INTEGRATED REGIONAL SIGNAL SYSTEM
BENEFITS OF REGIONAL TRAFFIC SIGNAL TIMING

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ABSTRACT

Traffic signal management systems have been proven to demonstrate significant benefits from the coordination of traffic signal operations. However, with the continued growth of the various urban areas in the Metro Vancouver area and the installation of an increasing number of signalized intersections, there is a growing need to coordinate the traffic signal operations between adjacent municipalities and agencies.

The goal of the Integrated Regional Signal System (IRSS) program is to make better use of available information and communications technologies to provide a 'system of systems' that facilitates coordinated operation between individual municipalities and jurisdictional agencies, while also allowing the individual agencies to maintain their autonomy with respect to signal control equipment selection and signal timing plan implementation.

Utilizing a centre-to-centre communications protocol that provides for the integration and interoperability of existing traffic signal management systems, the IRSS allows individual agencies to:

- Share information and data that encourages coordinated operations across jurisdictional boundaries;
- Coordinate operations along regional traffic corridors across jurisdictional boundaries through access to a common time source; and
- Send and receive event notices to/from adjacent municipalities and/or agencies to trigger special pre-approved timing plans.

The IRSS Pilot System was implemented along the following two corridors in the Langley area in BC, which include eleven signalized intersections belonging to four jurisdictions:

- 200 Street, from 66 Avenue to Fraser Highway; and
- Fraser Highway, from 64 Avenue to 200 Street.

As part of the pilot project, ‘before and after’ assessments showed a significant improvement to regional traffic flows along these two corridors, including reductions in vehicle travel times, delays and stops, and an estimated annual reduction of over 6 million kg of greenhouse gases.

This paper will present an overview of the IRSS operations and summarize the results of the ‘before and after’ studies with a focus on the benefits including the estimated GHG reductions attributed to improved signal coordination.

INTEGRATED REGIONAL SIGNAL SYSTEM

1. INTRODUCTION

Traffic signal management systems have been well proven to demonstrate significant benefits from the coordination of traffic signal operations. In this respect, most of the agencies in Metro Vancouver have recognized these benefits and have implemented traffic signal management systems within their own jurisdictions. In the past, this approach has served the individual municipalities and jurisdictional agencies reasonably well; however, with the continued growth of the various urban areas in Metro Vancouver and the installation of an increasing number of signalized intersections, there is a growing need to coordinate the traffic signal operations between adjacent municipalities and agencies. To date, very few agencies in Metro Vancouver have integrated their signal coordination with their neighbours.

The goal of the Integrated Regional Signal System (IRSS) is to make better use of available information and communications technologies to provide a 'system of systems' that facilitates coordinated traffic signal operations between individual municipalities and jurisdictional agencies, while also allowing the individual agencies to maintain their autonomy with respect to signal control equipment selection and signal timing plan implementation.

IRSS utilizes centre-to-centre communications protocols to provide integration and interoperability which allows individual agencies to:

- Share information and data that will encourage coordinated operations, as well as encourage common standards, across jurisdictional boundaries;
- Enable coordinated operations along regional traffic corridors across jurisdictional boundaries through access to a common time source; and
- Send and receive event notices to/from adjacent municipalities and/or agencies to trigger special pre-approved timing plans in response to measured traffic flows, incidents and special events.

IRSS is compatible with the ITS Architecture for Canada and other ITS initiatives set out in the BC Provincial ITS Vision and Strategic Plan. Over the longer term, IRSS will provide the necessary link between signal operation and other regional ITS initiatives (e.g., traveller information, incident management, railway advanced warning, etc.) to provide for the implementation of regional traffic management strategies that support all modes of transportation, and extend to both arterial and freeway networks.

1.1 Project Background

In November 2001, the ITS Corporation completed the BC Provincial ITS Vision and Strategic Plan, summarized in **Figure 1**, which provides overall direction for the deployment of ITS within the Province of British Columbia and Metro Vancouver by identifying 23 initiatives that provide the steps to achieving their ITS strategies. As an early step in the Strategic Plan, Initiative No. 1

calls for the implementation of Regional Traffic Management including a key component, an Integrated Regional Signal System.

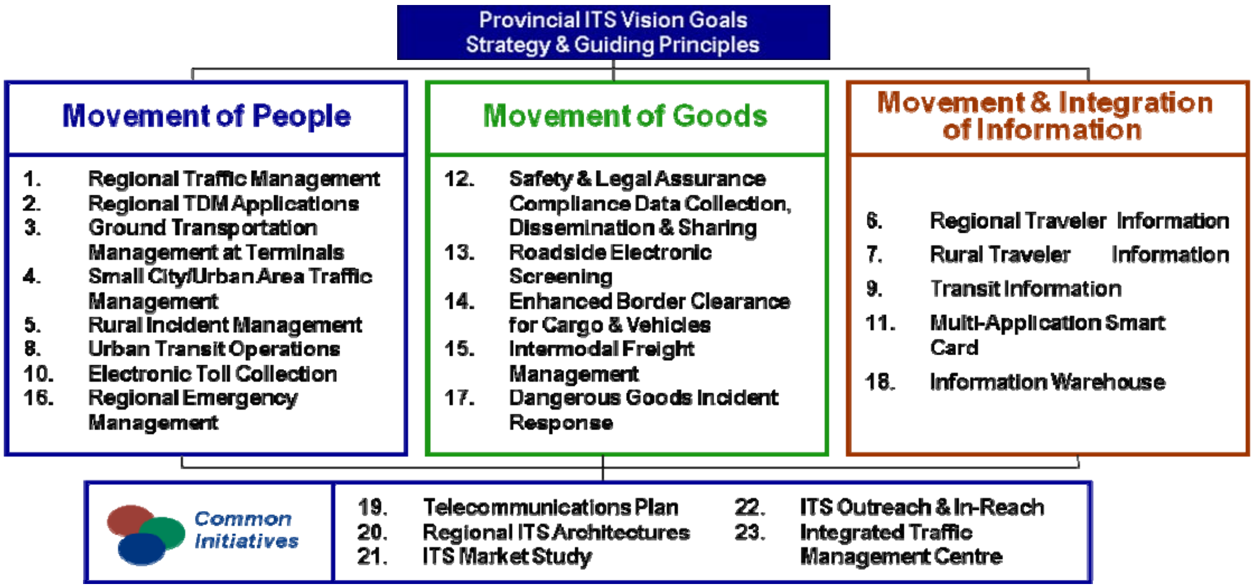

Figure 1 – BC Provincial ITS Vision and Strategic Plan

In January 2005, the ITS Corporation completed the Integrated Regional Signal System Study, which assessed needs, examined benefits, and developed a concept of operations for a 'system of systems' that facilitated coordinated traffic signal operations between individual municipalities and jurisdictional agencies. To demonstrate the benefits possible from regional coordination, the study recommended the deployment of an "early winner" pilot project, from a list of candidate corridors, which integrated 11 signalized intersections operated by four different jurisdictions in the Langley and Surrey area.

In May 2006, a public private partnership project was formed to implement the proposed IRSS Pilot Implementation project. The results of the pilot project are presented later in this report.

1.2 Project Partnership

This pilot implementation is a public private partnership project between:

- The South Coast British Columbia Transportation Authority, also known as 'TransLink';
- Transport Canada;
- The Insurance Corporation of British Columbia (ICBC);
- The four municipalities and jurisdictional agencies that own and operate the traffic signal controllers within the two selected regional corridors; namely:
    - Township of Langley;

    - City of Langley;
    - City of Surrey; and
    - BC Ministry of Transportation and Infrastructure (MoT);
- Delcan Corporation; and
- The three suppliers of the existing legacy traffic signal controllers and traffic signal management systems;
    - Econolite Canada;
    - McCain; and
    - Innovative Traffic Solutions.

TransLink, as the lead proponent, was responsible for the management of the project, and entered into an agreement with Transport Canada for the funding of the pilot project.

On the basis that the project improves motorists' safety through improved traffic signal coordination and reduced potential for predominantly rear-end collisions, ICBC provided funds in support of the project.

The Township of Langley, City of Langley, City of Surrey and MoT are responsible for the operation of the signalized intersections within their respective jurisdictional areas. For this project, each of these agencies provided their own Traffic Signal Management System (TSMS) for the direct management and control of the traffic signal controllers for which they are responsible, as well as manpower resources to assist in the commissioning of controllers to their TSMSs and implementation of new traffic signal timing plans.

Delcan Corporation led the detailed system design and development effort and also contributed a portion of this effort.

Less formal, but still important 'project partners' vital to the successful completion of the pilot implementation were the respective suppliers of the three different types of legacy traffic signal equipment and central TSMSs. Interfaces to the existing systems / field equipment were developed that required the following suppliers' involvement and support:

- Econolite Canada – supplier of the ASC traffic signal controllers and Aries TSMSs for the City of Langley and the Township of Langley;
- McCain – supplier of the Type 170 traffic signal controllers and QuicNet TSMS for the City of Surrey; and
- Innovative Traffic Solutions – supplier of the Peek LMD traffic signal controllers for the MoT.

1.3 Pilot Project Network

The IRSS pilot was implemented to demonstrate the benefits possible from regional signal coordination. The following two regional corridors were identified as 'early winner' corridors that had the potential to realize traffic operation and safety benefits from regional coordination, and were selected for implementation with the pilot:

- 200 Street, from 66 Avenue to Fraser Highway; and
- Fraser Highway, from 64 Avenue to 200 Street.

The locations of the eleven signalized intersections that comprise these two corridors are illustrated in **Figure 2**.

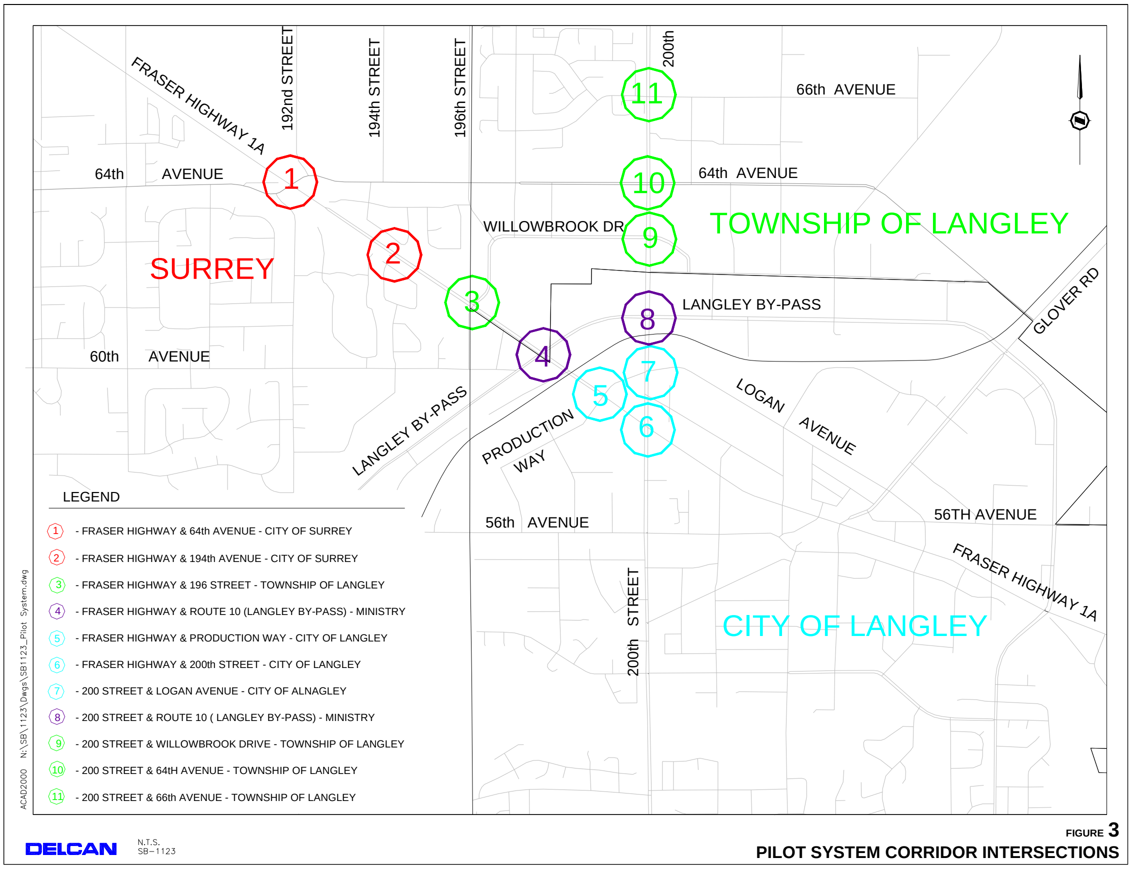

Figure 2 – IRSS Pilot Project Network

2. SYSTEM ARCHITECTURE

The Integrated Regional Signal System is a ‘system of systems’ that facilitates coordinated traffic signal operations between individual municipalities and jurisdictional agencies. As illustrated in **Figure 3**, IRSS consists of a single IRSS Collector and a single IRSS Gateway for each participating agency. Note that each agency uses a different system architecture, and in some cases, different communications media, for connecting to their local controllers.

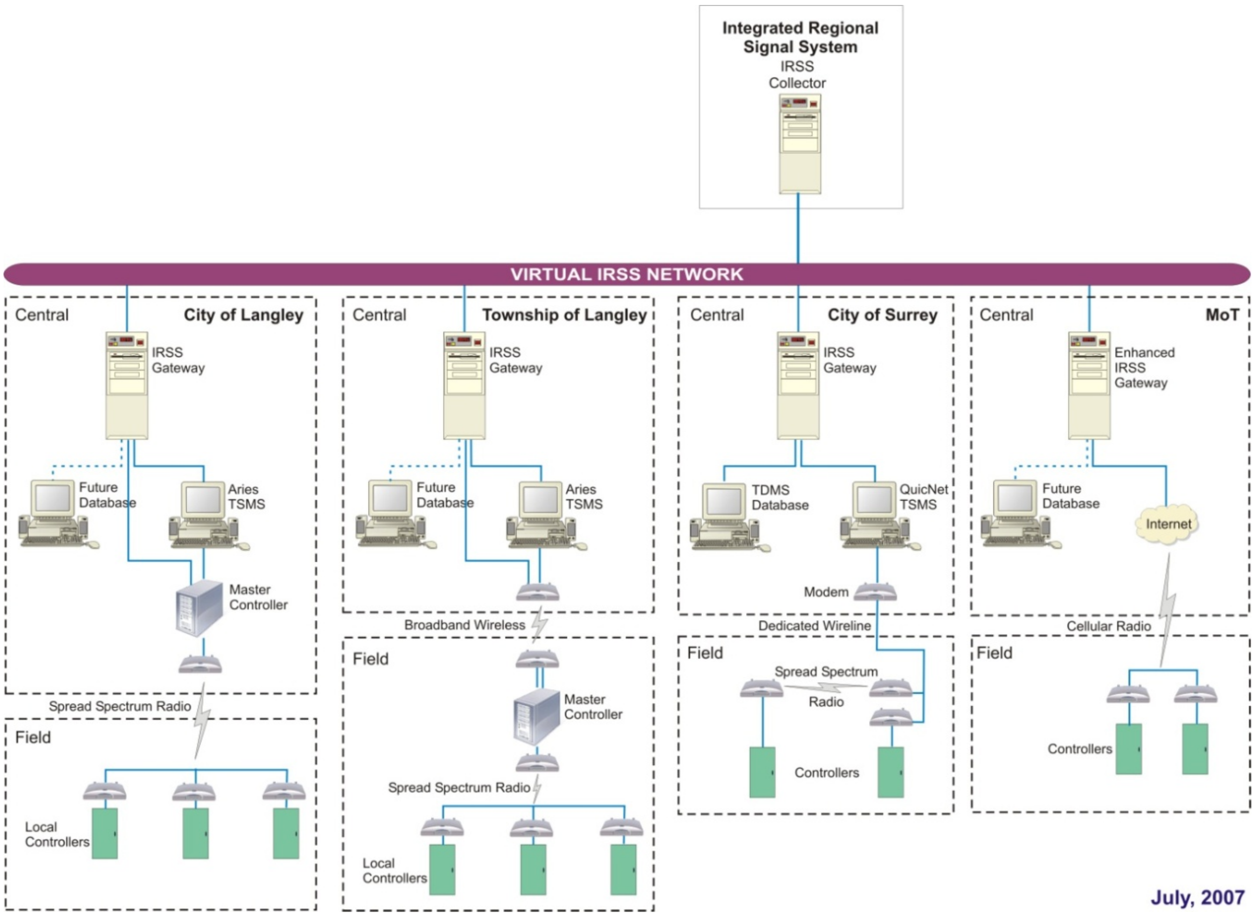

Figure 3 – Schematic Overview of IRSS System Architecture

The IRSS Gateway enables an agency to participate in IRSS. Using the Gateway, the agency can selectively share information from its Traffic Signal Management System (TSMS) and/or Traffic Data Management System (TDMS) with the other participating agencies via the IRSS Collector. The Gateway also forwards plan selection requests from the Collector to the TSMS for automated plan selection. Via an administrator interface, a system administrator can restrict information sharing and plan selection for the intersections within the agency’s jurisdiction.

For the interface to the MoT traffic signal controllers, in addition to the above functionality, the IRSS Gateway was enhanced to communicate directly with the local traffic signal controllers (i.e., in lieu of communicating via a TSMS).

The IRSS Collector provides a data collection function; providing a central point of access to all Gateway information. The IRSS Collector also monitors the network for loss of communication with the Gateways. Lastly, the IRSS Collector performs automated plan selection, issuing plan change requests to the individual Gateways in response to pre-emption, manual control, and traffic responsive events reported by the Gateways. Via an administrator interface, a system administrator can view communication status of each IRSS Gateway. The server for the IRSS Collector is located at TransLink's CMBC Gateway facility in Surrey. The system administration and operating costs are supported by the ITS Department in TransLink.

An IRSS Web Interface, illustrated in **Figure 4**, is also provided for each participating agency. The IRSS Web Interface allows traffic engineers, using a web browser, to access traffic counts, timing plans, schedules, and current traffic signal status from all agencies within the region; and to collaborate with other agencies to establish regional automated plan selection. The IRSS Web Interface utilizes the IRSS Collector to access these data and functions. In the event that the connection to the IRSS Collector is lost, the IRSS Web Interface can still provide local information from the local IRSS Gateway. IRSS Web Interfaces are installed alongside the IRSS Collector and each IRSS Gateway, hosted on the same physical computer.

Figure 4 – IRSS Web Interface

The IRSS Collector, Gateways, and Web Interfaces utilize a data exchange network built on open internet and (TCP/IP) ITS protocols to exchange information with one another (and with other ITSs in the future). The data exchange network runs over the Internet.

The IRSS Gateway and Collector system clocks are synchronized to a trusted public Internet time source (i.e., time.nrc.ca) using Network Time Protocol (NTP). The proprietary TSMS clocks are synchronized to the IRSS Gateway clock.

3. REGIONAL TRAFFIC SIGNAL TIMING DESIGN

Prior to initiating the IRSS pilot, intersection turning movement count data, required to produce updated signal timing plans, were collected for the majority of the signalized intersections. For some locations, recent traffic count data available from the project partner agencies was used. In addition, existing traffic signal timings were obtained from the respective agencies.

Synchro models were created to reflect existing conditions using the implemented timings and intersection geometry at all 11 signalized intersections within the Pilot System project area. These models covered the Weekday AM Peak, Mid-day Peak and PM Peak periods, and for the Saturday PM Peak period. Performance indicator information was then extracted from the Synchro files (LOS, v/c, average delays).

Optimized coordinated signal timings were then developed using Synchro initially to determine the optimum cycle lengths and phase splits for the entire network. The offsets were reviewed and adjusted manually using the time space facility within Synchro. Four peak period signal time plans were designed to cover the periods mentioned above. Here again, performance indicator information was then extracted from the Synchro files (LOS, v/c, average delays). In addition, for selected intersections that would be impacted by train operations at the at-grade rail crossings, rail pre-emption and rail pre-emption recovery timing plans were also prepared.

4. SYSTEM BENEFITS OF REGIONAL SIGNAL TIMING

The benefits realized from coordinated traffic signal operations along regional traffic corridors across jurisdiction boundaries were quantified in terms of the following measures of effectiveness:

- Improved Traffic Operations, as measured by;
    - Volume to Capacity Ratio (v/c ratio);
    - Average Intersection Delays; and
    - Intersection Level of Service (LOS).
- Reduced Travel Times;
- Improved Safety; and
- Reduced Green House Gas Emissions

These are discussed in the subsections below.

4.1 Maximum V/C Ratio

The maximum intersection v/c ratio is the highest volume/capacity ratio recorded by one of the individual movements at the signalized intersection. It reflects the amount of residual capacity to accommodate variations in traffic flow. The before / after maximum v/c ratios for each intersection for the AM and PM peak periods are illustrated in **Figures 5 & 6**.

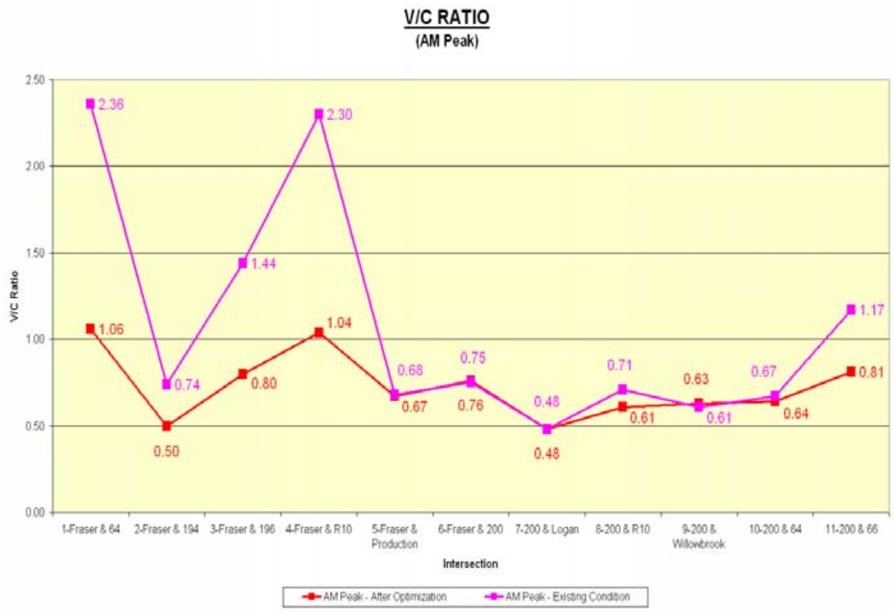

Figure 5 – Before/After Maximum V/C Ratios for AM Peak Period

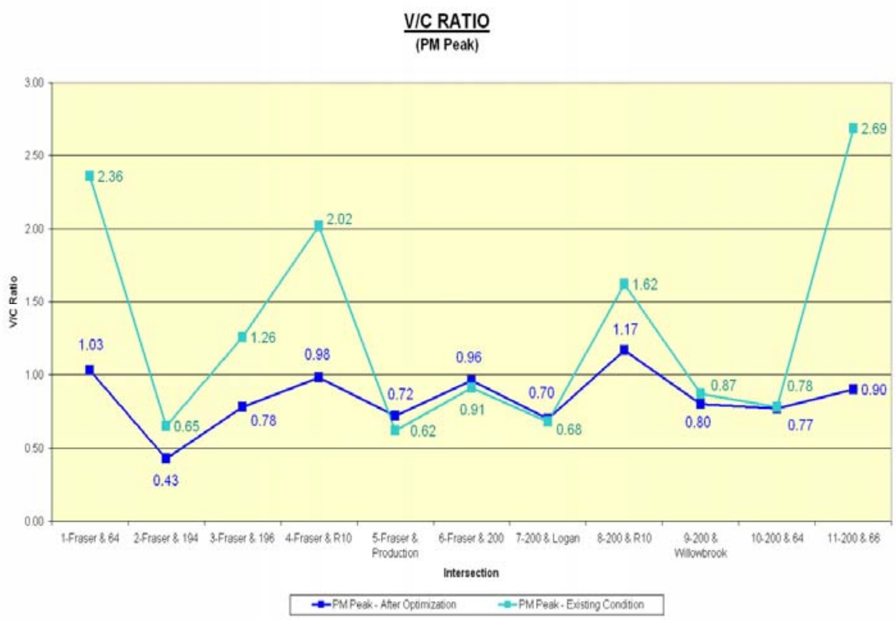

Figure 6 – Before/After Maximum V/C Ratios for PM Peak Period

As shown in the above figures, the overall result is a positive improvement in the maximum v/c ratio for most intersections, particularly for the intersection of 200 St / Logan Ave. The PM peak period has the greatest improvement with respect to maximum v/c ratios. It is also observed that the maximum v/c ratios at some intersections are slightly higher after optimization. This can occur when optimizing the signal timings for a network, where some individual movements might suffer for the sake of overall intersection and network improvements.

4.2 Average Intersection Delays

Intersection delay analyses the average total delay at an intersection. The total delay includes the control delay plus the queue delay. The control delay is the delay caused by the traffic control device (i.e., traffic signal lights), while queue delay takes into account the queuing effect and blocking of the short links and turning bays. The average total delay for an intersection is calculated by taking a volume weighted average of all the delays at the intersection. The before / after average intersection delays for the AM and PM peak periods are illustrated in **Figures 7 & 8**.

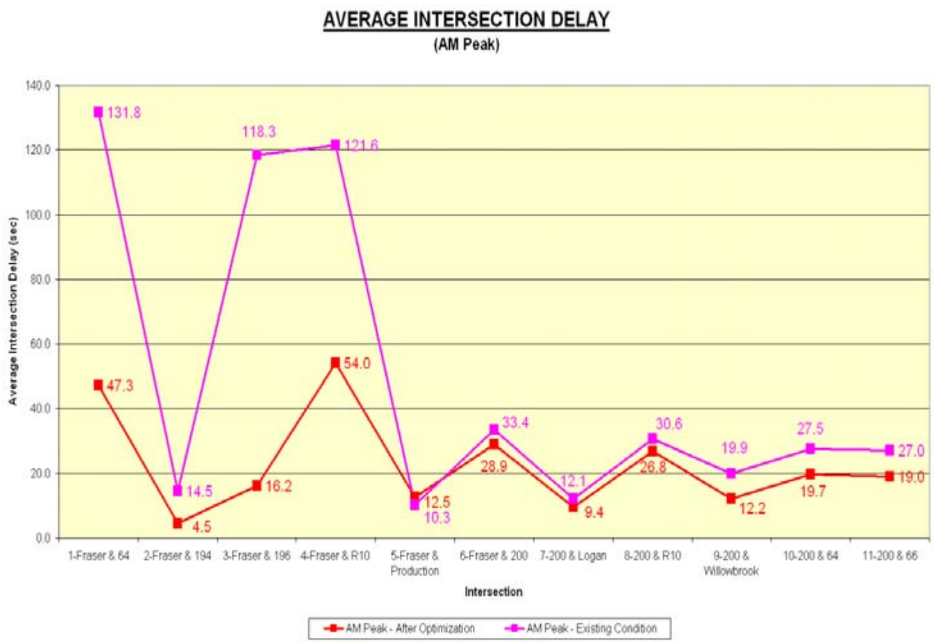

Figure 7 – Before/After Average Delays for AM Peak Period

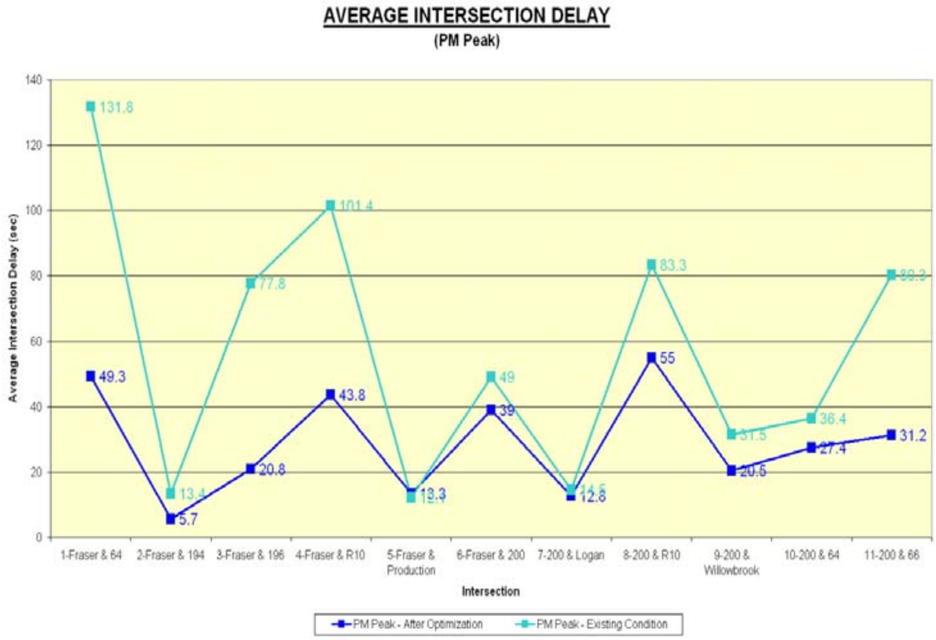

Figure 8 – Before/After Average Delays for PM Peak Period

Nearly all of the intersections benefit from the coordination of traffic signal operations in the peak periods. There are some intersections that show a slightly higher delay after optimization, but these disbenefits are far outweighed by the benefits at other intersections and for the network overall.

4.3 Level of Service

Level of service (LOS) is a term used to qualitatively describe the operating conditions of the signalized intersection. It is based on the average control delay for all vehicles approaching the intersection and converting it to a letter between A to F based on the delay; with A representing the best operating conditions and F the worst. The before / after average intersection LOS for the AM and PM peak periods are illustrated in **Figures 9 & 10**.

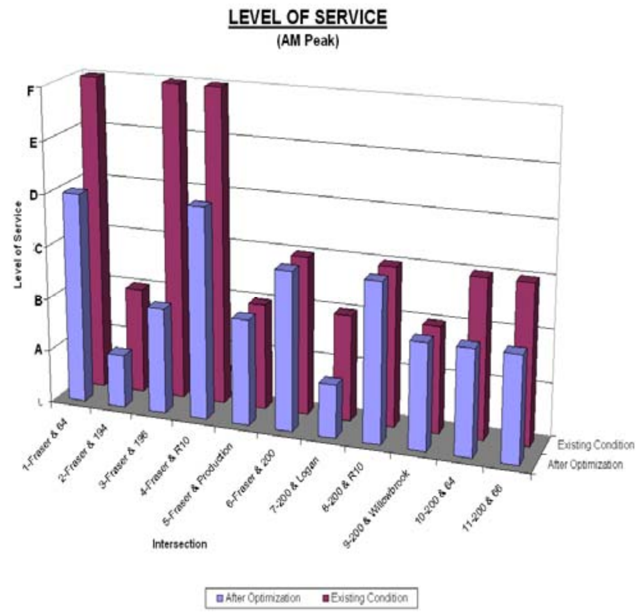

Figure 9 – Before/After LOS for AM Peak Period

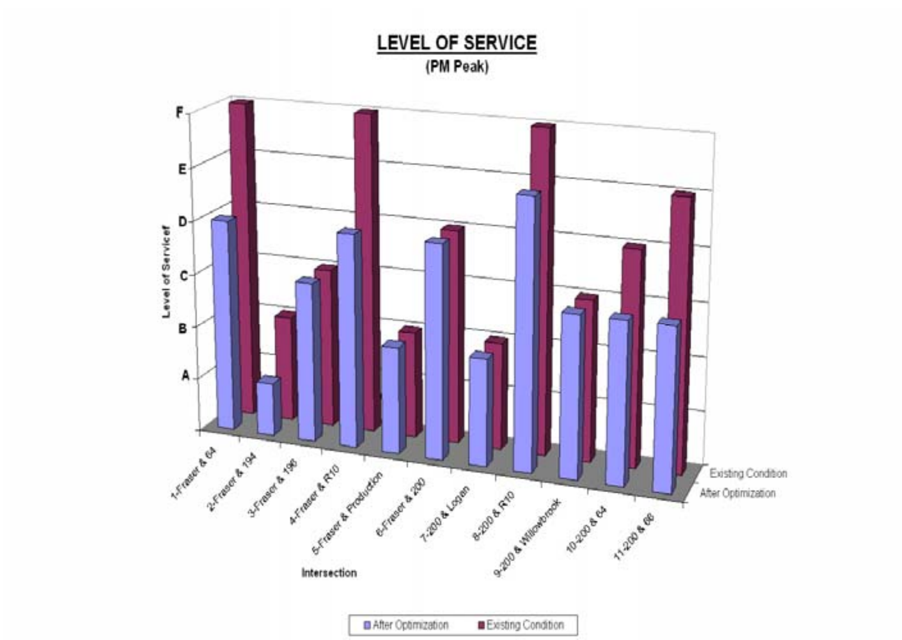

Figure 10 – Before/After LOS for PM Peak Period

Overall, after optimization, the signalized intersections either maintain the LOS or improve the LOS by one level. LOS 'F' was recorded at several intersections for the existing operation in both PM and Saturday peak periods. LOS 'F' implies forced traffic flow with heavy queuing of vehicles and frequent stops. After optimization, there is only one intersection remaining with LOS 'F' - Intersection No. 1, Fraser Highway / 64th Avenue - in the Saturday peak. In general, individual intersection operations are however improved.

4.4 Travel Time Surveys

To assist in the analysis of the effectiveness of the IRSS pilot, 'before' and 'after' travel time studies were conducted in September and December, 2007, respectively. This data was collected on Fraser Hwy and 200 St for the three Weekday peak periods and the Saturday afternoon peak period. To realize statistically significant results, each route was surveyed a minimum of six times within each time period.

Generally, the 'after' travel times are lower than the 'before' travel times (i.e., on average 8% lower), notwithstanding the fact that, during the 'after' surveys, the traffic volumes were a significantly higher (i.e., Christmas shopping trips). On Saturdays, the 'after' travel times were higher than 'before'. This is attributed to the 14% higher traffic volumes during the 'after' survey period; volumes which are associated with Christmas shopping on Saturday.

4.5 Safety

Uncoordinated traffic signal operations and congested traffic conditions are often accompanied by a high incidence of rear-end collisions due to the prevalence of stop-and-go traffic. Research by others has shown that the implementation of optimized and coordinated traffic signal timings has the potential to reduce collisions. Conservatively assuming a 3% reduction on collisions due to regional signal coordination, the predicted annual value of the reduction in collision related insurance claims was estimated to be $167,000 per year.

4.6 Green House Gas Emissions

With the implementation of IRSS regional signal timing optimization, preliminary evaluations were performed to estimate the reduction of green house gas (GHG) emissions that could be realized through reduction in vehicle stops and delays, and hence, reductions in fuel consumption. This evaluation was performed using simulation models that incorporated the before/after traffic signal timings. The model fuel usage output was used to estimate GHG emissions based on the assumption that a litre of gasoline would produce 2,479 grams of GHG from a light duty passenger vehicle (as per Transport Canada 'Urban Transportation Emission Calculator'). The evaluation was performed for the AM and PM peak periods and the results were inflated to daily and annual estimates using expansion factors.

The results suggest that with coordination of the traffic signals through the IRSS system, GHG emissions would be reduced by approximately 6 million kilograms per annum or 3.2%. This amount is equivalent to an annual reduction of approximately 1,500 vehicles from the study area.

5. CONCLUSIONS

The IRSS pilot implementation successfully met the goals and objectives for the project, and provided positive results in the evaluation. The implementation of IRSS enabled coordinated operations along regional traffic corridors across jurisdiction boundaries, resulting in better intersection Levels of Service and less intersection delays, while at the same time, accommodating greater traffic volumes. In addition, the implementation of coordinated traffic signal timings was shown to contribute to reducing GHG emissions. Further, the IRSS pilot serves as a model for regional multi-agency traffic signal coordination, which can also be used in other areas of Canada.