

The vehicle speed findings indicate that the vehicle speeds are generally consistent. The 85th percentile speeds and the upper limits of the pace speeds are generally between 70 and 85 kilometres per hour throughout the corridor irrespective of the posted speed limit. However, the findings indicate that the vehicle speeds are slightly higher toward the western part of the corridor. It is noted that the 85th percentile speeds near the 184th Street location are lower than the posted speed limit through the section. The vehicle speed characteristics by vehicle classification were also determined, and indicate that vehicle speeds of passenger vehicles, pick-up trucks, and vans travelled faster than other vehicle types.

8-2-5/8

Analyse the Collision Characteristics

The collision data consists of reported collisions recorded by the Surrey RCMP between January 1994 and December 1996 inclusive (three years of data). A total of 346 collisions occurred along the study section in three years. This results in a collision frequency rate of approximately 17 collisions per kilometre per year. The annual collision rate along the study section was found to be approximately 2.1 collisions per million vehicle kilometres. Both the frequency and rate along Fraser Highway are lower than the collision rates of other similar roadways in the City.

The collisions were recorded by site, and are summarized in FIGURE 4. The results indicate that collisions along the corridor are most common at intersections. However, the number of collisions occurring at mid-block and driveways total approximately 39 percent, a significant portion.

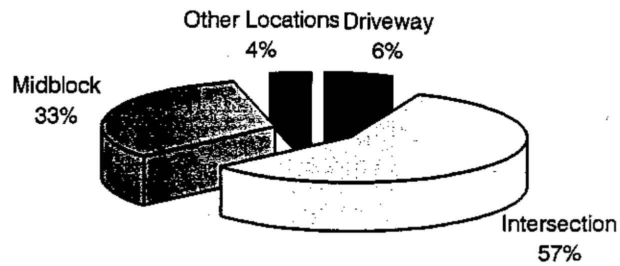

FIGURE 4 REPORTED COLLISION SITE

The results generally indicated that the highest collision frequencies are at major signalized intersections. No significant collision trends were observed along sections with horizontal and vertical curves, nor along locations with high density of driveways.

The collision types at mid-block locations were analysed, and the results are shown in FIGURE 5. It is noted that collisions involving vehicles leaving their lane (off-road-right, off-road-left, sideswipe, and head-on collisions) totalled approximately 29 percent, which is significantly high.

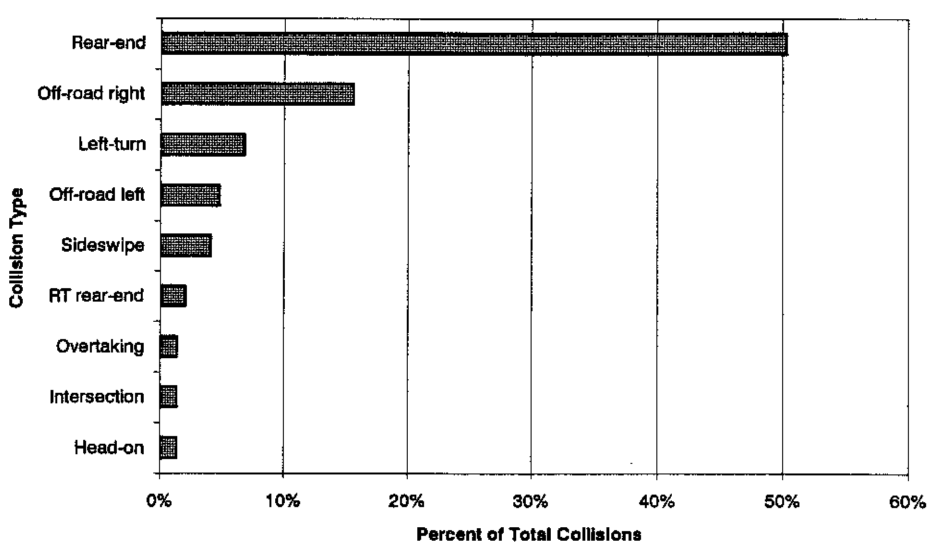

FIGURE 5 MID-BLOCK COLLISION TYPES

The analysis failed to determine whether a significant proportion of collisions along the corridor were attributed to high vehicle speeds, but did indicate that collisions involving vehicles leaving their lanes were significantly high. Vehicles typically leave their lanes and travel off the road or into adjacent lanes because of high vehicle speeds and/or inadequate design speeds for the posted speed limits.

Recommend New Posted Speed Limits or Geometric Changes

Based on the findings of the physical and speed characteristics, the methods described earlier were used to determine an appropriate posted speed limit.

Design Speeds

The analysis into the existing roadway cross-section elements, as well as horizontal and vertical curves indicate that several sections have a design speed of 80 kilometres per hour or lower. The lowest calculated design speed was found be 70 kilometres per hour at the section near 180th Street with a horizontal curve. Currently an advisory speed limit of 60 kilometres per hour is posted through the section. The design speed findings indicate that the posted speed limit in general should not be higher than 80 kilometres per hour.

Statutory Speeds

Based on statutory limits generally accepted by road authorities, the following speed limit guidelines were determined.

- The rural and low density sections between 168th Street and 64th Avenue should have a speed limit of between 70 and 120 kilometres per hour.
- The suburban sections east of 64th Avenue and west of 168th Avenue should be between 50 and 80 kilometres per hour.

85th Percentile Speeds

According to the spot speed survey results, the 85th percentile speeds were found to generally be consistent throughout the corridor. The 85th percentile speeds range between 70 and 85 kilometres per hour. Because the 85 percentile speed is generally accepted as an indicator of the desired posted speed limit, this method recommends a posted speed limit of either 70 or 80 kilometres per hour.

Pace Speeds

Much like the calculated 85th percentile speeds, the spot speed surveys indicate that the calculated pace speeds along the corridor are generally consistent. The pace speeds were between 75 and 90 kilometres per hour. These findings recommend a posted speed limit along Fraser Highway of close to 80 kilometres per hour.

Expert System Approach

The expert system approach was used to indicate what the posted speed limit should be given certain criteria. The Township of Langley system was used. According to the Township tree, the recommended posted speed limit was found to be 70 kilometres per hour.

Based on the above findings, the speed limit through the corridor should be either 70 and 80 kilometres per hour.

Also considered were the following findings.

- The collision analysis indicated that crashes involving vehicles leaving their lane and travelling off the roadway or encroaching onto other lanes were significantly higher than the provincial average. Based on the analysis, it is concluded that the generally high vehicle speeds likely contribute to an over-represented proportion of off-road, sideswipe, and head on collisions.

- The land use becomes primarily urban for eastbound traffic near the City of Langley and for westbound traffic approaching the Fleetwood neighbourhood. It is generally desirable to reduce the vehicle speeds in urban areas, as reflected in the posted speed limits of 50 kilometres per hour near the City of Langley and 60 kilometres per hour near Fleetwood. However, the spot speed analysis indicated that vehicle speeds were much higher than the posted speed limits. Based on the existing land uses at these areas, it would be undesirable to have a speed limit equal to the 85th percentile, pace, or expert system approach findings of approximately 70 to 80 kilometres per hour.

- As mentioned previously, the posting of four posted speed limits within the corridor is considered to be a frequent change in speed limits, and may result in poor expectancy and compliance at speed zones with lower posted speed limits. Because of the frequent changes in the posted speed and the relatively consistent vehicle speeds through the corridor, It is recommended that a consistent speed limit be posted throughout the corridor.

Based on the available physical, traffic, and collision characteristics, it is recommended that the posted speed limit be 70 kilometres per hour between 168th Street and 194th Street. As well, the westbound section near 180th Street with horizontal and vertical curves should continue to have an advisory speed of 60 kilometres per hour. It is also recommended that the existing speed limit of 60 kilometres per hour west of the corridor (in the Fleetwood area) and 50 kilometres per hour east of the corridor (in the City of Langley) be maintained. A short 60 kilometres per hour section near the City of Langley is also recommended, functioning as a "step-down" speed section and easing the speed limit transition.

It is also recommended that site-specific enforcement be implemented on the approaches into both the Fleetwood urban area and the City of Langley due to the high level of speed noncompliance. The literature review indicates the site-specific enforcement is the most effective means of police presence to reduce vehicle speeds. These studies also generally concluded that to achieve substantial speed reductions, police enforcement must be highly conspicuous, preferably by stopping offenders, and must be very intensive.

Based on the existing development in the Fleetwood area and the City of Langley, as well as the potential safety risks for pedestrians, it is recommended that streetscaping be constructed along the approaches to those urban areas. It is suggested that roadside objects such as sidewalks, trees, or street lamps be installed to create the appearance of an urban area. As well, welcome signs indicating to motorists that they are entering an urban area would add to the concept. The concept of a gateway into the City of Langley should be a collaboration between the City and the City of Langley.

A summary of the improvements is shown in FIGURE 6. The above recommendations are anticipated to diminish the safety risks associated with high vehicle speeds along the Fraser Highway through the study section, as well as improve the traffic safety within the Fleetwood area and City of Langley.

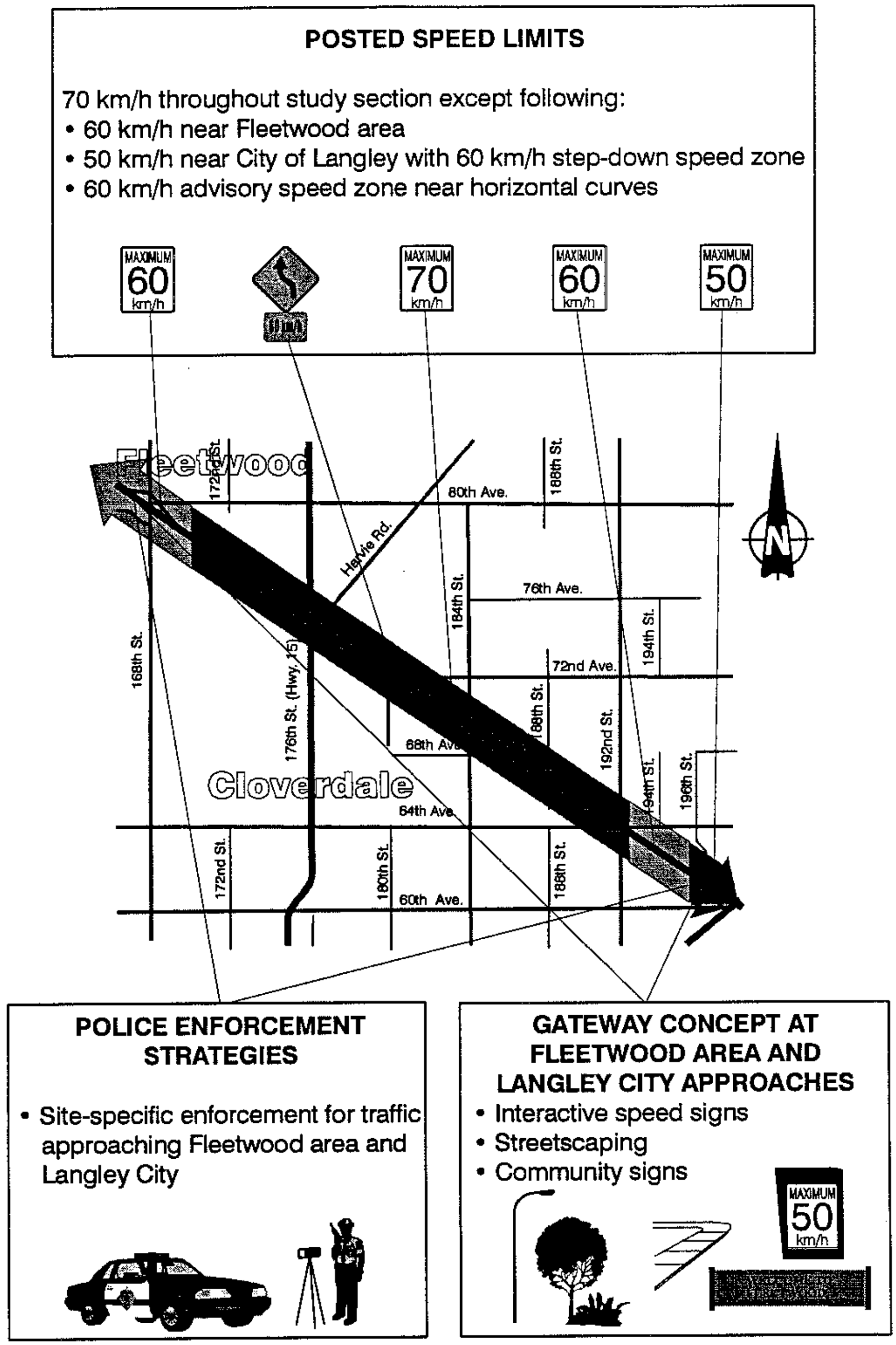

FIGURE 5 SUMMARY OF RECOMMENDED IMPROVEMENTS

B-3-1/1

AN INTEGRATED APPROACH TO CORRIDOR PLANNING –

HIGHWAY 97 NORTH OF OKANAGAN CMP

PREPARED BY:

John Steiner, M.Sc.(Eng.), MCIP
Principal
Urban Systems Ltd.
Jsteiner@urban-systems.com
(604)273-8700

B-3-1/2

John Steiner, M.Sc.(Eng).,MCIP
Principal
[redacted]

Table of Contents

B-3-1/3

John Steiner, M.Sc.(Eng).,MCIP
Principal
[redacted]

1. Introduction

Historically, municipal and provincial governments have invested in transportation systems without truly knowing the full costs including: maintaining new or improved assets; the benefits and impacts of the improvements; and the strategies needed to ensure sustained performance from the investment. In fact, many agencies that have implemented new corridors and bypasses have lost many of the assumed benefits due to the spread of development and the lack of support strategies.

With greater pressures on limited financial resources of municipal and provincial governments, investments in the roadway network must now be determined based on a comprehensive framework. In this regard, corridor management planning is seen to be an integrated approach for highways and major municipal streets to identify and protect long-term investments.

This paper provides a summary of the key elements of an integrated corridor management planning process for highway and urban roadway facilities, with examples from the Highway 97 North Okanagan – Shuswap Corridor Management Plan (CMP).

2. Why are CMPs Needed?

The primary goal of many CMPs is to develop a long-term strategy to achieve and maintain the performance of the highway or municipal corridor, to support the desired roles of the corridor, and to serve the needs of key user groups. The CMP should be considered a guide toward defining and achieving the desired vision for the transportation corridor, and designed to provide the framework for managing the process of change in everything from traffic conditions through to development patterns along the corridor and beyond. In this regard, the CMP can not be seen as the final step, but the means of directing and protecting transportation investments through an integrated process.

Although the objectives of each CMP are unique, there are five common objectives that must be addressed in order to develop a long-term plan for the corridor. The critical objectives are:

- To understand how the corridor performs in all capacities.
- To identify current and future uses and desired roles of the corridor prior to establishing performance goals.
- To identify and define problem areas.
- To identify and evaluate candidate long-term strategies that address problem areas, and to determine support initiatives that are needed to maintain performance.
- To develop the framework for implementation which goes well beyond the sequencing of improvements.

3. How Does the Corridor Perform?

The corridor performance is intended to provide a clear picture of the facility condition in very specific terms – historically, today and in the future without any changes to the corridor. Although the performance can be assessed in a variety of ways, it is important that the range of measures not only reflect the complexity of the corridor, but that the measures also provide sufficient knowledge needed to define problems and identify solutions.

The range of performance measures common to many highway and / or urban arterial roads fall within four broad categories as highlighted and briefly described below.

- ***Mobility*** reflects travel time in terms of the driver's experience. This is influenced by several factors including the posted speed, physical character of the roadway, access density, traffic controls, ability to pass and delays within the corridor. Within urban areas, it is also important to understand mobility conditions on supporting networks and / or parallel major corridors.

- ***Safety*** of a corridor is generally analyzed based on historical statistics and current experiences. While there are several measures available to assess corridor safety – including collision rate, critical rate and collision severity index – the lack of collision experience at specific intersections and mid-block areas with average collision patterns limits the range of improvement strategies that may be investigated. In other words, the benefits that may be derived through collision reductions would generally only justify minor modifications to address stakeholder concerns and other issues. Admittedly, the challenge for CMPs is to economically justify the benefits of pro-active strategies to address safety issues.

- ***Infrastructure condition*** is designed not only to determine need for road rehabilitation as part of the long-term strategy for the corridor, but to highlight the condition of the asset for the purpose of determining salvage value as part of any long-term improvement strategy. The infrastructure condition measures most commonly used are pavement condition rating and bridge condition index, both of which reflect a combination of several physical conditions.

- ***Reliability*** of a corridor refers to the frequency and duration of closures due to localized causes, such as motor vehicle accidents and natural causes. Along both urban and rural corridors, frequent closures due to collisions or other causes can affect the performance of the corridor in serving the desired roles.

4. Role(s) and Performance Goals

Along many major corridors in urban and rural areas, the types of traffic (i.e., cars, trucks, buses, bicycles, etc.), trip purposes (i.e., local and through trips), speeds and other conditions can vary significantly. This can affect the range of mobility and the resultant safety along the corridor. Before establishing the desired performance for the corridor, it is imperative that the CMP clearly identify the ranges of uses and the desired roles for the corridor over the long-term. This stage of the CMP is designed to establish a clear vision for the corridor in broad terms. Experience has shown that agency and stakeholder support for the desired roles is not only critical toward establishing performance goals, but ultimately in obtaining support for the entire corridor plan.

Determining Role(s)

The 'use' of a corridor goes well beyond the traffic characteristics or the mixture of vehicles. In fact, one of the fundamental goals of all transportation facilities is to serve the land use patterns and economic activity of a community. In an effort to determine the role of a corridor, the transportation professional must understand these factors and their inter-relationships with the corridor in order to determine and generate agreement on the desired role(s). The key factors that shape the roles for the corridor are briefly highlighted below.

- ***Community inter-relationships.*** Many highway facilities and major arterial roads pass through more than one jurisdiction. Within and between communities, the relationships between the corridor and land uses may be quite different. Within the North Okanagan area for example, the highway serves as a downtown street in communities such as Vernon and Enderby, and a limited access corridor in other communities such as Armstrong and Salmon Arm. Whether a highway facility or a municipal arterial corridor, the relationships can be examined based on current land use patterns, anticipated changes immediately surrounding the corridor and significant development areas beyond the facility.

- ***Economic activity.*** Many major roadways perform a vital role in supporting economic activity at various levels (i.e., local, regional, provincial, national and or inter-national). The economic activity supported by a corridor can range from the movement of goods and services through to ease in which goods and services can be accessed by customers in a particular area. In tourism-based communities, such as many areas of the Okanagan Valley, the ease of mobility by car is a critical factor in overall economic activity. For most corridors, the movement of goods and services can be measured through various surveys of vehicle mixture and road-side surveys. The economic impacts of mobility on customer attraction to an area can only be measured by understanding the general needs of the user groups.

- ***Traffic characteristics*** along a corridor may be measured in terms of peak, daily and seasonal traffic volumes, vehicle mixture and origin-destination patterns. Although the traffic characteristics along a facility provide a broad indication of the uses, they do not necessarily reflect the desired roles. For example, highways or major arterial roads where a significant proportion of trips are generated by the uses that surround the corridor may be a secondary role for the facility and indicative of limited alternative networks and / or incompatible land use patterns.

In general, there is no predetermined formula for establishing the desired roles for a particular facility. The economic role of a particular corridor may be of greater significance than some of the community inter-relationships – or vice versa. Within the North Okanagan area, the role of the highway was shaped by the need for the corridor to serve the '*higher order*' uses – in terms of the type of traffic, economic activity and community inter-relationships – whereby the local street system could and should be developed to support other '*lower order*' roles. For example, primary and secondary roles of major highway sections were established based on the need to serve inter-national, national, provincial and regional uses as illustrated below.

Performance Goals

Once the role(s) of the corridor is defined, performance goals may be established. For the CMP to be successful, the performance goals must be shaped by and supportive of the primary roles. Examples of the performance goals used in the Highway 97 North Okanagan CMP are briefly highlighted below.

- ***Mobility expectations*** of the target user groups in terms of travel times (or average travel speeds over large sections), levels of service, truck climbing and descending needs as well as passing lanes.

- ***Safety*** performance goals are primarily influenced by the collision rates and collision severities along a particular section or at an intersection. These are compared with the average patterns or critical rates for a similar facility envisioned within the planning horizon. While accident prone locations and safety issues are also considered within the plan, they should not imply the need for an improvement project unless tied to identified collision rate or severity index problems.

- ***Infrastructure condition*** performance includes measures of pavement and bridge condition. Within the CMP process, the infrastructure conditions can influence the optimum timing for candidate improvement projects within a particular area as well as the salvage value of the asset. As part of the overall investment strategy however, operation and maintenance of infrastructure is an essential component.

- ***Reliability*** reflects the degree to which the corridor experience closures or operating under limited conditions due to incidents such as major accidents, highway maintenance or natural events. This performance measure is designed to highlight problem locations in which significant and frequent impedance's to the traveling public occur, resulting in lost time and additional travel cost.

5. Problem Definition

The performance of the corridor – historical, existing and projected – is compared with the desired mobility, safety, infrastructure and reliability criteria for the facility. Experience has shown that while this stage of the CMP requires a certain amount of flexibility so as not to overlook key problem areas, the problems must have two characteristics in order to generate any benefits. In this regard, the problems must be:

- ***be quantifiable*** – Whether there is a mobility or safety problem, the issue must be quantifiable in order to generate any benefits. For example, perceived areas of congestion are not going to necessarily generate any meaningful travel time savings benefits. Further, quantifiable mobility issues must generally extend beyond a single intersection or movement in order to generate sufficient benefits for any major investment.

- ***show a demonstrated pattern.*** With safety issues in particular, variable collision patterns can imply a range of problems and solutions. In areas where there is no established pattern, the benefits of any high cost improvements may be diluted by the lack of a definable problem. In these cases, minor improvement strategies – such as signal timings, signage, etc. – may be cost-effective solutions to address some of the safety problems.

6. Long-term Strategies

The identification and evaluation of long-term corridor strategies must be designed to not only address problem areas, but to lead toward the development of a corridor plan that serves the desired roles identified at the outset of the CMP. This section of the paper provides a framework for identifying candidate long-term strategies and evaluating options.

Improvement Strategies

The range of corridor strategies that should be identified and investigated must be aimed at addressing the problem areas. In general, the candidate strategies may fall within four broad categories as illustrated and described below:

B.3.1/7

- ***Imminent Improvements*.** Within most large scale CMPs, there are often several projects that have been committed, but not yet built. In some cases, these may be under construction and assumed as part of the future condition, or in the design stage such that further input may be provided by the CMP.

- ***Rehabilitation and Maintenance*.** Regardless of the improvement strategies that are developed within the CMP, the costs of maintaining the assets are significant. In order to develop an affordable CMP, these committed costs must be clearly identified as part of the long-term strategy.

- ***Candidate Improvement Options*.** The strategies to address specific problem areas may be developed for site specific locations and / or across sections of the facility. While in many cases there may be competing options that need to be considered for the long-term plan, there may also be locations where only a single solution need be identified based on the clarity of the problem definition.

- ***Corridor Protection and Preservation*.** In order to sustain performance of either the existing corridor or improvement strategies, the CMP must identify and develop initiatives that include corridor protection and preservation. These strategies may be defined in very specific terms – such as identifying the spacing of full movement intersections, access restrictions or consolidations and closures, support network improvements and land use strategies – or as broad principles to guide future management activities.

Evaluation Framework

While the evaluation framework should provide decision-makers with a means of comparing optional improvement strategies along the corridor using a consistent method of evaluation that is used on other corridors, the 'values' of the local area must be incorporated within the framework. In this regard, the evaluation criteria may await the identification of long-term options to understand the potential issues that should be assessed and compared for each strategy.

The standard framework for identifying the criteria in which to evaluate options are briefly highlighted below.

- ***Financial*** – life cycle costs and economic indicators.
- ***Customer service*** – the ability of the improvement option to address travel time, vehicle operating cost and safety performance.
- ***Community / social*** – an assessment of how the improvement option affects the broader community interests and other development adjacent to the highway.
- ***Economic development*** – how the improvement may affect the economy at a regional and provincial level.
- ***Environmental*** – the effect of the improvement option on key environmental features.

While the criteria representing each category may be common amongst all options, the criteria must be flexible enough to address localized issues, particularly over very long corridors. Within the Highway 97 CMP for example, the range of options within the Vernon area included forming a couplet system as well as bypasses. While the overall impacts and benefits of the improvements may be compared using a standardized approach consistent with the remainder of the corridor, it was necessary to understand the localized impacts on access and circulation as well as overall traffic conditions beyond the corridor. In this regard, the key criteria extended beyond the corridor, in order to address the broader impacts of alternative strategies.

7. Completing the Plan

A fundamental goal of the CMP is to develop a long-term strategy to achieve and maintain the performance of the highway or municipal corridor that effectively supports the desired roles, and serves the needs of those user groups. The initial stages of the CMP provide the means of identifying desired roles and performance goals for the corridor, and identifying problem areas where the goals may not be achieved in the long-term without improvements to the corridor. The identification and evaluation of options to address individual problem areas contributing toward overall shortfalls in performance provides the range of strategies that may be considered for the long-term plan.

For most users of the transportation system and facility owners, the CMP is not as much about the collection of individual options, but about the performance of the entire corridor. In this regard, the final plan and investment strategy should be structured based on the performance indicators as the primary variable, and available funding as a secondary – yet fundamental – consideration. The framework that may be used to define and refine the range of optional improvement strategies are essentially shaped by three key elements as highlighted below:

- ***Corridor Performance.*** The long-term plan is ultimately designed to enhance and/or maintain the performance of the highway or urban roadway facility over the next 25 years and beyond. In this regard, the resultant corridor-wide performance – in terms of mobility and safety – is a critical factor in shaping the overall corridor improvement scenario(s). From the range of candidate improvements, various corridor scenarios may be developed to achieve mobility and safety targets. This approach will ensure that the resultant vision for the corridor is directly linked to the primary goals of the corridor.

- ***Cash Flow.*** The investments in capital projects are generally constrained by the available cash flows. In this regard, the optional scenarios to achieve performance goals will also be shaped by the funding available for capital improvement projects – thus further refining the range of long-term improvement scenarios that may be generated.

- ***Corridor Interests.*** The desire for and / or impacts of individual improvements within each scenario will also contribute toward further refining the range of corridor scenarios. In this regard, input received from the public and agencies participating in the CMP process will provide guidance on the selection of individual scenarios. In support of the goals for maintaining overall corridor performance, the preferred plan may be also shaped by the commitment toward actively pursuing corridor management and protection strategies identified throughout the corridor and for each of the major corridor improvements.

B-3.2 / 1

Multi-Modal Corridor Study
The Highway 99 North Corridor

Ian Rokeby, P.Eng. Earth Tech (Canada) Inc., 300 – 4170 Still Creek Drive, Burnaby, BC V5C 6C6 Tel: (604) 473-8526 Fax: (604) 294-3647 e-mail: irokeby@reid-crowther.com

Jane Farquharson, Earth Tech (Canada) Inc., c/o Sound Transit at OPUS East, 401 South Jackson Street, Seattle, WA 98104 Tel: (206) 956-4065 e-mail: farquharsonj@soundtransit.org

Peter Lyall, P.Eng. Apex Engineering Ltd., 2 – 750 W. 6th Ave. Vancouver, BC V5Z 1A5 Tel: (604) 872-1132 Fax: (604) 872-1131 e-mail plyall@telus.net

Don Smith, P.Eng. BC Ministry of Transportation and Highways, 7818 Sixth St. Burnaby, BC V3N 4N8 Tel: (604) 660-0339 Fax: (604) 660-2181 e-mail dsmith@vines.gems.gov.bc.ca

1.0 INTRODUCTION

For long-range strategic planning of transportation systems in multi-modal corridors, the selection of appropriate tactics to accommodate future growth is a complex task. For the corridor between Horseshoe Bay (near Vancouver, BC) and BC's interior near Lillooet, BC Ministry of Transportation and Highways (MoTH) wanted a higher level corridor planning study to support the development of a long-term vision for the future of transportation in the corridor. Figure 1 illustrates the study area.

Earth-Tech (formerly Reid Crowther & Partners Ltd.), in collaboration with Apex Engineering Ltd., developed a new approach for this assignment based on comparative scenarios. This approach provides an opportunity to study contrasting alternative "futures" describing population, transportation, and land use, to illustrate the choices facing society. Each of these scenarios was intentionally selected to be an "outlying point" on a continuum of feasible solutions. As relatively "pure" applications of a particular approach to the transportation issues in the corridor, their study provided insights into the implications of particular types of intervention in the transportation system. By analyzing the results of these "pure" strategies, it is believed that important insights will be gained. The value of the exercise then comes not from selecting the "right solution", but from defining the range of alternative futures which are possible in order to:

- Provide engineering input to a broad debate about the future of the corridor;
- Facilitate informed choices about the future of transportation in the corridor.

It is anticipated that none of the "pure" tactics embodied in the study scenarios will ultimately be implemented; rather, the ultimate corridor solutions will doubtless be a pragmatic combination of the compelling elements of each scenario studied. Other features of this approach include:

- Analytical focus on passenger trips rather than vehicle trips.
- Population growth is not exogenous—it does not have to occur if effective growth management policies are put in place, and may be reduced if the transportation system response does not fully support forecast growth.
- Explicit consideration of growth management and transportation demand management as variables in the transportation planning realm.
- Design standards and system capacity are not predetermined, but can be selected by the planner to achieve a particular objective.

- Travel demand doesn't have to be met--it can be managed and/or reduced instead. As a result, different scenarios offer differing levels of mobility.
- Valid transportation system responses exist in a number of different modes in addition to highway construction—including, in this case, rail, marine, air, and highway buses.
- Consideration of the full range of strategic, operational, and infrastructure responses to growth in travel demand, including; transportation demand and growth management; new infrastructure construction; operational strategies; reduced levels of corridor growth; and acceptance of higher levels of congestion.

For this study, MoTH elected to eliminate consideration of alternative routes which have been proposed in the past, as these have been assessed as substantially more difficult than the present corridor.

The Corridor

The 307 km long transportation corridor running from Horseshoe Bay to Highway 97 in BC's interior plays a critical role in the provincial economy. Containing both Highway 99 North and the BC Rail mainline, it was originally developed to support the traditional resource industries of south-western BC. Its role has broadened and changed considerably over the decades to function as a scenic destination route of importance to the provincial economy; a commuter corridor for residents of southerly communities; a goods movement corridor; access route to important year-round recreational opportunities, including the Whistler and Blackcomb ski resorts; and a primary arterial route within corridor municipalities. BC Rail freight and passenger trains share the corridor with the highway route for much of its length as well, making it a truly multi-modal corridor.

Context

In much of the southern corridor, recreation and tourism activity centres are now substantial economic generators. The recreational industry has grown and expanded in the corridor and now operates year-round. This has brought enormous pressure for urban development, particularly in proximity to Greater Vancouver.

The corridor includes some of the most difficult road-building terrain in Canada. Both the railway and the existing 2-lane highway cling to the steep and winding shore of Howe Sound. The traffic demands, as well as highway and railway geometry, combined with numerous debris torrent and rockfall hazard locations, make further corridor development very challenging.

The corridor is characterized by:

- Low average travel speeds in many of the 2-lane rural sections south of Whistler;
- Congestion and lower speeds through urban sections with traffic signals;
- Limited reserve passenger capacity during peak periods of travel;
- Highway accident rates and severities which exceed provincial averages in some sections of the corridor; and
- Significant reliability problems in selected sections of the highway route.

The corridor's terrain results in some of the highest costs for highway construction in Canada. Previous study of possibly upgrading this corridor to a 4-lane expressway standard from Horseshoe Bay to Whistler produced construction cost estimates measured in the billions of dollars.

The predominant modes of transportation in the corridor are the private automobile and bus. With its existing rail line and passenger rail service, extensive navigable waters in Howe Sound, and a number of small airports, there is substantial potential for the development of alternative, non-highway-based modes.

Traditional engineering approaches indicate the need for more passenger capacity in the corridor; current highway traffic volumes during high demand periods on winter and summer afternoons routinely overwhelm the capacity of the highway, particularly in the southbound direction. Peak period traffic volumes of 1,200 vph per lane are not uncommon. The highway's ability to recover from motor vehicle accidents, or other unforeseen incidents, is now relatively poor during peak periods of demand as queues take longer and longer to dissipate.

The Official Community Plans of the corridor communities indicate population growth of up to 200% over the next 25 years, concentrated in the busiest southern sections of the highway.

2.0 DEVELOPING A STUDY METHODOLOGY

Figure 2 provides a schematic view of the methodology developed for the study. The primary organizing principle of this methodology is the comparison of alternative corridor futures to gain insight into future decision-making. Key assumptions and principles included:

- The study relied extensively on the synthesis of previous technical studies; there was no major new data collection.
- Inclusion of a full exploration of non-highway-based responses to future travel demand.
- The development of three comparative scenarios, each embodying an alternative response to what was quickly identified as the major performance deficiency forecast over the time frame of the study capacity. These are summarized as follows:
  1. *Constrained Mobility Scenario:* Manage existing transportation infrastructure intensively, add minor focused improvements in infrastructure.
  2. *Multi-Modal Mobility Scenario:* Build additional peak period capacity in either passenger ferry, or passenger rail mode, (the passenger ferry option was later eliminated from further study).
  3. *Highway Mobility Scenario:* Build additional capacity in highway mode.

Methodology Overview

The tasks identified in Figure 2 were selected and structured to support the comparative approach desired by the project team. In the first phase, needs and operational analysis, together with problem identification, was used to identify the defining issues in the corridor. Full and careful review of previous highway improvement studies and existing operational issues in the corridor permitted the identification of a wide range of options with potential to address the identified performance problems.

B-3-2/4

Study Area

MULTI-MODAL CORRIDOR TRANSPORTATION STUDY:
Horseshoe Bay to Highway 97

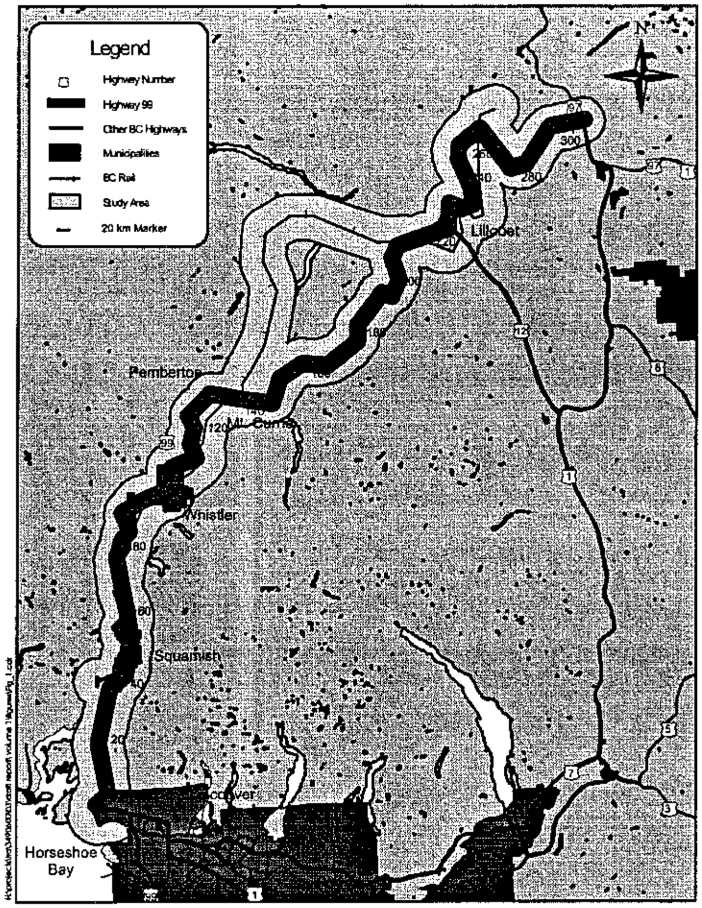

Figure 1
Corridor Map

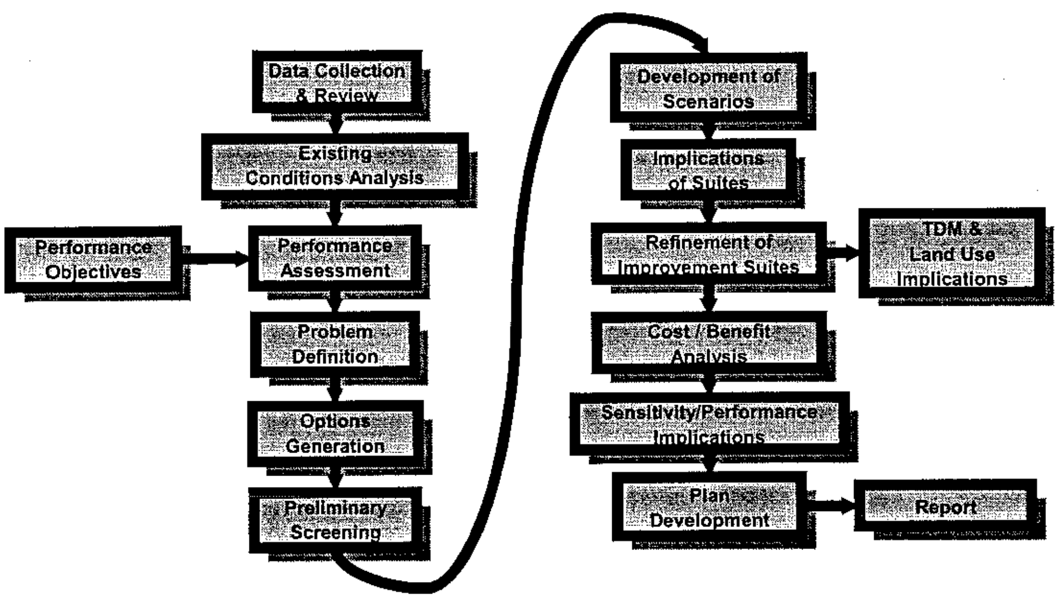

Figure 2
Methodology Schematic

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These were then screened in order to identify those with the strongest benefit/cost ratios. Finally, population and travel demand forecasts for 2025 were developed to permit the final shaping of the options to be incorporated into each of the three scenarios. It should be noted that these options were in a variety of modes, and included operational and demand management initiatives, as well as capital projects.

Phase 2 focused on the assessment of the three scenarios. With the scenarios roughed out and a travel demand forecast available, the next step was to determine the implication of each scenario (or "suite" of improvements) *vis-à-vis* capacity and ability to address forecasted unconstrained travel demand. This, in turn, supported a number of refinements to the scenarios and the cost-benefit assessment of the three scenarios at the corridor level. Sensitivity testing was used to confirm the range of applicability of the major conclusions drawn from the analysis. Finally, the Transportation Demand Management and Land Use implications of each scenario were assessed and initial suggestions for the necessary scope and objectives of these programs were developed.

3.0 ANALYSIS AND OBSERVATIONS

Brief discussions of the approaches taken and major results obtained from the analyses undertaken, are provided below:

Existing Conditions

- *Highway*: AADT is 13,700 at southern end of corridor near Horseshoe Bay. Volumes drop substantially north of Whistler, and are as low as 500 vpd between Pemberton and Lillooet. Summer and winter weekend peak periods are congested. Congestion is highest in Whistler on weekends. Weekday traffic ranges from 75% to 85% of weekend traffic volumes. At Horseshoe Bay, 99.8% of daily winter weekend travelers are in private vehicles or highway buses.
- *Bus and Rail:* Bus has a high mode share of passenger trips (up to 30%) during peak winter weekend afternoon periods. Average vehicle occupancy of all highway vehicles ranges between 1.5 to 3 throughout the corridor. Between Horseshoe Bay and Lillooet, one passenger train operates per day in each direction with a capacity of about 200 people per day. 1998 annual rail ridership was 60,000 people, which is now in decline due to reliability issues with aging rolling rock. During an average winter weekend, the existing rail passenger service moves approximately 0.2% of the travelers in the corridor.
- *Corridor Peak Capacity vs. Demand:* Earth Tech analyzed corridor capacity and corridor travel demand for four key periods (Summer Sunday, Summer Weekday, Winter Sunday, Winter Weekday). As measured in the afternoon peak period in the southbound direction, assuming the existing patterns of vehicle occupancy, on average, the passenger travel demand is satisfied. For Winter and Summer Sundays, the highway operates on average at up to 90% of the computed capacity of 2,500 passengers per hour. Weekday periods examined have substantial reserve capacity. This accounts for the relatively high frequency of substantial congestion in the corridor on weekends.
- *Performance Criteria and Objectives*: Performance objectives were not quantified. Instead, performance criteria were qualitatively identified in order to define the realm of interest for

performance improvement. Safety, Capacity, Mobility, and Reliability defined the realm of desired improvement. Improvement in this realm was desired, but no pro-established threshold was applied – these were determined analytically from the interaction of the various scenario elements.

- *Developing Scenarios*: In selecting scenario elements, there was a conscious effort not to try and respond to "unconstrained demand", but to select a basket of elements that supported a particular strategy. In subsequent analysis, the capacity/demand relationship was assessed for that scenario and corresponding transportation demand management and growth management elements were added, as necessary, to balance travel demand with corridor capacity.
- *Population Forecasting*: Official community plans of the corridor municipalities and official settlement plans of unorganized areas were used to develop Low, Medium, and High population forecasts for 2025. These are illustrated in **Figure 3**. For the purpose of this study, ultimate growth is assumed to occur by 2025.
- *Travel Demand Forecasts:* The Project Team proceeded to develop an understanding of future year travel demand in the corridor using the "Unconstrained" medium population forecasts. Planned population growth, planned major developments, and travel propensity (average annual trips per person) were considered explicitly for each municipality. A regression-based forecast of future travel demand between individual pairs of communities (an AADT trip table) was developed for each horizon year - 2000, 2010 and 2025. This information was then used to develop peak-day and peak-hour forecasts for each segment of the corridor. The result was an "Unconstrained" passenger demand forecast using the "Medium" corridor growth scenario.
- *Scenario Performance Assessment*: Using forecast travel demand, Earth Tech assessed the performance of each of the three scenarios as well as the "do nothing" situation under the performance criteria outlined above.
- *System Capacity:* **Figure 4** illustrates the forecasted 2025 unconstrained hourly passenger demand, graphed assuming the same daily patterns as today, for the Winter Sunday afternoon peak-hour at Horseshoe Bay. Also plotted on this Figure are the system capacities provided by the four scenarios considered. These graphs illustrate that, of these three scenarios, only the Multi-Modal Rail Scenario and the Highway Mobility Scenario provide sufficient capacity to address average demand during this period in 2025. The Constrained Mobility Scenario falls substantially short. Also indicated on this Figure are the forecast actual demands, taking into consideration the relationship between capacity and unconstrained demand. For the Constrained Mobility Scenario, actual travel demand, by definition, cannot exceed capacity, and has been set equal to capacity. This would suggest substantial congestion on a regular basis during these peak periods. Similar comparisons were carried out for other time periods in the corridor.
- *Safety:* Accident rates in the corridor overall are presently lower than provincial average accident rates for 2-lane highways. However, there are some sections with higher accident rates and higher accident severity value than the provincial averages. ICBC conducted a safety evaluation of Highway 99 North and produced a comprehensive list of countermeasures and recommendations for infrastructure improvements. These improvements have been included (where not made

8-3-2/7

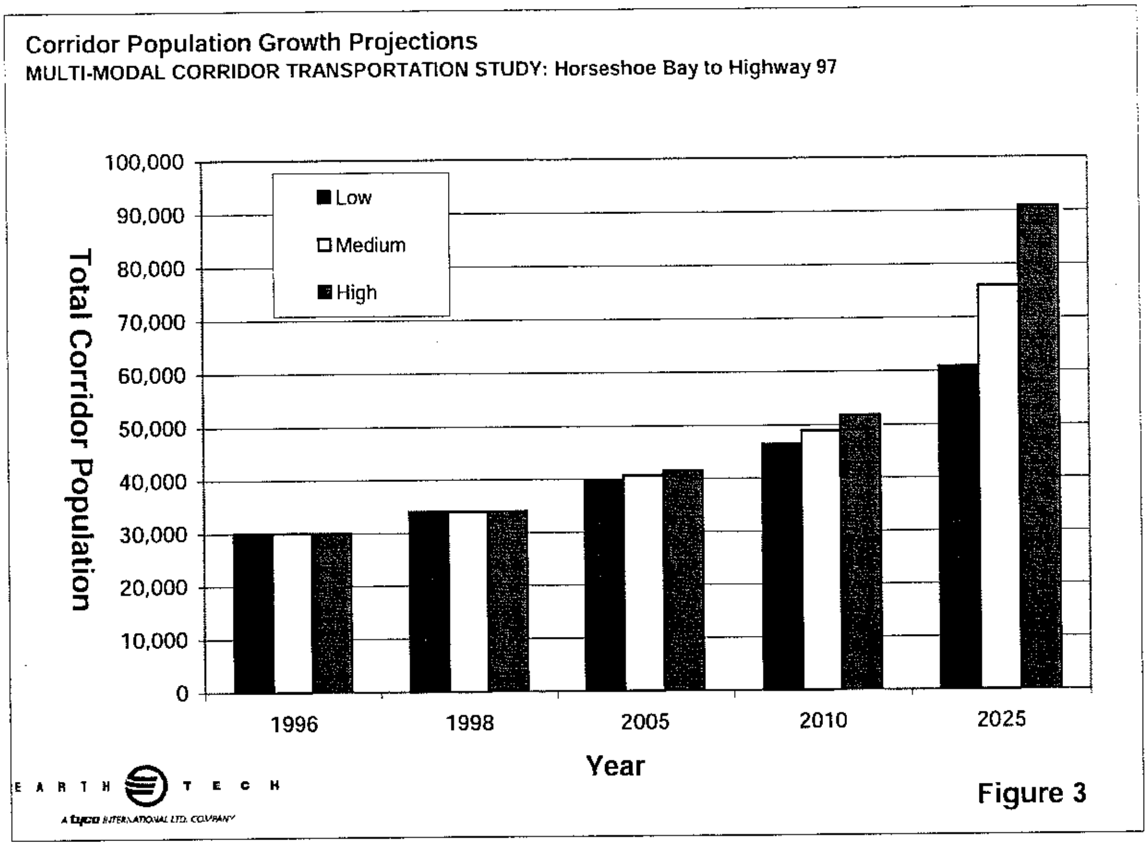

Figure 3

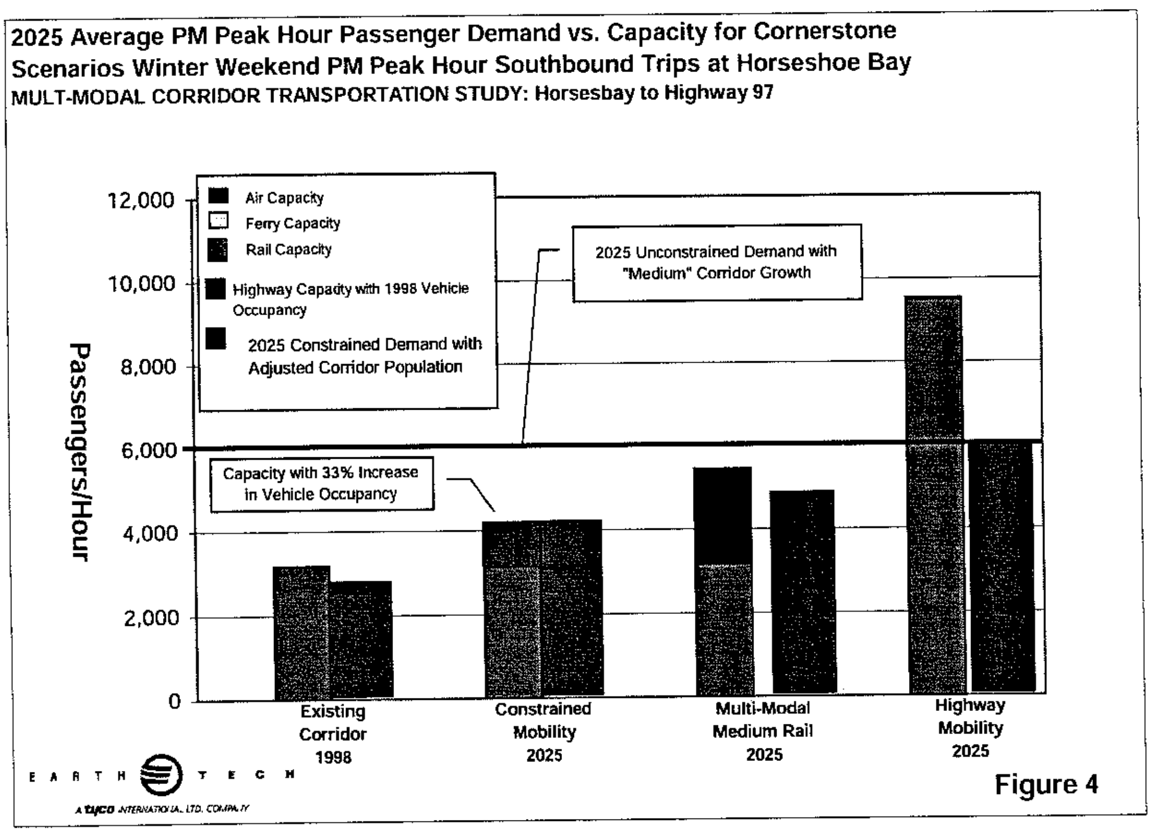

Figure 4

redundant by other infrastructure improvements) in each of the three scenarios, and resulting safety improvements computed.

- *Mobility:* Major challenges to mobility on the corridor are congestion, road closures, and travel speed. Of these, the biggest anticipated challenge is congestion. At present, some people elect to travel at off-peak periods rather than when they might otherwise choose, due to highway congestion. As highway congestion grows, this trend will continue if no additional corridor capacity is provided. Addressing the forecast capacity shortfall issues will improve mobility, but the mobility benefits of the three scenarios will vary due to the modal characteristics, capacity and congestion associated with each.
- *Reliability:* Between 1995 and 1998, the southern part of the corridor experienced a large number of closures, but the total duration was relatively small since the closures were due mainly to automobile accidents and emergency response was relatively quick. The reliability through the urban areas was reasonably good with few closures. The area between Pemberton and Lillooet exhibited few closures, but durations of closure were much longer, since they were primarily due to avalanches or washout problems that typically take some time to resolve. Each scenario has incorporated a number of measures to address the most significant challenges to reliability, in particular, those posed by natural hazards.
- *Cost Estimates:* Costs estimates were derived for each scenario from either previous planning and conceptual design reports, or where information did not exist; new estimates were created based on new concepts developed. Cost components from previous work were escalated to current dollars from their original 1990-91 estimates.
- *Scenario Evaluation:* The three scenarios were evaluated at the corridor level using conventional Multiple Account Evaluation, Cost/Benefit Analysis and Net Present Value techniques. The results of this work are summarized in **Table 1**.

4.0 FINDINGS

Table 1 summarizes the relevant aspects of each of the scenarios, together with their performance assessment results and economic evaluation.

5.0 CONCLUSIONS

Lessons Learned

- For multi-modal, high-level planning assignments on linear corridors, the analysis of comparative scenarios can provide useful understanding of the implications of alternative policy directions. This is useful where government wishes to compare fundamentally different approaches to a particular issue—e.g. rail vs. auto vs. growth management.
- Where providing significant additional system capacity is expensive and/or controversial, solutions which do not provide for all forecast demand conditions may be appropriate. In this situation, policy decision is necessary to establish what system demands will be met. The availability of travel capacity in the system becomes a determinant of travel demand which, in turn, affects congestion

- In corridors where transportation capacity is a constrained resource, the interaction between growth management, land use, and urban character and transportation, cannot be ignored.

The scenario analyses undertaken provided a number of useful insights into the implications of possible future directions for addressing travel demand in the corridor. These are briefly itemized below. It should be noted that these are representative outlying points on a continuum of possible corridor strategies, and are chiefly beneficial for the principles and relationships they illustrate. The ultimate course of action for this corridor will likely incorporate elements and insights gained from each of the scenarios studied.

- Intensive management of the existing corridor transportation resource has the potential to address some increase in travel demand through the planning horizon. Under this scenario, capital spending is limited to safety improvements and upgrades to urban sections. Achieving a balance between travel demand and corridor capacity would require the development and successful implementation of corridor-wide consensus on travel demand management and growth management.
- Introduction of a major commuter rail-style service in the corridor is technically feasible, and could address most of the forecast peak-period travel demand through the planning horizon. End of trip connections would require significant capital investment, as would highway improvements focused on safety and urban sections. Attractiveness of this travel option to the public has not been tested; there is significant risk to this scenario due to the uncertainty surrounding mode to rail. Travel time and transfer convenience will remain critical issues to success and are difficult to address.
- Upgrading the existing highway to a 4-lane standard from Horseshoe Bay north through either Squamish or Whistler would address forecast peak-period travel demand and provide reserve for future growth. Construction is expensive and it will be difficult to continue reasonable highway operations during construction due to the scale of the work involved. The impact of better access and higher capacity on the environment, the corridor economy, and the lifestyle of the corridor's inhabitants, has not been debated or quantified.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the executive and staff of the BC Ministry of Transportation and Highways and the BC Transportation Finance Authority for their support of and active participation in the processes described in this paper, and for the opportunity to take a new approach to unique assignment.

B-3-2/10

TABLE 1 Comparative Scenarios

	Constrained Mobility	Multi-Modal Mobility Medium Rail	Highway Mobility
Principles	• maximizing use of buses to increase capacity • reduce long-distance auto travel • accept more highway congestion • increase highway safety, reliability • minimize environmental impact • manage travel demand	• increase rail capacity to address peak demand • support bus mode share • increase highway safety • limit long-distance auto travel • manage travel growth and demand to maximize use of rail.	• increase highway capacity, safety, reliability; • support bus mode to maintain current mode share
Elements Incorporated	• rural safety, reliability highway improvements • increased urban highway capacity • new inter-city bus services and facilities • maintain existing rail service	• new rolling stock (six trains per day) • increased highway capacity in urban areas • new inter-city bus services and facilities • feeder bus systems at rail stations	• widen highway to 4 lanes, Horseshoe Bay to Whistler • urban highway capacity increases; • safety, reliability improvements only north of Whistler • new inter-city bus services and bus mode facilities • maintain existing passenger rail service
Land Use, Transportation Demand Management	• reduce total demand for travel • spread demand out • shift to bus mode	• encourage mode shift to rail	• support existing bus mode share
Performance Assessment	• unconstrained demand exceeds system capacity • demand will be constrained so that supply demand equals system capacity • safety and reliability will be improved	• can meet virtually all peak period average travel demand in 2025 • safety and reliability will be improved	• scenario can more than meet forecast peak period travel demand in 2025 • substantial improvements to safety and reliability
Cost estimates	• $ 363 million capital cost	• $728 million capital cost	• $1,346 million capital cost
Evaluation Results	• B/C=1.2 • NPV=$1.9 million	• B/C=1.1 • NPV=$69 million	• B/C=0.9 • NPV=$-162 million
Comment	• Can Growth Management and Transportation Demand Management be achieved in the corridor?	• Market study needed to determine potential market penetration, ridership, and fare structure of proposed passenger service.	• Design optimization, review of design standards may permit improvement of capital costs and b/c; impact on trip experience and recreation in the corridor? Construction impacts/ maintenance of traffic during construction difficult.

IAN D.G ROKEBY, M.B.A., P.ENG, M.ENG.

Ian Rokeby is a Senior Project Manager in Earth Tech's Vancouver Transportation practice. He has over 20 years' experience in civil and structural engineering related to the transportation field, including planning design, project management, preparation of contract documents, contract administration and construction services.

Since joining Reid Crowther in 1998, Ian has played a key role in both planning assignments and major projects in the transit and transportation planning fields. These projects included the SkyTrain Port Moody Coquitlam Line planning assignment; the SkyTrain Special Structures over Brunette Avenue and the Brunette River, and the Ministry of Transportation and Highway's Multi-Modal Corridor Study for Highway 99 North. Prior to joining Earth Tech, some of Ian's key projects included the design and project management of the Vancouver Port Authority's award-winning Deltaport Container Terminal and numerous major projects in the marine and transportation infrastructure field.

JANE FARQUHARSON, P.ENG.

Jane Farquharson is a Senior Transportation Engineer in Earth Tech's Vancouver practice and has over fifteen year's experience in traffic and transportation planning. Jane was a UBC Graduate (Honours) in 1986. She has worked for both the private and public sectors, including municipal and provincial governments. Jane's work experience has involved spending several years with N.D. Lea Consultants Ltd., the Ministry of Transportation and Highways and the City of Surrey. Her areas of expertise include strategic transportation planning, road network and highway corridor planning, traffic impact studies and conceptual/functional design.

Since joining Earth Tech, Jane has worked on several major transportation projects, including the South Newton Neighbourhood Concept Plan for the City of Surrey, the Comprehensive Transportation Strategy for the Resort Municipality of Whistler, and the Kootenay-Boundary Sub-Regional Transportation Systems Strategy with ADI Limited.

DON SMITH, P.ENG.

Don Smith joined Ministry of Transportation and Highways in 1989 and has since served as Corridor Planning Engineer.

After achieving his M.Eng. degree in Transportation Planning at Carleton University in Ottawa, Don worked as a Consulting Transportation Planning Engineer in Ottawa and Vancouver and later as a Transportation Research Engineer in the British Columbia forest industry.

PETER LYALL, P.ENG, M.SC.(ENG)

Peter Lyall is the president of the Apex Engineering Limited in Vancouver. He has 25 years of experience in transportation, specializing in Benefit Cost Analysis, Multiple Account Evaluation and Strategic Planning. Mr. Lyall was responsible for forecasting and benefit cost analysis on the Highway 99 project.

B-3-2/12

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Making the Right Decisions in the I-405 Corridor

Donald R. Samdahl, PE [1]
Mirai Associates, Bothell, WA

Today's transportation planners face many challenges within the complex urban environment of the Pacific Northwest. State, regional and local agencies are currently updating a regional transportation plan for Washington State's central Puget Sound region along with conducting several significant corridor planning studies. This paper describes lessons learned from one of these studies, the I-405 Corridor Program, a comprehensive 30-year study of transportation needs east of Seattle, home to much of the region's high-technology growth. The decisions to be made will shape this portion of the region for the next 20-30 years.

The paper will emphasize the following:

- Innovative methods to engage three committees consisting of citizens, agency staff, and elected officials;
- Evaluation process, including the use of technical and policy criteria to guide the decisions;
- Lessons learned from the technical, policy, and political process.

Our findings will be of particular interest to transportation planners in urban areas seeking to balance technical and policy issues.

BACKGROUND

Construction in the early 1960s of Interstate 405 in East King County provided a freight bypass to avoid Interstate 5 through Seattle, but it also opened the Lake Washington countryside to increased development. East King County now houses six of the County's 12 designated "urban centers", into which much of the region's growth will be funneled to help preserve outlying rural areas. Accordingly, I-405 has changed dramatically from a Seattle bypass to become the roadway of choice for most north-south trips for the area east of Lake Washington.

The I-405 Corridor is one of the fastest growing areas in Washington State (see **Figure 1**: Study Area Boundaries). Home to Microsoft and Boeing, this corridor is expected to grow over 50% in housing and employment over the next 20 years. Poor transportation conditions cause recurring congestion on the freeway and arterial systems during both the AM and PM peak periods. Portions of I-405 already experiencing over 10 hours of congestion a day will worsen significantly during the next few years. With I-405 as the backbone of East King County's transportation system, the growing traffic congestion along the corridor has serious implications for personal and freight mobility, the economy, the environment and residents' quality of life.

[1] Principal- Mirai Associates; Member ITE; 425-415-0905; don@miraiassociates.com

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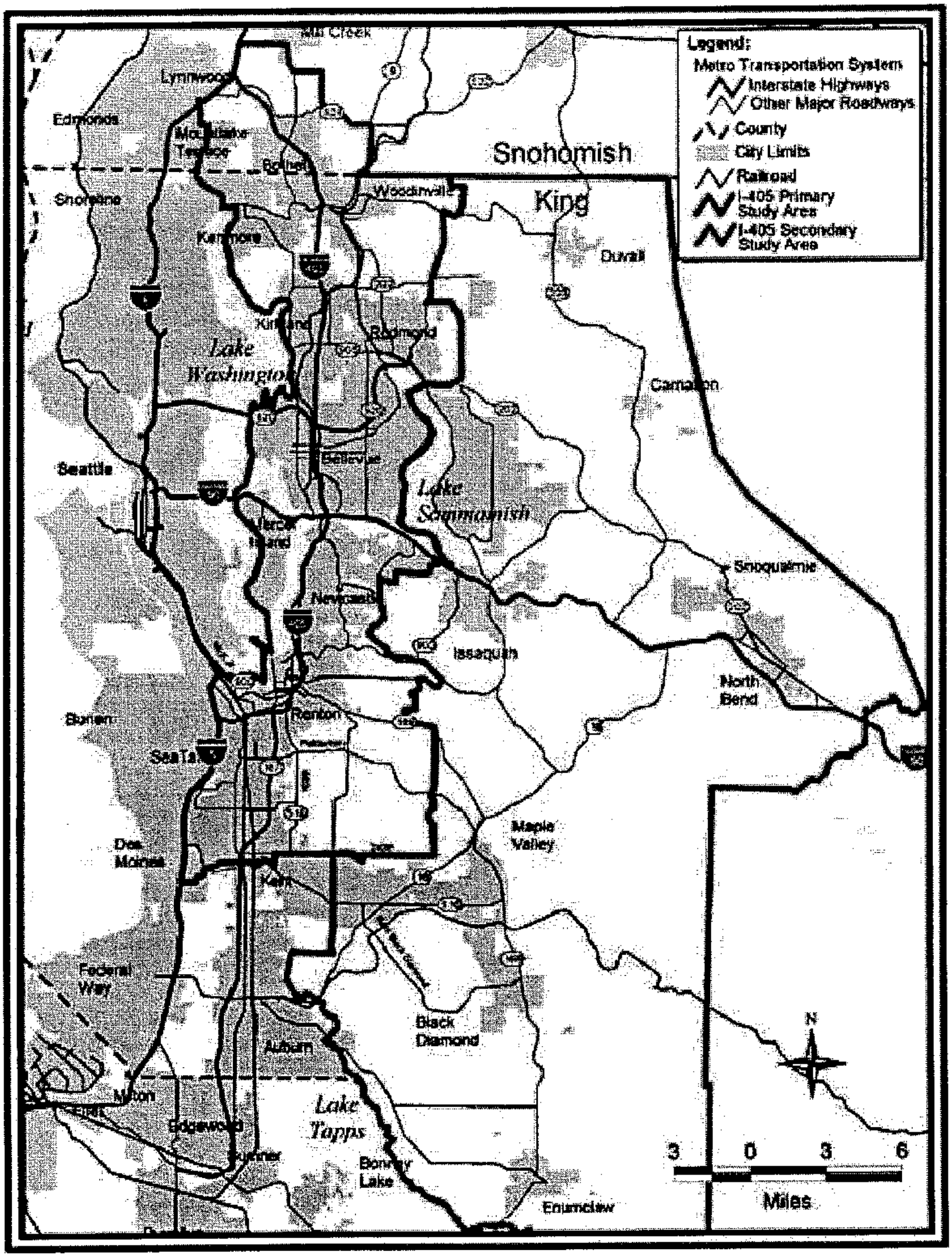
Figure 1. Study Area



In response to the mobility problems in this corridor the Washington State Legislature funded the I-405 Corridor Program. This is a cooperative effort involving over 30 agencies that have responsibilities to plan, regulate, and implement transportation improvements in this corridor. The program was developed to:

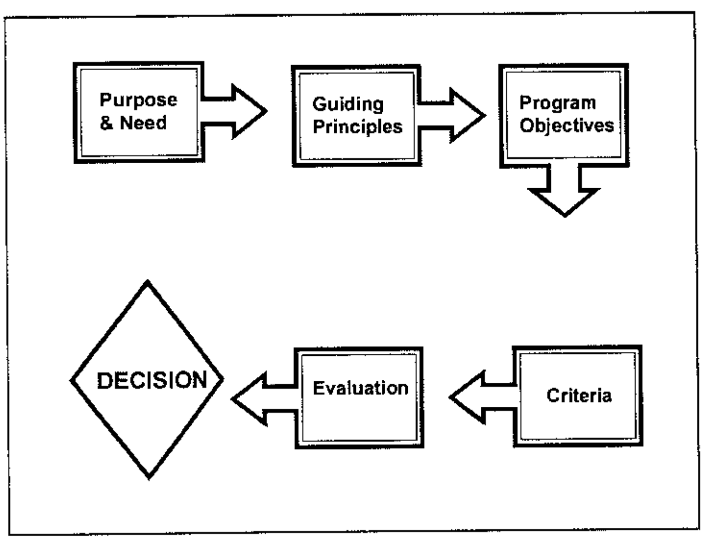
- Improve mobility for people and goods;
- Preserve environmental quality;
- Support vibrant, livable communities; and
- Establish the best package of transportation programs that can be realistically implemented.

OVERVIEW OF STUDY PROCESS

The I-405 Corridor Program project team developed a study process to identify, evaluate and select a package of improvements for the corridor. Using this process, three committees (policy leaders, staff and citizens -see below for details) developed four alternatives from an initial group of several hundred projects and strategies addressing issues in the corridor. Upon completion of an Environmental impact Statement, the Program's Executive Committee has proposed a final package of improvements as the "preferred alternative" for the I-405 Corridor, to be adopted into local, regional, state, and Federal transportation plans and programs.

The decision process follows a logical progression, starting with a clear statement of the study's purpose and need, followed by a thorough evaluation of alternatives, leading to a decision. This process is illustrated below **Figure 2.**

FIGURE 2. DECISION PROCESS



This program also serves as a national demonstration project for "Re-Inventing NEPA", an effort to integrate federal and state agency review under the National Environmental Policy Act (NEPA) early in the transportation planning process to ease implementation of decisions. The key element of this process is recognition of three specific decision making points called concurrence points. These concurrence points are:

- A purpose and need statement;
- Selection of alternatives to advance for detailed study in the Draft EIS; and
- Selection of the preferred alternative and mitigation concept in the Final EIS.

Agencies and Tribes with Jurisdiction (ATJ), including resource, regulatory, and jurisdictional agencies that have the ability to stop or deny a project either through a permit action, or project objection with regulatory weight have chartered responsibilities to review the program a each concurrence point. As a case in point, National Marine Fisheries Service (NMFS) questioned whether the solutions studied by the Program could hurt wild Chinook salmon, recently listed as an endangered species. In response, the Program initiated a dispute resolution process with NMFS to resolve their concerns.

COMMITTEE PROCESSES

An unprecedented partnership of federal, state and local elected officials, agency staff and private citizens guide decision-making for the I-405 Corridor Program. Nearly 100 federal, state, regional and local agency representatives, and environmental, business and local citizen representatives serve on one of three committees:

Executive Committee - Local, state, and federal officials will make the final selection of solutions, using input from the public and other committees. These solutions will then be incorporated into local and state transportation funding proposals.

Steering Committee - Technical staff from area municipalities, environmental and regulatory agencies, and transportation service providers will identify and screen possible solutions and present findings to the other committees.

Citizen Committee - Interested citizens representing a wide range of business, environmental, freight, modal, and neighborhood constituencies will provide valuable input and feedback on the proposed alternatives.

The committee structure (**Figure 3**) was designed to help information flow between the members of the committees to insure understanding of the issues and decisions. Joint meetings were held to create opportunities for discussions on different points of view.

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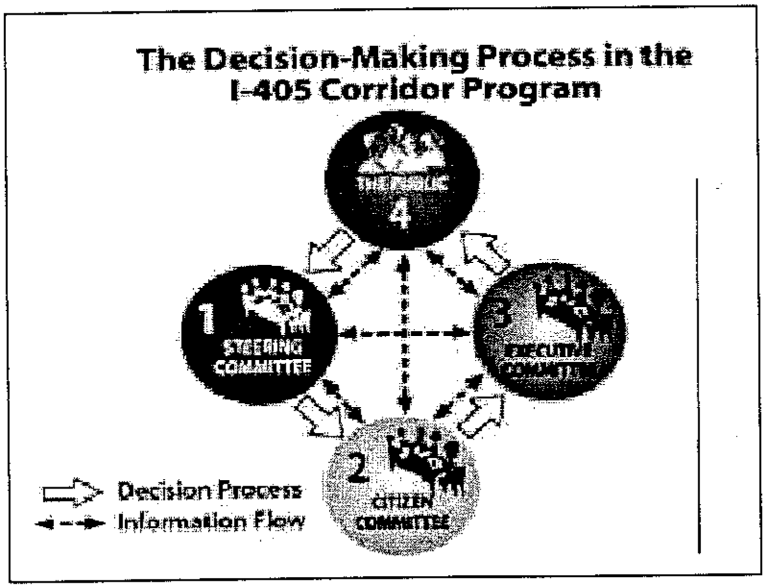
Figure 3. The Decision-Making Process in the I-405 Corridor Program



EVALUATION PROCESS

The I-405 evaluation process included two phases:

- Screening of Options
- Evaluation of Alternatives

Screening of Options

A screening process was used to narrow down the initial list of projects and strategies, leading to the development of four build alternatives that were moved forward to the EIS. This process is illustrated in **Figures 4** and **5.**

Over 300 individual projects or concepts were evaluated during the program. The range of potential solutions included the following:

- General freeway capacity increases up to 3 lanes in each direction
- Express lanes
- Development of a Managed, or HOT lane
- High capacity transit system serving the 30+ mile corridor
- Expansion of the HOV lanes on the freeway and arterial system
- Innovative Transportation Demand Management Program
- Significant increases in bus transit service
- Completion of Intelligent Transportation Systems within the corridor
- Improvements to bicycle and pedestrian connections within the corridor
- Freight and Goods programs
- Intelligent Transportation Systems

First Level Screening

Each of the potential projects, or concepts, were run through a first-level screening similar to a 'fatal flaw' analysis. Fatally flawed projects included any project, idea or concept that did not clearly meet the purpose and need for the I-405 Corridor Program or was clearly infeasible. For example, projects that would not improve mobility in the corridor clearly would not meet the needs of the I-405 Program. The following list describes the criteria adopted for the first-level screening:

- Does the concept meet the program™s objectives? Does it improve mobility? Reduce roadway traffic congestion? Improve safety?
- Can we reasonably mitigate any known environmental impacts?
- Is the concept feasible to implement?

The first-level screening showed that most of the ideas were considered reasonable.

Figure 4. Screening Process

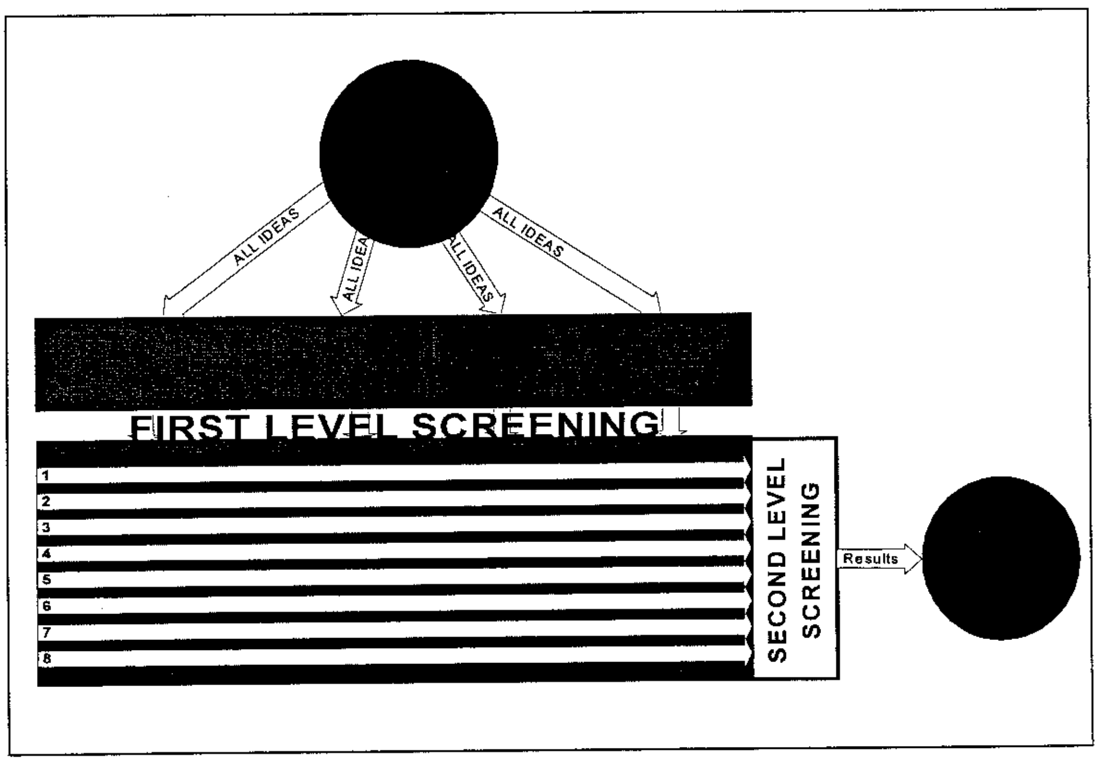
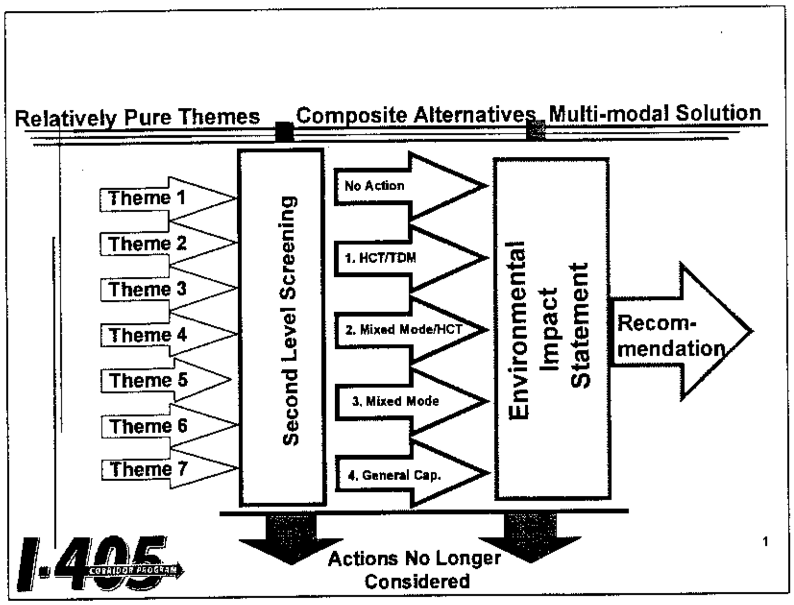


Figure 5. Corridor Program EIS Process



Second-Level Screening

The second-level screening was used to evaluate packages of projects, referred to as themes. The second-level screening was more detailed than the first-level screening. The modal themes were specifically designed to test the limits of various strategies in reducing congestion and improving mobility in the study area.

The second-level screening criteria sought answers to the several probing questions:

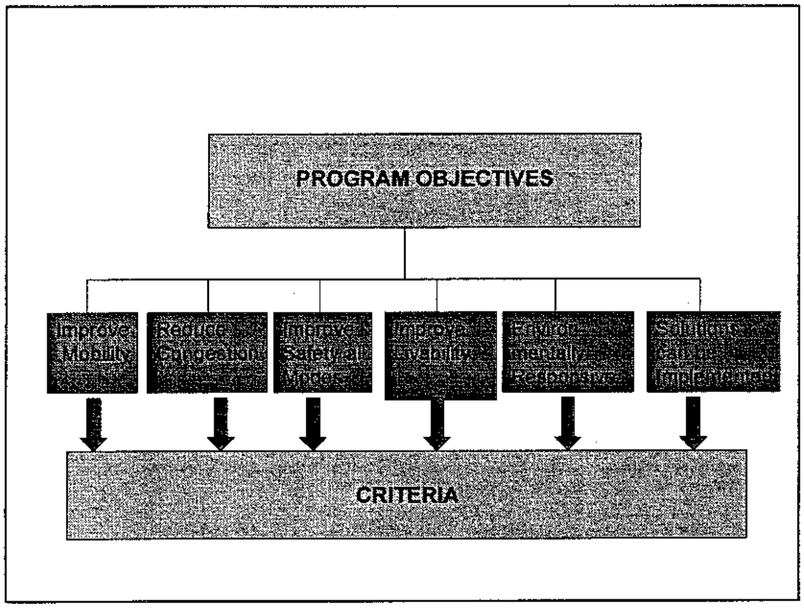
- **Transportation performance.** How many trips are served? How are people traveling? How well would the system work?
- **Financial/economic performance**. What are the total cost for capital facilities, right-of-way (ROW), and operations and maintenance. Measures the cost effectiveness of the project/strategy.
- **Social impacts.** What are the effects on the neighborhood? What properties are affected? Questions about environmental justice.
- **Land Use.** Reviewed consistency with land use plans and policies.
- **Environmental impacts**. What are the impacts on the natural environments?

Several projects were deleted from further consideration based upon the results of the second-level screening. After months of work, four build alternatives (plus a No Action Alternative) were crafted to closely meet the purpose and need of the I-405 Corridor Program and provide a reasonable range of transportation solutions. The four alternatives create a set of bookends around the feasible approaches to improve mobility in the corridor.

Alternatives Evaluation

The evaluation of the EIS alternatives used a series of criteria that related directly to the program's Purpose and Need statement and guiding principles that were established by the program committees, as shown in **Figure 6.**

Figure 6. Alternatives Evaluation



The evaluation results were extensively reviewed by the Study Committees during a series of workshops in late 2000.

Preliminary Preferred Alternative

After reviewing the results of the EIS evaluation, the three study committees agreed to a preliminary preferred alternative for the I-405 Corridor in January 2001. The preliminary preferred alternative is a "mixed mode package" that includes two new lanes each direction to I-405; an express bus system; potential for a high capacity transit system in the central corridor; fixing bottlenecks such as the SR 167/I-405 interchange; and taking steps to preserve the Burlington Northern Railroad alignment for a future transportation corridor. The specific strategies are listed in **Table 1**.

The Preliminary Preferred alternative provides a framework with the overall strategic mix of modes and system improvements that best meet the Purpose and Need of the I-405 Corridor Program.

Next Steps

During the next few months, the I-405 Corridor Program will complete the Draft and Final Environmental Impact Statements and select a preferred alternative. Additional details will be defined for this alternative within each community. At the same time, an implementation plan is being examined by the State legislature in hopes of obtaining significant project funding during the next 6 years. Given the magnitude of the project, an extensive phasing program will be developed.

Table 1. Summary of Preliminary Preferred Alternative Recommendations

Transportation Demand Management (TDM): Substantially increase the number of vanpools, improve public education, and expand employer-based programs. Suggested that TDM be an early-action strategy.

- **Pricing Strategies-** Members supported further study of pricing solutions in the I-405 corridor as part of a regional program. The Project Team will provide the committee further information for consideration.

High Occupancy Vehicle (HOV): Complete the HOV direct access interchanges and supporting investments (park-and-ride, etc.).

Transit: Implement a Bus Rapid Transit (BRT) service for north-south transit travel along with expanded transit service (up to 100%), park-and-ride, and transit centers in the corridor.

Roadway:

- **I-405-** Add up to two general-purpose lanes in each direction along the entire length of I-405. Include connecting freeway and arterial expansions.
- **SR 167**- Implement improvements to the SR 167/I-405 interchange. All but two members supported the addition of up to two general-purpose lanes on SR 167 south to at least Kent.
- **Arterials**- Implement planned arterial projects and the list of limited North-South arterial expansions.
- **High Occupancy Toll (i.e. HOT) Lanes**- The members supported further study and evaluation of a High Occupancy Toll operation on I-405. The Project Team should provide further information for consideration by the committee.

Non-Motorized: Strong majority to include corridor pedestrian and bicycle facilities.

Intelligent Transportation Systems (ITS): Continue implementation of ITS strategies along the I-405 corridor.

Freight Mobility: Include the identified freight mobility projects. Suggested that further information be developed related to cost impacts.

LESSONS LEARNED

A study the magnitude of the I-405 Corridor Program encounters numerous issues that require attention. In response, we have learned a number of lessons and tried some new approaches.

Policy Issues

- Involvement of the 3 committees was essential to achieving a preliminary decision. Not everyone agreed with every finding or decision, but they have respected the process.
- The 'Reinventing NEPA' process has been successful at bringing the various resource agencies to the table early in the planning process. Given that this is a 30-mile long programmatic corridor study, however, many of the permitting agencies (e.g. National Marine Fisheries, Department of Ecology, EPA) have reserved judgment until more detailed studies are completed.

- Decision making within the corridor has been able to continue at the same time that a host of regional discussions regarding Endangered Species Act implementation, transit system implementation, funding, and an update to the Regional Transportation Plan.

Technical Issues

- The travel forecasts were developed and applied at the same time that new land use and network forecasts were being regionally prepared. This required careful explanation of the modeling assumptions and limitations in order to gain technical credibility.
- The study developed a set of 'unconstrained' forecasts that provided the committees with helpful insights into travel demands within the corridor.
- The study developed Benefit-Cost data using FHWA's STEAM model. This is one of the more complex corridor studies to attempt to quantify a range of direct and indirect benefits.
- Corridor congestion was reported in terms of 'hours of congestion' rather than traditional peak hour level of service. This method allowed the committees to examine the duration of congestion throughout the day, while recognizing that the 'peak of the peak' levels of congestion would probably not improve significantly.
- The study specifically analyzed the land use-transportation connection that is becoming a very relevant discussion in the context of growth management and environmental concerns.
- The study initiated regional debate regarding the use of managed, or HOT, lanes as a mechanism to provide efficient travel within the corridor.
- The study explored the potential for Bus Rapid Transit as an option to a fixed-guideway rail system within the corridor. The BRT concept has gained further support within other corridors.

Political Issues

- The study area local political leaders joined with State and Federal officials to develop a preliminary preferred alternative.
- Substantial political briefings and one-on-one meetings with city councils and organizations helped to smooth the way to a preliminary decision.
- Inclusion of State Legislators on the Executive Committee helped to spur quick consideration of funding proposals in the 2001 Legislative Session.

ACKNOWLEDGEMENTS

I wish to acknowledge the input of the following individuals in preparation of this paper: Michael Cummings, I-405 Corridor Program Manager, WSDOT; Ron Anderson, Project Principal, David Evans and Associates; Lise Northey and Virginia Brix, Mirai Associates.

For more Information:

Log onto the I-405 web site at www.wsdot/wa/gov/I-405

B-3-4.1

Major Corridor Investment: A Puget Sound Case Study

The Corridor Needs Study for East King County (CONEKC) was conducted at the request of the Washington State Legislature to address increasing north-south highway congestion in the central Puget Sound region. Concerned that heavy traffic is threatening economic vitality and livability, legislators wanted to assess the need for additional north-south capacity to accommodate the growing transportation demand. The CONEKC study is unique, in that it evaluated the benefits of major infrastructure investment far beyond the level studied through the Metropolitan Transportation Plan or the WSDOT Highway Systems Plan. Three Strategies were evaluated: a new north-south "beltway" freeway; three north-south arterial parkways, in the suburban and ex-urban area; and a transit/arterial scenario. Primary system performance measures were: daily vehicle miles of travel (VMT), daily vehicle hours of travel (VHT), average travel speeds, and north-south travel time. Cost estimates were compared to a 2020 annual benefit measure for relative comparison of scenarios. The north-south freeway and the three north-south arterial parkways both showed a 5.8 percent reduction in VHT in the regional study area, significantly greater than the package of 2020 improvements in the Metropolitan Transportation Plan. This benefit must be considered relative to growth management and rural preservation policies, environmental concerns from thousands of wetlands, hundreds of stream crossings, and endangered species habitat.

Prepared by:

David M. Horn
Transportation Engineer
David Evans and Associates, Inc.
415 – 118th Avenue SE
Bellevue, WA 98005-3518
(425) 519-6500

Claudia S. Hirschey, P.E.
Senior Transportation Engineer
David Evans and Associates, Inc.
415 – 118th Avenue SE
Bellevue, WA 98005-3518
(425) 519-6500

Carol Hunter
Project Manager
Office of Urban Mobility
Washington State Department of Transportation
401 Second Avenue, Suite 300
Seattle, WA 98104-2887
(206) 464-6231

March 2001

Background

The Corridor Needs Study for East King County (CONEKC) was conducted at the request of the Washington State Legislature to address increasing north-south highway congestion in the central Puget Sound region. Concerned that heavy traffic is threatening regional economic vitality and livability, legislators wanted to assess the need for additional north-south capacity to accommodate the growing transportation demand. CONEKC, structured as a technical needs study, was coordinated with the I-405 Corridor Program to provide long-range planning in a regional context.

CONEKC provides information on a range of transportation scenarios developed and tested to learn how people and goods can travel more efficiently through the region. Sketch level planning was conducted for three hypothetical scenarios: a north-south freeway, an arterial parkway system, and major transit/arterial investments. Each scenario was assessed in terms of merits for the regional transportation network and impacts to east King County. These three scenarios were compared to a No-Action Scenario, which included the Puget Sound Regional Council's Six-Year Action Strategy.

Interagency Coordination

The CONEKC project staff was advised throughout the study by the Technical Working Group (TWG), comprised of staff from agencies and jurisdictions in the study area. They were responsible for ensuring that vital regional and corridor issues were identified and accounted for within the study. The TWG provided feedback and input about the reasonableness of scenarios and results produced by the project staff. Finally, it was the role of the TWG to ensure that the results were clear and understandable and that the study results and findings were clearly presented. All jurisdictions in east King County were invited to the TWG. Meetings were held in cities in east King County from Issaquah to Woodinville. Agencies participating in the TWG included the cities of Bellevue, Carnation, Duvall, Issaquah, Redmond, Renton, Sammamish, and Woodinville; King and Snohomish Counties; and the Puget Sound Regional Council (PSRC).

Study Area

The CONEKC Study Area Map (see page 2) shows the three study areas for this project. Analysis and scenarios for CONEKC were developed closely with the I-405 Corridor Program. Therefore, these two studies share common study boundaries, most of which are coincident with transportation analysis zones (TAZs) and county lines.

In general, the boundary of the CONEKC local impact area on the east includes the growth management areas of Duvall, Carnation, North Bend, Issaquah, Maple Valley, and Enumclaw. On the south and north, the boundary follows the King County lines. On the west, the boundary runs up the east side of Auburn up to the southern edge of the I-405 Study Area boundary. It then follows the I-405 Study Area boundary north to the Snohomish County line. The local impact area was a study area defined to capture impacts in the immediate area of a scenario.

The Regional Study Area was sized to assess regional trip patterns, especially those generated by regional freight traffic. The Regional Study Area includes significant trip generating facilities; the ports of Tacoma, Seattle, and Everett; and the north Everett industrial areas. This area extends from the Puget Sound on the west to the eastern edge of the CONEKC local impact area and from Marysville on the north to the southernmost edge of the CONEKC local impact area on the south.

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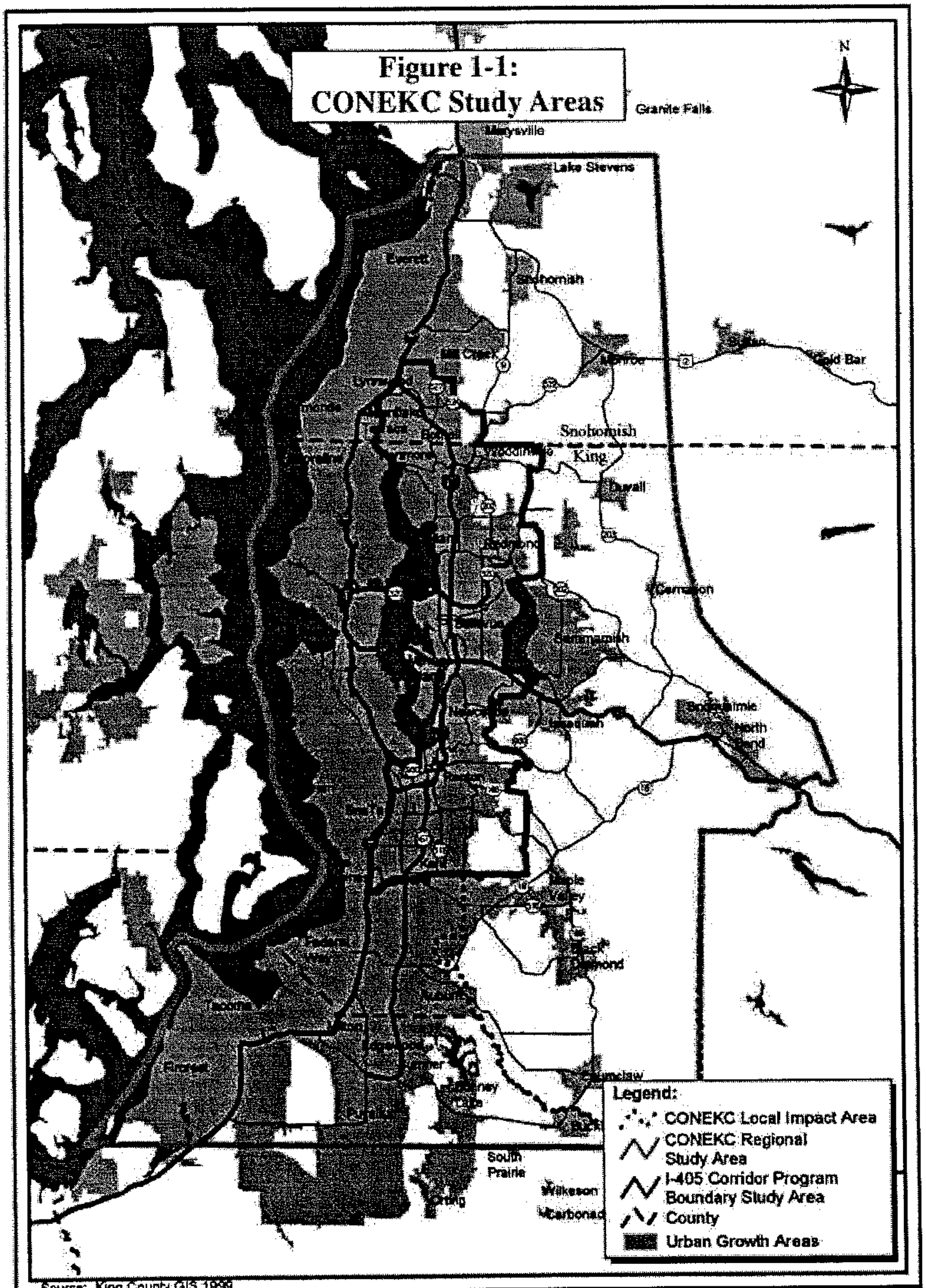

Figure 1-1: CONEKC Study Areas

WDOT0188 DEA Inc. 6/99 Draft

Traffic Congestion

Of growing concern is how the region's economic health and quality of life can be maintained while accommodating tremendous population and employment growth over the next two decades. Since 1980, communities in the regional study area have experienced a 38% increase in population coupled with a 60% increase in jobs. By 2020, the population in the regional study area will increase by an additional 42% (adding 1.3 million more people). Nearly two-thirds of the state's employment is located in the CONEKC regional study area.

One by-product of this thriving economy is significant traffic congestion on our limited transportation network. Currently, drivers on I-5 and I-405—the region's transportation backbone—can experience over 10 hours of congestion each weekday. By 2020 traffic will be heavy on I-5 and I-405 throughout most of every weekday, severely restricting mobility options for people and goods. This condition is aggravated by freeway incidents such as accidents and special events. A Texas Transportation Institute report showed that Everett-Seattle area drivers average about 69 hours of delay per year (October 1999).

Most of the western portion of the study area experiences significant congestion on freeways and arterials. As pressure on the transportation system continues, east King County communities are finding that increasing congestion is leading to Growth Management Act concurrency issues. With the continuation of rapid suburban-type development, and limited transportation improvements, congestion will only worsen as planned population and employment growth continues.

Major Travel Markets

The number of person trips within the study area is projected to grow significantly. Average daily trips in the region are expected to grow from 11.2 million in 1995 to 17.1 million in 2020 (about 53%); the vast majority of those will be by single occupant vehicle. Trips going all the way through King County are expected to double from 62,000 to 137,000 per day by 2020. Trips passing through Pierce, King, and Snohomish counties in the north-south direction are approximately 9,000. This number is expected to grow to about 22,000 trips by 2020.

The focus of this study is on north-south trips — almost two-thirds of the long-distance north-south through-trips are currently on I-5. In east King County 62% of the trips are east-west and 40% are north-south. Five percent of the trips are to and from the north and 33% are to and from the south. From east of the study area the distribution of trips through east King County is 24% to and from the north, 37% to and from the west, and 39% to and from the south. Major movements are in and out of the ports of Seattle and Tacoma from the east as well as north and south.

Freight Movement

Because of its strategic location, the Puget Sound region is a significant international freight corridor. Truck transportation provides a vital link to waterborne container trade. Most freight moving through Puget Sound ports also travels by truck on I-5. A large percentage of the region's export cargo is generated east of the Cascades, most arriving via I-90. The ports of Seattle and Tacoma each generate an estimated 1,500 – 2,000 truckloads per day and the Port of Everett generates an estimated 100 – 200.

In addition to trans-Pacific shipping, significant volumes of freight move through the region enroute to and from Canada, Mexico, Oregon, California, and points east. On I-5 at Blaine, NAFTA related traffic has grown 15% every year over the last 5 years. While this rate of growth is expected to level off, we can still expect an overall growth rate of at least 2% per year in truck traffic through the Puget Sound region.

Land Use

The east King County local impact area abuts three urban centers: Renton, Bellevue, and Redmond. Nine cities within the impact area are designated as "growth areas" with Urban Growth Area (UGA) boundaries: Duvall, North Bend, Snoqualmie, Sammamish, Maple Valley, Carnation, Enumclaw, Issaquah, and Black Diamond. By 2020, these communities are expected to accommodate a 22% population increase within their UGAs.

Comprehensive plans for these east King County communities emphasize a desire to maintain the existing rural character and quality of life as they accommodate this anticipated growth. These communities are concerned about the nature of the growth that will occur. Although land use within the UGAs is primarily single family residential, a large increase in commercial property development is occurring in North Bend and Issaquah. Land beyond the UGA boundaries is designated rural in Vision 2020.

The majority of the study area consists of unincorporated rural King County. Land use in this area is largely characterized by rural and resource lands. The countywide planning policies strongly advocate protection of the rural areas, containment of urban sprawl and directing growth to urban areas.

Natural Environment

Any of the hypothetical transportation investment scenarios for east King County are certain to impact sensitive areas. East King County has a large number of rivers, streams and other wildlife habitats. Thousands of wetlands and major lakes, rivers and sloughs exist in the area, several of which are located near existing transportation corridors. Almost all of the rivers and streams in the local impact area fall under the authority of the Endangered Species Act. Much of this area lies within the Snoqualmie-Skykomish Watershed and floodplain, which support wild runs of coho, chinook, pink, chum and steelhead salmon. Significant seismic faults and slide prone areas exist near I-90 and along SR-203. Finally, scores of parks, trails, refuges, and historic and culture resources will also need to be considered as mobility strategies are developed.

Travel Analysis

The total daily person trips in the study area are expected to grow significantly. Based on the output from the PSRC model, total daily person trips are expected to increase from 659,800 to 1,145,200 between 1995 and 2020, representing an increase of 74 percent. During the same time period, total daily person trips in the four-county region are expected to grow from 11,235,000 to 17,146,000 trips, which is about a 53 percent increase. The difference between travel growth in the study area and the region is further underscored by looking at these trips on annual basis. The study area is forecasted to experience a 2.23 percent increase per year in trips while the region's overall growth is anticipated to be somewhat lower with an increase of 1.71 percent per year.

Today, total person trips between Tacoma/Pierce County and Everett/Snohomish County that pass through King County are estimated to be about 62,000. Out of these 62,000 person trips, approximately 30 percent of the total through trips are external to the PSRC four-county region. Approximately 9,000 of these north-south through trips are external-to-external trips (e.g., Olympia to Vancouver, B.C.). By 2020, north-south through person trips passing through King County are expected to grow to 137,000; approximately, 22,000 of those through trips will be external to external trips. Thus, the total number of through trips and external-to-external trips will approximately double by 2020. It was estimated that in both 1995 and 2020, 64 percent of the person trips passing through King County used I-5, 18 percent used I-405, and the remaining 18 percent used other arterials.

The CONEKC study area is leading the region in terms of both population and employment growth; these trends will likely result in increased travel demand. In general, travel demand growth in the CONEKC study area is slightly higher than the region's. It is expected that the study area will continue to have considerably more trips in the 10 to 20 mile range, especially in comparison to the region as a whole. Of significance is the expected increase in the number of trips between Pierce and Snohomish Counties (through trips) and the number of external-to-external trips, which are expected to more than double from 1995 to 2020.

Capacity Improvements Scenarios

Three scenarios were developed intending to test different capacity improvements (e.g., a major new freeway under the Freeway Scenario). The starting point for modeling of all the scenarios was PSRC's 2020 No-Action Scenario. This scenario includes: the six-year action strategy, highway projects with committed funding (including projects funded under Referendum 49 that are expected to influence travel within the region); Metro's Six-Year Transit Plan; and Phase I of Sound Transit's Sound Move Plan (including light rail, commuter rail, and regional express bus service).

The Freeway Scenario considers the placement of a limited access facility east of I-405 in east King County. The purpose of the Freeway Scenario is to provide a route for regional north-south through trips as an alternate to the I-5 and I-405 corridors. The conceptual scenario places a freeway alignment from the Port of Tacoma to the Port of Everett via east King County. The freeway alignment would use a combination of new and existing alignments with interchanges at major highway crossings (SR 18 and US 2), provide access to Duvall (a UGA), and bypass Carnation. The total route length would be approximately 90 miles. The freeway is a four-lane facility with an assumed off-peak operating speed of 60 mph. The scenario also includes improvements to other facilities that would provide system continuity and prevent bottlenecks from developing so that the full potential of the scenario is reflected in the model results.

The Arterial Parkway Scenario includes developing three north-south arterials that would add north-south capacity throughout the corridor. The concept shows three corridors all east of Lake Sammamish, using a combination of new and existing arterial segments. The concept is a parkway with relatively limited access through landscaped median and an assumed operating speed of 45 mph. The parkway concept is an arterial with a landscaped median and limited access. Signals were assumed to be spaced at approximately 0.90-mile intervals on new alignment. The assumed off-peak travel speed is 45 mph. Much of the supporting infrastructure is identified by the WSDOT System Plan. Arterial improvements were also included to meet the needs for 2020 and to maintain system continuity. Finally, the additional capacity that was assumed under the Arterial Parkway Scenario was approximately equal to that assumed under the Freeway Scenario.

The Transit Scenario includes expanded transit service and park-and-ride (P&R) facilities. The arterial scenario is included with the transit scenario because it allows for more efficient access to the local impact area by transit and supports access by bicycle and pedestrian facilities. P&R expansion is a key element to this scenario since it will provide the opportunity for improved frequency of transit service. P&R capacity is not constrained in the modeling process, so a geographic variety of locations will reflect the overall effectiveness of expanded park-and-ride and transit service to transit ridership. This means that park-and-ride capacity is assumed to be available with any increase in transit service.

Additionally, an overall increase in transit frequency and coverage is a component of this scenario with a focus on additional north-south service just east of Lake Sammamish. Aggressive transit improvements, including the use of queue bypasses and HOV facilities, are expected to allow buses to travel at comparable average speeds to other vehicles.

Travel Demand Results

Forecasts of 2020 volumes reveal that new segments of a freeway in east King County are expected to carry approximately 62,000 vehicles per day. With a new freeway, traffic volumes on I-5 will decrease between five and eleven percent, depending on location. Minor decreases in traffic occur for other major facilities in the regional study area. Regional volumes overall are expected to increase by up to eight percent over the No-Action Scenario.

The arterial parkway system is forecasted to have significant increases in traffic volumes in 2020. Traffic on the west, central, and eastern arterial parkways are expected to increase by up to 24,000 vehicles per day. Decreases in traffic volumes on most major facilities are expected outside of the local impact area. Regional volumes overall are expected to increase by up to six percent over the No-Action Scenario.

Because the transit improvements were overlaid onto the Arterial Parkway Scenario, the impacts on forecasted traffic are similar. The additional transit related improvements (as part of the Transit/Arterial Scenario) did not have a considerable effect on trip distribution and highway assignment. Transit improvements did have an impact on transit ridership. The number of daily riders increased by 5,200 region-wide and by 4,100 in the I-405 and east King County study areas.

The travel demand results showed that a new freeway facility in east King County would tend to carry trips over 30 miles in length. However, the arterial parkway and transit/arterial scenarios would tend to carry a greater mix of trip lengths. The regional vehicle miles traveled would be expected to increase by less than two percent for each scenario, but the regional vehicle hours traveled would be expected to decrease by approximately five percent for all of the scenarios.

Future volumes of north-south truck traffic were estimated for the year 2020 by applying growth rates to the present level of traffic. The 2020 trend estimate of truck traffic growth selected for this study is two percent per year [1] or a 50 percent increase. This is a conservative rate, but also consistent with forecasts as presented in the 1999 marine Cargo Forecasts[2], which indicates that truck volumes from ports would increase at four percent per year. At two percent per year, daily *through* truck volumes will reach approximately 10,500 on I-5; and 2,250 on I-405; and 1,160 on SR 203.

Travel Time Savings

A measure of travel time for select regional movements was estimated for each of the CONEKC scenarios. Each travel time measure considered through trips and was compared against a baseline travel time measure. Travel times for I-5 and I-405 through trips were used for the baseline comparison, using peak and off-peak period conditions. The travel time calculations were completed for three of the predominant travel markets identified by the study. The first travel market examined was for north-south through trips. North-south through trips were estimated to travel from approximately the Port of Everett in the north to SR 12 at I-5, south of the Port of Tacoma. The east-north through trips were also estimated, beginning just east of North Bend and ending in the north near the Port of Everett. The east-south through trips were assumed to originate just east of North Bend and end near the Port of Tacoma. All of the trips ending or beginning in the north or south converge on I-5. The trips originating in the east converge on I-90 and remain on I-90 until the intersection with the appropriate north-south facility.

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1 EWITS Research Report No. 9. Movement of Freight on Washington's Highways: A Statewide Origin and Destination Study.

2 1999 Marine Cargo Forecast, Washington Public Ports Association (WPPA) and WSDOT.

The freeway scenario, which was approximately 25 miles longer than the I-5 and I-405 corridors, showed peak period travel times comparable for trips on I-5, I-405, and the new freeway. Travel time during the off-peak periods was longer for the freeway corridor, due to the additional length of the assumed "beltway" alignment. Travel time is reduced on I-5 and I-405 as compared to the No-Action Scenario by 15 to 25 minutes, showing that the increased regional capacity decreases congestion.

The lack of travel time savings for north-south trips on the new freeway relative to travel time on I-5, I-405, was a significant finding of the analysis. In sections of new alignment, the new freeway corridor is carrying volumes of approximately 62,000 vehicles per day and reaching a volume to capacity (v/c) ratio of 1.17 in the northbound direction and 0.90 in the southbound direction during the peak period. Of the 62,000 trips, an estimated 27,000 are long distance through trips that shifted to the new freeway corridor from I-5 and other corridors. These volumes are in addition to baseline volumes on SR 18 and US 2, resulting in those segments going over-capacity in 2020. When volumes in the model approach capacity on a particular facility, the model attempts to achieve equilibrium by re-assigning traffic until the shortest path is achieved for most of the traffic. This process is consistent with driver behavior. However, without significant post-processing of v/c ratios, the model cannot reflect that I-5 and I-405 would experience over five hours per day of peak period conditions (MTP 1995), whereas the new freeway would likely experience fewer hours per day of peak period conditions. Thus, the new freeway would result in more hours per day at higher speeds and reduced travel times. More detailed peak period analysis will be conducted under the I-405 Corridor Program.

The arterial parkway concept assumed relatively long signal spacing and limited access. The travel distance for through trips on the arterials was 10 to 24 miles longer than the I-5 and I-405 corridors. The off-peak period travel time for each of the arterial corridors was longer than the I-5 and I-405 travel times. The longest of the three arterials, located furthest east on the SR 203 alignment, has a longer through travel time in all conditions for north-south trips than do the I-5 and I-405 no-action corridors. However, the west and central parkways have roughly equivalent north-south through travel times in the peak period compared to through travel times on I-5 and I-405. The average travel speed is slower as a signalized arterial parkway than for a freeway.

For north-south through trips in the p.m. peak period, travel time was reduced by 15 to 20 minutes on I-5 and I-405, with the new arterials, but travel time via the new arterials was longer than on I-5 and I-405. For off-peak conditions, the parkways show travel time differences on the order of fifteen minutes shorter to twenty minutes longer than on I-5 and I-405 corridors. Note that not all of the parkway travel times were slower than those of the freeway corridors.

The transit scenario was modeled as the arterial scenario with unlimited P&R capacity and expanded transit service and coverage. For the transit scenario, additional service does have an east-west orientation due to the commuter market for transit service. However, the emphasis is from east King County to eastside employment centers, with additional north-south service between Issaquah and Redmond.

The model results show effectively no difference in volumes between the transit and arterial scenario results, even though a minimal shift in mode choice was measurable. The transit scenario assumed aggressive facility improvements, including queue bypasses and HOV facilities. Improved transit travel times were the expected result. These high-speed improvements that would cause transit vehicles to miss congestion would be counter-balanced by the requisite stop and dwell times associated with picking up and dropping off passengers. Aggressive transit improvements are expected to allow buses to travel at comparable average speeds to other vehicles. Thus, the transit travel time is assumed to be consistent with the travel times generated for vehicle travel.

Investment Relative to Merits

The transportation investment of each scenario relative to its estimated benefit is a key evaluation measure. This measure compared a conceptual, planning-level cost estimate of construction and annual operating costs of facilities with the benefits evaluated. A range of measures, which could be used to assign dollar values, were used to evaluate the benefits of the scenarios. The benefits evaluated relied on travel time savings for north-south through trips and congestion reduction relative to the future baseline. The results of this evaluation are described as the "merits" of the scenario, because it is not a rigorous cost-benefit analysis. High and low investment costs were defined relative to the potential for funding a scenario in the context of current regional funding levels.

The freeway scenario shows the greatest merit relative to the No-Action Scenario. A majority of the benefit is attributable to the travel time savings realized on all regional facilities with the increase in capacity. In addition, the large travel time savings was realized because access was very limited and land use assumptions remained constant. However, a new freeway in east King County may change land use patterns and cause less of a travel time benefit to be realized. The results of the analysis are shown in **Table 1**. The associated costs of the freeway scenario are shown in **Table 2**.

The analysis of the arterial scenario reveals a substantial benefit, though not as large as that of the freeway scenario. Like with the freeway scenario, the benefits of the scenario are largely attributable to the travel time reduction. However, the implications of holding land use constant may be of greater concern for the arterial scenario than the freeway scenario because the three arterial parkways provide easier opportunities for access than does the freeway scenario. The results of the merit analysis are shown in **Table1**. The associated costs are shown in **Table 2**.

Like the other scenarios, the merit of the transit scenario is primarily from the travel time savings and is based upon the assumption of fixed land use patterns. **Table 1** shows the results of the transit scenario analysis, which is very close to the results of the arterial scenario. As shown in **Table 2**, the estimated costs of the scenario include the costs of increased transit service. Overall, an increase in costs (transit service and P&R lots) realizes an increase in benefit (shift to transit trips).

Table 1: Annual Merit Relative to No-Action Scenario

	Freeway Merit	Arterial Merit	Transit Merit
Travel Time Savings	$1,650,146,000	$1,113,204,000	$1,114,434,000
Change in Vehicle Operating Cost	$219,353,000	($35,773,000)	($35,773,000)
Accident Cost Reduction	$56,849,000	($203,991,000)	($165,186,000)
External Environmental Cost	($122,202,000)	($19,929,000)	($19,929,000)
Total Annual Merit	**$1,365,441,000**	**$853,512,000**	**$893,547,000**

Table 2: Cost Estimates

	Freeway Cost	Arterial Cost	Transit Cost
Capital Cost			
Total 1997 dollars	$1,440,000,000	$1,517,700,000	$1,517,000,000
Annualized at 7% 50-yr life	$104,342,000	$109,972,000	$112,095,000
Annual Operations and Maintenance Cost			
Roadway	$5,460,000	$5,355,000	$5,355,000
Transit Service	N/A	N/A	6,300,000
Total Operations and Maintenance	$5,460,000	$5,355,000	$11,656,000
2020 Annual Cost	**$109,802,000**	**$115,327,000**	**$123,750,000**

Conclusions

This study shows that significant capacity increases in east King County can measurably ease congestion, reduce travel time, and increase travel speeds on the regional network. CONEKC revealed that there is sufficient north-south travel demand through the Puget Sound region to justify the addition of major infrastructure. The study shows that additional infrastructure has the potential to benefit the region by reducing vehicle hours of travel by five percent, a reduction of 200,000 hours. Additionally, the scenarios reduce traffic volumes on both I-5 and I-405, with a greater benefit received on I-5. The freeway scenario has the potential to reduce traffic volumes on I-5 and I-405 more so than the other scenarios. The study also showed that facility improvements do not need to be located in east King County to gain benefit since a sufficient north-south through trip travel demand exists.

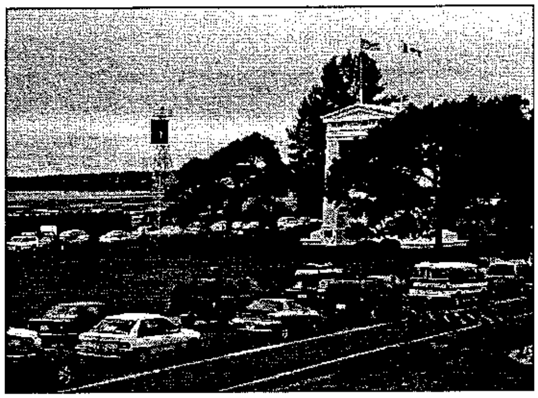
Under current conditions, most of I-5 and I-405 are congested for three to five hours per day, with segments of each experiencing over five hours of congestion per day. By 2020, about half the length of both I-5 and I-405 are estimated to reach over five hours of congestion per day. At these volumes, and level of congestion, the opportunity for trucks to travel during off peak conditions become more limited, thereby reducing freight mobility in King County. Approximately one-half of the daily flow value ($264,000) is delayed by congestion every working day. Sixty-six million dollars is moved annually within and through King County.

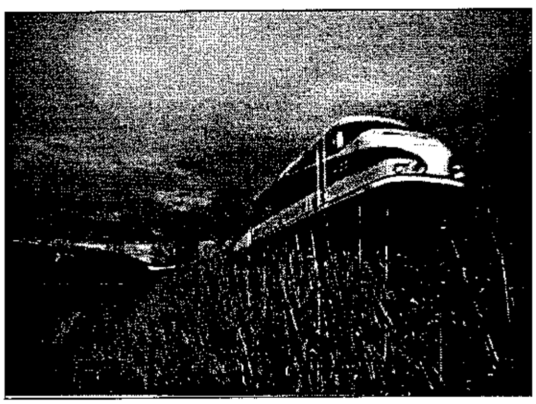
The study also revealed several obstacles that will cause capacity improvements difficult to build. Significant environmental constraints exist in east King County, including a large number of rivers, streams, and seismic areas. Additionally, endangered species are located in the study area, which places additional constraints on improvements. The comprehensive plans for east King County areas show a desire to minimize growth and maintain its rural character. The addition of capacity improvements in the area may contradict these plans.

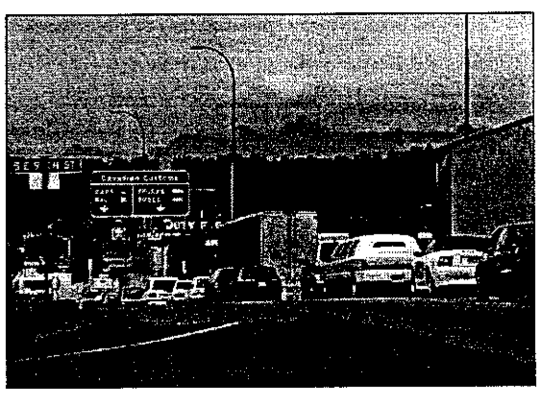
The region is faced with significant choices. CONEKC data clearly show that "no action" will result in increased congestion with impacts on our economy and quality of life. However, future decisions will require the weighing of many considerations—financial, technical, environmental, and social. Finding the right balance, and one that is supported by our communities, depends on a high level of public dialogue.

6-3-5.1

The Cascade Gateway: Cross-Border Transportation Issues







Presented to: 2001 ITE/Quad Conference, Vancouver, BC – April 6, 2001
Submitted by: Martin Kobayakawa, Senior Transportation Planner, TransLink

B-3-5.2

The Cascade Gateway: Cross-border Transportation Issues

Abstract: *This paper describes some of the major issues facing transportation in the Cascade Gateway border region, and then outlines key initiatives being put forward to address these issues. The paper concludes that cross-border flows of people and goods will increase in the future due to increased trade and the growing interdependence of the Cascadia region. As well, planning and decision-making through an inclusive, inter-agency approach, such as the International Mobility and Trade Corridor (IMTC) Project, has good potential to come up with consensual solutions. The U.S. TEA-21 program is a dedicated funding source, which may be used for cross-border transportation improvements on both sides of the border. Additionally, there is an opportunity to better utilize the rail mode for both passenger and freight travel across the Cascade Gateway.*

Introduction

> *"An ideal border would allow the free movement of goods, services and people between Canada and the U.S."*[1]

Cross-border transportation is primarily concerned with the movement of passengers and freight across international borders. This issue impacts transportation in the Greater Vancouver Regional District, due to the proximity of the U.S. – Canada border to the region, i.e. most of the GVRD is within 100 kilometres of the border. Additionally, the Pacific Northwest is becoming increasingly interdependent over a number of levels; this is reflected in the growing north-south movement of people and goods.

Dimensions of Cross-border Transportation

Within the context of the Vancouver region, cross-border transportation has several dimensions, including trade and the North American economy, the development of bi-national urban regions, tourism, the environment and immigration.

Since the signing of the North American Free Trade Agreement (NAFTA) in 1993, the U.S. – Canada border has been growing in importance and profile. With NAFTA, the economies of North America have become increasingly integrated and trade has flourished. The value of cross-border trade between Canada and the U.S. is now estimated at $1 million per minute, with trucks carrying 70% of the goods across the border. For goods produced in Canada, 16% of the final selling price of goods is related to transportation costs.

Similar to other regional economies in North America, the economy of British Columbia is very much trade-oriented, both for "old economy" and "new economy" sectors. As B.C. is a relatively small player in North America, cross-border trade is crucial to its economic well being.

The emergence of Cascadia, as a bi-national, urban-centred region is a key issue impacting cross-border transportation. The Cascadia region is made up of the province of

[1] Public Policy Forum Survey of Canadian business leaders, November 2000.

British Columbia and the states of Washington and Oregon. Major urban centres in this region include Vancouver (BC), Victoria (BC), Seattle (WA), Portland (OR) and Eugene (OR). The proximity of these centres to one another has resulted in important linkages between centres, e.g. economic activity, tourism and culture. As well, the natural environment of Cascadia is not restricted by national boundaries. For instance, both Vancouver and Seattle are situated on the Georgia Basin; Whatcom County and the GVRD share the same air basin.

The Cascade Gateway

i) Characteristics

There are four main border crossings in the Greater Vancouver area: the Peace Arch (Highway 99), Pacific Highway (Highway 15), Aldergrove – Lynden (Highway 13) and Abbotsford – Sumas crossings. An additional crossing connects Delta, BC and Point Roberts, WA, along Point Roberts Road. These border crossings are shown in Figure 1 below. The Peace Arch and Pacific Highway crossings, together are the third busiest vehicle crossing (9 million car trips annually) and fourth busiest commercial truck crossing (1.2 million truck trips annually) on the Canada – U.S. border. It is notable that since the NAFTA was signed in 1993, freight volumes have doubled.

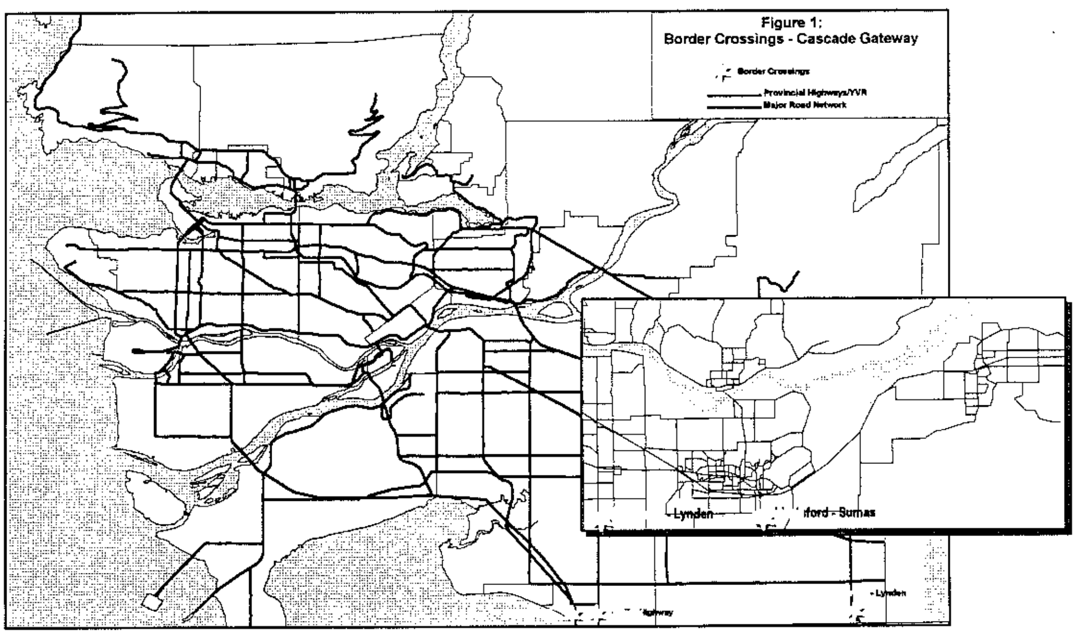


Figure 1: Border Crossings - Cascade Gateway

ii) Challenges

The key challenge to cross-border transportation has to do with the presence of the border and the large number of stakeholders – both governmental and non-governmental – on both sides of it. The need for co-operation and co-ordination in policy development and implementation presents a major challenge. This is further compounded by different priorities given to cross-border issues by different levels of government, and the lack of funding available for cross-border transportation improvements. For instance, the Canadian government currently does not have a federal highways program.

Further challenges to cross-border transportation include competition and possible conflict within the Pacific Northwest, e.g. competition between the ports of Seattle and Vancouver, and the lack of data on cross-border transportation flows (e.g. origins and destinations of freight, passenger/commuting flows).

iii) Freight Movement

Major characteristics and issues related to freight movement across the Cascade Gateway are summarized in Table 1. From this table, it is notable that trucking is by far the dominant mode used for cross-border freight movement. The main issue facing trucks are the delays at the border, which cost private carriers approximately $40 million ($U.S.) per annum. Opportunities to improve cross-border mobility include the application of Intelligent Transportation Systems (ITS) and the largely untapped potential of the rail mode.

Table 1:
Cascade Gateway – Freight Movement

Modes:	• Truck and rail
Main Gateways:	• Pacific Highway (Highway 15) • Burlington Northern Santa Fe (BNSF) rail line
Major Trends:	• 1.2 million truck crossings annually (1999) • Doubling of truck volumes since NAFTA (1993) • Commodity value of 11.7 billion ($U.S.) annually
Major Issues:	• Delays at border, with a cost to private carriers of $40 million ($U.S.) • Underutilization of rail
Opportunities:	• ITS applications • Better utilization of rail mode • Improvements to infrastructure

iv) Passenger Movement

Major characteristics and issues related to passenger movement across the Cascade Gateway are shown in Table 2. It is notable that cross-border passenger travel is mainly by private car, with approximately 9 million car border crossings being made per year. It is also notable that the new Amtrak 'Cascades' rail passenger service between Vancouver and Seattle was initiated in 1995.

The main issues related to passenger movement have to do with the car orientation of travel and delays at the border. Identified opportunities for improving cross-border passenger movement include measures to mitigate delays at the border (advanced traveller information and improved pre-clearance programs) and utilizing other travel modes (i.e. rail, public transit).

Table 2:
Cascade Gateway – Passenger Movement

Modes:	• Private car, private bus, rail
Main Gateways:	• Peace Arch (Highway 99/I-5) • Burlington Northern Santa Fe (BNSF) line (Amtrak)
Major Trends:	• 9 million car border crossings per year • New Amtrak service
Major Issues:	• Delays at border • Car orientation of travel
Opportunities:	• Advanced traveller information • Improved pre-clearance • Expanded Amtrak rail passenger service • Cross-border public transit

Institutional Responses

There have been a number of initiatives, undertaken mainly by governmental agencies, to address cross-border transportation and related issues.

These initiatives have consisted of the following:

- **International Mobility and Trade Corridor (IMTC) Project:** The IMTC Project is a U.S. – Canadian coalition of business and government entities in Washington State and B.C. that was formed to jointly identify and pursue improvements to cross-border mobility in the Cascade Gateway. Over 80 governmental and non-governmental agencies participate in the IMTC Project. The Whatcom Council of Governments (WCOG) is the lead agency for the IMTC Project.

- **Transportation Equity Act for the 21st Century (TEA-21):** TEA-21 is the U.S. government program for funding transportation improvements. Under the Co-ordinated Border Infrastructure (CBI) program, funding is available for planning, project development, construction and operation of projects serving border regions (defined as within 60 miles of the U.S. – Canada or U.S. – Mexico border).

- **Cascadia Project:** The mission of the Cascadia Project is to 'Co-operate Regionally to Compete Globally'- to increase co-operation within Cascadia in order to strengthen the region's economy and quality of life in the 21st Century. This mission is served through development of common strategies in support of intermodal transportation, trade, tourism, environment and technology. The Cascadia Project was formed in 1993 and is managed by the Seattle-based Discovery Institute, in co-operation with the Vancouver-based Cascadia Institute.

- **B.C./Washington Corridor Task Force:** The Task Force is the official British Columbia and Washington State response to the Cascadia initiative. The B.C./Washington Corridor Task Force and the Cascadia Project are working on cross-border agreements to focus on three issues: border infrastructure, connecting the gateways and corridors, and Georgia Basin – Puget Sound environmental issues.

Current Cross-Border Transportation Projects

Most cross-border transportation projects for the Cascade Gateway, either currently underway or planned for the future, are managed by the Whatcom Council of Governments and are funded through TEA-21.

Ongoing projects include the following:

- **Co-ordination of Binational Planning:** IMTC project co-ordination, research, data analysis and regional planning co-ordination. The Whatcom Council of Governments (WCOG) is the lead agency.

- **ITS-Commercial Vehicle Operations:** A pilot project that applies Intelligent Transportation Systems (ITS) to commercial vehicles at the Pacific Highway crossing. ITS applications could significantly reduce the delays at border crossings.

- **Advanced Traveller Information Systems:** Real-time traffic information (e.g. wait times, congestion) for northbound travellers along I-5. A similar project for southbound travellers along Highway 99 is planned for 2001.

- **Travel Demand Survey:** A survey of origins and destinations of cross-border freight and passenger travel.

- **Border Pre-clearance Programs:** Existing pre-approval programs include the CANPASS (Canada) and PACE (U.S.) pre-approval programs that allow registered participants to proceed through the border with minimal delays. A pilot project is currently underway at the Pacific Highway crossing for improved pre-clearance, which uses smart card technology and allows for photo identification.

Projects for the 2001 Fiscal Year, just underway include the following:

- **Abbotsford-Sumas Cross-border Access Improvement:** A binationally co-ordinated improvement plan for at-border approach roads both north and south of the Sumas-Huntingdon port-of-entry.
- **Cross-border Transit Framework:** A feasibility study and phased plan for cross-border public transit connections/services. Deliverables will include a demand analysis and a strategy to develop cross-border transit.
- **Cascade Gateway Rail Study:** A feasibility study for increasing the use of the rail mode for freight and passenger movement in the Cascade Gateway border region. The study will take a corridor approach to planning improvements to rail.
- **Advanced Traveller Information Systems:** Real-time traffic information (e.g. wait times, congestion) for southbound travellers along Highway 99.

Conclusions

Based on this discussion of cross-border transportation issues related to the Cascade Gateway border crossings, a number of conclusions can be reached:

1. Freight and passenger flows across the Cascade Gateway will increase significantly in the future, reflecting the growing ties within Cascadia as a binational urban region.
2. There are many institutional challenges to cross-border transportation. An inclusive, international and multi-agency approach to planning and implementing improvements, such as through the International Mobility and Trade Corridor (IMTC) Project, has a great deal of potential to address this issue.
3. The U.S. Transportation Equity Act for the Twenty First Century (TEA-21) is a dedicated funding source for improving cross-border transportation. TEA-21 presents an opportunity for Canadian government agencies to work in partnership with their American counterparts to develop cross-border transportation improvements.
4. There is much potential within the Cascade Gateway for a mode shift from highway modes of travel (i.e. trucking, private automobile) to rail for both freight and passenger movement. By increasing the rail mode share of cross-border travel, highway capacity issues being faced by truck and automobile travel may be mitigated.

B-3-5.6

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ROAD SAFETY AUDITS: LESSONS LEARNED TO DATE

Sany Zein, M.Eng., P.Eng.
Vice President of Transportation
Hamilton Associates, Vancouver, B.C.

Margaret Gibbs, P.Eng.
Project Engineer
Hamilton Associates, Vancouver, B.C.

1. Introduction

A road safety audit is defined as a formal and independent review of a proposed road design by an expert safety team to assess its multi-modal safety performance. In Canada, the audit is typically conducted at one or two points during the design stages, when a proactive approach to road safety can identify potential road hazards while they can still be corrected. Road safety auditors reviewing a conceptual, functional, or preliminary design can identify deficiencies before they are built into a project, and make recommendations that will improve road safety.

Road safety audits and reviews started in the early 1980s in the U.K., where local county councils initiated them to address issues arising from poor highway design. The first formal audit in North America was conducted for the construction of the Highway 1 HOV lane in Vancouver during the project's 50-percent design stage. The audit was conducted in 1997 by Professor Frank Navin and Hamilton Associates, and was based on Australian audit procedures. Around the same time, the U.S. Federal Highways Administration initiated a program of trial audits in Pennsylvania, also based on Australian methodologies.

2. Recent North American Experience

British Columbia

The Canadian road safety audit experience started in British Columbia in 1995, when the Insurance Corporation of British Columbia (ICBC) commissioned studies to review the audit concept and lessons learned in other jurisdictions. Since then, road safety audits have been conducted on highway, bridge, and interchange projects in British Columbia and across Canada. Major B.C. audits include those for the Vancouver-Richmond Rapid Bus project (preliminary design), the 200 Street interchange on Highway 1 in Langley (detailed design), the Lions Gate Bridge upgrade (preliminary design), and the Glenrosa interchange in Kelowna (preliminary and detailed designs). The latter project was a design/build project commissioned by the B.C. Ministry of Transportation and Highways. Design/build teams, typically consisting of a partnership between contractors and engineers, are frequently required by the Ministry to retain an independent road safety audit team to formally review the design at designated stages (usually the preliminary and detailed design stages) and prepare audit reports.

Other Provinces

Road safety audits were introduced to Alberta in 1998 when the first formal audit was undertaken for the widening of a municipal road in Red Deer. More recently, road safety audits have been conducted for Yellowhead Trail / Capilano Interchange project in Edmonton, and the Highway 22X / Deerfoot Trail Interchange in Calgary.

The 200-kilometre Fredericton-Moncton toll highway provided an opportunity for road safety audits to be introduced to New Brunswick. In 1997, a safety audit was performed for this major design/build facility as part of the proposal preparation stage, and road safety audits are being conducted during the detailed design stage. The University of New Brunswick has prepared a document on audit procedures.

Transportation Association of Canada (TAC)

In September 1999, the TAC Road Safety Subcommittee launched a project to prepare the National Road Safety Audit Guidelines. The Guidelines, which will constitute a Canadian reference document on best practices and guidelines for conducting road safety audits, are currently in draft form and under review. The Guidelines are based in part on the methodologies contained in the audit documents sponsored by ICBC and the University of New Brunswick.

United States

In the United States, road safety audits are supported by the U.S. Federal Highways Administration and the Institute of Transportation Engineers through their sponsorship of a website *(www.roadwaysafetyaudits.org)* and audit workshops and courses. The FHWA launched a pilot road safety audit project in 1998, in which 14 states participated. Pennsylvania was the most active participant, auditing several design projects and developing a North American version of the Australian safety audit checklists.

3. Lessons Learned: Audit Process

Quantify Risk

A road safety audit identifies elements of a design that may create a hazard for road users, such as a tight-radius curve or a short exit ramp. Where a risk is identified, it should be quantified to indicate its magnitude, both in absolute terms and relative to the other hazards identified in the audit. One possible quantification scheme involves an assessment of risk as a function of three elements:

- exposure — What proportion of the road users are expected to be affected by the potential hazard?
- probability — What is the probability that the presence of the hazard will result in a collision?
- consequence — What are the anticipated results of collisions in terms of their potential severity?

These elements of risk may be assessed qualitatively as high, medium, or low, and the rationale for the assessment should be explained.

Back Up Findings and Suggestions

When a possible improvement has been proposed to remedy a hazard identified during the safety audit, its potential benefits should be quantified by reference to reported road safety literature or local experience.

Good Reporting

The results of the road safety audits are typically reported in a letter to the design team. The letter identifies the materials and, if necessary, the assumptions on which the audit was based, specifies the scope of the audit and the methodology used, states the findings of the audit, and identifies potential improvements that may be considered by the design team to improve the safety of the design.

The design team is encouraged to respond to the audit findings (see *"Understanding Legal Liability"* below). Their responses may detail changes to the design made in response to the audit findings, or provide justification for design elements that have been cited in the audit report but cannot or will not be changed.

Sensitivity to Project Stage

The audit team should be aware of the design stage and its impact on certain design elements. Fundamental design elements such as design criteria and the broad alignment are adopted early in the life of a project. Recommendations concerning these elements need to be made in the early stages of the design, when changes may be made without incurring great expense or delay.

Understand Legal Liability

Road safety audits can reduce tort exposure by identifying safety issues early in the design process, when they can be amended. Reducing the risk of collisions reduces the risk of lawsuits arising from those collisions. However, safety audits also increase an agency's knowledge of the planning, design, and operations of its facilities. Liability may increase if courts find that an agency knew of deficiencies that it subsequently failed to address. Consequently, the written response of the design team to the audit report is key. An agency does not necessarily increase its liability if it rejects an audit recommendation and a crash occurs. The plaintiff must prove negligence and must prove that a problem was ignored after it was put on record. The key is to document and address the final actions taken in response to all of the audit findings.

4. Lessons Learned: Design Process

Table 1 identifies the findings and recommendations that have arisen from road safety audits conducted by Hamilton Associates in Canada. Common issues arising from road designs include the following:

- adequate shoulders and clear zones should be provided to accommodate errant vehicles that leave the travelled way;
- while minimum design values for various road elements such as radii and lane width may be acceptable, a combination of minimum values at a single site may have a detrimental effect on roadway safety, particularly where factors such as weather or the presence of intersections may distract drivers or affect their capabilities;
- adequate decision sight distance should be achieved in the design and should not be compromised by vertical curve crests, roadside landscaping, barriers, or bridge structures;
- where non-automotive users such as pedestrians and cyclists are expected, the design should accommodate them by providing continuous, safe, and convenient links;
- roadway design must meet the special requirements of large vehicles

such as trucks and buses, which have reduced acceleration, braking, and turning capabilities relative to automobiles;

- adequate consideration should be given to signs and pavement markings, which provide guidance to drivers.

TABLE 1 TYPICAL AUDIT RECOMMENDATIONS

PROJECT DESCRIPTION, AUDIT TYPE, AND LOCATION		improve clear zone / traversability	improve sight distances	provide median barriers / end treatments	improve lighting	improve weaving / left merges / intersection spacing	protect structure / hazards	improve drainage	improve pedestrian / bicycle facilities	improve cross section, lane width, shoulder, superelevation, curb	better provisions for buses and trucks	improve signing and pavement markings	improve interchange ramps (radius, grade)	improve vertical alignment	improve horizontal alignment / turn radii	improve design consistency / human factors	improve traffic control and warning devices	revised driveway accesses
Highway 407 (pre-opening)	ON	x					x				x	x	x					
Highway 1 HOV Lanes (50% design)	BC	x	x	x	x	x	x	x				x						
Fredericton-Moncton Highway (preliminary design)	NB	x	x	x		x		x		x		x	x	x	x	x		
Vancouver / Richmond Rapid Bus (preliminary design)	BC					x			x	x	x	x						
Highway 401 widening (preliminary design)	ON		x	x						x			x	x				
Highway 1 / 200 St interchange (detailed design)	BC										x		x				x	
Dogwood at Belaire and Bayview (conceptual design)	BC						x	x	x	x					x			
River Road at Nordel Way (preliminary design)	BC				x				x		x						x	
Lions Gate Bridge upgrade (preliminary design)	BC								x	x								
67 Street / 30 Avenue widening (preliminary design)	AB		x	x				x	x	x	x						x	
Highway 401 Extension (preliminary design)	ON		x										x	x	x	x		
Glenrosa interchange (preliminary and detailed design)	BC					x		x	x									
West and North Fernie bridges (conceptual design)	BC		x					x	x	x					x			
John Hart Bridge (conceptual design)	BC			x									x					
96th Avenue interchange (90% design)	AB	x				x		x		x		x						x
Surrey Place Development (conceptual design)	BC		x						x	x						x		x
Stanley Park Causeway (60% design audit)	BC	x				x	x		x	x		x						

5. Conclusions and Recommendations

Road safety audits, which originated in the U.K., are gaining acceptance throughout North America as a useful tool for ensuring that safety is adequately considered in roadway design. The realization that road safety could not be assured simply by complying with highway design standards has helped to motivate the acceptance of safety audits at the design stage.

As experience with road safety audits grows, both auditors and designers have a better idea of the application and benefits of the audit procedure. As the audit procedure is applied in increasing numbers of projects, auditors learn to increase the utility of the audit to achieve the maximum benefit at each stage in the design process. At the same time, designers gain a greater knowledge of the areas in which roadway designs can frequently be improved to increase the safety of the road user.

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Highway Safety Analysis Software

Alexander Mirsakov, P.E.
Civil Engineer/Software Developer, X32 Group, Inc.

119 Yorkshire Drive, Morganville, NJ 07751, USA, Tel: (917) 691-7524, Fax: (732) 591-7442
E-mail: hsa@x32group.com, Website: http://www.x32group.com

HSA Software is a tool for analyzing motor vehicle accident data and revealing accident patterns. HSA Software helps in developing road safety enhancements in order to reduce the number of accidents and improve traffic operation conditions. HSA Software includes accident data entry, editing and filtering, preparing accident summaries and data listing, calculating accident rates, estimating safety benefits, and generating Collision Diagrams.

1. HSA Software Overview.

Highway safety is an important element that affects quality of life of the society. Therefore, transportation agencies and companies all over the world pay a great deal of attention to identifying and addressing roadway safety deficiencies.

Traffic engineers use various techniques for conducting automobile accident investigations. The accident analysis process consumes a lot of time, as it is being done, in many cases, either manually or using standard database/spreadsheet programs for data entry and analysis.

Highway Safety Analysis Software (HSA Software) was developed to provide fast and easy way of conducting accident studies, and producing detailed and presentable results. HSA Software is used for accident analysis of roadway segments and intersections. Accident Reports or datasheets serve as an entry data for the software. The program output includes the following:

- Details of Accident History report that tabulates all accident records, and provides basic information on accident parameters and conditions.
- Accident Summary Sheet with proportional distribution of different accident categories.
- Accident Rate Calculation form for computing accident rates for the study segments or intersections.
- Collision Diagram generated for selected intersections or road segments. It may be prepared using various road geometry layouts. The diagram may be edited by moving and copying accident symbols, highlighting some accident categories, and displaying traffic control devices.
- Safety Benefits Evaluation Form for estimating the cost of accident reduction based on proposed safety improvements.
- Highway Safety Investigation Report used for summarizing identified safety deficiencies and listing proposed solutions.

The output forms may be generated for all accidents within the study section of road, as well as for selected intersection(s) or segment(s), or for different accident categories and conditions using data filtering feature. Accident Summary Sheets and Collision Diagrams produced for various locations and conditions allow identifying and visualizing accident patterns, and provide engineers with ideas on possible accident causes and ways to address them.

2. Accident Data Formats and Entry Process.

Accident data has various formats and structure, depending on Province, State, Country, or other jurisdiction where it was collected. In general, police officers or motorists file accident reports, and then this data is entered in the main database, or stored in microfilms. Transportation agencies receive this data from the Central office either as hard copies from microfilms, or in a form of database files or printouts.

HSA Software has the Accident Data Entry Form for manual data entry or editing. This form includes controls for accident date, time, location, type, pavement and weather conditions, traffic control, accident contributing factors, vehicle direction of travel, and more. All this information may be entered for each accident record, and edited later if necessary. To expedite manual data entry there is a voice assistant option, which lets user know which entry box he is currently using, so that he does not have to look at the screen all the time. Some data entry boxes on entry form have pull-down menus and/or help windows for assistance.

Separate data files may be created for each study location. Location Information form serves for entering road name or number, study limits, time interval, segment length, Average Annual Daily Traffic (AADT), and other general data.

Another way of entering accident data in the HSA Software is data transferring from a database file into the software. The HSA Data Transfer procedure, which converts data files from their original format into HSA Software format, has been developed and is being utilized in the states of Arizona and Connecticut, USA. It is planned to develop such procedure for other jurisdictions. However, some local accident databases may not be detailed enough for producing accident summaries and Collision Diagrams, and, in this case, manual data entry is required.

It is quite possible that in the future accident data would be entered by police officers using electronic datasheets, and immediately be transferred into the Central nationwide or international database. Then it could be easily imported into the HSA Software, as it would have the uniform format for all jurisdictions.

3. Data Filtering.

After accident data is entered in the HSA Software, it can be filtered based on different criteria. The filtered data is used for all output forms, including a Collision Diagram, and Accident Rate Calculation form. Filters enable reviewing accident data at different intersections or segments within the study area, different weather conditions, accident types, and many more other conditions or combinations of conditions. This helps revealing accident patterns and understanding accident causes. Selection of different time periods allows conducting "Before and After" accident studies in order to show how certain roadway or other improvements affected traffic safety at the study location.

4. Accident Analysis Results.

In order to analyze accident data, different forms and reports are produced by the HSA Software. They include Details of Accident History Report, Accident Summary Sheet, Accident Rate Calculation form, Highway Safety Investigation Report, Safety Benefits Evaluation Form, and Collision Diagram.

The Details of Accident History Report lists all accident records sorted by location (intersection), accident type, and sequential number. It includes information on accident parameters for each record. It is convenient to have this report while editing Collision Diagram, and then when analyzing accident patterns revealed on the diagram.

Accident Summary Sheet includes proportional distribution for different accident categories and conditions. It assists in revealing accident patterns and probable causes by showing the most frequently occurred accident types and unusually high proportions of various accident parameters.

Accident rates may be calculated for segments (using US customary or metric units for the segment length) or intersections. After the rate is calculated it may be compared to the average rate. Accident rates can also be calculated for different accident categories and time periods after filtering data and entering appropriate values in the accident rate formula.

Safety Benefits Evaluation Form is used to estimate benefits from accident reduction due to proposed safety improvement. To calculate accident costs user should enter the number of accidents reduced, future AADT, average accident costs and accident severity distribution for a similar facility type. HSA Software performs the significance analysis comparing accident severity distribution at the study location to the average distribution, and then estimates total accident costs with and without improvements.

All output forms in the HSA Software may be printed out (color or gray scale) and included in the accident analysis report, or plotted in large format for presentations.

5. Collision Diagram.

Collision Diagrams in the HSA Software are generated for intersections or segments within study location. User may select intersection layout from preset road geometry types such as 4-legged intersection (which may be modified into an offset intersection), T-intersection, a segment, or using an image file as a background.

Red arrows on the diagram represent vehicles and their direction of travel. Every accident type has its own unique symbol consisting of combination of two arrows, or one arrow and other symbol (a red square for a fixed object, "P" for pedestrian, "B" for bicycle, etc.). Every green box near an accident symbol represents specific accident and displays an accident record sequential number, the same number as appears on the Accident Data Entry Form or Details of Accident History report.

Collision Diagrams in the HSA Software may be edited. Accident symbols can be moved within a diagram to more precise location, or copied to display the same symbols at different areas on a diagram (for example some right angle accidents could have occurred at the intersection, and others at the driveway nearby).

Wet road, nighttime, injury, or fatal accidents may be highlighted on a Collision Diagram. This feature allows better identification of accident patterns and probable causes. For example, you may notice a pattern of wet road accidents existing only in eastbound direction, or at only one intersection approach, or only along the cross street. This would mean that pavements of different type or age may exist at this location, and there is no need to resurface entire segment or intersection, but do just a spot treatment. On other hand, the overall proportion of wet road accidents may not be significantly high, and the local problem area may not be noticed, unless you use the highlight feature.

Since every accident is represented by a number box, it is easy to visualize the most frequent accident types on the diagram. One diagram may display more than 300 accidents.

6. Technical Parameters and Requirements.

HSA Software was developed for Microsoft® Windows operating system. It runs under Microsoft® Access 97 or 2000 environment. The technical requirements are:

- IBM PC with standard hardware configuration;
- Windows 95/98/2000/NT;
- 5 MB worth of hard drive space;
- Microsoft® Access 97 or Access 2000. If you don't have Access, a free runtime for Access 2000 can be found on the installation CD. This option demands extra 70 MB on a hard disk.

One user license allows installing HSA Software on a single PC with any number of CPUs. The software may also be installed on a server, but operated by one user at a time. The Help file is provided for each program procedure, as well as the User's Manual. A free DEMO version of the HSA Software is available.

7. Summary.

HSA Software is a powerful, flexible, and user-friendly program. HSA Software allows saving a lot of time on accident analysis process by expediting data entry process, using data filtering, and producing various output forms, reports, and Collision Diagrams. It generates neat, informative, and presentable results of road accident investigation. HSA Software helps engineers and technicians in developing road safety improvements to reduce the number of traffic accidents.

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The City of Richmond's Lane Policy for Access Management

Jenny Beran, Planner, City of Richmond

The City of Richmond introduced a Lane Policy in 2000 to support the development of new lanes along major roads in conjunction with redevelopment. As redevelopment occurs along major roads, the lane policy ensures that the City acquires the land and capital to build new lanes and that individual accesses from the major arterial roads are therefore removed. The paper addresses issues that needed to be resolved prior to the adoption of the policy such as the definition of a lane, lane design standards, how to introduce lanes into an existing road network, where to apply the policy, implications for population growth, who should pay for them and other implementation issues.

THE LANE POLICY

The main clause of the Lane Policy reads as follows:

> "Where the City approves Rezoning, Development Permit and/or Subdivision applications for properties which:
> a) are outside the City Centre;
> b) are designated by the Official Community Plan (OCP) as "Neighbourhood Residential";
> c) front a major arterial road, or a local arterial road that is part of the Bike Network; and
> d) are illustrated generally on the attached map, "Lane Policy Development Areas";
>
> the City requires the applicant to:
> e) dedicate land at the rear and/or side of the properties for a lane and/or mid-block lane access; and
> f) pay for construction, to City standards, of such lane and/or mid-block lane access."

Attachment 1 contains the complete policy and map. The focus of this paper is the exceptions to the this main clause and forms the basis of the paper and clause 2 through 6 of the policy. The following sections provide the background and then separate the issues into those which are more technical in nature, larger policy issues and then implementation issues.

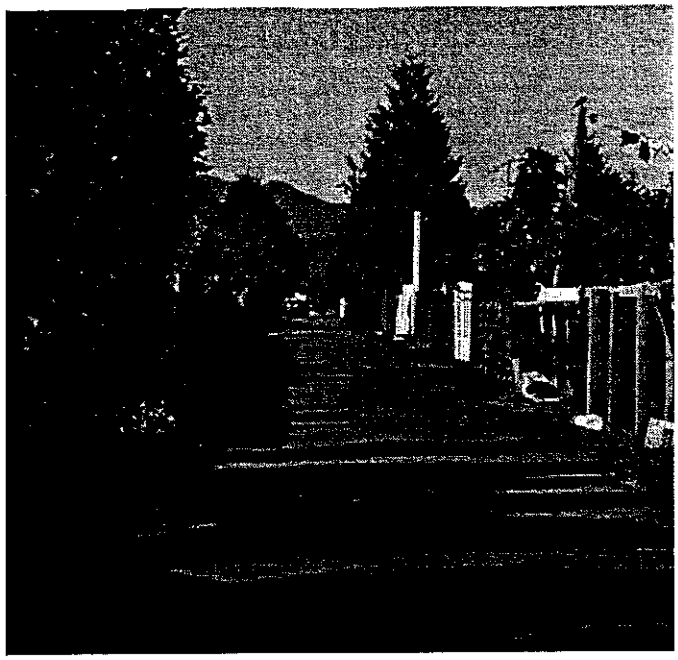
BACKGROUND

What motivated the City of Richmond to look at a Lane Policy?

1. Better traffic management was the second most requested improvement by residents in the 1997 OCP Survey. Traffic congestion along major roads continues to be an issue for Richmond residents and will only increase as the population of Richmond grows;
2. TransLink has approved a number of Richmond's major arterial roads as part of the regional Major Road Network (MRN), upon which it will be important to maintain regional traffic flow. A system of lanes behind the major roads will enhance traffic flow and road capacity; and
3. We are seeing a high proportion of development applications along major roads, partly due to the age of the housing stock along major roads (of all rezoning applications as of September 1999, 70% were along a major road). Some of these applications result in the provision of a lane behind a major arterial. However, a Lane Policy would ensure a more consistent and co-ordinated approach in terms of the City's requirements for lane development.

What was the City's history with lanes?

A number of lanes were built in Richmond when some of the earlier subdivisions were developed in the 1950's. While these lanes have a 6 m right-of-way, many of them are not built to current City standard as the paved surface is too narrow or there is no lighting and drainage. Since the development of these first lanes, relatively few lanes have been created. Even though there is general agreement that lanes are beneficial, the City of Richmond has not had a policy that specifically supports the creation of lanes.



Typical Older Lane

Were there any other policies that addressed lanes and access?

- Earlier initiatives to address the traffic flow and safety issues resulted in an Access Policy adopted by Council in 1989. The Access Policy restricts the creation of new access points along major and local arterial roads through the establishment of minimum lot sizes in areas where lane access is not provided. However, the Access Policy does not directly support the creation of lanes.

- The new Official Community Plan (OCP) supports the creation of lanes. The transportation objective and policy with regard to lanes reads: "Manage traffic flow for efficient and convenient travel while enhancing neighbourhood livability by requiring lanes parallel to major roads rather than driveways which impede traffic flow and create safety hazards for motorists, cyclists and pedestrians".

- The most direct action which the City of Richmond has taken with respect to lanes has been through development. In the recent past, where subdivision or rezoning has occurred along major roads, the City has somethimes required that the applicant either provide the land and/or construct and pay for a lane. However, there had not been a consistent or co-ordinated approach in terms of the City's requirements.

What were the "selling " features of a Lane Policy?

- enhanced traffic flow and road capacity due to the reduction in the number of points that cars entering or exiting to major roads; and
- increased safety through reducing conflicting traffic movements;
- improved accommodation of pedestrians, cyclists and transit;
- improved appearance of streets due to a continuous boulevard with street trees along the major roads and the relocation of garages to the rear of the property thereby increasing the front yard green space;

B-4-3/4

TECHNICAL ISSUES

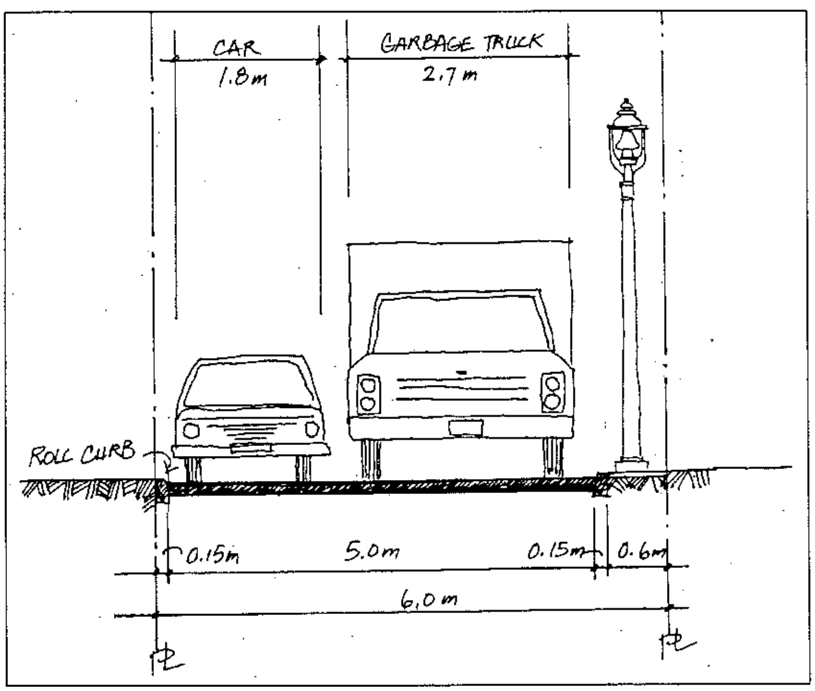
What is a lane?

The basic definition for a lane is that it provides access at the rear of abutting properties thereby eliminating the need for driveways onto the fronting street. A lane is not considered a "public road" as defined in the Zoning Bylaw because it does not have a minimum width of 9m (29.527 ft.); However, a lane is meant for public use. A lane is also different from a shared access driveway, that runs through the middle of a townhouse development, primarily because a lane is meant for public use whereas a shared driveway is meant for use by residents whose property access the driveway. The following chart shows additional differences between a shared driveway and a lane.

CHARACTERISTICS	SHARED ACCESS DRIVEWAY	LANE
Who owns it:	Strata Council	Province or City
Who is liable:	Strata Council	City
Who uses it:	Local residents or visitors	Public
Location:	Within site	Rear of property
Built to:	Building Code standards	Engineering standards
Maintained by:	Strata Council	City
Secured by:	Shared Access Agreement	Dedication/Public Rights of Passage

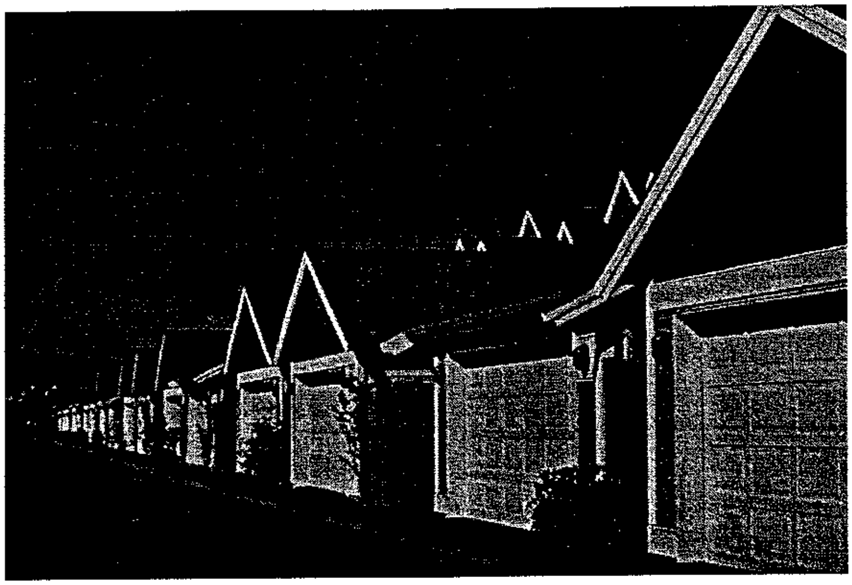
What are the lane design standards?

Standards for lanes outside the City Centre are shown on the following diagram and include the provision of paving, drainage, lighting, curbs and a 6m (19.685 ft) right-of-way:



- lanes are paved because it is cheaper to maintain than gravel and makes it easier for baby strollers, bikes and basketball games;
- Drainage is required so that storm water will not run onto the neighbours property;
- Lighting is provided but at a lower standard than a road (4 lux compared to 9 lux on a major road and 6 lux on a local road);

- Curbs are required because they prevent the breakup of pavement at the edges which in turn prevents the growth of brambles that eventually limit the driving width of the lane; and
- a right-of-way width of 6m (19.685 ft) is provided, which, after space is allocated for curb cuts and a street light, permits a driving surface of 5.1m wide (16.73 ft) which allows for a car and truck to pass.



A New Lane

Can a lane be located mid-way through a site?
Typically, NO. A lane is typically located at the rear of a property for a number of reasons:

- if it is located midway through the site, the City then has control over the middle of the site and it has the effect of splitting an existing site in two separate properties;
- a lane along a major road will likely serve townhouse, two-family dwelling or small lot single family developments. The lane would normally be located at the rear, rather than in the middle, to serve types of developments such as single family that have less flexibility in siting building envelopes; and
- a lane at the rear of the property has the potential to serve the most number of properties should the lots fronting the interior street choose to use the lane.

Should a frontage road be used instead of a lane?
Generally, No. Frontage roads have been used in some areas of Richmond and are preferred by some because they create a larger separation between the home and the busy street and they provide an opportunity for more landscaping and green along the streets. However, they are being phased out and are less desirable than lanes because:

- they cause awkward turning movements between the local road and major road;
- a "sea" of pavement is created when the major road and the frontage road are located next to one another;
- from a pedestrian point of view it is not as appealing because the corridor jogs in for the block length and then must jog back out at the major intersection; and
- they are less attractive and interesting for passing vehicles, cyclists and pedestrians.

How do lanes function – how should they be introduced into our existing road system?
The road system is classified by a hierarchy according to function. For example, the primary function of a lane in a residential area is to provide individual accesses for residential lots. The

primary function of a major road, on the other hand, is to move high volumes of traffic on an area or regional basis and therefore there is a need for access control.
In terms of safety and supporting traffic flow, cars should not travel directly from a lane to a major road or vice versa but rather enter a local or collector road first. In this way the change in speed is accomplished gradually and the number of potential points of conflict are reduced and focused.

Diagram 1: Preferred Road Hierarchy

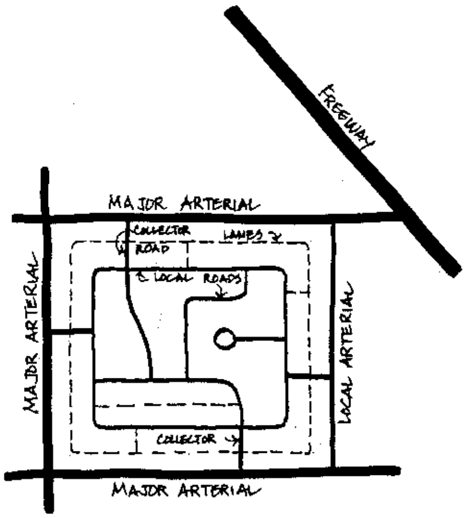
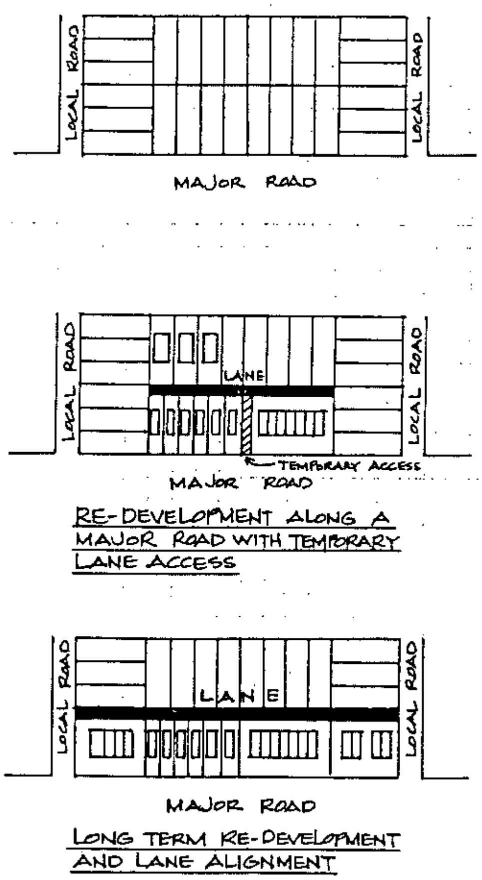


Diagram 2: Lane Development over Time

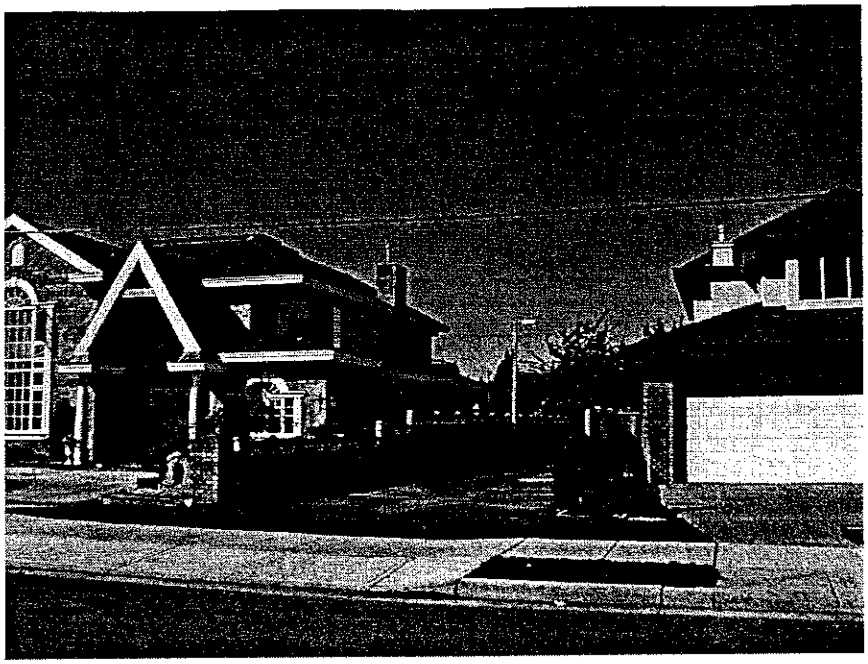


However, in older fully developed areas it is not always feasible for a lane to connect to a local road in the short term. At the end of the block it is possible in some cases to extend the lane to the local road but the property lines do not always line up or redevelopment of the properties at the end of the block may not occur for a considerable period of time. Additionally, it is difficult to obtain the land to provide mid-block lane access within the neighbourhood as redevelopment is unlikely on the local roads.

Therefore, every attempt should be made to ensure that the lane does not exit directly onto a major road. Where this is not feasible the following options may be possible:

- a full lane is provided with a permanent mid-block lane access with the new lots accessing their properties from the lane; or
- a full lane is provided with a temporary mid-block lane access with the new lots accessing their properties from the lane; or
- land is dedicated and monies are collected for the future construction of a lane with an interim, temporary single-width, shared access driveway provided for the use of the redeveloped lot(s).

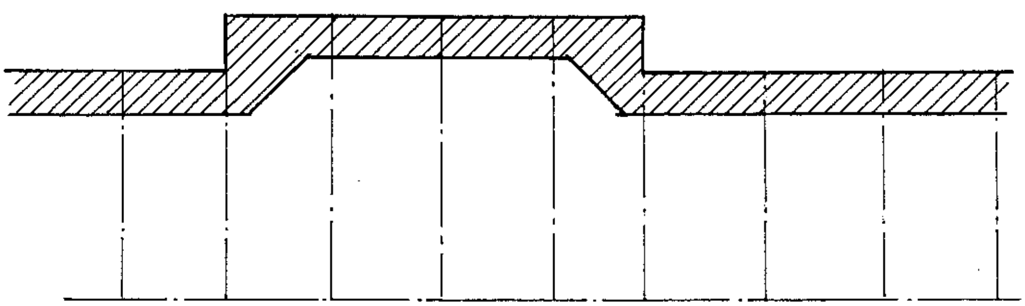
Diagram 2 shows how the preferred lane alignment could be achieved over the long term. While it is not ideal for a lane to connect directly to the major road, the number of individual access points to the major road will be reduced. Both temporary and permanent accesses would be considered part of the lane system and would be required to be constructed to the minimum lane standards.



Lane Exiting to a Local Road

Where the rear property lines do not line up, how is a continuous lane ensured?
In cases where rear property lines do not add up, the lane configuration would be adjusted and the City may require additional space from the applicant to accommodate turning.

Diagram 3: Lane Schematic Where Rear Property Lines Do Not Line Up



POLICY RELATED ISSUES

Where does the City target lane development?
The primary goal of lane development is to limit individual access points onto major roads. This is an issue where there are many single-family lots with individual access points. For example, a typical 800 metre long block face on an arterial road in west Richmond has 35 parcels/accesses whereas a typical 800 metre long block face on a residentially oriented arterial road in the City Centre has only 10 parcels/accesses.

Therefore, the policy supports lane development along arterial roads in residential areas primarily in West Richmond where there are a number of individual land parcels that directly access major arterial roads. These areas are designated "Neighbourhood Residential" on the Generalized Land

Use Map in Richmond's Official Community Plan. Attachment 1 shows the Lane Policy Development Areas.

What is the minimum lot depth to support a lane?
Under current zoning, the minimum subdivision lot depth for the single-family zone is 24 m (78.74 ft) and for the townhouse zones is 35 m (114.83 ft). However, the townhouse zone presupposes a certain form of development. It would be possible to accommodate some forms of townhouse development, for example a row house form, in the same depth of lot as a single family home. Therefore, the minimum lot depth before dedication of the lane would be 30 m (98.42 ft).

Are there population growth implications with the Lane Policy?
An increase in population would be attributable to the OCP, not to the Lane Policy. The OCP does suggest that some redevelopment in the form of smaller lots, two-family dwellings and townhomes along major roads is expected. The 2021 population projection in the OCP accounted for 2,400 additional units along major roads for a total additional population of approximately 5500 people.

Does the lane policy apply in every situation?
NO. There are certain situations where the lane policy would not apply:
- where there is a lane already built to City standards;
- where the property is less than 30m in depth; or
- where there is, or the City approves, an alternative permanent access, such as a frontage road, shared access, or internal road.

Where an alternative to a lane, such as a shared access, may be considered, the main principles used by staff to determine non-lane access suitability are:
- there are to be no additional accesses created to the major arterial road;
- the proposed access will not impede the intended function of the arterial road; and
- the type of access is consistent with the current or anticipated form of development.

Note that after all the exceptions are considered, only about half of all the frontages as shown in Attachment 1 will be required to provide land and pay for new lane construction.

IMPLEMENTATION ISSUES

Who should pay for the lanes?
The City had not been consistent in requiring applicants to provide land and/or pay for the provision of lanes. A range of standards had been applied including:
- requiring the applicant to dedicate the land and/or construct and/or pay for the lane;
- requiring a Public Rights-of-Passage for the lane but no monetary contribution; or
- requiring nothing from the applicant to facilitate lane development.

As in other development situations, where the City is clear about the need for a capital improvement, such as road widening, the applicant is required to pay. Therefore, the policy requires that the developer provide land and pay for the construction of a lane. In cases where the lane is not immediately constructed, the monies would be collected under the Neighbourhood Improvement Charge (NIC) Program.

Should the lane be secured through a right-of-way agreement or through dedication?
A previous section explored the difference between a shared access and a lane. A right-of-way or a dedication is just the legal means for securing the lane the same as a Shared Access Agreement is the legal means for securing a shared access. Therefore, both a right-of-way or dedication result

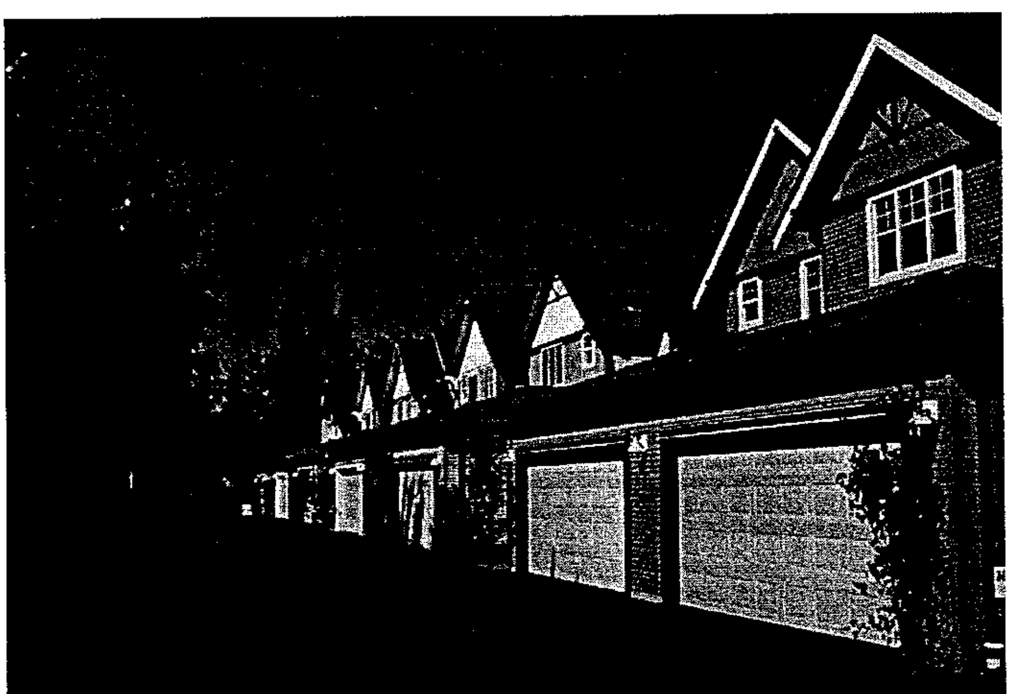
in the creation of a lane. However there are some differences between the two legal mechanisms which are detailed in the following chart.

DEDICATION (PREFERRED)	RIGHT-OF-WAY
Applicant loses density under conventional zoning	Applicant does not lose density under conventional zoning
Property lines for lane show up on maps	Property lines for lane do not show up maps
It is owned by the Province	It is privately owned
It is under the control of the City/the City is liable	It is under the control of the City/the City is liable
The City is responsible for maintenance	The City is responsible for maintenance unless otherwise arranged
No terms can be attached to the agreement	Special terms can be attached to the agreement
The property lines shift to the inside edge of the lane therefore no need to adjust existing building setbacks in the zone	Need to adjust zoning or use covenant to ensure appropriate building setbacks from the lane

The City prefers dedication because it is more straightforward. Once a lane is dedicated, there can be no argument about the terms. With a right-of-way, it is possible in the future for the property owner to argue about terms. Additionally, the legal conditions attached to each right-of-way can be different so, unlike a lane where one can look at a map and then understand exactly what its' role and function is, it makes it necessary to look up the conditions for each right-of-way.

How would the lanes actually get built?

When an application is received, staff must first determine whether a lane is required. As part of the application process, the City would determine the short and long term lane alignment. The developer would then either provide the land and build the lane, or they would provide the land and the money for future construction. The lane would only be constructed once it has an access/egress point. This access/egress point may be a long term temporary access to a major road. A servicing agreement would be made with the developer to actually construct the lane. Another option would be that the City would construct the lane when enough money had been collected from the individual developments on that street. Both options would be followed.

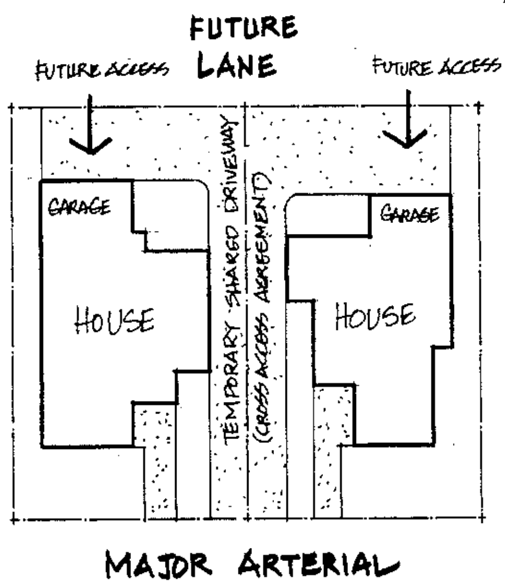


Typical Upgraded Lane

How does the City ensure that the raising of properties does not limit lane access?
Often there is a difference in grade between the arterial roads and the local roads. Generally, when a lane is constructed, it is built at the height of the local road to ensure that the internal properties have access to the lane. However, as properties along arterial roads are generally lower than the arterial road bed, some properties are raised or filled to a higher level and are therefore higher than the lane. Therefore, covenants would be required to ensure that raised sites are accessible by vehicles from the lane.

Once a section of lane is operational, how is it ensured that the lane would be used to access individual properties?
Through the rezoning process the City should ensure that the garages are located at the rear of the property. A covenant would be attached to the property to ensure that when the lane is operational, the access to the road is closed. *Diagram 4* shows one way that a garage can be located for use before and after a lane is made operational.

Diagram 4: Garages Located For Use Before and After Lane Development

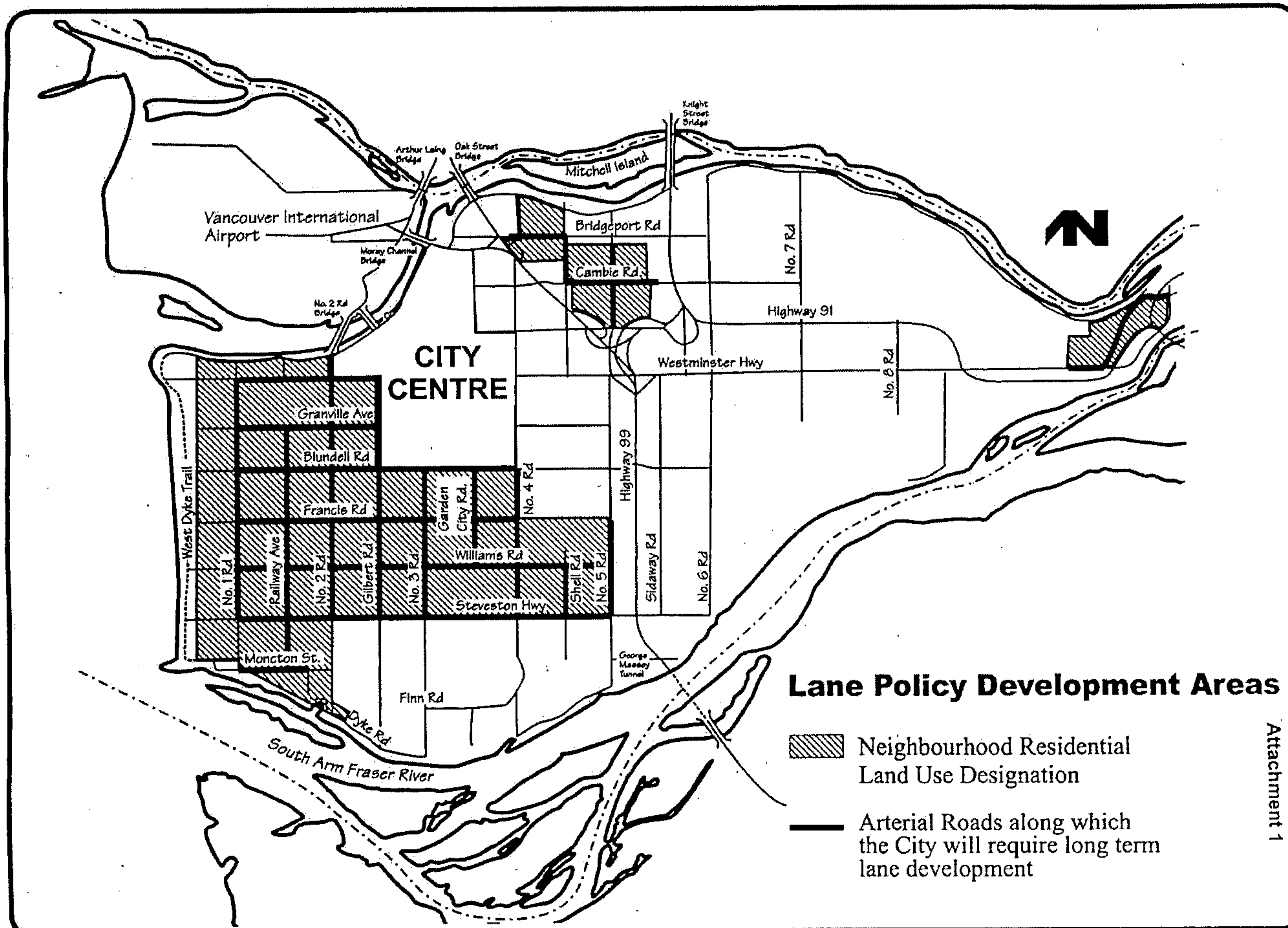


How long would it take before the results can be seen?
Lane creation is to be viewed as a long term endeavour. Lane development is relatively easy in large undeveloped areas; however, it is considerably more time consuming in existing built up areas. The rate of lane development would be dependent on the rate of redevelopment. There are some blocks for which redevelopment and lane creation will occur soon and others where it may be decades before redevelopment and lane creation occurs. The age of existing housing is a factor. As much of the housing along the major roads is getting older, there is a high potential for lane creation over the next decade as the second generation of housing is built.

CONCLUSION

The Lane Policy was the result of efforts by staff in Development Applications, Policy Planning, Transportation, Engineering and Public Works that met for over a year to work out the issues. Since the policy was adopted by Council in June 2000, a number of development applications have been processed. The first new lane resulting from the policy is still a couple of years away.

Attachment 1



Lane Policy Development Areas

- Neighbourhood Residential Land Use Designation
- Arterial Roads along which the City will require long term lane development

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ILLEGAL DRAG RACING IN DELTA – PROBLEMS AND SOLUTIONS

Goffrey Gosonhing, AScT
Roads and Transportation Technologist

Corporation of Delta

Illegal drag racing is a concern in many Lower Mainland and Fraser Valley municipalities. This paper discusses the problems experienced at the Corporation of Delta (Delta) and the engineering solutions developed to mitigate the problems.

Problem

Locations

1. Annacis Island
2. Tilbury Industrial Park
3. Deltaport Way

Solutions

1. Enforcement
2. Road Narrowing
3. Speed Humps
4. Rumble Strips

Conclusions

The Problem

Delta Police have been combating drag racing within Delta for several years. The problem consists of large groups of drivers conducting illegal drag races on municipal streets during the late evenings. The sites are straight, undivided, two-lane roads with very low nighttime traffic. The drivers select a section of straight road in excess of a quarter-mile in length. Two cars race side by side (one driver racing in the oncoming lane) and compete for the best quarter-mile times.

Delta Police and the Engineering Department as well as Delta's Municipal Traffic and Safety Committee are extremely concerned about the serious traffic hazard inherent with the illegal drag racing activity. Aside from the obvious dangers to the participants, hundreds of spectators (some of whom are usually intoxicated) are also at risk as bystanders in this illegal activity. Not to mention the hazard to legitimate road users coming into conflict with high-speed vehicles travelling in the opposite direction in their lane.

Many people think of illegal drag racing as an activity of young teenage drivers. This may be true for some of the drivers, but not all. Most of the cars participating in these events are highly modified. Police estimate that many of the vehicles generate in excess of 500 horsepower. Some of these vehicles are not street-legal, and the drivers tow the cars on trailers to the sites.

The drag racers are highly organized. Many of these illegal events consist of over fifty participants and over one hundred spectators. Police reports indicate that the drivers use portable start-stop lighting systems. Some groups advertise the race location on street racing web pages guarded by passwords.

The Sites

The majority of illegal drag racing in Delta occurs in three areas:

1. Annacis Island
2. Tilbury Industrial Park
3. Deltaport Way.

Annacis Island and Tilbury are industrial parks with straight sections of municipal road wide enough to accommodate heavy truck traffic and on-street parking. The two areas also experience very low nighttime traffic volumes.

Deltaport Way is a Provincial Highway under the jurisdiction of the Ministry of Transportation and Highways (MOTH). However, policing the road is a municipal responsibility. Deltaport Way, west of Arthur Drive to the Deltaport causeway consists of a straight, undivided, roadway with an 80 km/h posted speed. Nighttime traffic volumes along Deltaport Way are also very low. The infrastructure found in Annacis

Island, Tilbury Industrial Park and Deltaport Way, together with the rural surroundings make all three locations very conducive to drag racing.

Solutions

Police enforcement by itself will not deter illegal drag racing. Ongoing police enforcement is extremely personnel intensive and hence expensive. Alone, it really has not had any significant impact on deterring drag racing at any of the three Delta problem areas. Racing usually occurs in the summer on Friday and Saturday nights, which are the busiest policing periods. Police resources are already stretched across the community. Race organizers often use lookouts and cellular phones to warn of police presence, so the opportunity to witness and take action on unlawful activity is limited. Short of full-time police presence on site, enforcement alone is clearly not the solution.

The Engineering Department has used different methods of traffic calming as a more permanent deterrent to drag racing. Since Deltaport Way is under the jurisdiction of MOTH, Annacis and Tilbury were the initial focus of the traffic calming measures. The traffic calming methods tried were:

1. Road narrowing
2. Speed humps
3. Rumble strips

Road narrowing

When we started reviewing the use of traffic calming methods to deter drag racing, we reviewed similar situations in other municipalities. The City of Richmond had a similar drag racing problem along Hammersmith Way, a street in an industrial area. Richmond staff addressed the problem by using road narrowing.

Delta staff duplicated the Richmond road narrowing solution (See Figure 1) along a section of Derwent Way on Annacis Island. The road narrowing consisted of curb extensions and a raised median to reduce the width of the travel lanes to 3.5 m. The narrowing is well-signed and marked with painted gore areas, hazard markers, reflectors and traffic signs.

Initially the road narrowing was effective. However, the straight section of Derwent Way was in excess of 400 m. After a few weeks, Delta staff received reports of drag racers moving the race further down the road, avoiding the narrowing. Drag racing continued and the median was used as a starting point. Further work would still be required to deter the problem.

As a result of our experience with the road narrowing, we offer the following pros and cons to this type of treatment:

Pros

- Deters drag racing, yet allows regular flow of traffic.
- Opportunity for planting, beautification.

Cons

- Not effective in isolation for long sections of straight road exceeding 500 m.
- Expensive, Derwent Way construction costs approximately $10,000.
- Drainage may be an issue with curb extensions.

Speed Humps

With road narrowing being limited in effectiveness and expensive, other engineering options were reviewed. The Corporation of Delta had recent success using speed humps for residential traffic calming in the Burnsview area. Speed humps are an accepted method of traffic calming to reduce speed of vehicles, yet allow the regular flow of traffic. The Corporation of Delta decided to try speed humps as a possible deterrent to drag racing.

Our first trial with a speed hump was along Progress Way in the Tilbury Industrial Park. A temporary speed hump, made from recycled rubber, was placed at a mid-block location, and each approach was signed with a WA-50 "Speed Hump" sign. Delta staff were reasonably confident that the humps would be an effective deterrent. Staff's main concern was the affect the speed hump would have on heavy trucks in the Tilbury area. After a few days, staff did not observe any problems with trucks travelling over the hump. However, the trial period was cut short due to the damage inflicted by the trucks to the rubber speed hump. After a few days, the hump was literally torn apart by the action of the heavy trucks.

Upon completion of the trial, Delta proceeded to install permanent asphalt speed humps See Figure 2). The specifications for the hump were as per TAC's Guide to Traffic Calming. As expected, the humps were effective in deterring drag racing on Progress Way. As a bonus, many of the tenants were pleased that the humps also seemed to reduce the speed of regular traffic. Subsequent installations have been performed on three other streets.

As a result of our experience with the road narrowing, we offer the following pros and cons to this type of treatment:

Pros:

- Less expensive than narrowing, $1500 per hump (keyed in to existing roadway).
- Effective at deterring racing.
- Reduces speed of regular traffic.
- No drainage concerns.

Cons

- May be a problem for buses.
- Not suitable for high speed applications.

Rumble strips

On a Provincial Highway, speed humps and road narrowing were not practical due to the 80 km/h posted speed limit. Another solution would be required to deter drag racing along Deltaport Way. The Engineering Department recently retained Urban Systems Limited to assess engineering options to deter drag racing on highways. The recommended option was raised thermoplastic strips, or "rumble strips." These have been used effectively on a 45-mph (72-km/h) roadway in San Diego, California.

The design features of the raised thermoplastic strips include:

- 2.5 cm in height.
- 15 to 20 cm wide.
- Groups of three spaced, with each strip spaced 15-m apart.
- Each group of strips spaced 250 m apart.

The strips were designed to create an uncomfortable ride and "ruin" a perfectly good drag strip. Engineering wanted to prove the effectiveness of the strips on a municipal road before requesting a trial on Deltaport Way. We installed three groups of three strips along River Way in the Tilbury Industrial Park as per Urban Systems' guidelines (See Figure 3). Prior to entering the rumble strip zone, the approaches were signed with WA-22 warning signs indicating "bump ahead."

Initial reports from the police indicate that the strips were effective at deterring the drag racing. However, they created other problems. One of the local machine shops, located next to a group of strips, complained that the vibrations from heavy trucks travelling over the strips caused their million-dollar laser-cutting machine to go out of alignment. Other

offices also complained of the vibrations. Eventually, some of the strips had to be removed (by grinding), and re-installed at other locations.
After trials with rumble strips, we offer the following pros and cons to this type of treatment:

Pros:

- No significant effect on regular traffic.
- Effective deterrent to drag racing.

Cons:

- Not suitable in an urban setting due to noise and vibration.
- Maintenance upkeep required on worn strips.
- Costs approximately $2500 per three strips – more expensive than speed humps.

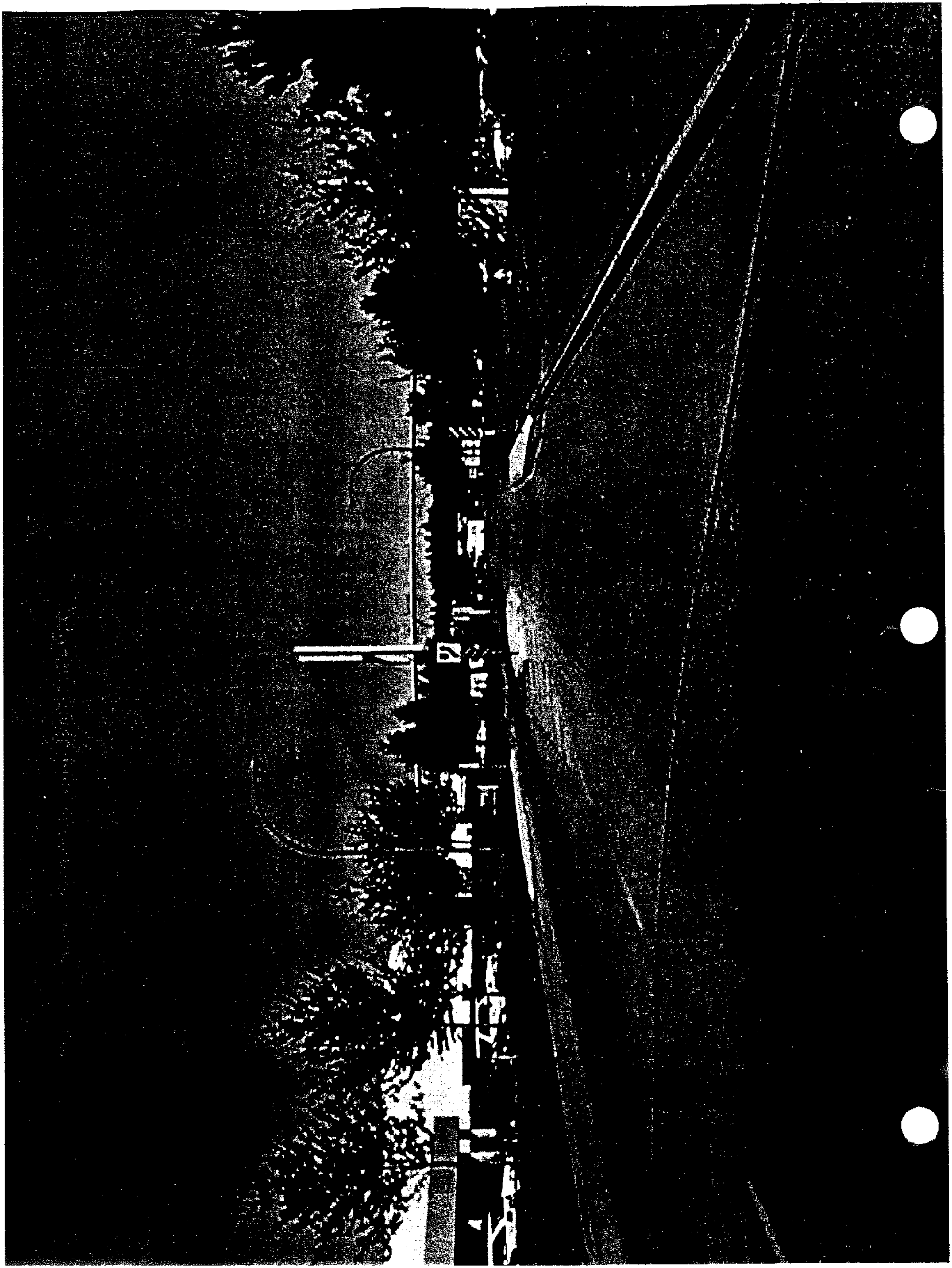
With engineering solutions in place at Annacis Island and Tilbury Industrial Park, illegal drag racing activities were concentrating on Deltaport Way. Events at the other locations were growing fewer in number.

MOTH has allowed the Corporation of Delta to install one set of rumble strips on for noise monitoring purposes. We will continue with the monitoring later this year. It is important to note that although noise is a disadvantage of rumble strips, the rural nature of Deltaport Way would probably not make noise an issue. As well, traffic volumes are sufficiently low that vehicles slowing at the strips would not likely be a safety concern.

Conclusions

In conclusion, the nature of the illegal drag racing made police enforcement difficult. The aim of the engineering solutions was to ruin a perfectly good "high speed drag strip" with minimal affects on regular traffic. The traffic calming solutions implemented have had a significant impact at reducing illegal drag racing on municipal roads. Delta Police have also adopted a "zero tolerance" policy with suspected drag racers. Drivers of highly modified vehicles are fined for vehicle modifications that do not comply with the Motor Vehicle Act.

The combination of traffic calming and hard enforcement seems to have had an effect on the illegal racing community. Not only are the activities down, but an illegal drag racer was quoted in The Province newspaper as saying that Delta was no longer a preferred site.



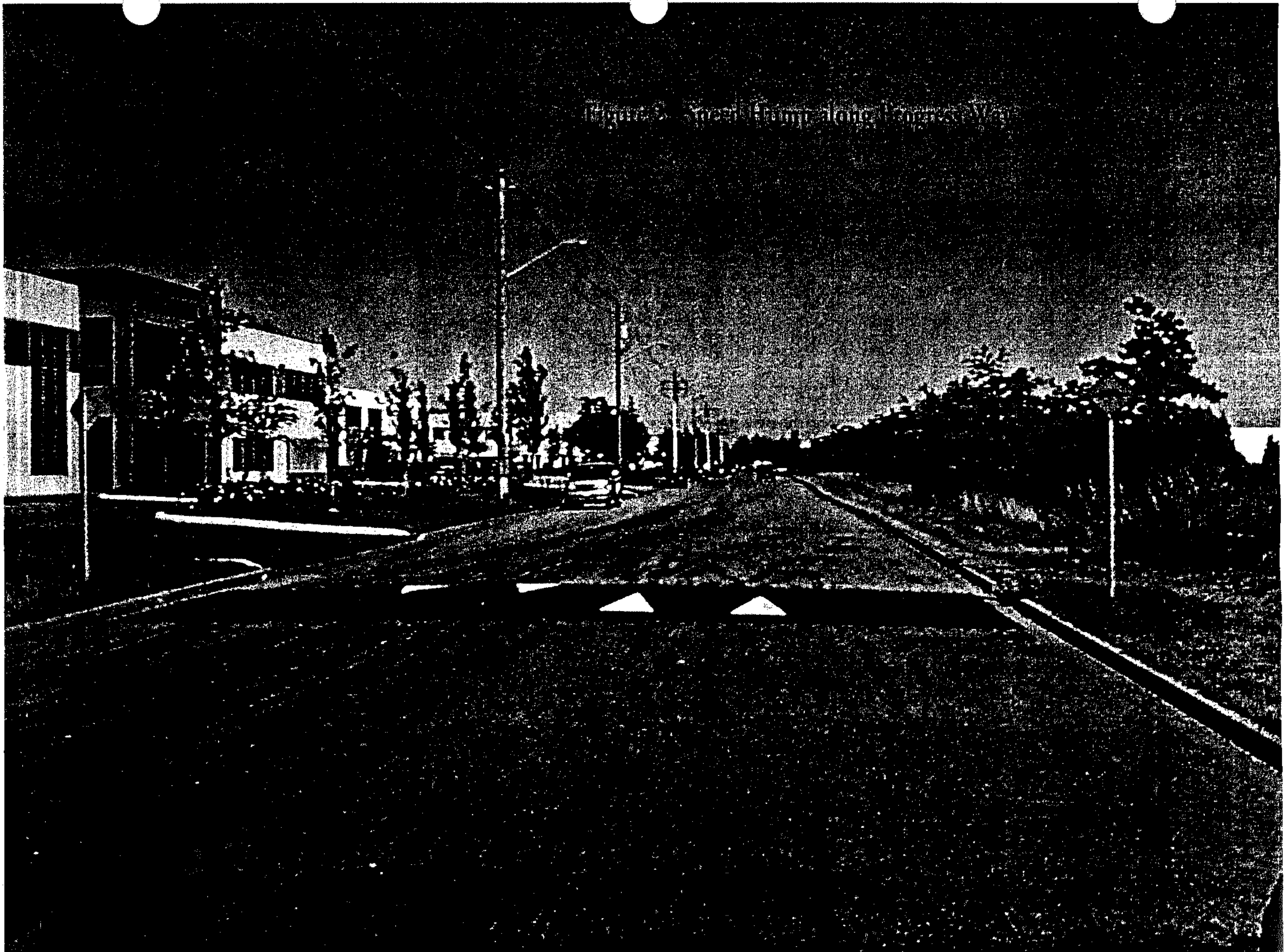


Figure 3. Speed Hump along Progress Way

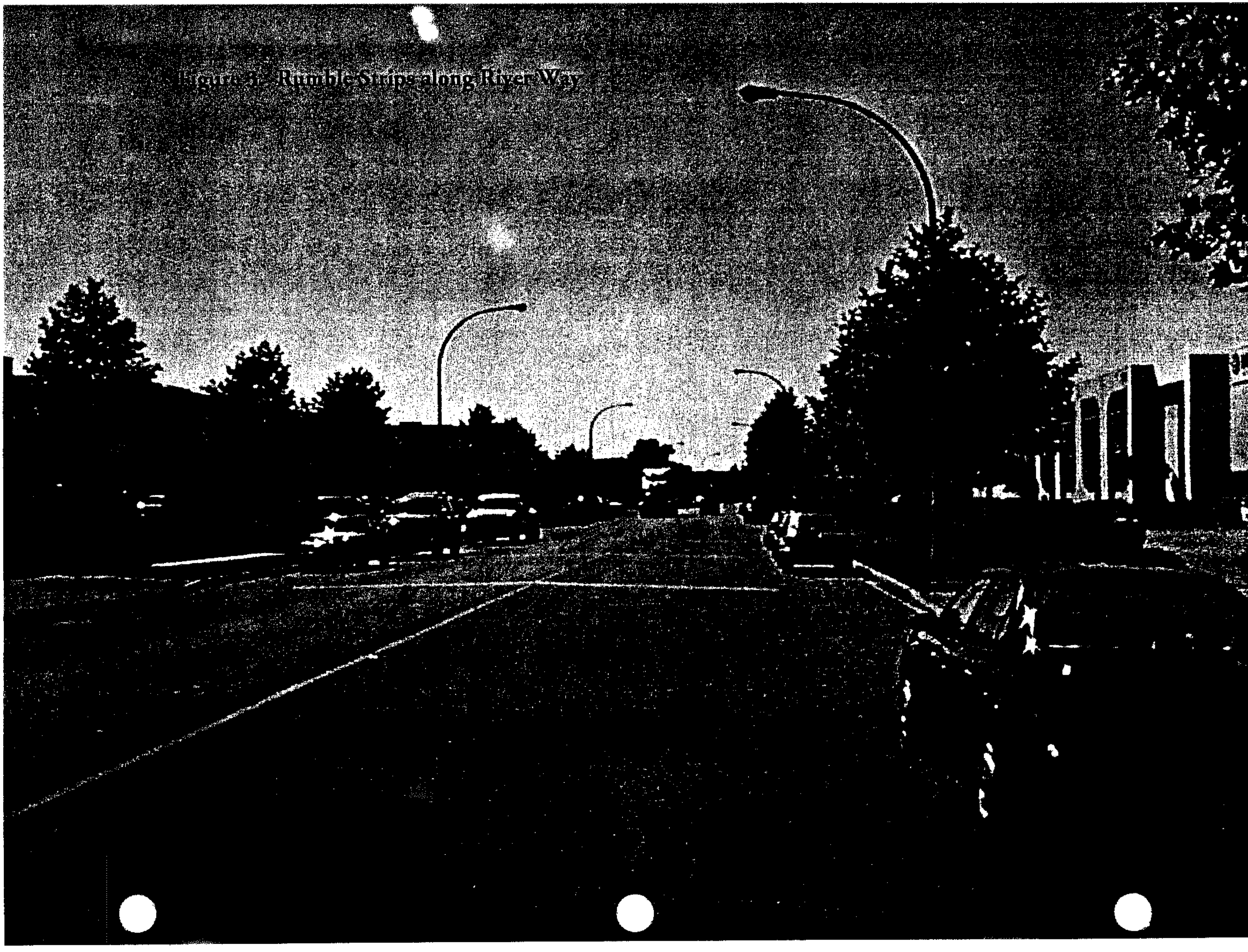
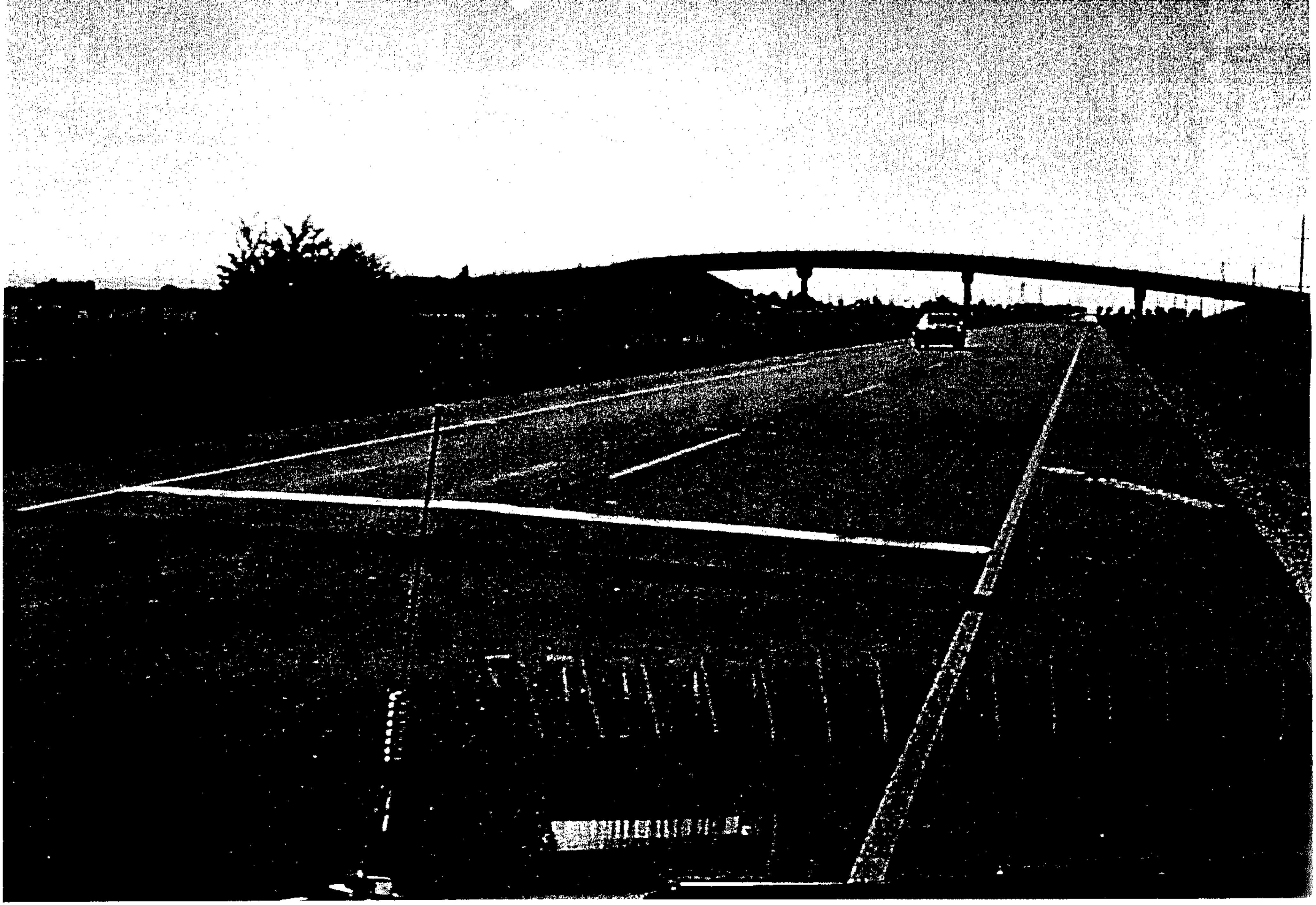


Figure 3: Rumble Strips along River Way

Figure 4. Rumble Strip along Deltaport Way



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Crossing the International Border: A Bi-national ITS System

2001 ITE Quad Conference/IMSA
Vancouver B.C., April 5 – 7, 2001

The Province of British Columbia and the State of Washington are jointly developing Intelligent Transportation System (ITS) based improvements that facilitate the movement of commercial vehicles over the international border. These border ITS improvements are being completed in two phases. The first phase, developed in conjunction with U.S. Customs, uses electronic data tags (transponders) to track export containers that travel by truck between the ports of Seattle/Tacoma and Canada. The second phase will build on the phase 1 border project and uses communication and information technology to integrate American and Canadian commercial vehicle border export data systems in the southbound direction. This paper will report on the technology and integration needed to make the system work. The importance of institutional cooperation will be stressed and some of the challenges of working in a bi-national environment will also be reviewed. The paper will conclude with a discussion on how these projects fit within the ITS community's longer term goal of developing a technology-based trade corridor extending from Mexico, through the U.S., to Canada.

Keenan Kitasaka, M.Eng., P.Eng.,
Manager,
Intelligent Transportation Systems
TransLink
1700-4720 Kingsway
Burnaby BC V5H 4N2
(604) 453-4602
keenan_kitasaka@translink.bc.ca

Dr. Edward McCormack
Senior Research Engineer
Washington State Transportation Cntr
Advanced Technology Branch
1107 NE 45th Street, Suite 535
Seattle, WA 98905
(206) 543-3348
edm@u.washington.edu

Terry Walton, P.Eng.,
Project Director
B.C. Ministry of Transportation & Hwys
7818 Sixth Street
Burnaby, BC
(604) 660-1235
Terry.Walton@gems2.gov.bc.ca

Crossing the International Border: A Bi-national ITS

A Shared Border with Common Interests and Problems

The province of British Columbia, Canada and Washington State, U.S. share a common international border. Trade across this border is of economic importance for both countries. In 1996, according to an estimate by the United States Department of Transportation Bureau of Transportation Statistics, $32 million (U.S.) a day in two-way trade crossed the border. This trade has steadily increased, over the past decade. Commercial truck traffic, for example, has increased by 80 percent over the Washington/BC border since AFTA began in 1993 (source – Whatcom Council of Governments).

A consequence of this growth has been increasing pressure on the border facilities and border enforcement agencies. Commercial vehicles crossing the border are often delayed and long queues of trucks waiting to cross in either direction are a common sight. A 1998 Whatcom County Council of Governments survey of British Columbia and Washington trucking companies estimated that $40 million (U.S.) is lost annually as a result of delays in crossing the border. Recognizing this problem, the Province of British Columbia and the State of Washington are jointly developing an intelligent transportation system (ITS) program to facilitate the movement of commercial vehicles over the international border.

This border-oriented ITS is designed to take full advantage of advances in computer and communication technologies. The system being developed by Washington and British Columbia will incorporate a number of technologies but its major focus is the electronic transponder tags that are increasingly being used for commercial vehicle operations. These radio tags, typically mounted in the cabs of trucks, permit the transmission of information between the tag and roadside readers while trucks travel at highway speeds. This allows transactions that previously depended on paperwork to be performed electronically. At border stations, the use of these tags can provide inspection agencies with electronic information before a cargo actually arrives at a border facility. This pre-arrival information allows the inspection agencies to use their limited resources more productively. It also saves commercial vehicle operators both time and money because enforcement agencies can focus on more problematic carriers, reducing the negative impacts of safety and customs inspections on safe and reputable carriers. These existing systems will also likely provide a foundation for the border technologies of the future.

British Columbia and Washington's application of ITS at the border is being carried out in two phases. The first phase, which is mostly completed, focuses on northbound truck movements. The second phase, which started in January 2001, focuses on southbound movements.

Phase One – The Intermodal Trade Operations Project

In 1997, the Washington State Department of Transportation (WSDOT) received $1.85 million (U.S.) from the U.S. Federal Highway Administration to apply ITS technologies to border operations at the Washington - British Columbia border. WSDOT hired the consulting firm of TransCore to assist in the technical aspects of the project and started by developing a technical committee that included staff from the ports of Seattle and Tacoma, U.S. Customs, several maritime shipping lines, and British Columbia's Ministry of Transportation and Highways (MOTH).

The resulting system is designed to facilitate the movement of northbound trucks through the Blaine/Douglas port of entry. This crossing is 40 kilometers south of Vancouver on Washington State Route 543 and British Columbia Provincial Highway 15. The crossing is the fourth-busiest truck crossing on the U.S.-Canada border and was used in 1999 by more 900,000 trucks (source - Whatcom Council of Governments). This represents a doubling of truck traffic since 1991, while enforcement agency staff levels at this crossing have not increased at the same pace and congestion at this crossing is on the rise.

The resulting ITS uses transponder tags to track in-bond export containers that travel by truck between the ports of Seattle/Tacoma and Canada. The tags are installed in the cab of the truck and contain an ID number that references shipping manifest data. Tag readers have been installed at the exit gates of the American President Lines terminal at the Port of Seattle and at the Maersk SeaLand terminal at the Port of Tacoma. These readers alert U.S. Customs that a container has left the maritime terminal and is heading north. A tag reader installed one kilometer south of the border gives Customs inspectors at the Blaine border station sufficient time to preview the documentation for these trucks before their to arrival. The inspectors then have the option of allowing the container and truck to pass through the border with little or no delay. A final reader at the border automatically clears out the bond on the container and marks the cargo as exported.

In addition to the hardware, the ITS uses an information management system known as the Trade Corridor Operation System (TCOS). This Internet-based system links the shipping line's information system and U.S. Customs' Automated Manifest System (AMS). Currently, the system is being operated in San Diego at a TransCore service center. For security and privacy protection, information from the TCOS is only available to authorized, registered users.

The second element of the phase one project is a tag-based weigh-in-motion (WIM) facility being completed in coordination with the Washington State Patrol (WSP). The system gives commercial vehicle enforcement officers at the Bow Hill weigh station, 70 kilometers south of the border, tools to preview vehicle and driver information and the option to allow approved drivers to by-pass the station. The tags (which are the same as those used for the border crossing system) contain links to a database related to safety, weight, permits, and licensing. Tag readers and a WIM scale system have been installed ahead of the weigh station. WSP officers can view the information and decide which vehicles to grant by-pass approval. Drivers considered to be traveling safely, legally, and not overweight will receive a green light on their tag and will be able to continue down the highway without stopping. The physical installation of this system is complete and is currently in a functional test phase before full operation.

Phase 2 – Southbound Improvements

Phase one of the project was designed to be the electronic and institutional foundation for a more comprehensive border crossing and commercial vehicle data system. Funding for the second phase was initially made available through a TEA-21 grant to the International Mobility and Trade Corridor Project (IMTC). IMTC is a US - Canadian coalition of 80 business and government agencies that jointly identify and pursue improvements to cross-border mobility at four western British Columbia - Washington State border stations. Matching funds were added to the project by Transport Canada, WSDOT, British Columbia Transportation Finance Authority, and the Insurance Corporation of British Columbia (ICBC). The total project funding is $2.5 million U.S. (approximately $3.8 million Canadian).

The project involves several related elements. The main element is a system designed to assist Canada Customs in tracking exported cargo and providing U.S. Customs with advance notice of imports. The will be accomplished by installing tag reading hardware on Highway 15 in British Columbia. This system will use the same transponder tags as used in phase one. Completion of this element will require the development of institutional interfaces with relevant agencies, as well as the design of a number of databases and process interfaces. The resulting systems will integrate the border agencies, trucking firms, port authorities, and regulators. Ultimately, this system will assist in the transfer of vehicle, driver, and cargo status information between the Canadian and American Customs' databases.

A second element of this project is the construction of a truck staging area in British Columbia on the approach to the U.S. commercial inspection facility. This staging area will improve access for tag-equipped trucks and will support U.S. brokerage activities.

This project will also install a weigh-in-motion system in Canada. This facility will be border-oriented and will be completed in a manner that supports the integration of existing and planned WIM facilities in both Washington and British Columbia.

The Future – An International Trade Corridor

The phase one and two projects are viewed as effective tools to address some of the major freight-oriented congestion problems at the Blaine/Douglas border crossing. Because of these projects' support of economic trade, consideration was given to their expansion to additional areas and jurisdictions. The result was development of a conceptual ITS international trade corridor.

The idea of ITS international trade corridor recognizes that commercial traffic moving in the western part of Canada and the United States (the Pacific Rim Corridor) is delayed not only by congestion at the border but at other points where vehicle and information flow are restricted. Unfortunately, such restrictions are common. For example, in many jurisdictions, terminal operators are not notified before the arrival of trucks to pickup loads, while the truckers are not aware of the availability of a pickup. This can cause inefficiency and delays at terminals' in-bound gates. Along the roadways, truckers often must pull into weigh scales for manual inspections, compliance checks, and license enquiries. Multiple manual filings are required for permits, bonds, and driver clearances. During a trip, truckers frequently have to travel in urban areas, resulting in significant delays if they cannot avoid congestion. All of these restrictions impede the economy, contribute to safety problems, decrease air quality, and increase uncertainty for the carriers. The ITS trade corridor concept was developed to address these problems.

Operation of the trade corridor will involve integration of existing and planned commercial vehicle ITS programs through the use of a common architecture and operating system. The integrated ITS technology will typically include systems designed to facilitate movement through freight choke points at port terminals, weigh scales, and border ports of entry including WIM, over-height detection, and electronic credentialing. This technology will support the functions of the regulatory jurisdictions by improving their efficiency and permitting them to identify and focus their scarce resources on high risk, non-compliant carriers.

The integration of these ITS to create a trade corridor will consist of five deployment phases, the first two of which have been described in this paper. These phases are as follows:

- Phase 1: Northbound Intermodal Trade Operations Project
- Phase 2: Southbound BC Improvements
- Phase 3: Integration of Bordering States and Provinces (Oregon, Alaska, and Alberta)
- Phase 4: Integration of California
- Phase 5: Mexican Border Operations

The development of an ITS trade corridor will also promote the involvement of private sector user services by offering opportunities for the private sector to providing value-added subscription services, operate and maintain the trade corridor service centers and assist in the marketing and expansion of each phase. Such services, which can be of notable benefit to freight movers, include road and weather information, traveller information for urban congestion, roadway construction advisories, fleet management, confirmation of load status and driver/carrier location, and electronic filing of permits and licences.

Expanding the System

The most significant challenge to deploying the various phases of the project and reaping the benefits of the Pacific Rim International Trade Corridor remains institutional. Despite the use of common technologies, the integration of the freight-oriented ITS programs in multiple jurisdictions and two countries is an institutionally formidable task. Differences between the regulatory frameworks of jurisdictions are common. For example, some jurisdictions charge truckers with transponders separately for each bypass of a WIM system, while others choose to charge an annual fee for use of the transponder device. The different approaches limit the sharing of data and use of the infrastructure. Overcoming institutions' historical reliance on manual and paper-based processing in favor of electronic techniques is also a major difficulty for most successful ITS deployments.

Conclusions

The potential for ITS applications to support the movement of goods on commercial vehicles between Washington State and British Columbia is high and will be demonstrated when the two projects currently under way have been completed. These phase one and two projects are using proven ITS technology, and the cooperation between stakeholder institutions has been outstanding. The development of a larger Pacific Rim Trade corridor as a means to move freight and promote economic growth, while not certain, is promising. If successful, the trade corridor is could be lucrative for both the public sector in its regulatory role and the private sector in providing value-added user services.

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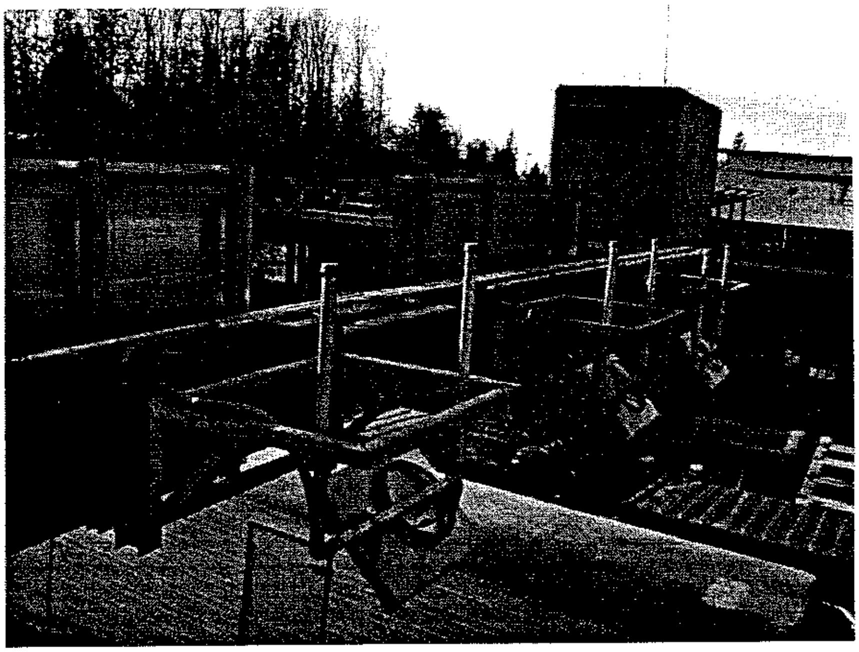

Figure 1 Tag Antennas at the Blaine Customs Station

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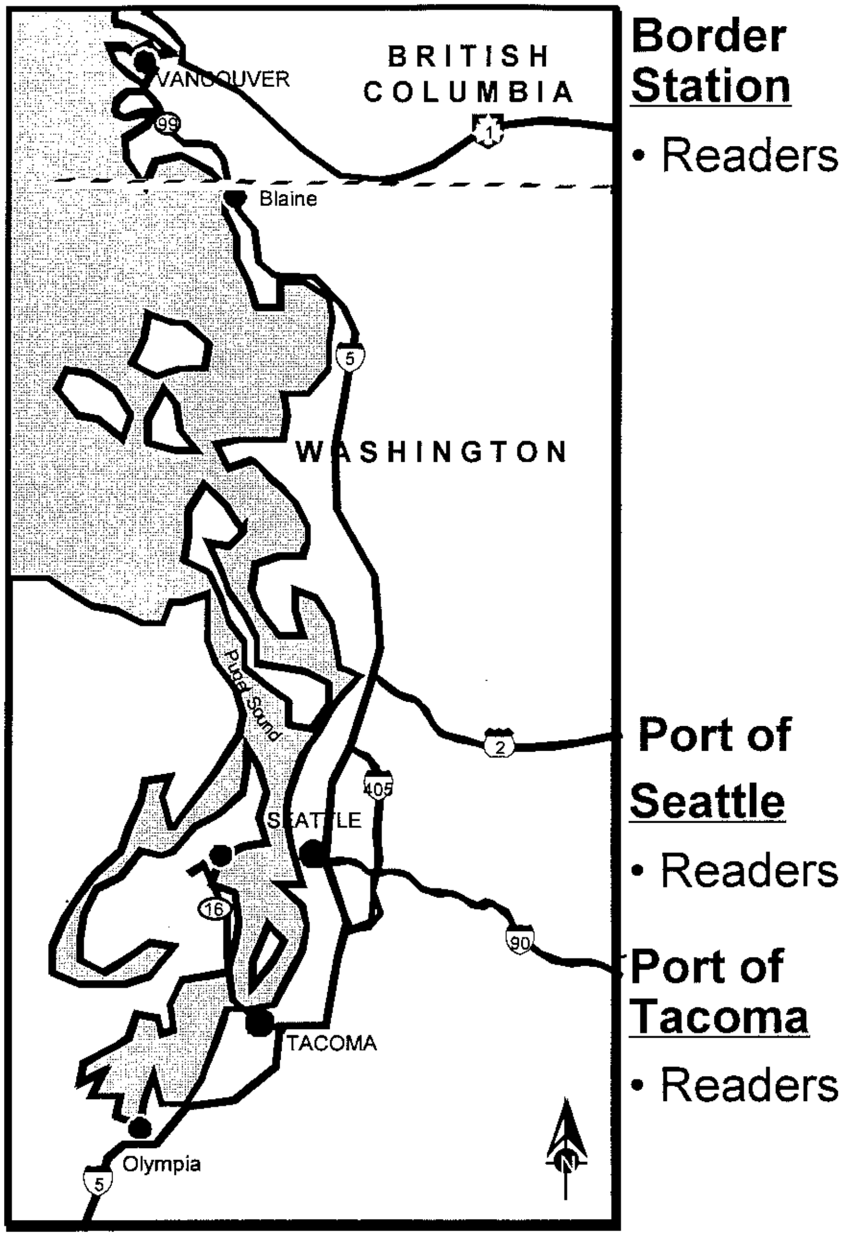

Figure 2- Phase One Hardware Location

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COATS: A Case Study In Cross-Border ITS Implementation

Katharine Hunter-Zaworski. P.E. , Ph.D.
Civil, Construction and Environmental Engineering Department
Apperson Hall 202
Oregon State University
Corvallis, OR 97331-2302
Phone: 541-737-4982
Fax: 541-737-3052
hunterz@engr.orst.edu

Robert Fynn
ITS Engineer
Oregon Department of Transportation
5th Floor Transportation Building
Salem, OR 97310-1354
Phone: (503) 986-3588
Fax: (503) 986-4063
Robert.K.Fynn@odot.state.or.us

Abstract
The California-Oregon Advanced Transportation Systems (COATS) project is a project that involves the design and implementation of advanced technology to solve common regional problems in Southern Oregon and Northern California. The project includes public and private partnerships that span across state lines and many jurisdictional boundaries. An ITS Architecture has been developed for the region. The ITS architecture and the strategic deployment plan development process highlighted many of the issues associated with ITS implementation across multi-jurisdictional boundaries.

Summary of Issues:

✔ The COATS stakeholders are much broader than most traditional ITS projects. This is due to the rural nature of the region, and the enormous geographic diversity. In addition, the region crosses many state and county lines and each region is represented by local, regional and state level stakeholders for many entities impacted by ITS. Many of the cross border issues are related to contractual constraints of each state as well as the communication infrastructure of related agencies.

✔ The COATS ITS Architecture reflects the diversity of: the stakeholders, the transportation and communication infrastructure and the geo-political regional characteristics. The diversity affects information flows, as this is influenced by communication infrastructure and policies.

✔ The political boundaries are usually transparent to travelers, unless the road conditions change dramatically. But the communication infrastructure and protocols may make cross border communication between similar agencies very difficult.

COATS: A Case Study In Cross-Border ITS Implementation

Introduction:

With the current and foreseeable trend toward globalization of economies, most jurisdictions, ranging from county to country, are realizing that their economic progress is directly connected with that of their neighbors. Transportation has been identified as playing an essential role in economic growth, and with the advent and use of Intelligent Transportation Systems, various states are forming alliances to promote travel in their wider geographic areas.

National Perspective

Over the last few years, several coalitions have been formed among states, mostly neighboring each other, although some coalitions have had members that are geographically dispersed. Most of these efforts have concentrated in urban/metropolitan areas, and others have concentrated on individual corridors, or on individual components of the ITS program, like Commercial Vehicle Operations (CVO). COATS is very unique because it is one of a very few efforts, if not the only one, that studies, plans for and applies ITS to a large, rural, cross-border geographic region with unique challenges.

California –Oregon Advanced Transportation System - COATS :

Background:

In 1997, the Oregon Department of Transportation (ODOT) and the California Transportation Department (CALTRANS) began individually and separately investigating solutions to transportation issues in their rural areas: southern Oregon and Northern California. Both states realized the marked difference between issues in the urban and rural areas; but also more importantly realized that their respective rural areas, which together formed a huge geographic region, had very similar characteristics. These two portions of the states have very significant tourist travel to various destinations such as National Forests, Lands and Parks, and festivals such as the Ashland Shakespeare Festival and popular coastal destinations. Interstate 5, the main north to south route from Canada to Mexico on the West Coast, traverses the region, carrying significant volumes of passenger car, truck and recreational vehicle traffic. To the east of I-5, US 97 is another major north to south highway which carries significant truck traffic; US 101 carries significant tourist traffic along the Pacific Coast from California to Washington. Other highways provide east-west connections between these major north-south routes. The area also has significant geographic, weather, and communication challenges that tend to make travel unpredictable, especially in the winter months.

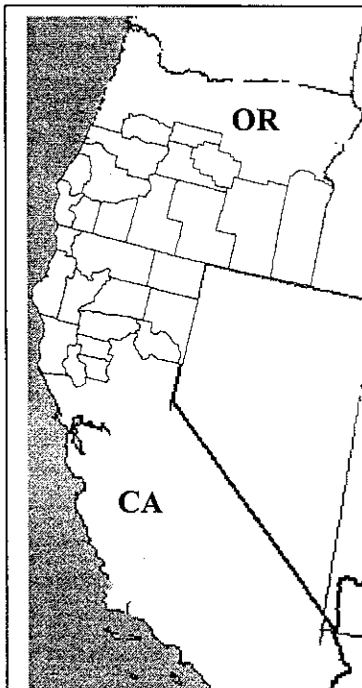

FIG 1 – COATS region

In March of 1998, the two states initiated the Rural California Oregon Advanced Transportation Systems ("Rural COATS") study, a bi-state project, which was intended to study ITS and its applicability in addressing the unique transportation challenges faced by travelers in rural areas. Fig 1 shows the counties in the area bounded by the Rural COATS project.
COATS was seen as a means to improve interstate cooperation and also to use more efficiently each states resources in achieving the following:

- improve safety in the movement of people, goods and services,
- improve detection and response times to rural accidents
- collect and share realtime information with each other and the traveling public
- improve cooperation among the various agencies having jurisdiction in the area, and thus
- provide an impetus for the economic growth of the region.

The two states, serving on the Board of Directors of the Western Transportation Institute (WTI) of the Montana State University –Bozeman, sought the services of the institute to collaborate on the study.

The mission statement developed by the partners of the project addresses the goals and objectives of the COATS Project in the Northern California/Southern Oregon Region. "The Rural COATS project will serve as to unify member agencies, focusing on a seamless, state-of-the art, multi-modal transportation network benefiting travelers, goods movement, economic activity, and transportation operators in Oregon and California. Through communication and cooperation, the COATS project and it's partnership coalition will serve as an information clearinghouse to provide for 1) effective and efficient ITS development, demonstration, and delivery and 2) the promotion of safety, mobility, trip enhancement, and environmental quality."

The objectives of this project include:

- identifying the transportation and information needs within the study area;
- determining ITS solutions that are beneficial, cost-effective, and deployable within the study area on the basis of the identified needs;
- identifying, designing and deploying initial, small-scale "Early Winner" projects with existing funds on a multi-year basis to test the feasibility of rural ITS;
- developing a Strategic Deployment Plan that describes a strategic approach for implementing rural ITS strategies on a larger scale. Emphasis is placed on integration and expansion of future ITS components within the study area based on evaluation results; and
- preparing and securing federal funds to implement Rural Model Deployment Initiative projects.

Stakeholders/Partners

The COATS region encompasses 11 counties from each state, and numerous public and private agencies having jurisdictions in this area. These agencies represent public safety, tourism, local media, planning agencies, forest service and public lands, cities, trucking and other private entities.

Several administrative and jurisdictional difficulties presented themselves that had to be resolved in order for COATS to proceed:

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1. Funding for COATS was obtained through the FHWA's Statewide Planning and Research (SPR) programming. Each state got approval to use SPR funds, and ODOT had to supplement its share of the budget from internal funds. CALTRANS was designated the lead agency and had responsibility for overall COATS budget, and ODOT therefore had to transfer funds to Caltrans. Neither state had a process for transferring funds to or from another state and FHWA had to act as an intermediary for the fund transfer.
2. Several of the smaller stakeholder agencies did not have budgets to permit their representatives to travel to COATS meetings, which were scheduled to be held approximately every quarter, at venues in both states. Furthermore, some of the agencies had limitations on out-of-state travel. Meeting venues were chosen that were mostly close to the state borders, to enable attendance by most representatives.

In order to involve these agencies in the project at the optimal levels of participation, an organizational structure was developed (Fig. 2) that included the following tiers: Governing Board, Steering Committee, and Regional Teams, as well as other administrative layers.

Fig. 2 – COATS Stakeholder Organizational Structure

Scope/Execution:
The flowchart in Fig. 3 depicts the various analyses and deliverables that were produced to lead into the generation of the Strategic Deployment Plan[1].

Outreach
Most of the data collection, surveys and analyses for the various stages were conducted for the region as a whole
Outreach also included production of brochures, newsletters, and a website, http://www.ruralits.org/projects/coats, to disseminate findings of the project and provide the public with easy access to up-to-date information on COATS.

Surveys targeted motorists in both states, and used a questionnaire that had been discussed and approved by the COATS Steering Committee. Motorist surveys were conducted throughout the COATS region. Other data collection activities resulted in the following deliverables: an infrastructure report, a conditions and performance report, a legacy systems report, and a motorist needs survey report.

Results of analyses of the data collected, though, were related to each state's specific criteria. For example, the two states collected and coded road closure duration and accidents differently, and therefore the results of the analyses had to reflect each states severity criteria.

After the preliminary activities, and other activities such as the market package exercise, an Early Winner Report was produced. After this report was produced, the steering committee selected the early winners. The two key products of this activity were the Operations and Maintenance report, and the Siskiyou Pass early Winner project.

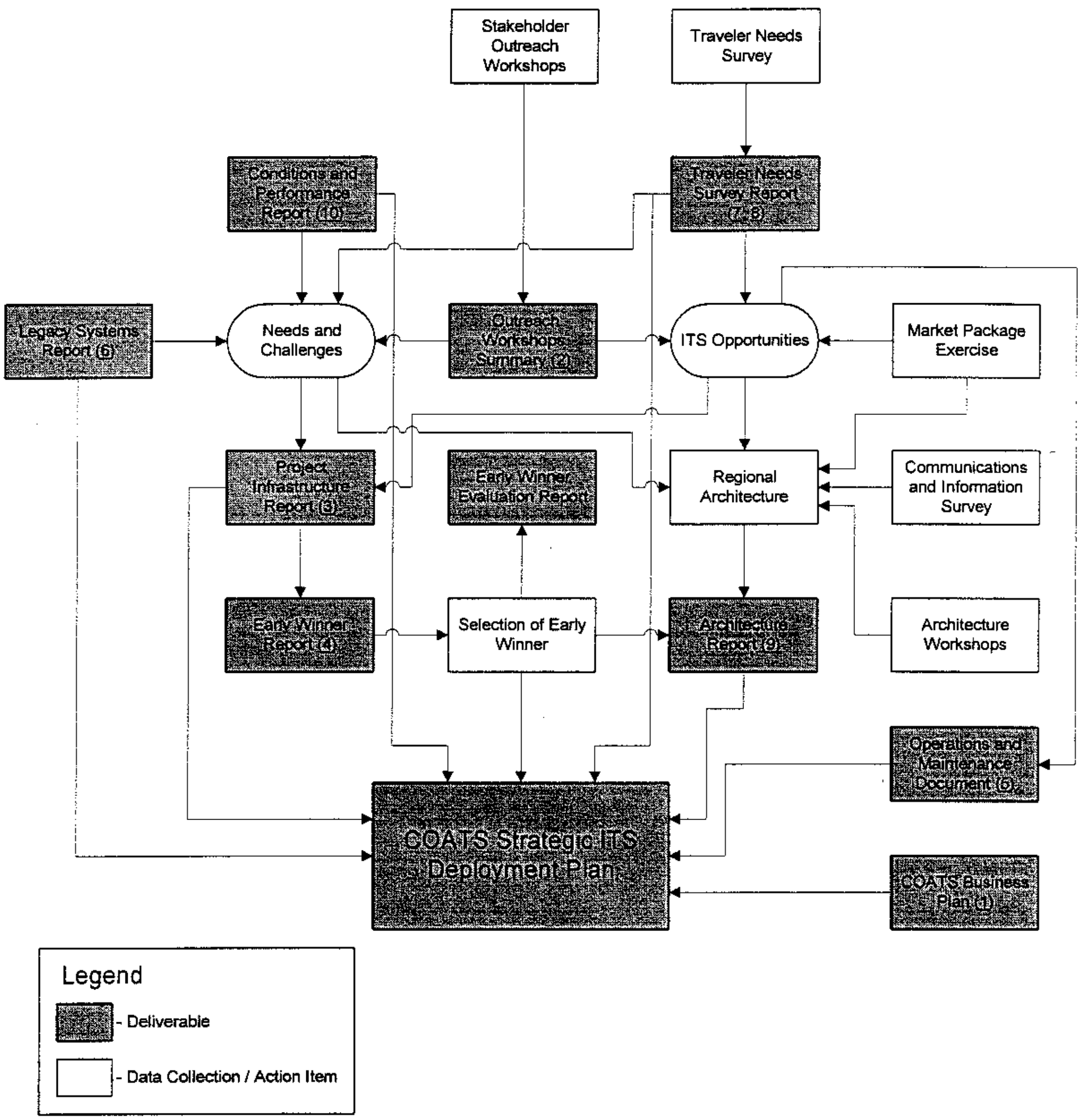

Figure 3. Project Analyses and Deliverables

Architecture - The COATS regional architecture was built as a result of all the data collection activities that produced the all the reports documenting the existing conditions. Additional activities were undertaken specifically for developing the regional architecture. These activities included the identification of ITS opportunities, the Market Package exercise, the regional needs and challenges, the communication and information survey and the architecture workshops. The communication and information survey was used to identify who and how the regional stakeholders communicate today and how they hope to communication and share information in the future. The architecture workshops were designed to both educate regional stakeholders about the COATS project and also to validate the communication and information survey results. The architecture's information flows and entities were structured about a predictable event such as a major festival and an unpredictable event such as a winter storm. The results of the architecture workshops were used to craft the regional and sub-regional ITS architectures[2]. Turbo Architecture is being used to support the architecture. The COATS architecture is a "living" architecture and is in a format that permits modification of communication and data flows. The COATS architecture resides at the following site: http://www.coe.montana.edu/wti/

Strategic Deployment Plan

The SDP is one of the main products of COATS. It summarizes all the work that was done in the earlier stages of COATS- data collection, surveys, workshops, analyses, regional architecture – and makes recommendations to the stakeholders on projects to be implemented to solve identified challenges. The SDP lists projects by county, identifies timeframes for their implementation and provides approximate deployment and operating costs. Emphasis is placed on integration and expansion of future ITS components within the study area based on evaluation results, and also on the Regional Architecture described above.

Early Winner Projects

A unique feature of the COATS project was that it set aside a significant amount of the total budget for an "Early Winner" project. This was supposed to be a project that could be implemented and would return benefits in the short timeframe, such that it could be used to gain wider acceptance and support for this and other rural ITS projects. Based on initial analysis, 6 projects were identified to solve geographic groupings of challenges. The top-ranked Early winner project turned out to be the one that best fits the regional flavor of COATS – the Bi-State Traveler Safety & Incident Management System.

Siskiyou Pass Early Winner Project

The Bi-State Traveler Safety & Incident Management System, also referred to as the Siskiyou Pass Early Winner Project, is focused primarily on a stretch of Interstate 5 running from Medford, Oregon in the north to Yreka, California in the south, as shown in Figure 4. Interstate 5 is the most direct connecting route between these. Average Daily Traffic volume in the area ranges from 35,000 vehicles per day at Medford, to 12,500 vehicles per day at the border, with an average daily truck and recreational vehicle proportion of 36 %. I-5 crosses Siskiyou Pass at the Oregon / California border, at an elevation of 4300 feet, and with grades of up to 6% in both directions.

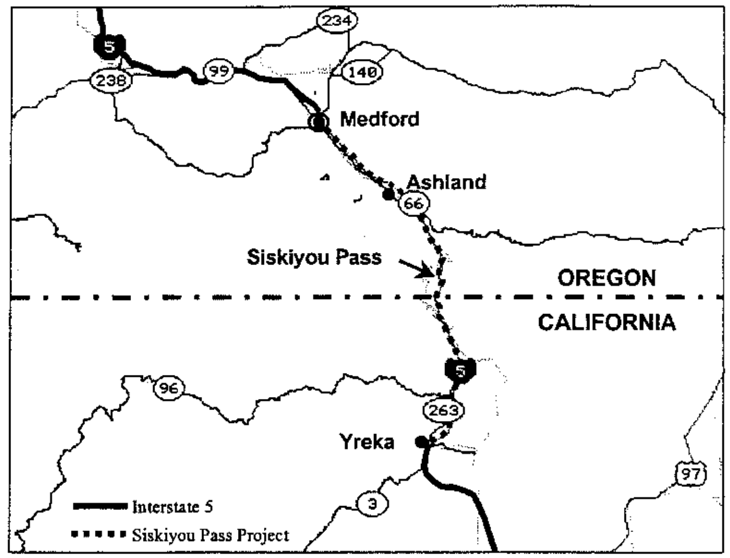

Figure 4: Siskiyou Pass Early Winner Project Limits.

In the winter months, the rapidly changing weather is very unpredictable, and frequently very different on either side of the pass. Frequently, pass conditions require complete closures or restrictions to certain classes of vehicles, or chains/traction devices are required. When this happens, vehicles are delayed, with backups extending for miles. The two DOTs have to make quick decisions to mitigate the situation. To aid this, some ITS devices had been deployed for information gathering and dissemination. Other equipment were planned and deployed to fill in information gaps.

Issues

It was quite apparent that what one DOT or law enforcement agency did on their side of the pass affected the other DOT and law enforcement agency and that more coordination was needed. Some of the issues that had to be worked out included the following:

- The DOTs are responsible for deciding what chain restrictions are in effect during inclement weather, but do not have the authority to enforce them
- During inclement weather, deciding when to impose chain restrictions is critical: restrictions applied too early, then there is the risk of an unnecessary backup; too much delay and vehicles were backed up for miles, with travelers being very frustrated at the lack of notification and the incurred delay. On the other hand, imposing chain restrictions too late often means that the State Police can not get to the Pass to help with enforcement, due to the queues and jams already on the highway.

- Travelers are very frustrated about lack of information on alternate routes when the pass is experiencing unfavorable weather as well as other incidents that result in the closure of one or more lanes.

Solutions

Snowflake: A few years ago, several agencies that were involved in managing the Pass got together to discuss cooperation during bad weather. The name 'Snowflake' was given to what became an annual meeting to discuss and update procedures for managing the pass. Snowflake continues to meet every October to update the overall pass management strategy and share information on each agency's procedures. Membership is from both the public and private sectors.

Coordinating Group: This group, consisting of personnel from the two DOTs, was formed to manage and coordinate the implementation of the technology aspects Siskiyou pass project, and continues to meet regularly to discuss ways to integrate the states' information

Lessons learned/conclusions

The major lessons learned and opportunities identified by the COATS project include: Communication. The COATS project has provided an opportunity for two state departments of transportation to work together on common issues of regional importance. In addition the COATS project has also brought two state public safety agencies together. All the meetings and outreach activities associated with the COATS project have provided public and private agencies and opportunity to meet, discuss and seek solutions of with common problems that impact one large region that is transparent to jurisdictional boundaries. The COATS project has also caused the state transportation agencies to seek creative methods to solve inter-agency challenges imposed by state or federal regulations. The COATS project has clearly demonstrated how public and private entities can work together to seek creative solutions to problems of regional importance.

Reference:

1. **California – Oregon Advanced Transportation System: Strategic Deployment Plan,** Christopher Strong, Research Associate, & Stephen Albert, Director
2. **California – Oregon Advanced Transportation System Regional Architecture;** Katharine Hunter-Zaworski, Senior Research Engineer, Chris Strong, Research Associate, of the Western Transportation Institute; and Ron Ice, R.C. Ice and Associates

B-5-3/1

Digital Video for ITS Applications

ITE "Quad" and IMSA B.C. Joint Conference and Trade Show

Vancouver British Columbia

Digital video is becoming a popular and cost effective choice for deploying CCTV for traffic management systems. Digital video permits more flexible interconnections with the all-digital public telecommunication networks. This in turn will facilitate the dissemination of information to the public as ITS deployments proliferate. Digital video promises many advantages over traditional analog video transmission systems. This paper intends to shed some light on industry trends and pros/cons of digital video.

Prepared by

Hicham F. Chatila, P.E., P.T.O.E.
The Transpo Group
11730 118th Avenue N.E., Suite 600
Kirkland, WA 98034-7120
425-821-3665 (Phone)
425-825-8434 (Fax)
Hichamc@thetranspogroup.com

DIGITAL VIDEO FOR ITS APPLICATIONS

Introduction

As Intelligent Transportation System (ITS) applications become more popular, ITS communication networks at the municipal and metropolitan levels are becoming more challenging. These networks must integrate several distinct communication formats, such as video, voice and data, for transmission over short and long distances. CCTV systems require a high number of broadcast-quality video circuits connecting the remote surveillance cameras to one or several Traffic Management Centers (TMC). This high bandwidth requirement puts a lot of strain on existing and new communications networks. This translates to high cost of installation, training, operation, and maintenance of these systems.

Digital video is becoming a popular and cost effective choice for deploying CCTV for traffic management systems. Digital video permits more flexible interconnections with the all-digital public telecommunication networks. This in turn will facilitate the dissemination of information to the public as ITS deployments proliferate.

One of the great benefits and attractiveness of digital video is the ability to compress it and reduce the required transmission bandwidth. Without compression, digital video still requires a large amount of transmission bandwidth.

New technology promises to enhance the operation and maintenance ITS. Digital video also promises many advantages over traditional analog video transmission systems. This paper intends to shed some light on pros and cons of digital video and to provide explanations and clarifications for the following:

- ITS applications
- Digital video technologies
- Networking topologies
- Cost

Video for ITS Applications

Video is used in many ITS applications such as:

- Surveillance and Monitoring (Intersections, Arterials, and Freeways)
- Security (On board transit systems, transit hubs, and park & ride lots)
- Enforcement (red light violations and Toll Facilities)

- Incident Management (sharing video with Emergency Management Services)
- Broadcasting (Sharing of video with Information Service Providers (ISP), and local TV stations)

The ITS applications listed above require different video technologies. For freeway surveillance, flow and motion of the video signal is more important than the resolution and image quality. While, for security and enforcement image quality is critical. Agencies should be careful in choosing a video standard that is going to meet their requirements, be cost effective, easily expandable, and meets current and emerging industry standards.

There are three main reasons for using and deploying digital video for ITS applications: Compression/Bandwidth, Network Management, and Integration with public telecom networks.

Deploying digital video is heavily influenced and affected by the type of available bandwidth, compression technology, communication technology, and network topology.

Digital Video Technologies (Industry Trends)

Currently there are three key compression standards in addition to many proprietary compression techniques. The choice of the compression technology is critical since it is directly related to bandwidth/capacity requirements, which effects cost and quality of the video. Uncompressed digital video requires large amounts of bandwidth and is very expensive to transmit. The three key compression standards are:

1. JPEG compression standards
2. Mpeg compression standards
3. H.xxx compression standards

JPEG (pronounced J-peg) was developed by the Joint Picture Expert Group. Initially JPEG was used for the compression of still digital pictures and is commonly used over the Internet to transmit photos and pictures. M-JPEG (Motion JPEG) was the standard developed for transmitting motion pictures. This is done by transmitting a sequence of picture frames in quick succession. M-JPEG usually sacrifices motion for resolution It has not been widely adopted as a common video compression standard for transport on private or public networks.

MPEG (pronounced M-peg), which stands for Moving Picture Experts Group, is the nickname given to a family of International Standards used for coding audio-visual information in a digital compressed format. The MPEG family of standards includes MPEG-1, MPEG-2 and MPEG-4. In addition, MPEG 7 and MPEG 21 are under development. MPEG-2 is being used in the satellite broadcasting industry and is gaining some acceptance in ITS applications. MPEG-2 requires approximately 4 to 7 mbps for near broadcast quality video.

H.XXX such as H.261 is a compression algorithm developed in the telecommunications industry for the use in the videoconferencing. This standard requires low bandwidth, typically in increments of 64kbps. Picture quality is not very suitable for many ITS application.

MPEG-2 is gaining more acceptance as a standard for implementing video applications for ITS applications. Typically, each field camera would require an encoder to convert the analog video into an MPEG-2 digital stream. MPEG-2 encoders and decoders are starting to appear on the market that are specially designed ITS applications. In addition, the cost of MPEG-2 encoders/decoders is becoming reasonable. Several years ago the cost of an MPEG-2 encoder was almost $10,000. Now there are several vendors supplying MPEG-2 encoders for as low as $2,000.

Video over IP is also gaining some acceptance especially as Quality of Service (QoS) in networks is being addressed. The major advantage of Video over IP is the ability to view video from anywhere in the world (via Internet) using browsing technology. As streaming Internet video over IP becomes easy and cost effective to deploy, more ITS application will use this technology, particularly for security systems. Generally video over IP will provide good resolution but at the expense of motion. Resolution and picture quality is highly dependent on available bandwidth.

Digital Video Network Architectures

How you deploy digital video is highly dependant on the available communication network and topology. If an agency does not own its own fiber optic network and its planning to lease fiber or bandwidth from a local telecommunication company, then the use of digital video becomes very cost effective since it reduces the amount of data from approximately 250 mbps to approximately 5 mpbs per device. If the agency owns its own fiber, using digital video could still be very cost effective in the long term assuming network and device management features are included in the system design.

Another option includes Point-to-Point. However, digital video is very expensive and not very cost effective due to the inefficient use of fiber and the need for a high number encoders and decoders. Refer to Figure 1.

Hicham. F. Chatila, P.E., P.T.O.E.
The Transpo Group
Kirkland/Spokane

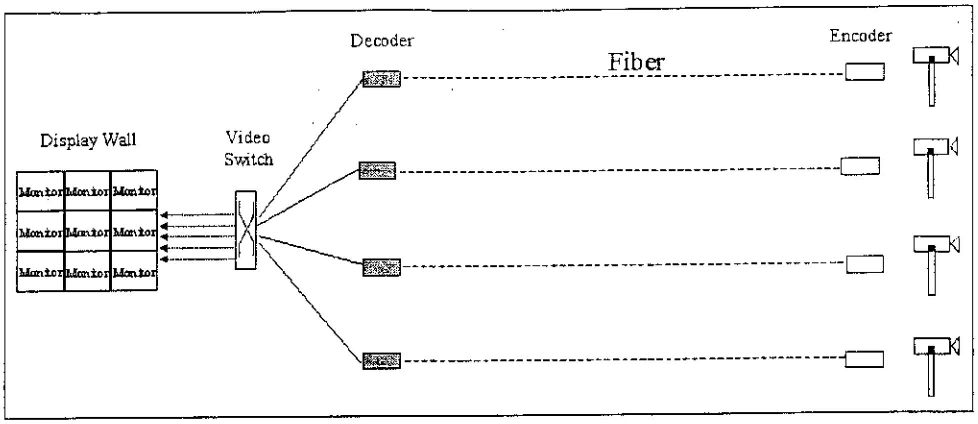

Figure 1

Video multiplexing (combining) is more cost effective than the point-to-point topology but since it uses the fiber infrastructure more efficiently. But the encoder and decoder requirement is still high especially if all the video signals have to be transmitted between remote sites and a central Traffic Management Center (TMC). Refer to Figure 2

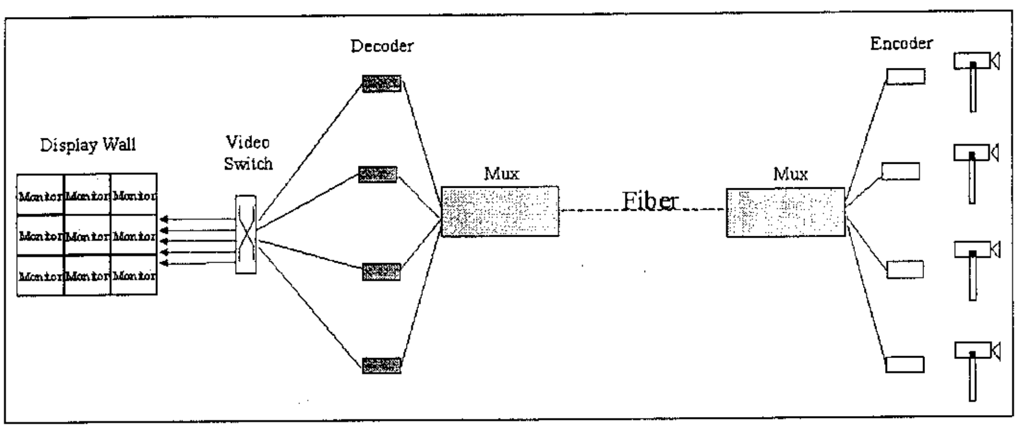

Figure 2

At the TMC there is a limit to how many video display devices are available. Therefore it does not make a lot of sense to transport all the signals from all the remote cameras back to the TMC. It is much more cost effective to transport only the video signals that need to be viewed at any time (view on demand). Typically a minimum number of video signals would be transported to the TMC based on the available number of displays/monitors. Utilizing field switching devices could provide a more cost effective solution if well planned and designed.

Transmitting video over a public telecommunications network could be highly cost effective if only the required analog video signals are transmitted to a central hub and/or the telecommunications company central office and the video is digitized and transmitted back to the TMC. Refer to Figure 3.

Hicham. F. Chatila, P.E., P.T.O.E.
The Transpo Group
Kirkland/Spokane

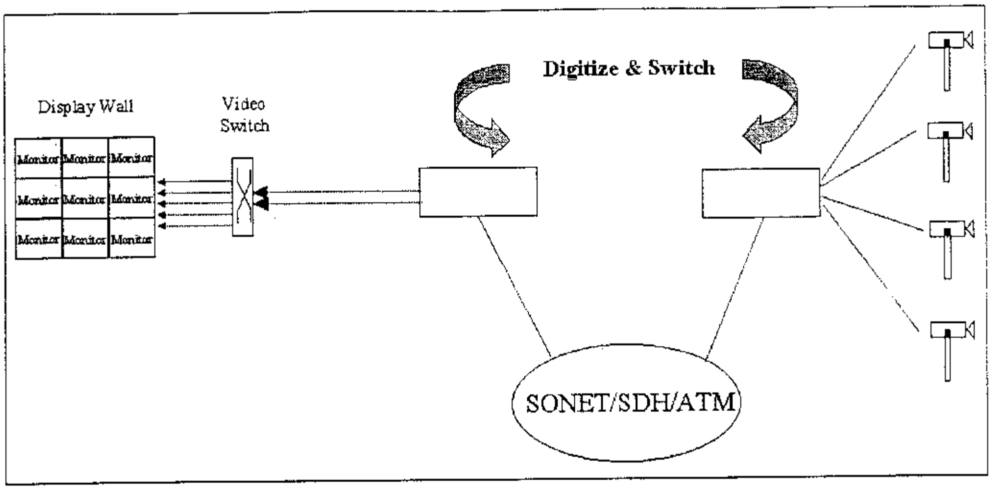

Figure 3

There are key items to consider in deploying digital video no matter what type of network topology and communication network you have in place or designing. These are:

- Determine your particular ITS application needs and functional requirements,
- Do not digitize all video. Digitize if cost effective and where needed;
- Do not transmit all the video, just the ones you need or can physically view;
- Use telecommunication industry standards whenever possible;
- Deploy network management software to minimize total operation cost;
- Design your network architecture with future expansion in mind; and
- Plan the network to allow for video switching and sharing.

Conclusions

The decision to implement digital video is not as clear-cut as one could think. Also there is no one solution that will accommodate all users (i.e. it is not one size fits all). Each application should be evaluated individually and designed accordingly. Another key issue that should be considered is the fast pace of technology development. Any system design should carefully consider the life cycle of the system and account for future system expansion and/or upgrade. Therefore the decision to when, where, and how to use digital video is dependant on many factors such as:

1. The type of ITS application being considered
2. Communications infrastructure (existing and proposed)
3. Network topology
4. Cost of digital encoders/decoders and networking electronics
5. Integration of new digital video with existing analog systems
6. Video sharing needs
7. Network management (operation and maintenance)

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A Look into the Future of ITS in British Columbia:
The Provincial ITS Vision and Strategic Plan

2001 ITE Quad Conference/IMSA
Vancouver, B.C., April 5 – 7, 2001

The Provincial ITS Vision and Strategic Plan is a roadmap for the development and deployment of ITS in British Columbia. The first phase of the plan includes an extensive consultation with stakeholders to obtain input, information and data on existing ITS projects and infrastructure and future requirements. Phase 1 concludes with the development of a provincial ITS initiatives to address identified problems and needs as well as a preliminary risk assessment. Based on the recommended initiatives, the second phase proceeds to develop a provincial ITS architecture, a detailed risk assessment and a phased implementation plan. This paper will provide insight on the process used to develop the ITS program, stressing the importance of a strong consultation component. The paper will also report on results to date and will confirm the importance of ITS architecture to the interoperability and integration of transportation facilities. The paper will conclude with a brief discussion on the future of ITS in British Columbia.

Keenan Kitasaka, M.Eng., P.Eng.,
Manager, Intelligent Transportation Systems
TransLink
1600 – 4720 Kingsway
Burnaby, B.C. V5H 4N2
Canada
(604) 453-4602
keenan_kitasaka@translink.bc.ca

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A Look into the Future of ITS in British Columbia: The Provincial ITS Vision and Strategic Plan

Background

On the evolution of transportation, Carl Sagan once said at an ITS conference that what has changed is the *speed* of movement. We have evolved from a pedestrian society in early human history moving at a few miles per hour into a technologically advanced culture in which the Galileo satellite orbits Jupiter's moons at 25,200 mph. Data can be transmitted instantly around the world at the speed of light and processed. Everything from computers to databases are becoming faster and smaller. So if society is so technologically advanced, why are there so many problems in our transportation network? The problems and answers are certainly complicated and multi-dimensional.

Firstly, the demands on the transportation network are ever increasing…there are simply more of us who want to travel at the same time in the same space. This problem is apparent in every commuting day in urban centres around the world and in British Columbia. Secondly, the ability of governments and transportation agencies to respond to these demands is becoming limited. The financial, political and environmental impacts of continuing to build more capacity are simply not feasible, sustainable nor livable. And finally, for our urban centres to compete in the global marketplace and support the economy, which in turn pays for many other public services, the transportation network needs to be as efficient as possible.

In British Columbia, these transportation problems are prevalent and complicated by the institutional framework that governs the network. A vast array of government agencies with varying mandates are responsible for the regulation, development, operation and maintenance of the transportation network in this province. Some agencies are responsible for a segment of the infrastructure (highways, major road network, etc.) whereas others have mandates that are specific to a particular mode such as ferries, transit and air. Thus, while transportation problems often cover multiple jurisdictions, infrastructure projects are usually more narrowly focused, requiring significant coordination amongst agencies, creating additional layers of complexity.

What is ITS?

The traditional approach to addressing transportation problems, such as congestion and delays, is to build more capacity and infrastructure. Given the financial, political and environmental constraints of today, many government agencies are focusing on maximizing the efficiency of the existing transportation network using Intelligent Transportation Systems (ITS). Internationally and within North America, ITS has emerged from a period of research and development to enter a deployment era.

ITS involves the application of technology, such as computers, electronic devices, communications and information systems, to improve the efficiency, safety and air quality of the transportation network and make our trips safer, smoother and smarter.

Some ITS applications involve performing basic and common tasks, such as traffic control, more efficiently. Other ITS applications, such as collision avoidance and automated highways, are in the early stages of development and are considered longer term programs.

With proven benefits in many application areas, ITS can provide the framework that enables the seamless integration of the transportation network and systems, particularly between jurisdictions. Thus, ITS provides a cost effective option in our broad menu of solutions to address transportation problems and it presents an opportunity for the private sector to play a role in providing user services without public resources.

The ITS Corporation – A Unique Approach

Within Greater Vancouver, there is a strong interest to pursue ITS both regionally and provincially by the government agencies responsible for transportation. Many agencies have already started development of ITS projects and programs to address some of their problems. Yet, within this province, there was not a single agency or alliance responsible for coordinating or integrating these ITS programs and projects.

In an innovative approach, TransLink, Greater Vancouver's regional transportation authority, created an operating subsidiary called the *ITS Corporation* in December 1999 with the overall mandate to coordinate ITS activities and act as a forum for member agencies to develop their ITS programs. The ITS Corporation is led by a Board of Directors whose membership comprises many of the major transportation agencies in the Province including:

- TransLink
- B.C. Ministry of Transportation & Highways
- B.C. Transportation Financing Authority
- Insurance Corporation of B.C.
- Greater Vancouver municipalities
- Vancouver International Airport Authority
- Vancouver Port Authority
- University of British Columbia
- Pacific Corridor Enterprise Council (PACE)
- Transport Canada (Associate Member)

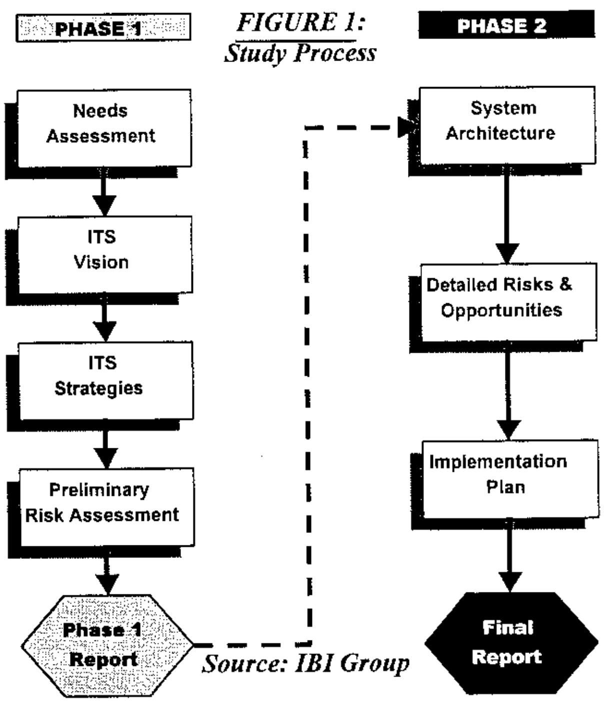
TransLink itself has a very unique mandate with the legislated authority, not only to fund its activities through a variety of means, but to also plan, deploy and operate the systems. This structure combines the traditional role of senior governments as potential sources of funding and policy with the local role of planning, deployment and operations. As an operating subsidiary of TransLink dedicated to the development, deployment and operation of ITS, the ITS Corporation is somewhat unique to Canada and possibly North America.

To coordinate activities, the ITS Corporation members recognized that a roadmap was needed to guide the development and deployment of ITS. While the initial concept of the plan was regional in scope, it was noted that many members had provincial mandates and in some cases, had federal and international interests. The plan also had to consider the needs of non-member stakeholders, some of whom serve significant roles within our transportation network. One such example is the B.C. Ferry Corporation which, while not a current member of the ITS Corporation, affects the transportation network. Consistency with Federal initiatives such as the Canadian ITS architecture and interoperability with cross border U.S. applications was also deemed desirable. Finally, the purpose of the plan was to guide the ITS Corporation into a deployment phase and hence, had to provide sound advice pertaining to implementation, costs and benefits, potential integration and partnering opportunities between agencies, and possible risks and barriers. Ultimately, the ITS strategic plan was expanded to become provincial in scope and include an extensive ITS architecture phase.

The Provincial ITS Vision and Strategic Plan – A Blueprint for the Future

The ITS Corporation and its team of consultants led by IBI Group began work on the Provincial ITS Vision and Strategic Plan in August 2000. The consultant team also includes Lockheed Martin, Delcan Corporation, Shaflik Engineering, and PBA Engineering as well as a number of individual domain experts. The ITS strategic plan was conceived in two sequential phases. Phase 1 is intended to assess the provincial transportation needs that may be addressed by ITS and develop an overall vision and direction for ITS. This vision is a critical step in obtaining member agency consensus, prior to developing more detailed goals and a set of ITS strategies to achieve them. Phase 2 compiles these strategies into logical groupings that will be developed into a provincial ITS architecture, which is critical to enabling future interoperability and integration of ITS deployments. The architecture will also enable a more detailed review of risks, opportunities and barriers and will confirm integration opportunities between agencies that are developed in earlier iterations. An important output of Phase 2 will be an implementation plan that will include major initiatives and projects that follow the user service bundles of the ITS architecture and project prospectuses. Throughout the process, a critical aspect of the plan will be the concept of traceability to ensure that each recommended project is related back to specific strategies, goals, and ultimately supportive of the vision. Figure 1 illustrates the study process.

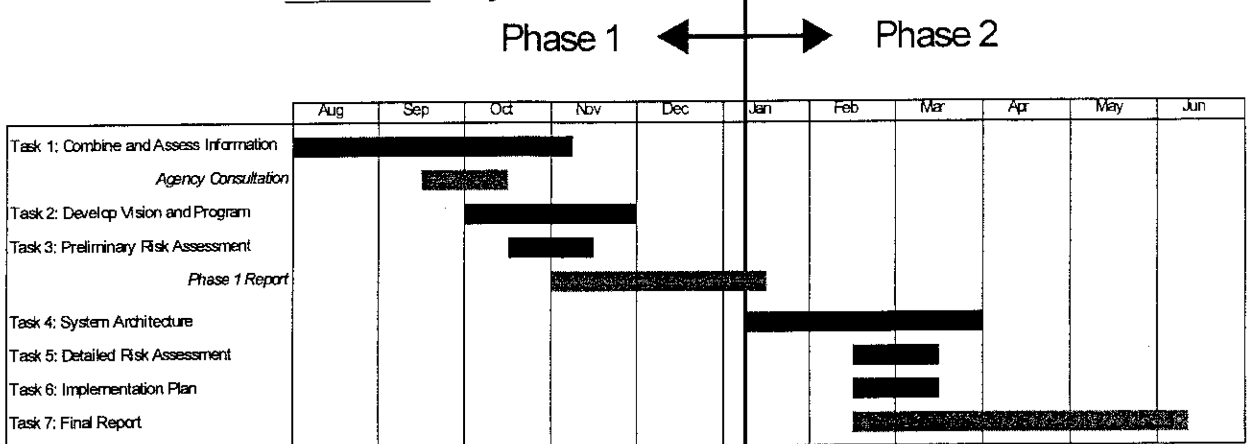
FIGURE 1: Study Process



Source: IBI Group

The Provincial ITS Vision and Strategic Plan's time duration is approximately 10 months, to be completed in early June 2001. Figure 2 illustrates the project schedule and timing of the tasks in Phases 1 and 2.

FIGURE 2: Project Schedule



Source: IBI Group

Phase 1 – Development of the Blueprint for Success

Phase 1 of the Provincial ITS Vision and Strategic Plan involved a significant consultation process with the stakeholders from which the elements of the ITS program would emerge. Since the ITS strategic plan must reflect a provincial perspective, it was important to capture the unique transportation needs of the outlying rural areas of British Columbia via regional workshops, in addition to the urban centres. Specifically, the components of Phase 1 included:

- Needs Assessment based on an extensive consultation of stakeholders throughout the province. This section of the strategic plan was focused on obtaining data, information and input from stakeholders through a number of mediums including:
  - Consultation with ITS Corporation member agencies via meetings and by completing detailed workbooks to provide the corporate objectives and views on their needs
  - Consultation with stakeholders throughout the province via a series of four regional workshops in Kelowna, Prince George, Victoria and Vancouver. Attendees at the workshops also completed workbooks to document their input.
  - Meetings with targeted focus groups to fill any information gaps that were missing, particularly from key stakeholders not in attendance at the workshops.
  - Literature review of similar ITS strategic planning and development activities throughout other jurisdictions worldwide.
  - Review of a detailed Commercial Vehicle Operations (CVO) Strategic Plan for the province that addressed the specific needs of this user service bundle.
  - Input from other stakeholders through a project website at www.itsbc.org

  Throughout the stakeholder consultation process, the most common need that was identified is to improve inter-agency cooperation and coordination of services. The second major identified need is the availability of funding. Further, a significant number of participants identified the availability of timely and consistent high quality data as a key issue or need.

- Development of an ITS vision, goals, and measures of effectiveness to gauge future performance of the ITS plan and deployments. The development of a vision based on the needs assessment provides general direction for ITS in the province. The vision statement for B.C.'s Provincial ITS Vision and Strategic Plan is:

  > *" ...to apply advanced technologies, deploy and integrate systems, and establish innovative partnerships that increase mobility and safety, while enhancing the efficiency of the transportation system."*

- From the vision, a set of broad goals were developed as follows:
  - Make travel safer for the public and commercial vehicle operators
  - Minimize delays and congestion to reduce costs and boost economic activity
  - Manage travel demand to use the transportation network more effectively
  - Provide fast and co-ordinated responses to incidents and other emergencies
  - Improve data collection, management and sharing
  - Improve inter-agency co-ordination and co-operation

  In support of the vision and goals for the plan, several key objectives emerged. The objectives were developed from the distinct and different perspectives of both users and providers. For example, access to timely and accurate traveller information was an objective from a user's perspective to enable informed decisions on mode, schedule, time and route. Access to this information was considered to be a key objective from the provider's perspective to address daily operations and planning needs. Finally, the business relationships between the users and providers were considered in developing the set of provincial transportation needs to be addressed by ITS.
- Mapping of ITS implementation strategies to the vision, goals, and objectives. These ITS strategies involve the deployment of user services that support and achieve these goals and objectives. Together, these ITS strategies comprise the suite of user services that will evolve into the implementation plan in Phase 2.
- Preparation of a preliminary risk assessment of these ITS strategies.

Phase 1 of the Provincial ITS Vision and Strategic Plan is complete and can be viewed on the project website.

<u>Phase 2 – ITS Architecture and the Key to Interoperability</u>

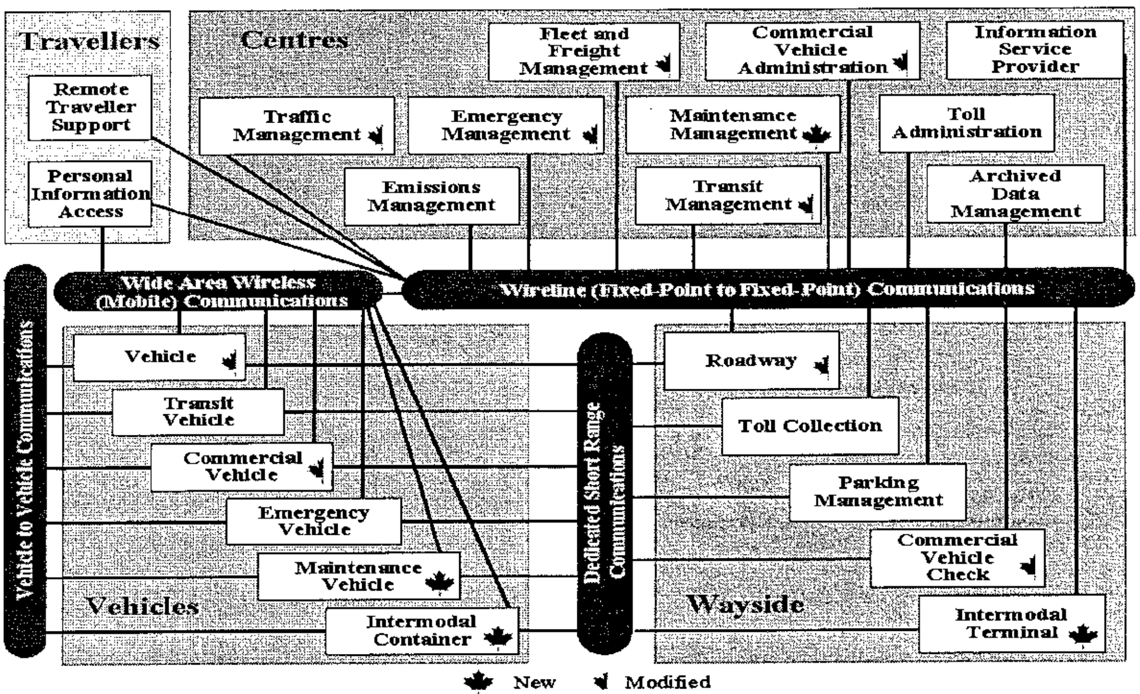
As Phase 1 primarily involved needs assessment, the next step focuses on preparing the provincial ITS architecture in Phase 2. The development of a provincial ITS architecture is an important step in ensuring that the recommendations of the plan are interoperable within the province, across Canada and with the United States. The ITS architecture provides the framework that promotes integration, allowing member agencies to pursue interoperable ITS initiatives and projects that maximize deployment benefits.

Specifically, Phase 2 will involve:

- Development of a provincial ITS architecture based on the suite of user services from the ITS strategies in Phase 1. This task essentially prepares the ITS Corporation for deployment by developing a common physical and logical architecture, identifying sub-system components, and defining the flow of information between these components. The ITS architecture will permit agencies of the ITS Corporation to pursue ITS initiatives and projects that will be interoperable and integrated with the provincial and regional systems. The ITS architecture will also validate the integration based initiatives identified in earlier iterations with the member agencies.

  The Canadian physical architecture is illustrated in Figure 3 below, known by many as the "sausage diagram". Components of this diagram will be used to capture and illustrate the sub-systems that apply to the provincial ITS strategies.

FIGURE 3: Physical ITS Architecture *Source: Cdn ITS* Arch



- Preparation of a detailed assessment of risks, opportunities and barriers to deployment.
- Completion of a detailed implementation plan which will focus on the potential integration opportunities, key linkages and synergies between the members of the ITS Corporation. Thus, the implementation plan will be comprised of major initiatives, each with recommended projects, that are in one of several categories:
  - Initiatives that must be implemented in common with a high degree of integration between agencies. An example of this type of initiative would be multi-application smart cards which require key linkages between agencies responsible for transit, parking, tolls and other payment systems to be successful.

- Initiatives that would be more efficiently and desirably implemented in common by several agencies but not absolutely necessary. An example of this type of initiative would be an ITS deployment such as the Ministry of Transportation & Highways' TMP pilot project that is currently corridor focused on the Trans Canada Highway but may be integrated with the other network systems in the future.
- Initiatives that can be undertaken by individual agencies independently and do not affect the others. An example of this type of initiative is road and weather information systems (RWIS) that can be deployed independently but can be shared with other agencies in the future.

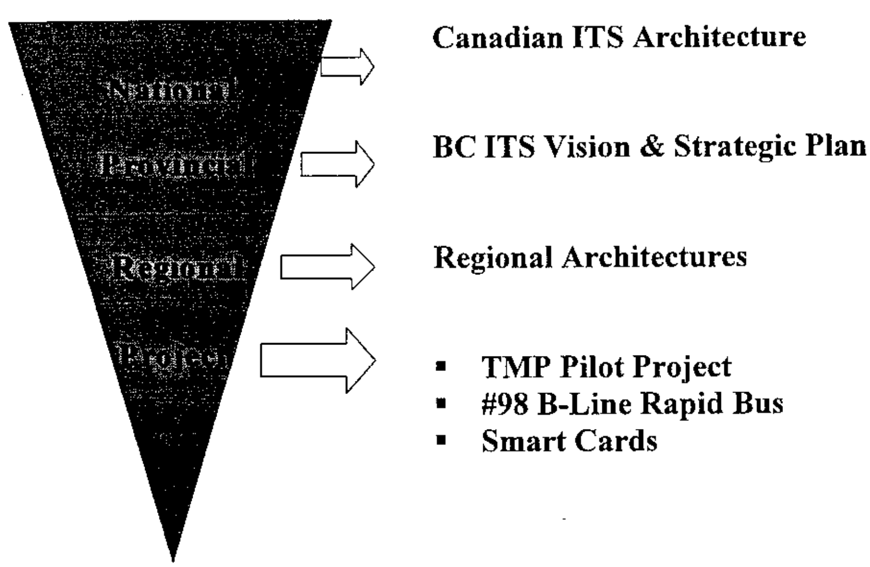
How does the ITS architecture fit within other initiatives?

Some ITS Corporation member agencies have already begun to move forward with ITS deployments. Examples include:

- TransLink's #98 B-Line rapid bus route between Richmond and Vancouver will feature automatic vehicle location technology to track bus location which will be used to determine time to arrival at the next station, transmitted to electronic customer information signs. The buses will also be equipped with infrared transponders to communicate with the signal controllers to request pre-emption of the traffic lights when buses are behind schedule.
- B.C. Ministry of Transportation and Highways' Traffic Management Program pilot project on about 30 kilometres of the Trans Canada Highway that will focus on incident management and traveller information systems.
- Cross border systems that permit faster, more efficient processing of trucks.

Regional and project level ITS architectures of such initiatives are the next detailed step in development of the ITS program, beyond the provincial architecture. At a broader level, the Provincial ITS Vision and Strategic Plan will bring all these deployments together, with the future recommended projects, into one plan promoting a truly integrated and interoperable future transportation system. Figure 4 illustrates the relationship between the provincial ITS architecture and other regional and project level initiatives.

FIGURE 4: Provincial ITS Architecture and Other Initiatives Source: IBI Group



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The Final Report – the Future of ITS in British Columbia

The final report for the ITS Vision and Strategic Plan will define the future of ITS in this province for many stakeholders including the ITS Corporation and it's member agencies. Specific outcomes of the plan include:

- A blueprint or roadmap for the application of ITS solutions to address the transportation needs in the province
- An ITS strategy and architecture that will promote interoperability and integration between agencies
- A multi-agency long term implementation plan with cost estimates leading to the development and deployment of ITS initiatives and projects.
- A first test of the Canadian ITS architecture.

Beyond these technical products, the ITS Vision and Strategic Plan will also provide recommendations on the organizational structure, innovative financing, and creative public-private partnerships to promote the implementation of ITS projects.

Conclusions … Life after the ITS Strategic Plan

In many respects, the ultimate success of this ITS strategic plan will rest in the results of ITS deployments, long after completion of this document. Indeed, this plan represents a unique opportunity to improve the transportation network through the deployment of ITS initiatives, starting from a relatively blank slate and with the benefits of lessons learned from other jurisdictions. This plan has the potential to shape and influence our transportation future and, in effect, change how we do business for the better, focus our programs to meet customer demands, and provide a safe and efficient multi-modal system.

Equally influential will be the approach of member agencies in embracing the ITS recommendations and embedding ITS into their strategic plans and programs. To be successful, ITS requires this institutional support through the policies, enabling legislation, and funding of the transportation agencies of this province and in Canada.

The Provincial ITS Vision and Strategic Plan is a landmark study that will have significant impacts on the transportation community including users and customers, owners of systems, service providers and other stakeholders for many years. Successfully developed, the resultant ITS initiatives have the potential to leave a legacy of improvements for future generations.

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