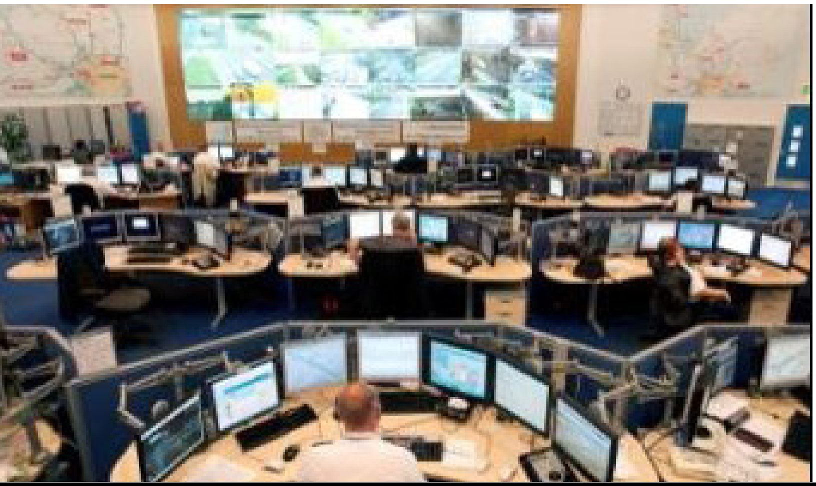
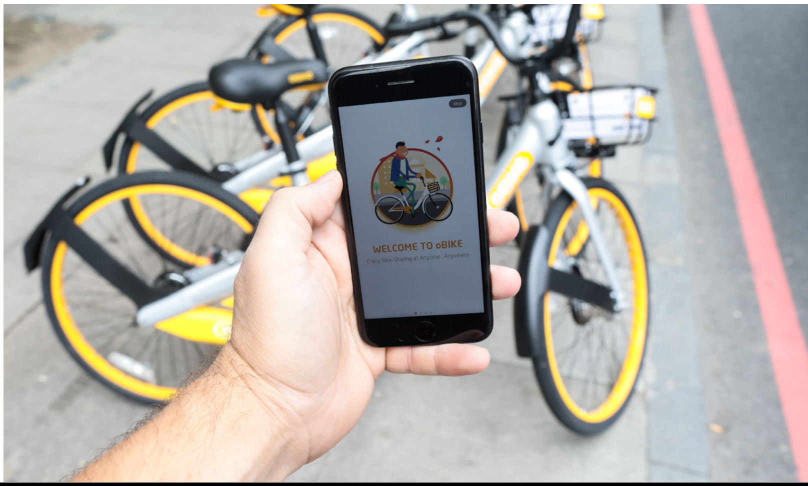
Attachment 1

City of Saskatoon





FINAL REPORT | #114098

Development of an Intelligent Transportation Systems (ITS) Strategic Plan

Submitted to City of Saskatoon
by IBI Group
November 2018

Executive Summary

[BRUNO TO PROVIDE TEXT]

Contents

Abbreviations and Acronyms

The table below lists the abbreviations and acronyms found in this document.

ABBREVIATION/ ACRONYM	DESCRIPTION
ACTIVE	Alberta Cooperative Transportation Infrastructure and Vehicle Environment
AI	Artificial Intelligence
API	Application Program Interface
ATMS	Advanced Traffic Management System
AURORA	Automotive test bed for Reconfigurable and Optimized Radio Access
AVL	Automatic Vehicle Locator
BIFA	Border Information Flow Architecture
BOC	Bristol Operations Centre
BRT	Bus Rapid Transit
C/AV	Connected and Autonomous Vehicles
CCTV	Closed Circuit Television
CV	Connected Vehicle
DMS	Dynamic Message Sign
DOT	Department of Transportation
DSRC	Dedicated Short Range Communication
EMO	Emergency Management Organization
FHWA	Federal Highway Administration
GIS	Geographic Information System
GPS	Global Positioning System
ICM	Integrated Corridor Management
IoT	Internet of Things
ITS	Intelligent Transportation Systems
ISP	Internet Service Provider
IT	Information Technology
KPI	Key Performance Indicators
LTE	Long Term Evolution

ABBREVIATION/ ACRONYM	DESCRIPTION
MaaS	Mobility as a Service
NITTEC	Niagara International Transportation Technology Coalition
NTCIP	National Transportation Communications for ITS Protocol
RCIS	Rail Crossing Information System
O&M	Operations and Maintenance
PTZ	Pan-Tilt-Zoom
TIS	Traveller Information System
TMC	Traffic Management Centre
TSMO	Transportation System Management and Operations
USDOT	United States Department of Transportation
V2I	Vehicle to Infrastructure Communications
V2V	Vehicle to Vehicle Communications
VII	Vehicle Infrastructure Integration
VSLS	Variable Speed Limit System

1 Introduction

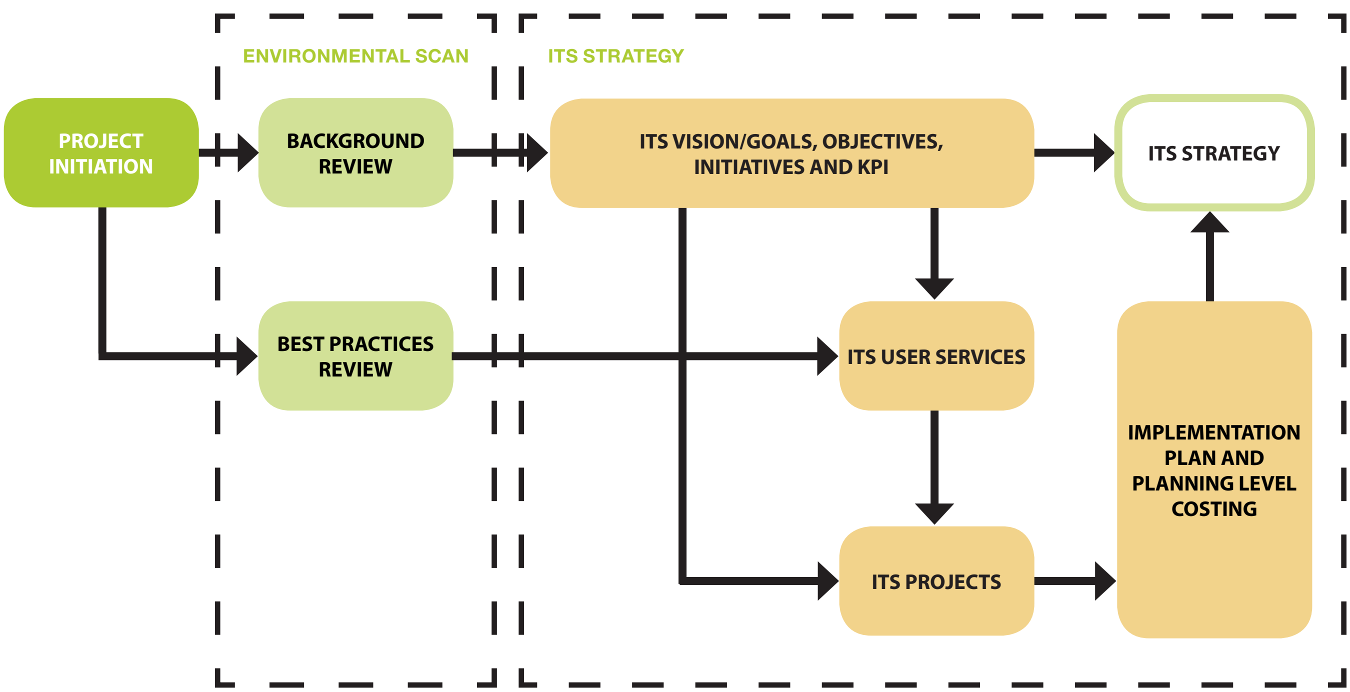
The City of Saskatoon is investing in the development of an Intelligent Transportation System (ITS) Strategic Plan. IBI Group has been engaged to work with the City to discover the most effective projects that will help shape the transportation network in Saskatoon as the City continues to grow. This project and resulting report builds on the preceding work to meet with the larger transportation community and complete a needs assessment for ITS in the City of Saskatoon including supporting the longer growth plan. The goal was to develop a strategy that can support the growth plan for an urban area expected to double in population in 30 years.

The project undertook a step-wise approach to developing the strategy culminating in the development of projects and budget to consider in the coming years. The steps as illustrated in **Exhibit 1.1** included:

- Background review;
- Best Practices and emerging trends;
- ITS vision, goals & KPIs;
- ITS user services;
- ITS projects; and
- Planning level costs and implementation plan.

The following sections will describe the results of the efforts undertaken for each element of the project contributing to this final report.

Exhibit 1.1 - Project Approach



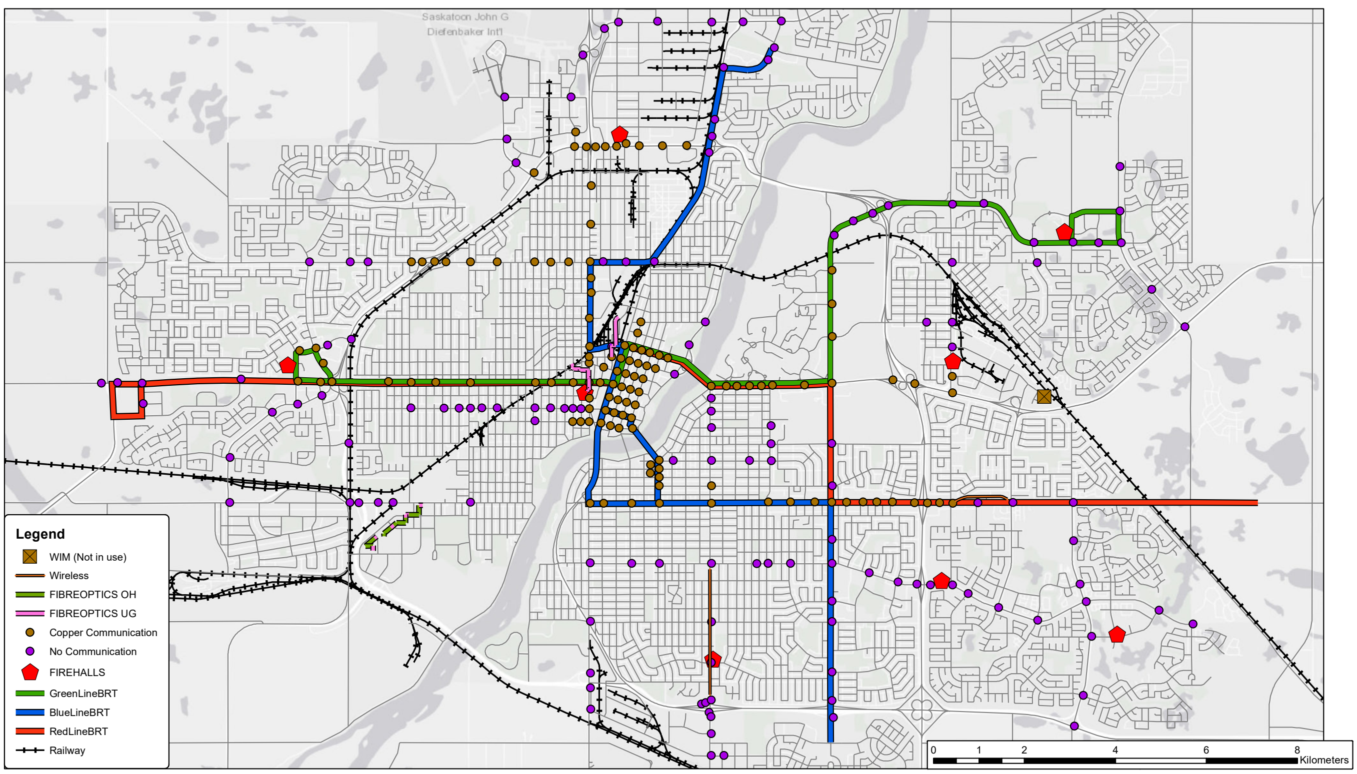
2 Background Review

The first stage of the ITS Strategic Plan was to collect, analyse, understand, and summarize the background information provided by the City of Saskatoon that was considered pertinent to ITS. The documents provided included a recent Needs and Gap Assessment Report, the City of Saskatoon Growth Plan, and various transit, infrastructure, and regional plans. Some of this material is summarized below.

2.1 Current State Map

The map below is a composite of existing copper and fibre networks, firehalls, railway, and signalized intersections, as well as the three planned BRT routes. This provided an overview of the current investment in technologies that support ITS.

Exhibit 2.1 - Current State ITS Map of Saskatoon



2.2 Document Summaries

The Saskatoon Bus Rapid Transit – Preferred Configuration plans from October 2017 include Transit Signal Priority intersections, real-time next bus information, wayfinding, and dynamic message signs.

The Saskatoon ITS Needs & Gap Assessment Final Report from May 2017 provided the following list of needs:

1. Traffic signal coordination
2. Incident management
3. Wireless and communication networks
4. Congestion issues on corridors and at key locations
5. Commercial goods movement
6. Congestion related to trains blocking railway crossings
7. Public transportation
8. Traveller information systems
9. Data management including telecommunications
10. Institutional issues including organizational structure, coordination between departments, common standards

The objectives from the *City of Saskatoon Official Community Plan Bylaw No. 8769* match the ITS Goals identified in Task 5:

> 21.2.b To provide a mix of land uses and densities that support and encourage the use of the Bus Rapid Transit service and multi-modal transportation options.

2.3 Existing Systems

An inventory of existing systems includes:

- Advanced Traffic Management Software (TransSuite/TransCore);
- Pedestrian controlled signals;
- Electronic Parking Payment system;
- Econolite and Naztec Traffic Controllers; and
- Transit Fleet Location GPS.

Planned ITS systems include:

- Highway-Rail Intersection Management System;
- Emergency Vehicle Signal Priority;
- Dynamic Message Signs;
- CCTV PTZ Traffic Cameras; and
- Intelight X3 Controllers.

A comprehensive inventory is in **Appendix C**.

2.4 Stakeholders

Through the engagement phase and development of projects as part of this report a core group of stakeholders were identified to be included as important to lead or be engaged through the development and implementation of the various projects. These stakeholders include:

- Construction and Design;
- Corporate Performance - IT;
- Facilities & Fleet;
- Saskatoon Fire;
- Long Range Planning;
- Major Projects and Preservation;
- Roadways and Operations;
- Saskatoon Police Service;
- Saskatoon Transit;
- Transportation;
- Transportation Customer Service;
- Saskatchewan Ministry of Highways & Infrastructure;
- Emergency Management Organization (EMO);
- Parking Services; and
- Service Saskatoon.

3 Best Practice and Emerging Trends

The following reference documents were reviewed as part of this project to identify industry trends and lessons learned that informed this strategy.

- Region of Niagara Intelligent Transportation Systems (ITS) Strategic Plan,unpublished draft, 2017;
- USDOT Intelligent Transportation Systems Benefits, Costs and Lessons Learned, 2017 Update Report;
- Southwest Washington Regional Transportation Council TSMO Plan Update and Implementation Plan, 2016;
- USDOT ITS Strategic Plan 2015-2019;
- Grand Forks-East Grand Forks Regional ITS Architecture Update, 2014;
- Alberta Transportation Intelligent Transportation Systems Strategy, 2014; and
- Saskatchewan Ministry of Highways and Infrastructure, Intelligent Transportation Systems Technical Strategy, April 2015.

Other inputs to this review include ongoing project work underway by IBI Group locally and internationally including ITS strategy and implementation that provide a strong basis for understanding of trends as well as a real-world assessment of what is being seen from other studies.

3.1 Canadian Architecture for ITS as a Best Practice

3.1.1 Overview of the Canadian Architecture

In context of Intelligent Transportation Systems, the term “architecture” refers to the relationship between transportation-related systems and institutions. An ITS architecture covers how systems interface and interact, as well as the institutional relationships that are required to support these interfaces. An ITS architecture, therefore, describes how a set of departments or agencies will share responsibility and information for the vast array of technologies and systems deployed in a region.

On behalf of Transport Canada, IBI Group developed the Intelligent Transportation Systems (ITS) Architecture for Canada in 2001, which was subsequently updated in 2011. This undertaking benefited from, and leveraged, the large body of material from the ITS architecture program in the United States (US), while accommodating a number of areas of unique needs as expressed by Canadian stakeholders. Since its introduction, the Architecture has served as a key component of the ITS Plan for Canada. The Architecture has lent direction to ITS projects in jurisdictions from coast to coast. It has been applied to produce Regional ITS Architectures in various jurisdictions in British Columbia, Alberta, Ontario, Manitoba and Quebec. This uniformity of approach in planning and deploying ITS in Canada will continue to take on increasing importance as the installed base of ITS applications continues to grow and the emphasis shifts to system interfaces and interoperability.

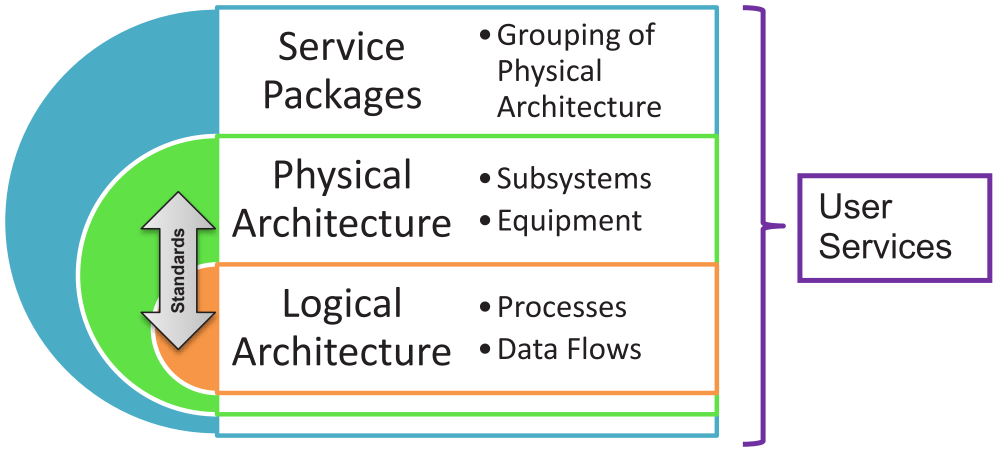
The ITS Architecture for Canada also assumes an important role in enabling Canadian transportation stakeholders to coordinate their ITS applications with their counterparts in the U.S. For example, Transport Canada has cooperated with the U.S. Federal Highway Administration (FHWA) in the development of the Border Information Flow Architecture (BIFA) and cross-border regional architectures, such as what is in place for the Niagara International Transportation Technology Coalition (NITTEC) on the Niagara Frontier.

For these reasons, the Canadian ITS Architecture provides an important framework for describing how ITS can contribute to addressing key transportation challenges in Saskatoon, especially as it pertains to the needs of transit, traveler information systems, and Highway-Rail Intersection (HRI) systems.

3.1.2 Key Elements of the Canadian ITS Architecture

The Canadian ITS Architecture can be referenced and used using a number of different approaches (or “entry points”). **Exhibit 3.1** graphically illustrates these key elements of the architecture, followed by a description of each, and a recommendation on how it can be used as a reference for the City of Saskatoon ITS Strategic Plan.

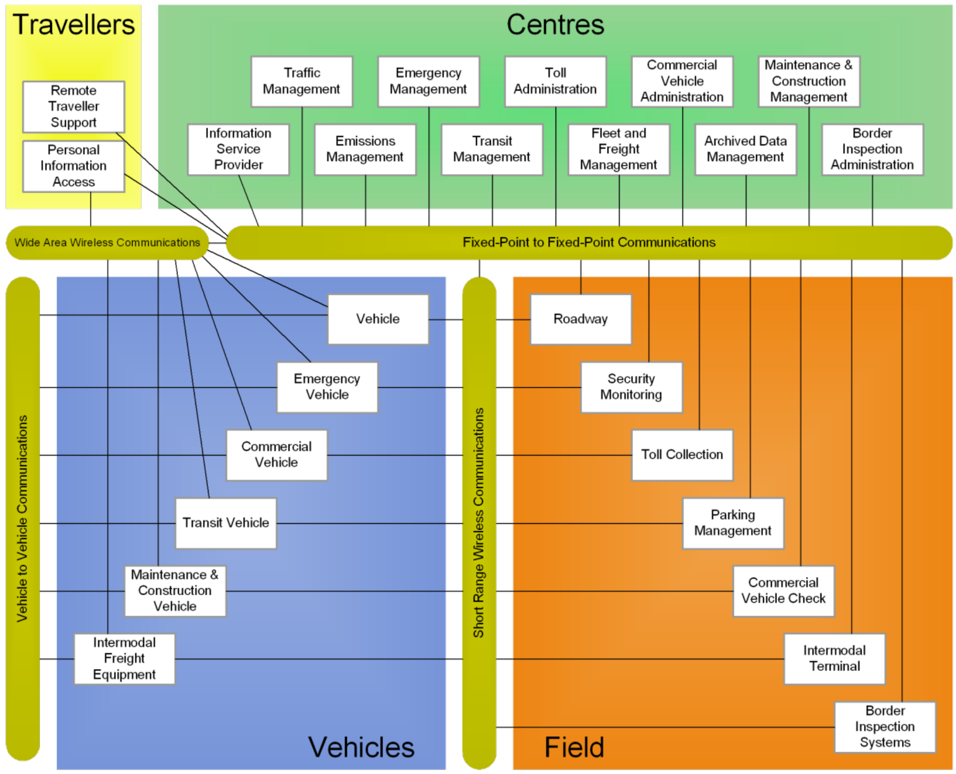
Exhibit 3.1: Key Elements of the Canadian ITS Architecture



- **User Services** describe what the system will do from the user's perspective. To date, thirty-seven User Services have been developed. A set of requirements covering each of these User Services are the basis for the ITS Architecture for Canada. The User Services entry point leads to the full set of user service requirements and allows easy traversal between the user service requirements and the components of the architecture that satisfy these requirements.
- **Logical Architecture** defines the Processes (the activities or functions) that are required to satisfy the User Services. Many different Processes must work together and share information to provide a User Service. Data Flows identify the information that is shared by the Processes. These Logical Architecture entry points lead to ordered lists of processes and data flows and also allow access to data flow diagrams that provide a graphical view of how the processes and data flows fit together.
- **Physical Architecture** forms a high-level structure around the processes and data flows in the Logical Architecture. The physical architecture defines the Physical Entities (Subsystems and users/endpoints) that make up an intelligent transportation system. Exhibit 3.2 provides a top-layer illustration of the physical architecture that encompasses the Canadian ITS Architecture. Subsequent layers define the Architecture Flows that connect the various Subsystems into an integrated system. The subsystems generally provide a rich set of capabilities,more than would be implemented at any one place or time. Equipment Packages break up the subsystems into deployment-sized pieces.
- **Service Packages** represent slices of the Physical Architecture that address specific services like surface-street control. A service package collects together several different subsystems, equipment packages, terminators, and architecture flows that provide the desired service. The Service Packages entry point leads to a menu of service packages with underlying graphics and definitions. Appendix B presents the graphical illustration of a sample Service Package within the Canadian ITS Architecture,
- **Standards:** The ITS Architecture for Canada and the U.S. National ITS Architecture are reference frameworks for the development of Standards. The Logical and Physical Architecture provide a starting point for ITS standards development activities by identifying the applicable architecture flows and data flows to be standardized and the way in which the information is exchanged across those interfaces. The Standards entry point leads to an overview of the ITS standards activities and their relationship to the ITS Architecture for Canada. Application Areas represent deployment-oriented categories of ITS Standards and are useful to deployers who wish to select only those ITS standards relevant to the services or systems they plan to deploy.

A best practice for ITS planning is to use the "Service Packages" as the mechanism to map needs to ITS solutions. This approach provides a traceability between the needs and a "deployment oriented" view of the architecture without the details of the logical or physical architecture.

Exhibit 3.2: Canadian ITS Architecture Diagram



3.1.3 Service Packages in the Canadian ITS Architecture

The Canadian ITS Architecture identifies a total of 98 service packages that reflect the current suite and evolving implementations of ITS. **Appendix B** contains a complete listing of all service packages grouped by major application area.

When referencing service packages it is important to be cognizant of the following:

- A given service package may only provide part of the functionality of a need, but generally serves as a building block by allowing more advanced packages to use its components.
- Service packages also allow early deployments to be separated from higher risk services and can specifically address varied regional needs.
- Service packages are not intended to be tied to specific technologies, but are based on the current technology and product market in order to actually be implementable. Accordingly, as transportation needs evolve, technology advances, and new devices are developed, service packages may change and new service packages may be defined.

In short, service packages provide a key method for entering into the Canadian ITS Architecture and can be used as a foundation for the development of regional ITS architectures. The important point to remember is that they provide a set of manageable, service-oriented views which allow the user to jump right into the physical architecture definition.

A subset of these Service Packages will need to be selected in implementing the suite of ITS projects that are recommended for the City of Saskatoon.

The full list of service packages available as well as a sample service package developed for Advanced Railroad Crossings can be found in **Appendix B**.

3.2 Future Enabling Technologies

In addition to the ITS trends identified above there are a number of future enabling smart city technologies that will have an impact on the deployment or approach to ITS in the future. These include:

- The Internet of Things (IoT);
- Artificial Intelligence (AI);
- Connected and Automated Vehicles (C/AV as referenced in the trends as well);
- Blockchain; and
- 5G dedicated short range wireless communications.

These technologies are summarized in **Exhibit 3.3** below and their potential impacts are referenced in the specific projects identified later in this report.

Exhibit 3.3: Technology Summaries

IoT	The Internet of Things is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and network connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing internet infrastructure.
AI	Artificial Intelligence is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions), and self-correction. Particular applications of AI include machine learning, speech recognition, and machine vision.
C/AV	Connected Vehicles (CVs) are vehicles that are connected to infrastructure, mobile devices, and other CVs and are capable of sharing information with each other to optimize their function and performance. Autonomous Vehicles (AVs) interpret the world around them and navigate roads without human intervention. Driverless cars are fully autonomous vehicles. Connected and Autonomous Vehicles (CAVs) are capable of synergizing the abilities of both the autonomous and connected components and will be the vehicles of the future.
Blockchain	A blockchain is a continuously growing list of records, called blocks, which are linked and secured using cryptography. Each block typically contains a hash pointer as a link to a previous block, a timestamp and transaction data. By design, blockchains are inherently resistant to modification of the data. It is "an open, distributed ledger that can record transactions between two parties in a verifiable and permanent way." For use as a distributed ledger, a blockchain is typically managed by a peer-to-peer network collectively adhering to a protocol for validating new blocks. Blockchain technologies may become a significant enabler for implementation of the longer term projects including mobility as a Service.
5G / DSRC	5G is a wireless cellular standard that increases internet download speeds to 10 Gb/second. 5G is essentially the next generation of mobile data services for which radio spectrum will be auctioned and presumably services delivered by SaskTel and others. 5G will be particularly effective for widely distributed systems with limited amounts of data. An alternative to 5G is Dedicated Short Range Communication (DSRC) which would be built into the infrastructure to support C/AV and IoT. DSRC designed to specifically to support the communication from vehicle to vehicle (V2V) and from vehicle to the infrastructure (V2I).

3.3 Emerging Trends

Based on the documents reviewed for this task and the IBI team's recent ITS experience, a number of ITS trends were identified as relevant to the City of Saskatoon. These trends are provided for information as they may impact how the projects identified are delivered. They will need to be assessed further as the project business cases and plan are created. The trends include:

- Connected / Automated Vehicles;
- Open Data;
- Data Warehousing, Business Intelligence, Analytics;
- Telecommunications Infrastructure and Services;
- Private Sector Delivery & Hosted Solutions; and
- Smart City Operations Centres.

3.3.1 Connected / Automated Vehicles

State of the art signalized intersections could broadcast traffic control information to approaching and waiting vehicles to notify of upcoming red lights, pending green lights, traffic queues, and pedestrians in crosswalks. USDOT research has so far estimated that only a 10% market penetration of C/AV into a city will result in fewer accidents, less congestion, and millions saved.

The US National Highway Traffic Safety Administration proposes rules that would require automakers to install V2V communications in their vehicles by 2020. The Southwest Washington Regional Transportation Council aims to future proof infrastructure to accommodate C/AVs by installing the highest bandwidth and capability signal controllers available.

The US National Operations Center of Excellence recently launched a Signal Phase and Timing (SPaT) Challenge for cities to deploy V2I corridors by 2020. Eight cities are SPaT operational and 20 more have deployments underway. Small scale tests demonstrated reduced magnitudes of speed drops between vehicles as evidence of queue warning safety improvements.

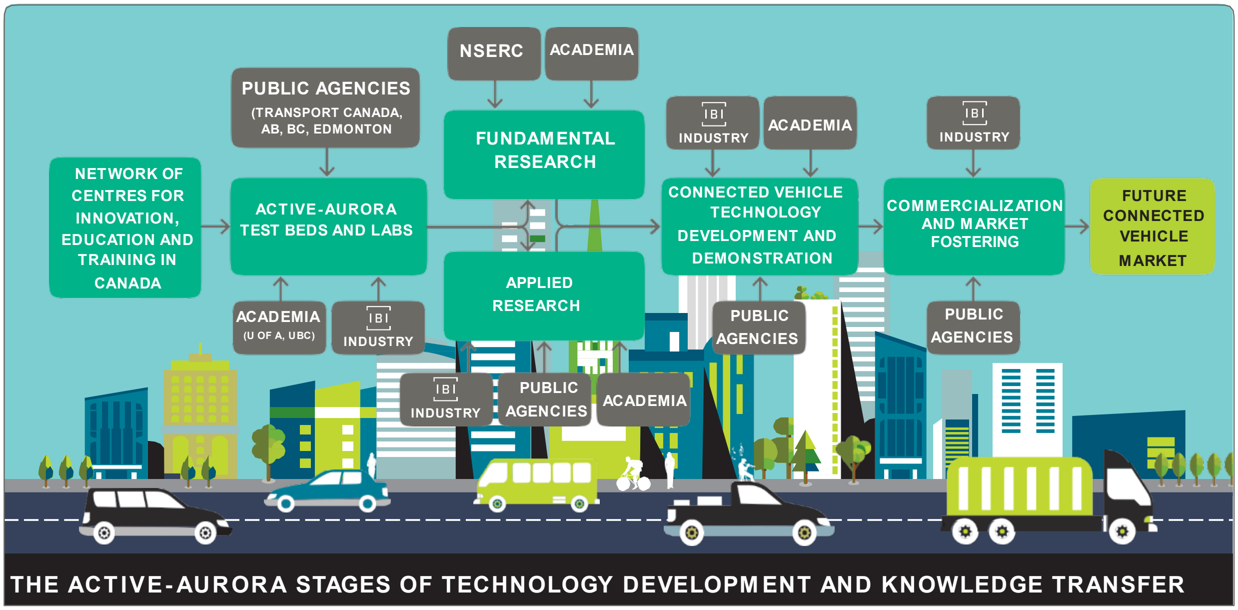
The University of Alberta Centre for Smart Transportation, in collaboration the University of British Columbia and public and private industry partners, are developing Canada's first Connected Vehicle test bed: ACTIVE-AURORA. The test bed is a research circuit, which is a network of six on-road and in-lab test beds equipped with CV technology. The test beds focus on the testing and evaluation of new and emerging connected vehicle systems, applications and services for both active traffic management and freight security and efficiency. The ACTIVE-AURORA test bed infrastructure provides UofA and UBC with the ability to actively collaborate with other industrial and research organizations from across Canada and around the world.

In Alberta, three on-road ACTIVE (Alberta Cooperative Transportation Infrastructure and Vehicle Environment) test bed sites are located in the greater Edmonton area. The test beds enhance the ability to develop, test, demonstrate and commercialize innovations for active traffic management. In British Columbia, the on-road AURORA (Automotive test bed for Reconfigurable and Optimized Radio Access) test bed will cover up to 10km along both two and four-lane roadway within and adjacent to the UBC campus. AURORA will incorporate a range of new and emerging wireless technologies such as Long Term Evolution (LTE), and 5.9 GHz Dedicated Short Range Communication (DSRC), and permit a variety of radio and network configurations.

Takeaways:

- A rising level of government and corporate investment;
- Agencies are establishing C/AV working groups in an attempt to better understand and prepare for infrastructure investments, and test bed initiatives; and
- Potential for high ROI when comparing infrastructure investment to reduced congestion costs.

Exhibit 3.4: The ACTIVE-AURORA Stages of Technology Development & Knowledge Transfer



3.3.2 Open Data

Governments are increasingly making the data and information that is collected as part of City operations open to citizens and businesses. This approach allows for better reporting on operational performance and also allows for the private sector to utilize this information for their own planning purposes as well as for the development of applications that add additional value to the services that the City provides. Enabling the private sector to innovate, developing new services and solutions (such as mobile apps) is a basis for many broader Smart City strategies as well as ITS strategies.

As an example, future implementation of Mobility as a Service concepts will require data sharing between transit, ridesharing, bike sharing, ticketing, parking, real-time traffic, map data, and any future transportation services to route a traveler to their destination on a variety of modalities. Open data allows rapid entrepreneurial innovation and complimentary mobile app development.

The Government of Alberta aims for open access to the data it collects, where this is cost-effective and consistent with privacy concerns, including data collected by Alberta Transportation.

V2V and V2I rely on open data formats that allow vehicle manufacturers and 3rd party developers to send and receive information. Open data sharing between vehicles, authorities, and private businesses will increase transparency and reliability of transportation data, resulting in faster routes for commercial deliveries, fewer accidents, and less congestion.

Takeaways:

- Governments are encouraging open standards where possible; and
- Open data allows for private sector value to be added to the investment already made by Cities.

3.3.3 Data Warehousing, Business Intelligence, Analytics

Data warehousing is more than a repository of raw data from users and devices. It also includes third party data (as allowed) and other civic/public data that together might provide useful data insights. The stakeholders who are running reports or generating analytics should clarify what sources and granularity of data they require now and in the future, so data fields can be aggregated and stored in 5-minute, hourly, or daily increments as needed. It is appropriate to understand data visualization requirements and ensure all data sources are captured at similar frequencies to enable insightful transportation research, management, and performance measurement. For example, the BC Ministry of Transportation and Infrastructure traffic engineers review traffic congestion information stored per detector in 5 minute aggregate intervals.

With the broader more affordable deployment of internet and private network sensors, known as Internet of Things (IoT) sensors, as well as third party and crowd-sourced data being collected, there is significantly more information available to operators and planners than there ever was before. In addition to this, there is significant investment being made in business intelligence and analytics tools that allows for ingestion and analysis of large amounts of data to assist in real-time decision making.

Private sectors companies driven by a need for more efficient and safe operations are turning to business intelligence technologies to ingest data from multiple sources including both private and public sector sources such as Waze, public open data, and social media to better predict service needs, disruptions and transportation modes/routes. Ride hailing companies such as Uber are able to use real-time traffic data, crowd source data, transit disruptions, major event schedules and social media feeds to better predict the needs of their customers and where additional services may be required.

Data warehousing can help provide key inputs to both private sector and public sector Business intelligence and analytics tools. The data warehouse should support the business strategies of the stakeholders.

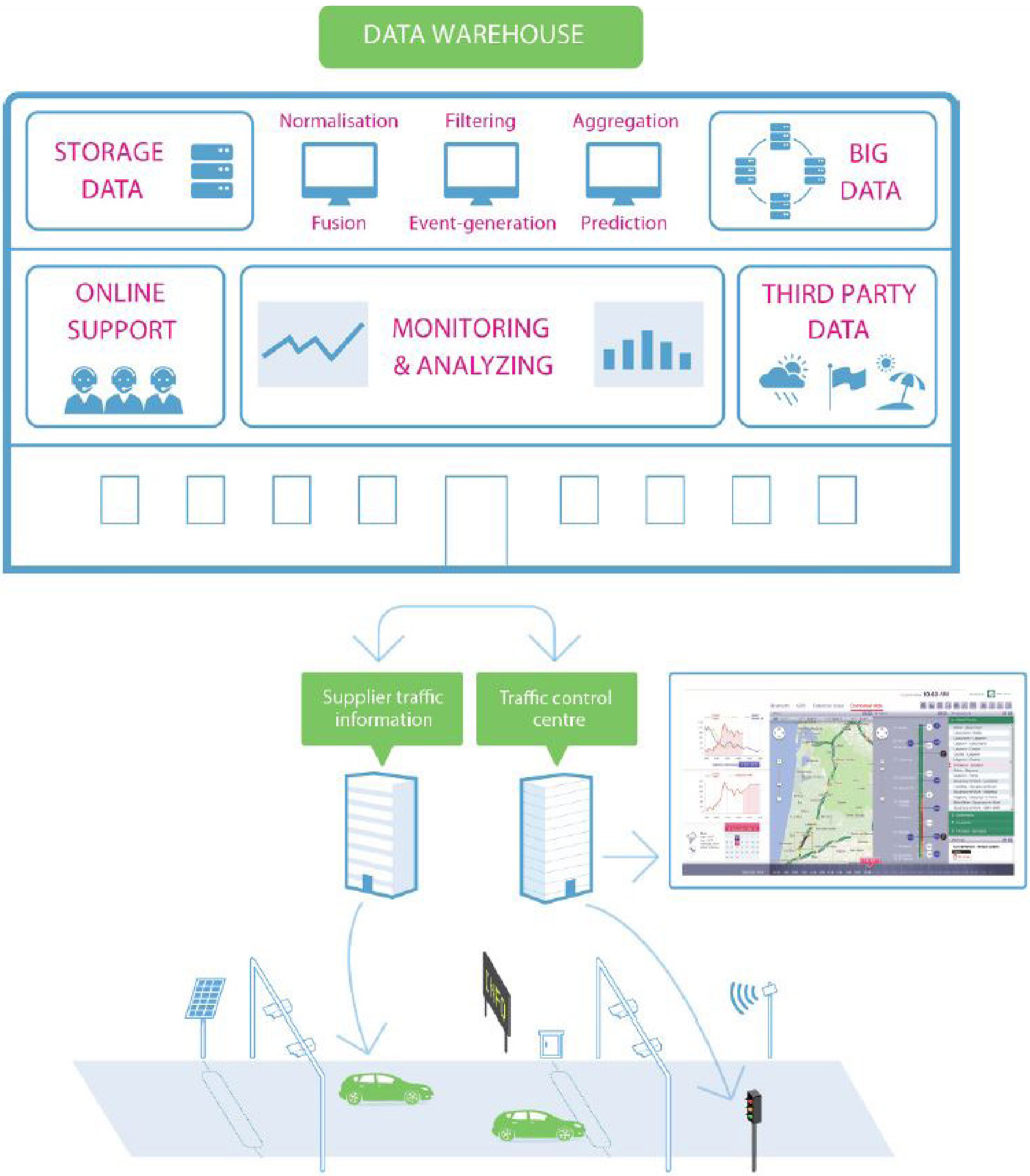
Minnesota DOT ITS planners identified seven key principles for managing data and information system investments:

1. Data will be managed as state assets;
2. Data quality will fit its purpose;
3. Data will be accessible and shared as permitted;
4. Data will include standard meta data;
5. Data definitions will be consistently used;
6. Data management is everybody's responsibility; and
7. Data shall not be duplicated.

Takeaways:

- Open data can support the business strategies of the stakeholders;
- Public and private data together with powerful business intelligence and analytics can add significant value to mobility services; and
- Business intelligence and analytics are tools of the future that can drive more value from major mobility infrastructure investments.

Exhibit 3.5: Benefits of a Data Warehouse



3.3.4 Telecommunications Infrastructure and Services

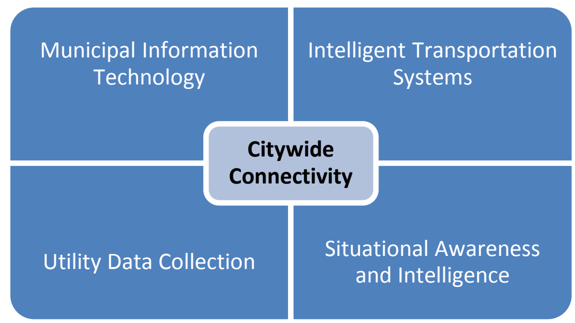
The increase in the deployment of connected sensor and control technologies throughout a city comes with an increased expectation on reliable telecommunications services. These services include both low speed telecommunications for simple control and monitoring to high speed required to support video based solutions.

One solution to support telecommunications needs is through the service providers that can deliver wireless services, largely through existing infrastructure (i.e. SaskTel, Bell, Rogers). In the future, there will be additional service offerings through what is known as 5G technology that will enable broadband services to a large number of low powered IoT devices. While the mobile technology service offering promises to be a good option for ITS in the future, the reality is still that for areas with a higher density of devices, fibre optic infrastructure is the best recommended future proofed strategy.

Another challenge that presents itself for many Cities is that the business case for private sectors to build the infrastructure to support the telecommunication needs for City departments simply is not viable. As a result, many cities and departments are resorting to build their own systems to support their needs. This includes both fibre optic and wireless technologies. The Cities that are more advanced and are taking a Smart City approach to telecommunications are building networks that support the needs of all departments and other agencies to build more cost effective and efficient solutions. This often takes the form of starting with a larger City telecommunications strategic plan and building out a hybrid fibre optic and wireless network solution that may have a tie in with the telecommunications providers. This often gets built out over time, sometimes in conjunction with other infrastructure projects.

Some cities have adopted a “Dig Once” policy, which requires any road, sidewalk, or utility work to include fibre optic cable conduits as an accessible utility corridor. This reduces broadband costs, expands the core fibre optic network, and reduces future traffic disruptions that might occur if this infrastructure is placed in a more ad hoc manner.

Telecommunications infrastructure investments and data can be shared across other City or regional departments when mutual goals converge, such as transit, utilities, security, and environment. All recent ITS Strategic Plans have fibre conduit expansion priorities. Fire, Ambulance, and Police vehicles often share coordination of traffic signal pre-emption communication strategies.



The City of St. Albert, Alberta, as part of the Smart Cities Master Plan, realized the need for and developed a Municipal Area Network Plan that supported Smart Cities, the department specific needs, as well as the needs of residents and businesses. The plan evaluated the current state of commercial network services in the City of St. Albert, provided guidance on network architecture and ownership options as well as provided reference examples of other municipalities through case studies. The plan identified and is now implementing a core fibre optic backbone that is supporting the short and longer term needs of ITS including future connected vehicle options as well as the needs of other departments. Because of the geographic spread of ITS, it has become the core driver of the infrastructure.

Takeaways:

- All stakeholders are interested in more telecommunications infrastructure;
- Private sector will play an increasing role however the city may need to invest in core infrastructure to meet their needs; and
- Significant coordination and planning is required.

3.3.5 Private Sector Delivery & Hosted Solutions

Because private sector business cases for new technology did not previously exist, Cities invested in and implemented many infrastructure based solutions. These included vehicle detection stations for counting and classifying traffic, weather monitoring, central traffic management system solutions, video image based monitoring systems as well as the central server and storage infrastructure and support services required for the technology. Based on new emerging business models, lower cost technology as well as social based platforms, companies are now offering hosted models where cities and consumers can purchase services on a monthly basis hosted by the vendors that utilizes data from multiple sources and provides real and historical data and can benefit the City operations with minimal infrastructure investment.

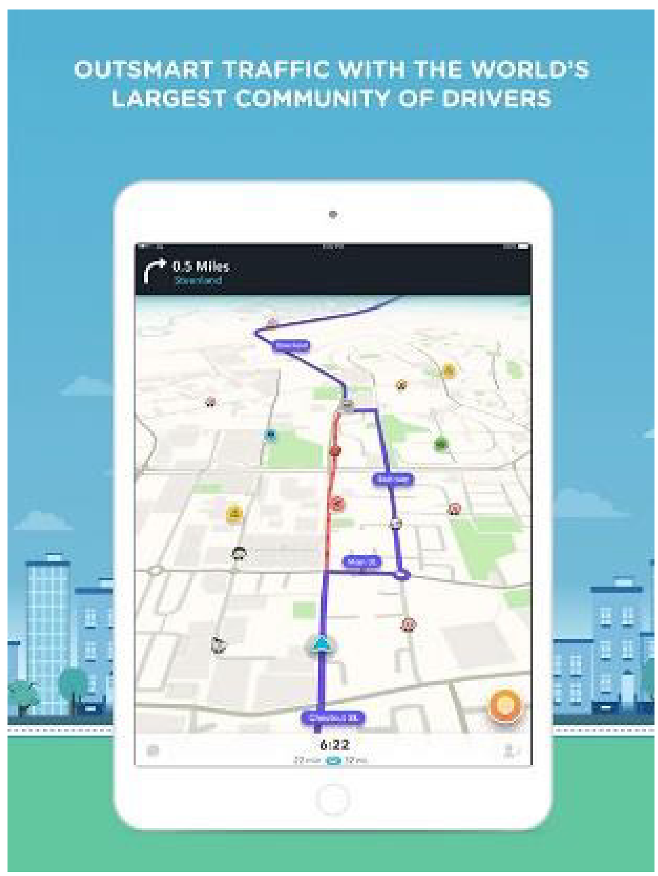
As an example, the City of Winnipeg has established a relationship with Waze to collect and share real-time traffic information with the City and the public leveraging the data collected by the drivers on the road who are impacted by the road and traffic conditions and by the City's own operational decisions. The intent is for the information sharing to lead to smoother flowing traffic as well as real-time traffic information for Winnipeg drivers so they can make better decisions on their commute. By using the Waze app, Winnipeg drivers can share and receive anonymous traffic information from the Winnipeg Traffic Management Centre to assist them with deciding which routes to take and which routes to avoid.

This model reduces the need for technical infrastructure, hosting and technical staff resourcing by the City while benefiting the private sector supplier. Alberta Transportation is moving towards a hosted service based model for the traveller information system that will leverage real-time data sets from multiple private sector resources that will require minimal infrastructure to implement and operate.

Municipalities should balance the benefits of in-house data management, traffic information systems management, transit information, and any other ITS User Service versus the cost of deployment, and ongoing O&M.

Takeaways:

- Monitor the availability of and consider leveraging existing privately available services; and
- Consider the benefits of an ITS public-private partnership.



3.3.6 Smart City Operations Centres

While coordination with other agencies and departments seems like an obvious goal, it is often more challenging in reality from the perspective of changing the past ways of operating, particularly in larger organizations.

Smart Cities Operations Centres are able to benefit from large amounts of information shared between traditionally separate institutions like Traffic, Fire, Police, Utilities, etc. A Smart Cities Operation Centre has the mandate and ability to share data and resources, improving overall situational awareness and response to changing operating conditions and events. This approach has proven to be cost-effective for municipalities. Small to medium sized organizations that have difficulty justifying operational centres for smaller individual departments are able to pool operational and capital funding resources to build and operate effective operational centres with higher level functionality and situational awareness compared to smaller separately operated units.

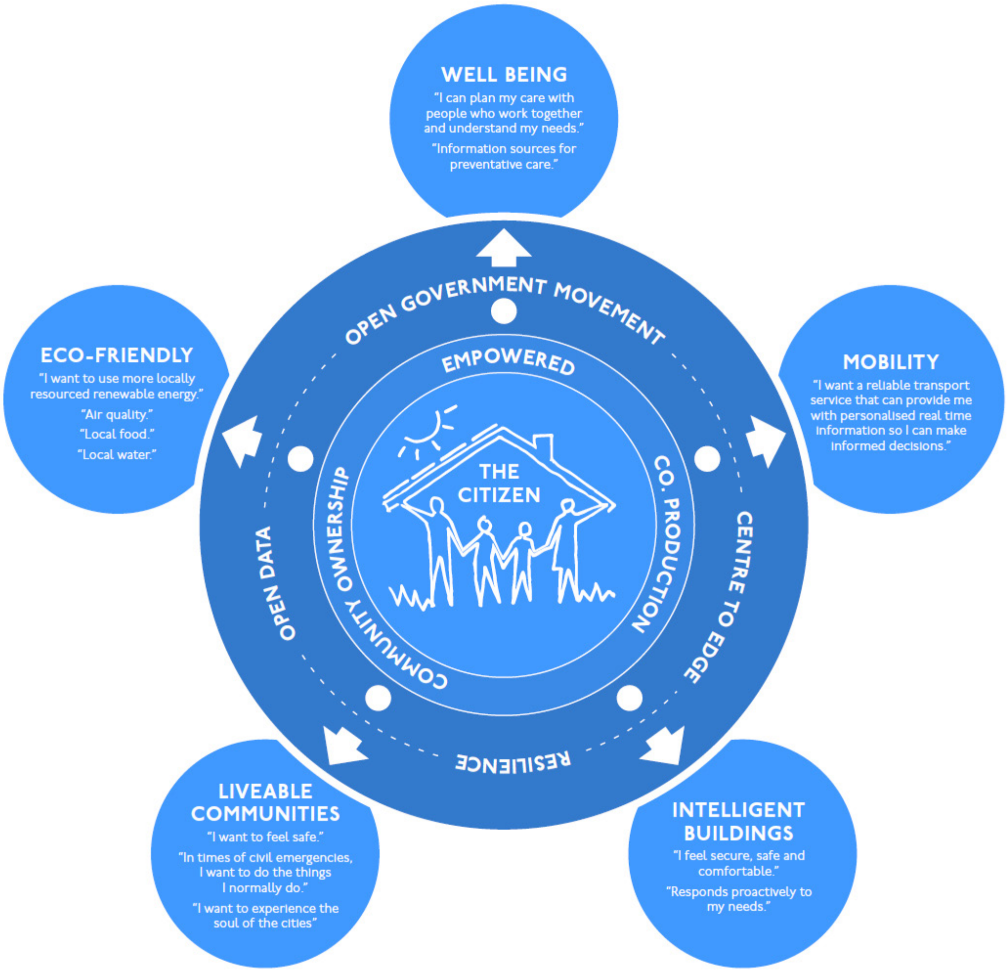
Supported by a Smart City strategy and now implementation, Bristol City, UK has implemented its new Bristol Operations Centre (BOC), within one of its landmark buildings in the heart of the city centre. The BOC includes an initial offering of co-location of services, including Wellbeing (assisted and integrated care delivery), Safety and Security (alarm monitoring and event management), Mobility (integrated network management in real-time and off-line), and Customer Services (out of hours call handling). The delivery of an open-architecture, integrated and centralized platform for delivering municipal services will foster innovation and collaboration between public service providers and departments as well as with the academic and business community. Based on the strategy and follow-up implementation, in the fall of 2017 Bristol surpassed London as UK's smartest city as determined by the second annual UK Smart Cities Index from Navigant Consulting.

Some Operational Centres also offset costs by generating additional revenue by providing collocated space or offering additional monitoring and response services such as after-hours phone support for 311, Parks, Utilities, or other departments. The City of Calgary Traffic Management Centre generates revenue from the province in exchange from monitoring a portion of the provincial highway network that passes through the City (Highway 2) and from other City departments that rely on infrequent 24/7 dispatch capacity. In Vancouver this includes monitoring bridge and tunnel security for vehicles and pedestrians, and in Medicine Hat this includes 911 dispatch for surrounding communities.

Takeaways:

- A municipal operation centre can serve multiple stakeholder groups, share data, reduce operational costs and improve situational awareness and response to incidents.

Exhibit 3.6: Bristol Smart Cities Open Government Movement



4 ITS Vision

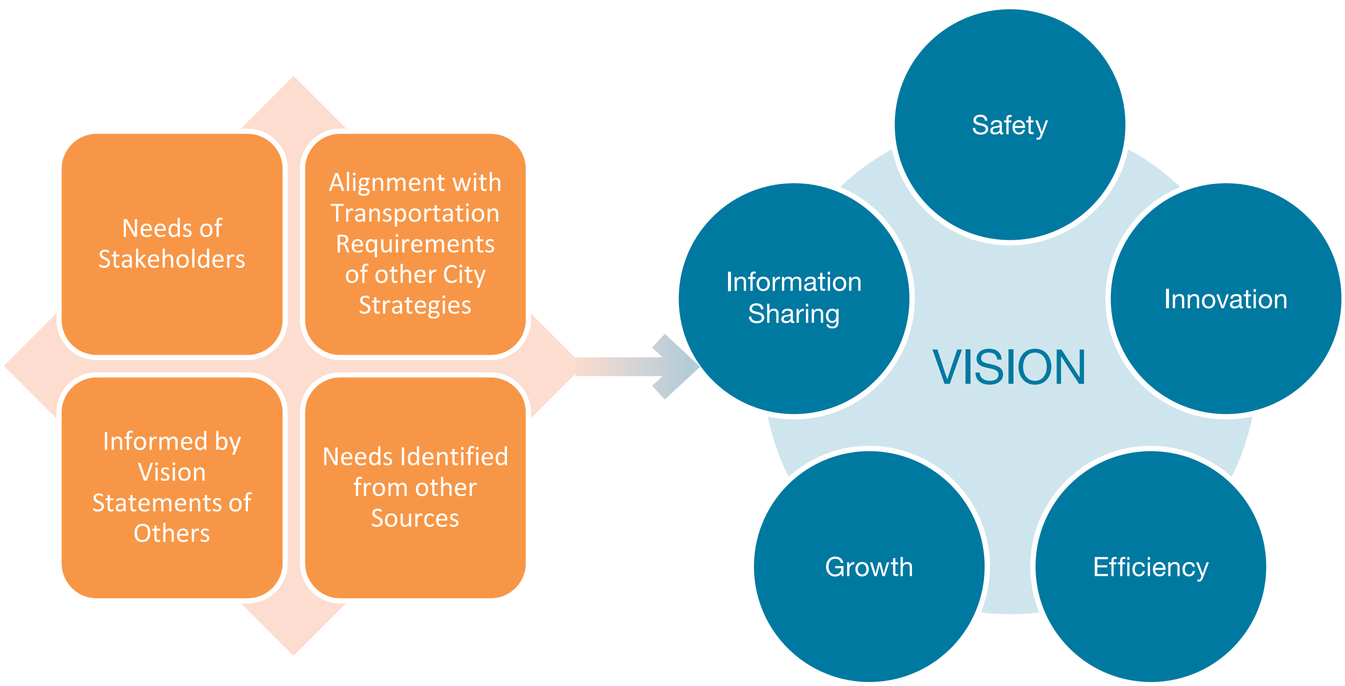
While the stakeholders' needs and the supplied documents were the main inputs used for creating the vision statements, Needs expressed from other local sources as well as the vision statements of other agencies were used to verify the direction.

The four main input strata for the ITS Vision Statement were:

- Needs of Stakeholders;
- Alignment with Transportation Requirements of other City Strategies;
- Informed by Vision Statements of Others; and
- Needs Identified from other Sources.

The five main themes that fueled the ITS Vision Statement were derived from the Background Review and Emerging Trends deliverables were:

- Safety;
- Innovation;
- Efficiency;
- Growth; and
- Information Sharing.



Draft vision statements were prepared and reviewed with the steering committee. The agreed upon vision statement was concluded to be:

"Invest strategically in innovations that maximize public safety and efficiency, encourage all modes of transportation, and support our region's growth through improved information access and network adaptability."

5 ITS Goals and Key Performance Indicators

Based on the needs, existing conditions and vision statement eight specific goals were developed to support the needs for the City of Saskatoon. The goals were established such that they were specific, measurable and clear.

The Goals for the City of Saskatoon ITS strategy are:

A. Improve transportation flexibility (improving the mode split).

B. Reduce travel times along major corridors.

C. Improve emergency response efficiency.

D. Improve transit schedule adherence.

E. Manage commercial vehicle movements to preserve road infrastructure.

F. Mitigate impacts of train-road crossing disruptions.

G. Improve access to traveler information.

H. Improve multi-agency ITS stakeholder business intelligence for real-time operations and planning purposes.

The following is a breakdown of the goals and how they support the needs' themes as well as the potential KPIs that can be utilized to measure progress. Note that baselining of KPIs early in the program will help to measure the success of the objectives and projects developed as part of the strategy.

KPIs can be derived from existing data sources, requested from third parties or municipal colleagues, or may require infrastructure built to measure these indicators. If the City of Saskatoon Planning Department conducts an annual opinion survey that contains many KPIs relevant to your goals, is this frequent enough or is there a benefit to conducting this monthly?

For example, average travel times is a KPI typically measured by installing a Bluetooth travel time system, which might have capital and O&M costs. On the other hand, it is easy to obtain the KPI for the Number of Train/Vehicle Collisions from the Saskatoon Police.

A preliminary table of KPIs is included in **Appendix A**.

5.1 Goal 1: Improve transportation flexibility

An important aspect of the Growth Plan for the City of Saskatoon is to provide infrastructure and land use regulation to promote many modes of travel. With increased access to information and shared everything,

KPIs related to this goal:

Mode Shift:

- Percentage of commuters using non-single-vehicle/single-driver modes;
- Transit ridership as volume per day;
- Bike route kms of travel (or other bicycle count strategies);
- Pedestrian kms of travel (or other pedestrian count strategies); and
- Ride share usage person - kms of travel.

Traveller Satisfaction:

- Customer satisfaction through survey instruments.

Needs' Themes	
Innovation	✓
Safety	
Efficiency	
Growth	✓
Information Sharing	✓

5.2 Goal 2: Reduce travel times along major corridors

Commute times are extended by congestion, incidents, and other obstacles, which lead to dissatisfaction, pollution, and even secondary incidents. Travel times can be reduced with route information being shared to travelers, more efficient transit, and reduced incidents.

KPIs related to this goal:

- Change in number and duration incidents per vehicle km;
- Average travel times for major routes at peak times;
- Transit route travel times for major routes at peak times; and
- Fuel and/or energy used weekly for fleet vehicles.

Needs' Themes	
Innovation	✓
Safety	✓
Efficiency	✓
Growth	
Information Sharing	

5.3 Goal 3: Improve emergency response efficiency

Intelligent Transportation Systems can greatly assist the response time for emergency vehicles by bringing traffic flow awareness to the dispatcher and by clearing the route ahead of the emergency vehicles.

KPIs related to this goal:

- Percentage of emergency services delivered within minimum threshold time (or variance from thresholds);
- Emergency route travel times for major routes;
- Fuel and/or energy used weekly for fleet vehicles; and
- Travel delay time introduced by train movements.

Needs' Themes	
Innovation	✓
Safety	✓
Efficiency	✓
Growth	
Information Sharing	

5.4 Goal 4: Improve transit schedule adherence

Intelligent Transportation Systems can assist the travel time and schedule adherence for transit vehicles by bringing traffic flow awareness to the dispatcher and by providing transit bypass lights at intersections.

KPIs related to this goal:

- Percentage of transit trips on schedule; and
- Transit route trip time reliability and variance from schedule.

Needs' Themes	
Innovation	✓
Safety	✓
Efficiency	
Growth	✓
Information Sharing	

5.5 Goal 5: Manage commercial vehicle movements to preserve road infrastructure

Commercial vehicles should be monitored and guided through the city on routes that minimize their travel time to reduce pollution costs and deliver goods in a timely manner. Commercial vehicles should also be directed to use roads that are configured and maintained to accommodate heavy, oversize or dangerous loads.

KPIs related to this goal:

- Average travel times for major routes at peak times; and
- Percentage of commercial traffic adhering to heavy load restrictions.

Needs' Themes	
Innovation	✓
Safety	
Efficiency	✓
Growth	
Information Sharing	

5. 6 Goal 6: Mitigate impacts of train-road crossing disruptions

Train crossings within the city are unpredictable and cause long delays. Intelligent Transportation Systems provide solutions to bring train awareness and information to travelers who can navigate this obstacle.

KPIs related to this goal:

- Travel delay time introduced by train movements;
- Secondary incidents or collisions due to train disruptions; and
- Number of train/vehicle collisions.

Needs' Themes	
Innovation	✓
Safety	✓
Efficiency	✓
Growth	
Information Sharing	

5.7 Goal 7: Improve access to traveler information

An informed traveler can change their route, their departure time, or their mode of travel based on their up-to-the-minute real-time needs. Route, incident, construction, and other relevant information can be delivered via many media through ITS.

KPIs related to this goal:

- Percentage of arterial and freeway road network covered by websites offering traffic and travel information;
- Number of uses of websites and apps that offer traveler information;
- Number of vehicles connected to the infrastructure providing real time data (i.e. connected vehicle); and
- Positive Traveler Opinion Surveys.

Needs' Themes	
Innovation	✓
Safety	✓
Efficiency	✓
Growth	
Information Sharing	✓

5.8 Goal 8: Improve multi-agency ITS stakeholder business intelligence for real-time operations and planning purposes

Cities benefit from sharing resources and information and not duplicating efforts.

KPIs related to this goal:

- Number of types of information sources that impact travel decisions available on all delivery channels (includes internal and 3rd party sources);
- Number of 3rd party applications that access the data through open data; and
- Positive Opinion Surveys.

Needs' Themes	
Innovation	✓
Safety	
Efficiency	
Growth	✓
Information Sharing	✓

6 Proposed ITS Projects

6.1 Technology that supports ITS

The projects identified in this section reference and include a number of unique technologies that support ITS. These technologies would be integrated into the projects and further refined through the project development. These technologies are provided here for reference and understanding as they are included in the proposed projects.

APIs	An accessible interface to a software environment that creates a secure custom handshake between data sources. APIs are usually packages of functionality that add many features to a project without having to write everything from scratch.
ATMS	An Advanced Traffic Management System is a software platform that combines traffic surveillance inputs from cameras and sensors with lane management and signal controls.
AV	Automated vehicles are capable of self-driving. The US Department of Transportation's National Highway Traffic Safety Administration has designated 5 levels of autonomy, from Level 0 meaning no AV control, to Level 2 which includes cruise control and lane centering, to Level 5 which is a fully autonomous vehicle driving in all circumstances.
Bike Share Technology	Publicly shared bicycles which can be rented for a short term and either returned to a dock or returned to the inventor of a dockless queue. Apps handle locating, unlocking, and fee processing of bikes.
CV	To enhance safety, vehicles can communicate with other vehicles, roadside infrastructure, the cloud, pedestrians, or anything. Information about road conditions ahead could be relayed to CV-equipped vehicles, in-dash displays (or audio system interrupts), or prompt with automated response.
CCTV	Roadside pan-tilt-zoom cameras are used by TMC operators to confirm incidents and clearance.
Data Warehousing	One of the key outputs of a Data Warehouse is business intelligence reporting. The data warehouse is the central repository for all traffic information that supports the operations and reporting needs of a TMC and stakeholders. An aggregated average of data might be the data of record for a source.
Environmental detection	Road and weather sensors can detect wind speed, visibility, traction, temperature, humidity, etc. to provide information for TMC operators or algorithms to recommend reduced speeds or initiate de-icing mitigation.
Lane control and management signals	On corridors or bridges where traffic flow has peak period volume, central lanes can reverse direction by means of overhead signs or gates.
Loop based detection	Inductive loops consist of wires embedded in the asphalt to detect traffic movements in a lane.
MaaS	Mobility as a Service is a technology platform that supports trip planning for travel on public or private shared transportation, including transit, Uber, shared bicycles, and any connected modality.
Open Data	Open Data refers to a freely accessible data repository which can be shared across departments and with the public.
Probe Data	City fleet vehicles equipped with GPS or electronic tags which passively and continuously measure travel time, speed and location.
Radar and microwave detection	Roadside sensors that capture traffic volume, speed, and vehicle type, usually per lane.
Telecommunications networks	Cellular, fibre, and wifi networks that are shared or bespoke and suitable for a high volume of traffic data.
Variable speed signs	Centrally controlled roadside (or suspended) speed signs that can be adjusted to control traffic speed based on travel conditions.

6.2 Proposed ITS Projects

The projects described in this section cover a wide range of needs that can be addressed with ITS investment by the City of Saskatoon. The benefits of this investment will be faster travel times along major routes, fewer freight train interruptions, more traveller information and support for diverse travel mode choices.

Each project is supported by one or more of the City's ITS Strategic Goals, and can be measured by discrete Key Performance Indicators (KPIs) that require technology investment. This section presents the projects proposed that the City should focus on in the short and long term. Additional details are provided in the following sections for each near term project in terms of the priority, sequencing, time frames and high level steps and budget to implement. Budget ranges are provided to indicate the level of capital and operational resources required. Each project is provided as a template which includes stakeholders, goals, KPIs, etc., and these are included below as a reference.


PROJECT 1 - TRAFFIC MANAGEMENT

DESCRIPTION	LOCATION
The purpose of this project will be to implement traffic management system technologies that support traffic flow monitoring, incident management, and traffic control. This will include probe based traffic flow monitoring for network-wide conditions, CCTV monitoring at hot-spots and congestion points, integration with NTCIP compliant traffic signal controllers for the implementation of response plans based on traffic monitoring information and incident/special events. The traffic management system will also include interfaces to the City's traveller information systems for information dissemination and conditions reporting.	• Probe based monitoring; network wide • CCTV monitoring at hotspots and congestion points • ATMS hardware/software/APIs at City's TMC

TIMELINE: 2019 2020 2021 2022 2023 2024 2025 2026 2027

STAKEHOLDERS	GOALS SUPPORTED
• City of Saskatoon Traffic Operations • Saskatchewan Ministry of Highways and Infrastructure • Police and Emergency Services	✓ Reduce travel times along major corridors ✓ Improve emergency response efficiency ✓ Improve access to traveler information

KPIs	ENABLING SERVICE PACKAGES
• Change in number and duration incidents per vehicle km • Average travel times for major routes at peak times • Fuel and/or energy used weekly for fleet vehicles • Number of vehicles connected to the infrastructure	• ATMS01 Network Surveillance • ATMS08 Traffic Incident Management System • ATMS02 Traffic Probe Surveillance • ATMS03 Surface Street Control • ATMS06 Traffic Information Dissemination

IMPACT OF FUTURE TRENDS	TECHNOLOGY
AI: Low Impact | Longer Term **C/AV:** Medium Impact | Longer Term **5G:** High Impact | Medium Term	• Probe Data • CCTV • ATMS • APIs • Open Data • Lane Control • Radar and Microwaves

OVERALL INDICATORS	COSTS
Cost: Medium **Technological Barriers:** Low **Institutional Barriers:** Low	(Task 9)

PRIORITY	DEPENDENT PROJECTS
(Task 9)	(Task 9)

Ten ITS projects have been identified that support Saskatoon's needs and goals of today and the next 10 years. The projects include:

- Project 1 - Rail Crossing Information System (RCIS)
- Project 2 - Data Warehouse
- Project 3 - Traffic Management
- Project 4 - Traveller Information
- Project 5 - Emergency Traffic Management
- Project 6 - Transit Priority
- Project 7 - Expanded Data Collection
- Project 8 - Support Integrated Multi-Modal Trip Planning
- Project 9 - Mobility as a Service
- Project 10 - Integrated Corridor Management

The following pages include single sheet project descriptions of each project that include:

DESCRIPTION: Description of the project

LOCATION: Where in the City or what types of corridors may be applicable for the project?

TIMELINE: Estimated duration of the project (to be revised as part of the implementation planning in the next tasks).

STAKEHOLDERS: Specific stakeholders that would have an interest, input or lead the project.

GOALS SUPPORTED: What previously identified goals are supported by the project?

KPIs: Key performance indicators that will help to measure the success and value of the project.

ENABLING SERVICE PACKAGES: Relevant service packages from the ITS Architecture for Canada.

IMPACT OF FUTURE TRENDS: Relative potential impact the future technology and trends might have on how and what is implemented in the project.

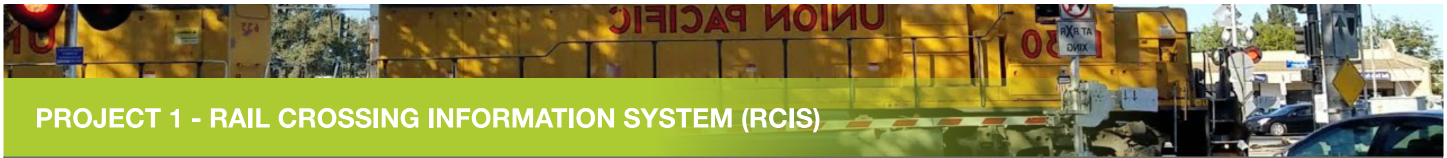
TECHNOLOGY: Type of technology expected to be implemented or leveraged.

OVERALL INDICATORS: How cost, technology and institutional barriers might influence the project.

COSTS: High level budgets for capital as well as operations and maintenance.

PRIORITY: Early win, short and long term.

DEPENDENT PROJECTS : What other projects is this project dependent upon for implementation and realizing the full benefit?



PROJECT 1 - RAIL CROSSING INFORMATION SYSTEM (RCIS)

DESCRIPTION

The purpose of this project will be to implement a Rail Crossing Information System (RCIS) that helps mitigate the impacts of at-grade rail crossings along busy corridors. The RCIS would use sensors to measure the speed and length of trains approaching intersections to estimate the arrival time and blockage duration at downstream intersections using a central software and algorithm. The information would then be disseminated using Roadside Dynamic Message signs (DMS) in advance of the intersections, and via web and mobile push notifications. Traffic signals would respond to the event by implementing queue clearing recovery sequences. Prerequisite to the design of the RCIS, a study would need to be undertaken to identify problem at-grade crossings, impacts and benefits of such a system. The study would also include functional requirements and a Concept of Operations outlining high-level requirements of the system in terms of sensors, number of DMS, etc.

LOCATION

- Critical transportation corridors with one or more at-grade rail crossings
- Specific locations to be determined based on delays identified by travel time data

TIMELINE

2019 · 2020 · 2021 · 2022 · 2023 · 2024 · 2025 · 2026 · 2027

STAKEHOLDERS

- Transportation
- Applicable Rail Authority
- Transit / Bus Rapid Transit (BRT) Team
- Corporate Performance - IT
- EMO
- Saskatoon Police
- Saskatoon Fire

GOALS SUPPORTED

✓ Mitigate impacts of train-road crossing disruptions
✓ Reduce travel times along major corridors
✓ Improve access to traveller information

KPIs

- Average delay at crossing

ENABLING SERVICE PACKAGES

- ATMS13 Standard Railroad Grade Crossing
- ATMS06 Traffic Information Dissemination
- ATIS01 Broadcast Traveller Information
- EM02 Emergency Routing

IMPACT OF FUTURE TRENDS

AI: High Impact | Medium Term
C/AV: High Impact | Medium Term

TECHNOLOGY

- Sensor and algorithmic based systems for measuring train speed and length to predict crossing durations
- DMS
- Central hardware/software

OVERALL INDICATORS

Cost: Medium
Technological Barriers: Low
Institutional Barriers: Medium

COSTS

- Capital: $260,000 - $350,000
- O&M: $1500-$4000 / month

PRIORITY

- Early Win

DEPENDENT PROJECTS

- Partial Dependency: Data Warehouse

PROJECT 2 - DATA WAREHOUSE

DESCRIPTION

The purpose of this project will be to develop and deploy a system that will collect and manage the existing and future transportation data for Saskatoon. Having all data managed in a central location will help to ensure timely and accurate information is available for all operational and planning decision making in the City.

As the City begins to deploy more systems and collect more information it will be important to ensure that the data is structured according to the data warehouse standards including data format, quality control and retention requirements. Data from the warehouse will assist the City in meeting the objectives of the other ITS projects and provide a solid framework for sharing of data with other agencies and private sector service providers. The warehouse will be able to leverage existing data sets from the City and be in alignment with other GIS and data collection initiatives. As the data sources grow the various stakeholders will be able to conduct data mining, analytics and be able to assist with the performance indicators monitored through the other projects.

The starting point for the Data Warehouse project is to develop an overall system architecture and approach that integrates with the other city data strategies. The initial task will be to conduct a data audit that will identify the existing and near term data sources allowing for the development of the architecture, standards and policies enabling the specification and procurement of the necessary system or services.

LOCATION

- Hardware/ Software/APIs at City's TMC
- Offsite Backup

TIMELINE

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

STAKEHOLDERS

- Corporate Performance - IT

GOALS SUPPORTED

✓ Improve multi-agency ITS stakeholder business intelligence for real-time operations and planning purposes

✓ Improve access to traveller information

KPIs

- Number of types of information sources that impact travel decisions available on all delivery channels (includes internal and 3rd party sources)
- Number of 3rd party applications that access the data through open data

ENABLING SERVICE PACKAGES

- AD1 ITS Data Mart
- AD2 ITS Data Warehouse
- AD3 ITS Virtual Data Warehouse
- ATMS09 Traffic Forecast and Demand Management
- MC03 Road Weather Data Collection
- ATIS06 Transportation Operations Data Sharing

IMPACT OF FUTURE TRENDS

AI: Medium Impact | Longer Term

TECHNOLOGY

- APIs
- Open Data
- Data Warehousing

OVERALL INDICATORS

Cost: Medium
Technological Barriers: Medium
Institutional Barriers: Medium

COSTS

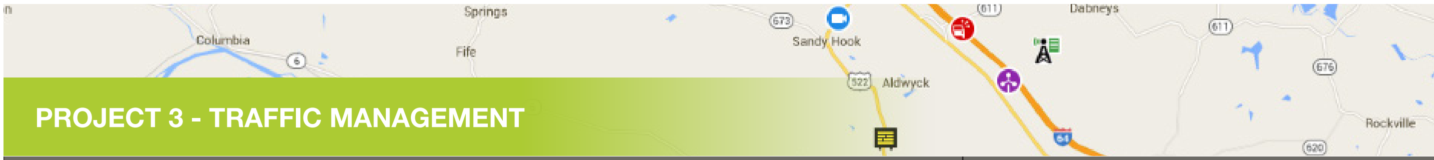
- Capital: $310,000 - $620,000
- O&M: $2000 - $5000 / month

PRIORITY

- Short Term

DEPENDENT PROJECTS

- Dependent Project: Traffic Management
- Partially Dependent: Traveller Information



PROJECT 3 - TRAFFIC MANAGEMENT

DESCRIPTION

The purpose of this project will be to implement traffic management system technologies that support traffic flow monitoring, incident management, and traffic control. This will include probe-based traffic flow monitoring for network-wide conditions, CCTV monitoring at hot-spots and congestion points, integration with NTCIP compliant traffic signal controllers for the implementation of response plans based on traffic monitoring information and incident/special events. The traffic management system will also include interfaces to the City's traveller information systems for information dissemination and conditions reporting. This project will leverage the existing central systems ATMS upgrade that are underway as part of the traffic signal system improvements. The work will primarily focus on implementation of the field systems referenced above to enable improved traffic flow through the existing systems.

LOCATION

- ATMS hardware/software/APIs at City's TMC
- CCTV monitoring at hotspots and congestion points
- Probe-based monitoring; network wide

TIMELINE

2019 2020 2021 2022 2023 2024 2025 2026 2027

STAKEHOLDERS

- Transportation
- Corporate Performance - IT
- Saskatoon Police and Emergency Services
- Saskatoon Transit
- Saskatchewan Ministry of Highways and Infrastructure

GOALS SUPPORTED

✓ Reduce travel times along major corridors
✓ Improve emergency response efficiency
✓ Improve access to traveller information

KPIs

- Change in number and duration incidents per vehicle km
- Average travel times for major routes at peak times
- Fuel and/or energy used weekly for fleet vehicles
- Number of vehicles connected to the infrastructure

ENABLING SERVICE PACKAGES

- ATMS01 Network Surveillance
- ATMS08 Traffic Incident Management System
- ATMS02 Traffic Probe Surveillance
- ATMS03 Surface Street Control
- ATMS06 Traffic Information Dissemination

IMPACT OF FUTURE TRENDS

AI: Low Impact | Longer Term
C/AV: Medium Impact | Longer Term
5G: High Impact | Medium Term

TECHNOLOGY

- Probe Data
- CCTV
- ATMS
- APIs
- Open Data
- Lane Control
- Radar and Microwaves

OVERALL INDICATORS

Cost: Medium
Technological Barriers: Low
Institutional Barriers: Low

COSTS

- Capital: $1,350,000 - $3,050,000
- O&M: $3,000 - $10,000 / month

PRIORITY

- Short Term

DEPENDENT PROJECTS

- Partially Dependent: Data Warehouse, Expanded Data Collection

PROJECT 4 - TRAVELLER INFORMATION

DESCRIPTION	LOCATION
The purpose of this project is to provide more information to motorists to allow for better decision making about their travel both during their trip and as part of pre-trip planning. This project will make multi-modal data available for travellers through multiple methods including traditional websites, mobile friendly applications and through open data sets that allow for third party agencies and application developers to access and provide data to the public through their own products. Information collected for use will come from multiple sources including sensors, detectors and third party data subscription services making this project dependent on the other data collection projects and the data warehouse project. The starting point for this project will be to assess and review the data sources available and determine the most appropriate procurement and operational model for a City delivered mobile and web system. Based on the technologies and vendors available it is likely that a City-led outsourced and hosted model will be most appropriate.	• City-wide • Commuter freeway corridors seeing increased congestion and lower safety performance • BRT Corridors • Railroad crossing corridors

TIMELINE

2019 2020 2021 2022 2023 2024 2025 2026 2027

STAKEHOLDERS	GOALS SUPPORTED
• Corporate Performance - IT • Saskatoon Fire • Saskatoon Police Service • Saskatoon Transit • Service Saskatoon	✓ Improve access to traveller information

KPIs	ENABLING SERVICE PACKAGES
• Average travel times for major routes at peak times • Percentage of arterial and freeway road network covered by websites offering traffic and travel information • Number of uses of websites and apps that offer traveller information • Customer satisfaction through survey	• ATIS01 Broadcast Traveller Information • ATIS02 Interactive Traveller Information • ATIS05 ISP Based Trip Planning and Route Guidance • ATIS06 Transportation Operations Data Sharing • ATIS09 In Vehicle Signing • ATIS10 VII Traveller Information

IMPACT OF FUTURE TRENDS	TECHNOLOGY
IoT: High Impact | Medium Term **C/AV:** High Impact | Medium Term **AI:** High Impact | Medium Term	• Central Hardware & Software • APIs • Open Data • Variable Speed Signs

OVERALL INDICATORS	COSTS
Cost: Medium **Technological Barriers:** Low **Institutional Barriers:** Low	• Capital: $1,100,000 - $3,200,000 • O&M: $10,000 - $20,000 / month

PRIORITY	DEPENDENT PROJECTS
• Short Term	• Partially Dependent: Data Warehouse, Traffic Management

PROJECT 5 - EMERGENCY TRAFFIC MANAGEMENT

DESCRIPTION	LOCATION
The purpose of this project will be to follow an integrated approach for deploying emergency pre-emption capabilities along key corridors. Key intersections along emergency response routes will be equipped with detection equipment necessary to detect approaching emergency vehicles; upon detection an interface with the traffic signal control system will be used to pre-empt the traffic signal phase in order to provide priority for the approaching emergency vehicle.	• Key intersections along emergency response routes determined by travel time response data

TIMELINE

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

STAKEHOLDERS	GOALS SUPPORTED
• Saskatoon Fire • Saskatoon Police • EMO • Transportation • Corporate Performance - IT	✓ Improve emergency response efficiency

KPIs	ENABLING SERVICE PACKAGES
• Emergency vehicle travel times	• EM02 Emergency Routing • ATMS08 Regional traffic Management

IMPACT OF FUTURE TRENDS	TECHNOLOGY
5G: Low - Medium Impact | Medium Term **AI:** Low Impact | Longer Term **C/AV:** Low Impact | Medium Term	• Emergency Vehicle Detection • Centralized Signal Pre-emption Systems • Connected Vehicle Technology • ATMS • CV • Telecommunication • VSLS

OVERALL INDICATORS	COSTS
Cost: Medium **Technological Barriers:** Low **Institutional Barriers:** Medium	• Capital: $160,000 - $300,000 • O&M: $2,000 - $4,000 / month

PRIORITY	DEPENDENT PROJECTS
• Short Term	• Partially Dependent: Data Warehouse, Traffic Management

PROJECT 6 - TRANSIT PRIORITY

DESCRIPTION	LOCATION
The purpose of this project will be to implement traffic signal priority technologies that enable buses to receive priority at signalized intersections, for the purpose of reducing time stopped at signals and improving overall trip time reliability. The primary focus of this project will be to support the BRT initiatives already underway and make sure that (from an ITS perspective) the design of the transit priority system considers integration with AVL/location monitoring, and with the city's new traffic signal controllers. Additional corridors and bus routes could be added to expand the transit priority beyond the BRT corridors in the future.	• BRT Corridors • Other frequent transit routes affected by traffic signals

TIMELINE

2019	2020	2021	2022	2023	2024	2025	2026	2027

STAKEHOLDERS	GOALS SUPPORTED
• Transit / BRT Team • Transportation • Corporate Performance - IT	✓ Improve transit schedule adherence ✓ Improve transportation flexibility (improving the mode split)

KPIs	ENABLING SERVICE PACKAGES
• Transit route trip time reliability and variance from schedule • Transit route travel times for major routes at peak times	• APTS01 Transit vehicle Tracking • APTS06 Transit Fleet management • APTS09 Transit Priority

IMPACT OF FUTURE TRENDS	TECHNOLOGY
AI: Medium Impact | Medium Term **IoT:** Medium Impact | Longer Term **C/AV:** High Impact | Longer Term	• AVL • ATMS • CV • Centralized Transit Signal Priority Systems • Connected Vehicle Traffic Signal Systems

OVERALL INDICATORS	COSTS
Cost: Medium **Technological Barriers:** Medium **Institutional Barriers:** Low - Medium	• Capital: $210,000 - $350,000 • O&M: $2,000 - $4,000 / month

PRIORITY	DEPENDENT PROJECTS
• Short Term	• Partially Dependent: Data Warehouse, Traffic Management

PROJECT 7 - EXPANDED DATA COLLECTION

DESCRIPTION

The Expanded data collection project will establish a program of transportation related data collection that will support other projects both from a planning and operations perspective. Some other projects will have specific data collection requirements that may be initiated in advance of this work but all data collection should be planned to support multiple projects and departments where possible. Technology will include in-road and above ground sensors for vehicle, pedestrian and cycling users of the City's infrastructure. The method of obtaining the data will include Saskatoon deployed sensors as well as data purchased from other data collectors such as probe-based services, commercial AVL systems or IoT data collection companies. The data collected and brought into a common data warehouse for sharing includes type of traffic, volume, occupancy, and incident related information. Commercial vehicle corridors may have further classification sensors added. The data collected will provide information and insights into locations and corridors that have opportunity for improvement and will also support regular update and optimization of the traffic signal timings and future traffic responsive implementations. The underlying need is that consistent and reliable data is required to support future decision making and real-time operations on key arterials.

LOCATION

- Areas of known congestion
- Planned pedestrian and cycling corridors
- Key river crossings and road weather "hot spots"
- Railroad crossing corridors

TIMELINE

2019	2020	**2021**	**2022**	**2023**	2024	2025	2026	2027

STAKEHOLDERS

- Corporate Performance - IT
- Facilities & Fleet
- Saskatoon Fire
- Major Projects and Preservation
- Saskatoon Transit
- Transportation

GOALS SUPPORTED

✓ This project is a fundamental component of the Saskatoon ITS program and as a result supports all 8 goals

KPIs

- Percentage of commuters using non-single-vehicle/single-driver modes
- Bike route kms of travel
- Pedestrian kms of travel
- Change in number and duration incidents per vehicle km
- Average travel times for major routes at peak times
- Percentage of commercial traffic adhering to heavy load restrictions
- Number of vehicles connected to the infrastructure providing real-time data

ENABLING SERVICE PACKAGES

- ATMS09 Traffic Forecast and Demand Management
- APTS06 Transit Fleet Management
- APTS07 Multi-Modal Coordination
- ATMS02 Traffic Probe Surveillance
- AD2 ITS Data Warehouse

IMPACT OF FUTURE TRENDS

IoT: High Impact | Near Term
AI: Medium Impact | Medium Term
C/AV: High Impact | Longer Term

TECHNOLOGY

- Connected Vehicle Infrastructure and Data Feeds
- Data Feeds from AVL Systems
- Loop Based Detection
- Radar and Microwave Detection
- Probe-Based Detection
- Environmental Detection
- Supporting Telecommunications Networks

OVERALL INDICATORS

Cost: Low
Technological Barriers: Low
Institutional Barriers: Low

COSTS

- Capital: $130,000 - $225,000
- O&M: $10,000 - $30,000 / month

PRIORITY

- Short Term

DEPENDENT PROJECTS

- Dependent: Data Warehouse
- Partially Dependent: Traffic Management

PROJECT 8 - SUPPORT INTEGRATED MULTI-MODAL TRIP PLANNING

DESCRIPTION	LOCATION
The purpose of this project is to develop a Traveller Information System (TIS) infrastructure capable of fully supporting a door to door trip planner that handles all modalities such as walking, driving, cycling, transit, and handles payment transactions for transit, parking, carsharing, bikesharing, and special events. The Multi-modal Trip Planner would also support dynamic ridesharing, up-to-the-minute AVL for all rentables, route recommendations, and parking inventory. The system will consolidate and make data available for third parties to develop and host trip planning applications.	• Supported City-Wide, including Provincial road network.

TIMELINE

2019	2020	2021	2022	2023	2024	2025	2026	2027

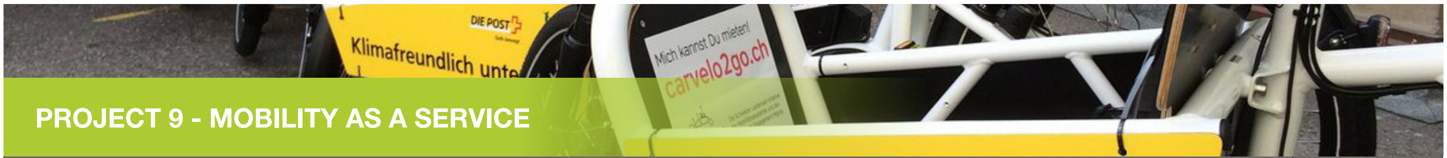
STAKEHOLDERS	GOALS SUPPORTED
• Parking Services • Service Saskatoon • Transportation • Unidentified Third Parties	✓ Improve access to traveller information ✓ Improve transportation flexibility

KPIs	ENABLING SERVICE PACKAGES
• Percentage of commuters using non-single-vehicle/single-driver modes • Transit ridership as volume per day • Bike route kms of travel (or other bicycle count strategies) • Pedestrian kms of travel (or other pedestrian count strategies) • Ride share usage person - kms of travel	• ATIS05 ISP Based Trip Planning and Route Guidance • ATIS07 Traveller Services Payment and Reservation • ATIS08 Dynamic Ridesharing • ATMS16 Parking Facility Management • ATMS17 Regional Parking Management • APTS01 Transit Vehicle Tracking • APTS03 Demand Response Transit Operations • APTS04 Transit Fare Collection Management • APTS101 Multi-Modal Connection Protection

IMPACT OF FUTURE TRENDS	TECHNOLOGY
AI: High Impact | Longer Term **C/AV:** Medium Impact | Longer Term	• APIs • Open Data • Bike share technology • MaaS platforms

OVERALL INDICATORS	COSTS
Cost: Medium **Technological Barriers:** Low **Institutional Barriers:** Medium	• Determined later in ITS program

PRIORITY	DEPENDENT PROJECTS
• Medium Term	• Dependent: Data Warehouse, Traffic Management, Traveller Information



PROJECT 9 - MOBILITY AS A SERVICE

DESCRIPTION	LOCATION
The purpose of this project is to improve transportation flexibility including mode split and reduce congestion along major corridors. Mobility as a Service (MaaS) is seen as an approach that can assist with these goals by providing the opportunity to offer end to end mobility that also includes public transit as a major underpinning of the service offering. Saskatoon can position itself as an early adopter of mobility as a service platforms (MaaS) as they evolve for the benefit of residents. As MaaS evolves in terms of service offerings there is a potential to have a net reducing effect on the need for roadway infrastructure and therefore reduced congestion, costs and greenhouse gases produced from mobility. As this service offering is likely to be an ongoing evolution there is a need for Saskatoon to review its internal policies and to work with the provincial government on provincial policies that build on the recent ride hailing act passed by the province, for example. The Integrated Multi-Modal Trip Planner project can be a foundational element to MaaS where the City and other service providers can participate in the trip planner project to expand the service offerings to travellers that falls within the policies and objectives identified by this project. While the private sector will play a large role in MaaS, the starting point for the City will be to identify stakeholders, the policies involved and to become active in MaaS working groups in Canada and Europe to capture the latest policies and understanding of the best approaches, lessons learned and benefits.	• City-wide

TIMELINE

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027

STAKEHOLDERS

- Saskatoon Transit
- Transportation
- Corporate Performance - IT

GOALS SUPPORTED

- ✓ Improve transportation flexibility (improving the mode split)
- ✓ Reduce travel times along major corridors

KPIs

- Percentage of commuters using non-single vehicle/single-driver modes
- Transit ridership as volume per day
- Bike route kms of travel
- Pedestrian kms of travel
- Ride share usage person - kms of travel
- Customer satisfaction through survey instruments
- Average travel times for major routes at peak times

ENABLING SERVICE PACKAGES

- ATIS08 Dynamic Ridesharing
- APTS Multi-modal Connection Protection
- ATIS02 Interactive Traveller Information
- ATIS05 ISP Based Trip Planning and Route Guidance

IMPACT OF FUTURE TRENDS

AI: High Impact | Longer Term
C/AV: High Impact | Longer Term
Blockchain: High Impact | Longer Term

TECHNOLOGY

- Ride Hailing Technology
- Bike Share Technology
- MaaS Platforms
- Data Warehousing

OVERALL INDICATORS

Cost: Low
Technological Barriers: Low
Institutional Barriers: High

COSTS

- Determined later in ITS program

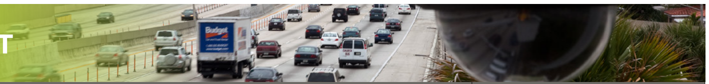
PRIORITY

- Medium Term

DEPENDENT PROJECTS

- Dependent: Data Warehouse, Traveller Information
- Partially Dependent: Traffic Management

PROJECT 10 - INTEGRATED CORRIDOR MANAGEMENT



DESCRIPTION	LOCATION
The purpose of this project will be to build on the traffic management, traveller information, expanded data collection, and rail crossing system projects to optimize the use of available transportation system capacity. Integrated Corridor Management (ICM) represents an ITS approach to manage multiple facilities in a coordinated manner through active traffic management and control based on prevailing conditions, to optimize use of available infrastructure. ICM can also span modes using services that can direct travellers to underused capacity and modes by shifting departure times, routes, or modal choices. Finally ICM can span multiple agencies, allowing provincial, municipal, and transit agencies to collaborate, share systems and data to maximize efficiency of all modes. This project can begin with a pilot implementation of traffic adaptive signaling along congested corridors taking advantage of the expanded data collection deployments. As the City grows and alternative commuting routes become available ICM could be piloted between differing commuter routes, where vehicular traffic demand management can be optimized by using traffic monitoring, traveller information, and traffic adaptive signal timing adjustments to optimize use of available capacity and thus throughput. Future phases of this project would entail integration and coordination with the trip planning, and MaaS initiatives to achieve optimization across multiple modes, and multiple corridors. ICM solutions incorporate monitoring systems to assess condition of facilities and assets, such as field devices and probe data. Another key component of ICM systems is use of data portal or hub used to exchange information to and from the various subsystem and agencies. These also typically make use of response plans or decision support systems that make recommendations on how to respond. Many ICM systems integrate performance measurement to evaluate in both real-time and historically, how well the system has helped meet performance goals.	• Pilot on a parallel congested corridor (TBD) • Expansion to network level

TIMELINE

2019 · 2020 · 2021 · 2022 · 2023 · 2024 · 2025 · 2026 · **2027**

STAKEHOLDERS

- Construction and Design
- Long Range Planning
- Major Projects and Preservation
- Roadways and Operations
- Saskatoon Transit
- Transportation
- Saskatoon Highways
- Detours Group
- Corporate Performance - IT

GOALS SUPPORTED

✓ Reduce travel times along major corridors
✓ Improve transit schedule adherence
✓ Manage commercial vehicle movements to preserve road infrastructure

KPIs

- Customer satisfaction through survey instruments
- Change in number and duration incidents per vehicle km
- Fuel and/or energy used weekly for fleet vehicles
- Average travel times for major routes at peak times
- Number of vehicles connected to the infrastructure providing real-time data (i.e. connected vehicle)
- Positive Traveller Opinion Surveys

ENABLING SERVICE PACKAGES

- ATMS101 Dynamic Roadway Management
- ATMS06 Traffic Information Dissemination
- ATIS02 Interactive Traveller Information
- AD2 ITS Data Warehouse
- ATMS07 Regional Traffic Management

IMPACT OF FUTURE TRENDS

IoT: High Impact | Longer Term
AI: High Impact | Longer Term
C/AV: High Impact | Medium Term

TECHNOLOGY

- Connected Vehicle Infrastructure and Data Feeds
- Data from Data Collection Project
- Variable Speed Signs
- Lane Control and Management Signals
- Environmental Detection
- Supporting Telecommunications Networks

OVERALL INDICATORS

Cost: High
Technological Barriers: Medium
Institutional Barriers: High

COSTS

- Determined later in ITS program

PRIORITY

- Longer Term

DEPENDENT PROJECTS

- Dependent: Data Warehouse, Traffic Management
- Partially Dependent: Traveller Information

7 Goals and Projects

Each project was assessed to confirm the specific goals previously identified that are expected to be at least partially addressed by each project.

GOALS / PROJECTS	Project 1 - Rail Crossing Information System (RCIS)	Project 2 - Data Warehouse	Project 3 - Traffic Management	Project 4 - Traveller Information	Project 5 - Emergency Traffic Management	Project 6 - Transit Priority	Project 7 - Expanded Data Collection	Project 8 - Support Integrated Multi-Modal Trip Planning	Project 9 - Mobility as a Service	Project 10 - Integrated Corridor Management
Improve transportation flexibility (improving the mode split).						●	●	●	●	
Reduce travel times along major corridors.	●		●				●		●	●
Improve emergency response efficiency.			●		●		●			
Improve transit schedule adherence.						●	●			●
Manage commercial vehicle movements to preserve road infrastructure.							●			●
Mitigate impacts of train-road crossing disruptions.	●						●			
Improve access to traveller information.	●	●	●	●			●	●		
Improve multi-agency ITS stakeholder business intelligence for real-time operations and planning purposes.		●					●			

8 ITS Deployment Plan

8.1 Project Dependencies

Each project was reviewed to determine the dependencies on other projects for implementation. Some projects have a strong reliance (full dependency) on other projects while other projects have partial dependency. Partial dependency means that the project could proceed and the full benefits may be realized once the dependent project is implemented.

LEGEND

(blank)	No Dependency
○	Partial Dependency
●	Full Dependency

NOTES

* Minimal dependencies, could be an early win. Emergency Management Dispatch would benefit from real-time data from RCIS.

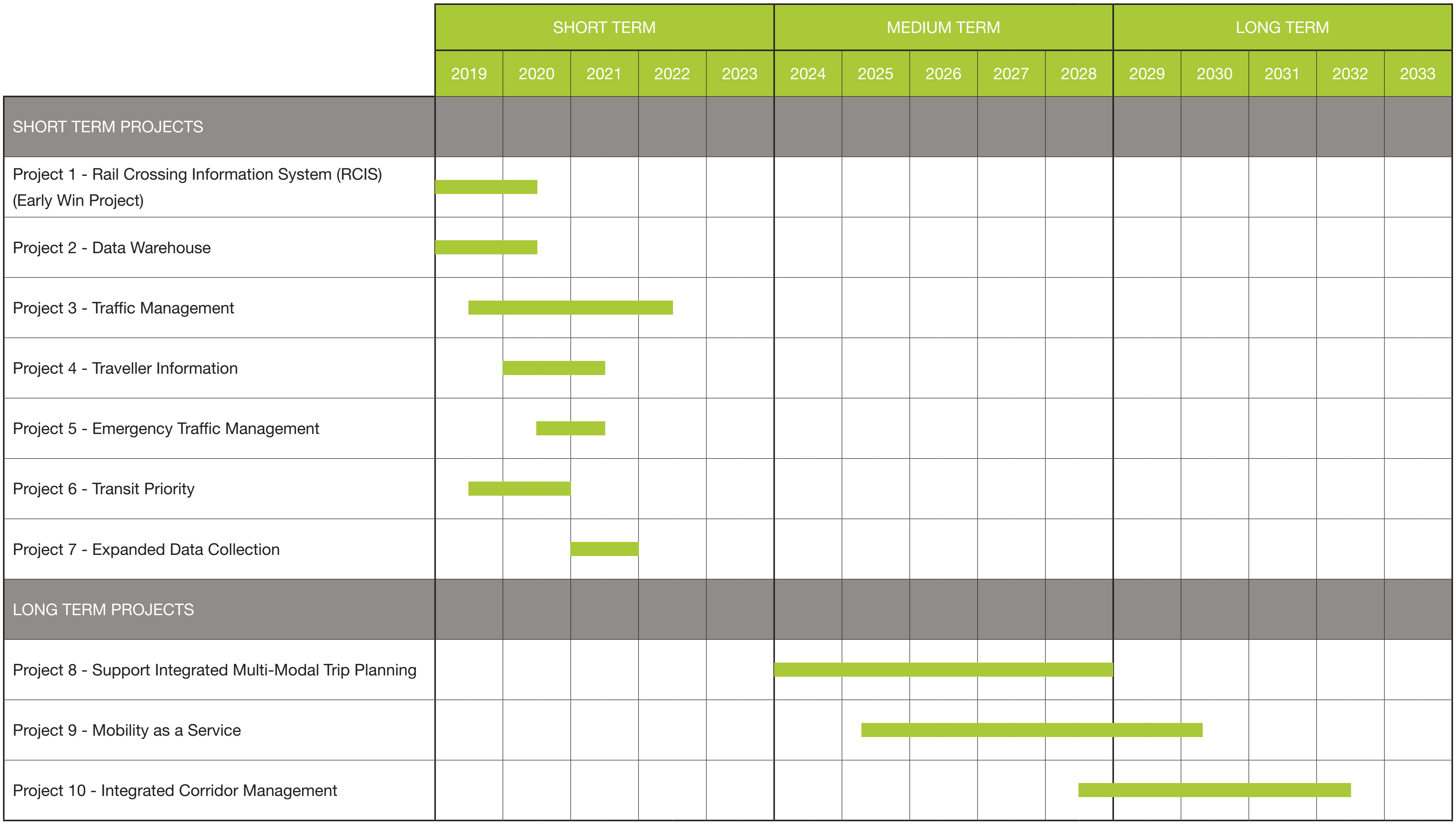
** Could be focused on newer or upgraded intersections, also recommend data warehouse collect data on activations, usage, performance etc.

*** Also dependent on the BRT projects and data from the Transit systems.

	Project 1 - Rail Crossing Information System (RCIS)	Project 2 - Data Warehouse	Project 3 - Traffic Management	Project 4 - Traveller Information	Project 5 - Emergency Traffic Management	Project 6 - Transit Priority	Project 7 - Expanded Data Collection	Project 8 - Support Integrated Multi-Modal Trip Planning	Project 9 - Mobility as a Service	Project 10 - Integrated Corridor Management
SHORT TERM PROJECTS 2019 - 2022										
Project 1 - Rail Crossing Information System (RCIS) *		○								
Project 2 - Data Warehouse			●	○						
Project 3 - Traffic Management		○					○			
Project 4 - Traveller Information	○	○	○				○			
Project 5 - Emergency Traffic Management **	○	○	○			○				
Project 6 - Transit Priority ***		○	○	○	○		○			
Project 7 - Expanded Data Collection		●	○							
MEDIUM AND LONG TERM PROJECTS										
Project 8 - Support Integrated Multi-Modal Trip Planning		●	●	●						
Project 9 - Mobility as a Service		●	○	●						
Project 10 - Integrated Corridor Management		●	●	○						

8.2 Project Timelines

The following illustration shows the recommended sequencing and timing of the projects based upon the dependencies, timelines, goals met, and ability to quickly implement.



8.2 Project Action Plans

For each of the near term projects, action plans have been developed to understand the types of activities that will need to be undertaken to implement the projects. This action plan is a framework of activities that are described in the 4 steps of:

- Concept of Operations;
- Design;
- Implementation; and
- Operations and Monitoring.

For the longer term projects, action plans would follow a similar format but it is too premature at this point to pre-suppose the activities as the opportunities and the nature of how they would be implemented are likely to be somewhat different than envisioned today. Longer term projects are identified as such as they will require more time for the technologies to mature and for needs to be more definitive, the business cases to be developed. In addition the implementation of the near term projects including lessons learned will further inform if, how and when these project should proceed.

Each of the 4 steps are deliberate sets of activities that advance the projects toward reaching milestones that have clear checkpoints that ensure meeting goals and KPIs while minimizing risks in investment. The high level outputs from each step include:

Concept of Operations	• Understanding of existing conditions, technical approach and approach to procurement. • Scope, schedule, budget justification for deployment.
Design	• Design and specifications for procurement. • Further refined budget and schedule.
Implementation	• Oversight of implementation. • Coordination with all stakeholders until operational.
Operations and Monitoring	• Operating Systems and measurement/reporting of KPIs.

The budget range for each project is determined by a number of factors including:

- The extent of implementation including number of km of network covered, number of intersections, size of data to be managed etc.;
- The method of procurement including traditional, design-build or third party hosted and operated;
- The state and cost of the technology at the time of implementation;
- The availability of local or regional resources to implement or operate the projects and technology; and
- The costs of technology at the time of implementation.

The budget ranges provided are based on a combination of our industry experience coupled with an estimated rollout as well as published industry norms.

Additional costs considerations not included in the estimates:

- Cost for telecommunications assumed to be delivered by a common IT telecommunication network; and
- Staff resources to manage and monitor activities.

Project 1 - Rail Crossing Information System (RCIS)				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Includes site and benefits assessment, current technology and vendor assessment as well as high level technical operational requirements and costs. Prepare project rollout plan, budget and business case.	3 months	30	50
Design	Prepare design for the site chosen and develop terms of reference for implementation, coordinate with Data Warehouse project.	3 months	30	50
Implementation	Conduct procurements, oversight of implementation and coordination with other projects. Budgets based on a single crossing implementation. There will be two phases: 1) Early Roll-out - Focused on leveraging pre-emption where it exists. 2) Expansion to prioritized crossings - Focused on 'occupied'.	9 months	200	250
Operations and Monitoring	Monitor and adjust operation, review operation against KPIs.	9 months + ongoing	1.5 per month	4 per month

Source: Intelligent Transportation Systems: Benefits, Costs, Deployment, and Lessons Learned U.S. Department of Transportation Research and Innovative Technology Administration 2008 Update, pg 71
See the attached Rail Grade Crossing Budget document.

Project 2 - Data Warehouse				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Perform a data audit for existing and near term data needs, develop architecture and hosting model based on IT policies on data management, privacy, security and open data requirements. Prepare project rollout plan, budget and business case.	3 months	30	60
Design	Prepare the specifications, operational requirements and terms of reference for procurement and implementation. Identify specific activities of other data owners for preparedness including interface specifications and data sharing agreements.	3 months	30	60
Implementation	Implement project procurement, liaise with other data owners and begin implementation of data interfaces as implemented and available.	12 months	250	500
Operations and Monitoring	Monitor and adjust operation, review operation against KPIs. Continue to bring in new data sources and provide data to others including projects, departments and open data.	18 months + ongoing	2 per month	5 per month

Source: https://www.itscosts.its.dot.gov/ITS

Project 3 - Traffic Management				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Review of data sources available and department information to identify potential early candidate hotspots for traffic management. Identify the preferred approach to network wide monitoring (i.e. probe-based service vs. owned infrastructure). Identify the operational policies guiding implementation or new policies that are required to be developed. Identify method of integrating with the Data Warehouse. Prepare project rollout plan, budget and business case.	6 months	150	250
Design	Develop operational procedures based on policy that will support the traffic management systems meeting the objectives, review personnel and operational space required. Prepare functional specifications for the detection systems and early corridors identified. Prepare specifications for central system operations and space upgrades required.	6 months	200	800
Implementation	Implementation of multiple contracts that would include network-wide monitoring, targeted implementation, telecommunication upgrades (in collaboration with IT), traffic management system software/integration, and central system hardware and space upgrades. Budget assumes Central System Implementation and Traffic Management Monitoring of 10 locations at a estimated budget of $100,000 to $2,000 per site. There will be two phases: 1) Traffic Signal Management/ATMS Software (currently underway) 2) Traffic Management Field Deployment (this project)	24 months	1,000	2,000
Operations and Monitoring	Traffic Management Centre operations, field and central operations, baseline and monitoring of KPIs.	12 months + ongoing	3 per month	10 per month

Project 4 - Traveller Information				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Identify and work with stakeholders to determine the preferred approach to traveller information including data sources available and methods of dissemination. Identify potential third party service providers and App developers Work through the data warehouse to ensure consistency of data to be shared. Review and determine the most appropriate procurement and operational model. Prepare project rollout plan, budget and business case.	6 months	50	100
Design	Confirm operational procedures and performance metrics. Prepare functional specifications including specifications for obtaining additional data sources and integration with the data warehouse as well as the real-time Traffic Management System.	6 months	50	100
Implementation	Oversee procurement and implementation contract including coordinating data interfaces with other systems. Manage public communications to promote use of the system by travellers as well as other service providers and App developers.	6 months	1,000	3,000
Operations and Monitoring	Manage operational contract, set baseline KPIs and monitor on an ongoing basis. Add new data sources and promote private sector value add.	30 months + ongoing	10 per month	20 per month

Source: https://www.itscosts.its.dot.gov/ITS

Project 5 - Emergency Traffic Management				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Work with the EMO to understand baseline performance response times and identify the top traffic signal locations with significant delays for emergency vehicles. Review existing traffic signal system and traffic controller specifications for ability to integrate or upgrade to include GPS based emergency vehicle pre-emption. Formalize Concept of Operations. Prepare project rollout plan, budget and business case.	3 months	30	50
Design	Confirm operational procedures and performance metrics. Prepare functional specifications including specifications for obtaining additional data sources and integration with the data warehouse as well as the traffic signal system.	3 months	30	50
Implementation	Oversee procurement and implementation contract including coordinating data interfaces with other systems. Implement priority locations for review of performance prior to committing to additional signal locations. Budget assumes 4 intersections at a budget range of $25,000 to $50,000 per intersection.	6 months	100	200
Operations and Monitoring	Set baseline KPIs and monitor on an ongoing basis. Determine potential expansion locations or recommend alternate approaches.	12 months + ongoing	2 per month	4 per month

Source: Intelligent Transportation Systems: Benefits, Costs, Deployment, and Lessons Learned U.S. Department of Transportation Research and Innovative Technology Administration 2008 Update, pg 71

Project 6 - Transit Priority				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Review technology and results of traffic signal priority deployed as part of the Bus Rapid Transit Program. Confirm use of same technology and potential enhancements from other data sources. Prepare project rollout plan, budget and business case.	3 months	30	50
Design	Leveraging data from transit and the additional sources available through the data warehouse, analyze and determine candidate locations for additional deployment. Prepare specifications for procurement.	3 months	30	50
Implementation	Oversee procurement and implementation contract. Implement priority locations for review of performance prior to committing to additional signal priority locations. Assumes 10 additional sites would be implemented at a budget of $15,000 to $25,000 per site. There will be two phases: 1) BRT Roll-out 2) Expansion	12 months	150	250
Operations and Monitoring	Set baseline KPIs and monitor on an ongoing basis. Determine potential expansion locations or recommend alternate approaches.	6 months + ongoing	2 per month	4 per month

Source: Intelligent Transportation Systems: Benefits, Costs, Deployment, and Lessons Learned U.S. Department of Transportation Research and Innovative Technology Administration 2008 Update, pg 118

Project 7 - Expanded Data Collection				
Step	**Description**	**Duration**	**Budget Range (x $1,000)**	
Concept of Operations	Review data collection methodologies implemented in projects 1 to 6. Identify gaps in location specific multi-modal data. Identify city-wide data collection operational model including service models.	3 months	30	50
Design	Confirm operational procedures and performance metrics for collecting data. Prepare functional specifications including specifications for data collection and integration with the data warehouse as well as the traffic signal and traffic management system.	3 months	50	75
Implementation	Oversee procurement and implementation contract. Implement data collection with data warehouse.	6 months	50	100
Operations and Monitoring	Set baseline KPIs and monitor on an ongoing basis. Determine potential expansion locations or recommend alternate approaches as technology advances. Assumes purchase of traffic data from third party provider (50 km).	12 months + ongoing	10	30

9 Related Saskatoon IT Initiatives

Known Saskatoon IT initiatives that are planned or underway are described below. Some of these projects will be influenced by the ITS projects and as a result, close coordination is required to ensure there are no duplicate or conflicting efforts and technology can be properly planned and supported by the relevant groups. As a result, we have identified a starting point for coordination by indicating what ITS projects have a strong relation to each of the IT initiatives. The time frames for these IT initiatives should be coordinated with the ITS projects to ensure maximum results.

Saskatoon IT Initiatives	Related Proposed ITS Project
IoT Centralization Strategy – centralizes the governance and security of all of the City's IoT sensors and devices in order to address the considerable risks around security, privacy, and data complexity. Includes documenting all existing IoT devices and transitioning them to a managed, secure network. Also includes implementing a data warehouse platform to gather all IoT data. A standardized process for deploying and documenting new IoT devices will be created.	Project 1 - Rail Crossing Information System Project 2 - Data Warehouse Project 3 - Traffic Management Project 4 - Traveller Information Project 7 - Expanded Data Collection Project 10 - Integrated Corridor Management
Fibre Strategy – defines the City's approach to fibre optic cable infrastructure, including governance, management, accountability, and support. Includes an implementation plan that will detail the logical deployment of fibre to minimize cost and maximize availability to the business. This plan will leverage existing fibre investments as much as possible and will include a multi-year roadmap to allow for budget planning in the future.	Project 1 - Rail Crossing Information System (RCIS) Project 3 - Traffic Management Project 7 - Expanded Data Collection Project 10 - Integrated Corridor Management
Data Services Roadmap and Strategy – This strategy outlines the steps to be taken to manage data at the City of Saskatoon. This includes defining the data available and determining an appropriate governance model. Following that, it involves determining the appropriate management and architecture models, followed by the delivery of technologies to support analytics and business intelligence.	Project 4 - Traveller Information Project 7 - Expanded Data Collection Project 8 - Support Integrated Multi-Modal Trip Planning Project 10 - Integrated Corridor Management
Network and Communications Strategy – The City of Saskatoon IT department will be leading a strategy, combining all telecommunication practices. This holistic strategy will allow the City to plan and meet technical communication needs of the City. This includes physical network, low level IoT, fibre and all radio communications.	Project 1 - Rail Crossing Information System (RCIS) Project 3 - Traffic Management Project 5 - Emergency Traffic Management Project 6 - Transit Priority Project 7 - Expanded Data Collection Project 10 - Integrated Corridor Management
Bus Rapid Transit – Saskatoon Transit has a plan for 3 BRT corridors and transit villages, and are anticipating travel time and reliability improvements. Transit Signal Priority will be deployed at all beneficial locations, as well as destination and wayfinding information, route and schedule information, real-time next bus information, and security monitoring.	Project 3 - Traffic Management Project 6 - Transit Priority

10 Short Term Budget

For each of the near term projects identified budget ranges were developed for capital and operations/ maintenance as indicated in the project action plans. The timing of the need for these budgets will be dependent on the development and approval of each business case and the actual completion dates for each project that will then activate the need for the operational funding. The current anticipated timing for the need of the budget is shown in **Exhibit 10.1** below.

An additional consideration is that there will be a need to have the relevant staff complement to manage these projects as well as oversee the operations and maintenance. Staffing needs will be impacted by the level of outsourcing of expertise anticipated. **Exhibit 10.1** below shows a minimum complement to support the ITS projects.

Exhibit 10.1: Budget and FTE Timeline

	Budget (x $1,000)				
SHORT TERM PROJECTS	2019	2020	2021	2022	2023
Project 1 - Rail Crossing Information System (RCIS) (Early Win Project) *	190-200	60-90	**18-48**	**18-48**	**18-48**
Project 2 - Data Warehouse	185-370	125-250	24-60	**24-60**	**24-60**
Project 3 - Traffic Management	150-250	700-1000	500-1000	250-500	**36-120**
Project 4 - Traveller Information	---	100-200	1000-3000	**120-240**	**120-240**
Project 5 - Emergency Traffic Management	---	60-100	100-200	**24-48**	**24-48**
Project 6 - Transit Priority	60-100	150-250	**24-48**	**24-48**	**24-48**
Project 7 - Expanded Data Collection	---	---	130-235	**120-360**	**120-360**
Capital Budget Range	585-980	1195-1890	1754-4485	250-500	**---**
Operations and Maintenance (O&M) Budget Range	---	---	**42-96**	**366-924**	**366-924**
Estimated Supporting Staffing Augmentation (Full Time Equivalents)	1	1	1-2	**1-2**	**2-3**

O&M (shaded cells)

Appendix A: Key Performance Indicators (KPIs)

KPI	Method of Measurement	Source (Internal, City, etc.)	Frequency of Measurement	Cost Estimate (Range)
Percentage of commuters using non-single-vehicle/single-driver modes	Census Stats Canada	Federal	Every 5 years	None
	Travel Survey, eg. Ipsos Reid Travel Survey	Project	Annual	Low
Transit ridership as volume per day	Saskatoon Transit	City	Daily	Low
Bike route kms of travel (or other bicycle count strategies)	Travel Survey, eg. Ipsos Reid Travel Survey	Project	Annual	Low
	Bicycle pathway loop detection, eg http://www.pedbikesafe.org	Project	Up to the minute	Medium
Pedestrian kms of travel (or other pedestrian count strategies)	Travel Survey, eg. Ipsos Reid Travel Survey	Project	Annual	Low
	Pedestrian detection sensors/cameras, eg https://www.density.io/	Project	Up to the minute	Medium
Ride share usage person - kms of travel.	Travel Survey, eg. Ipsos Reid Travel Survey	Project	Annual	Low
Customer satisfaction through survey instruments.	Travel Survey, eg. Ipsos Reid Travel Survey	Project	Annual	Low
Change in number and duration incidents per vehicle km	Loop detectors (or radar) on major corridors to capture total vehicle km and Saskatoon Police to capture incidents	Project	Daily	High
Transit route travel times for major routes at peak times	Saskatoon Transit	City	Daily	Low
Fuel and/or energy used weekly for fleet vehicles.	Saskatoon Transit, Roadways, Solid Waste	City	Weekly	Low
Transit route trip time reliability and variance from schedule.	Saskatoon Transit	City	Daily	Low
Average travel times for major routes at peak times	Bluetooth travel time system	Project	Up to the minute	Medium
	Third party service, such as TomTom, or INRIX	External	Up to the minute	Medium
Percentage of commercial traffic adhering to heavy load restrictions.	Loop detectors (or radar) on major corridors and sensitive routes	Project	Up to the minute	High
Percentage of arterial and freeway road network covered by websites offering traffic and travel information	Google search	Internal	Monthly	None
Number of uses of websites and apps that offer traveller information	App store search, Google search	Internal	Monthly	None
Number of vehicles connected to the infrastructure providing real-time data (i.e. connected vehicle)	Saskatoon Transit, Roads, Police, Fire, etc	City	Monthly	None
Emergency vehicle travel times	CAD/AVL system data	City	By Event	Low
Number of types of information sources that impact travel decisions available on all delivery channels (includes internal and 3rd party sources)	Saskatoon City IT	City	Monthly	None
Number of 3rd party applications that access the data through open data	Saskatoon City IT	City	Monthly	None

Appendix B: Sample Service Package

Exhibit B-1: Sample Service Package Diagram

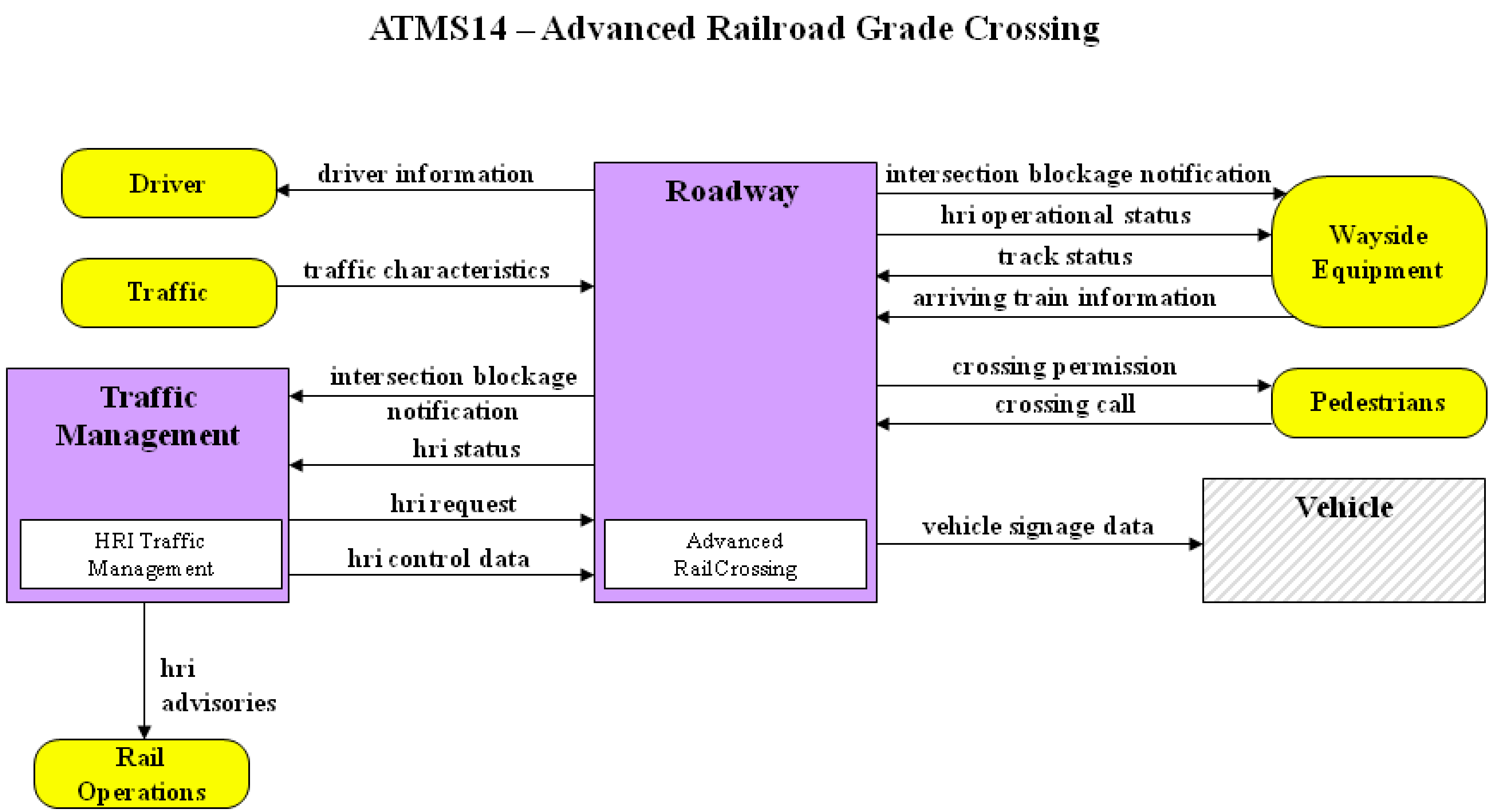


Exhibit B-2: Suite of ITS Service Packages in the Canadian ITS Architecture

Traffic Management
ATMS01 - Network Surveillance
ATMS02 - Traffic Probe Surveillance
ATMS03 - Surface Street Control
ATMS04 - Freeway Control
ATMS05 - HOV Lane Management
ATMS06 - Traffic Information Dissemination
ATMS07 - Regional Traffic Management
ATMS08 - Traffic Incident Management System
ATMS09 - Traffic Forecast & Demand Management
ATMS10 - Electronic Toll Collection
ATMS11 - Emissions Monitoring & Management
ATMS12 - Roadside Lighting System Control
ATMS13 - Standard Railroad Grade Crossing
ATMS14 - Advanced Railroad Grade Crossing
ATMS15 - Multimodal Operations Coordination
ATMS16 - Parking Facility Management
ATMS17 - Regional Parking Management
ATMS18 - Reversible Lane Management
ATMS19 - Variable Speed Limit & Enforcement
ATMS20 - Drawbridge Management
ATMS21 - Roadway Closure Management
ATMS101 - Dynamic Roadway Warning
ATMS102 - Signal Enforcement
ATMS103 - Standard Mixed Use Warning Systems
ATMS104 - Advanced Mixed Use Warning Systems

Traveller Information
ATIS01 - Broadcast Traveller Information
ATIS02 - Interactive Traveller Information
ATIS03 - Autonomous Route Guidance
ATIS04 - Dynamic Route Guidance
ATIS05 - ISP Based Trip Planning & Route Guidance
ATIS06 - Transportation Operations Data Sharing
ATIS07 - Traveller Services Payment & Reservation
ATIS08 - Dynamic Ridesharing
ATIS09 - In Vehicle Signing
ATIS10 - VII Traveller Information

Public Transportation
APTS01 - Transit Vehicle Tracking
APTS02 - Transit Fixed-Route Operations
APTS03 - Demand Response Transit Operations
APTS04 - Transit Fare Collection Management
APTS05 - Transit Security
APTS06 - Transit Fleet Management
APTS07 - Multi-Modal Coordination
APTS08 - Transit Traveller Information
APTS09 - Transit Signal Priority
APTS10 - Transit Passenger Counting
APTS101 - Multi-Modal Connection Protection

Commercial Vehicle Operations
CVO01 - Fleet Administration
CVO02 - Freight Administration
CVO03 - Electronic Clearance
CVO04 - CV Administrative Processes
CVO05 - International Border Electronic Clearance
CVO06 - Weigh-In-Motion
CVO07 - Roadside CVO Safety
CVO08 - On-Board CVO & Freight Safety & Security
CVO09 - CVO Fleet Maintenance
CVO10 - Hazardous Material Planning & Incident Response
CVO11 - Roadside Hazardous Material Security Detection & Mitigation
CVO12 - CV Driver Security Authentication
CVO13 - Freight Assignment Tracking
CVO101 - Freight Terminal Management
CVO102 - International Border Registration
CVO103 - International Border Pre-Processing
CVO104 - International Border Inspection

Maintenance & Construction
MC01 - Maintenance & Construction Vehicle & Equipment Tracking
MC02 - Maintenance & Construction Vehicle Maintenance
MC03 - Road Weather Data Collection
MC04 - Weather Information Processing & Distribution
MC05 - Roadway Automated Treatment
MC06 - Winter Maintenance
MC07 - Roadway Maintenance & Construction
MC08 - Work Zone Management
MC09 - Work Zone Safety Monitoring
MC10 - Maintenance & Construction Activity Coordination
MC11 - Environmental Probe Surveillance
MC12 - Infrastructure Monitoring
MC101 - Roadway Micro-Prediction

Emergency Management
EM01 - Emergency Call-Taking & Dispatch
EM02 - Emergency Routing
EM03 - Personal Security & Mayday Support
EM04 - Roadway Service Patrols
EM05 - Transportation Infrastructure Protection
EM06 - Wide-Area Alert
EM07 - Early Warning System
EM08 - Disaster Response & Recovery
EM09 - Evacuation & Re-entry Management
EM10 - Disaster Traveller Information

Vehicle Safety
AVSS01 - Vehicle Safety Monitoring
AVSS02 - Driver Safety Monitoring
AVSS03 - Longitudinal Safety Warning
AVSS04 - Lateral Safety Warning
AVSS05 - Intersection Safety Warning
AVSS06 - Pre-Collision Restraint Deployment
AVSS07 - Driver Visibility Improvement
AVSS08 - Advanced Vehicle Longitudinal Control
AVSS09 - Advanced Vehicle Lateral Control
AVSS10 - Intersection Collision Avoidance
AVSS11 - Automated Highway System
AVSS12 - Cooperative Vehicle Safety Systems

Appendix C: Existing Systems

The current state of the City of Saskatoon ITS deployments are organized below into Traffic, Transit, and Telecommunications subsystems. The source of the inventory items in the table below are attributed in the Source column, either from the Kick-Off Meeting notes, the City's website, or the City-supplied documents.

Device Type		Application Status		
		Current	Planned	Source
Traffic	Advanced Traffic Management Software (ATMS)-TransSuite/TransCore	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	Video Management System for traffic cameras, this is a feature of TransSuite	No	Yes	Kick-off Meeting Oct 25
Traffic	Electronic Parking Payment system	Yes	-	Saskatoon.ca website
Traffic	Highway-Rail Intersection Management System	No	Yes	Kick-off Meeting Oct 25
Traffic	Emergency Vehicle Signal Priority, for signals aside from hardwired outputs at intersections near fire halls	No	Yes	Emergency management System.msg
Traffic	Pedestrian controlled signals	Yes	-	Saskatoon.ca website
Traffic	Dynamic Message Signs	No	Yes	Kick-off Meeting Oct 25
Traffic	Weigh in Motion stations (not in use)	-	-	2900057001r007_C98-Signal Location Map.dwg
Traffic	Aldis/GridSmart Cameras (5 Intersections), fisheye intersection camera	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	Autoscope Cameras (Clarence and College), for video vehicle detection	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	CCTV PTZ Traffic Cameras	No	Yes	Kick-off Meeting Oct 25
Traffic	Matrix Radar Units	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	Traffic Controller-Econolite AS3/2100, AS2 and ASC8000 (deprecated)	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	Traffic Controller-Naztec980 (deprecated)	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx
Traffic	Intelight X3 Controllers	No	Yes	Currently Deployed ITS Devices and Components in Saskatoon.docx
Transit	Transit Management Centre	No	Yes	Kick-off Meeting Oct 25
Transit	BRT Transit Signal Priority	No	Yes	Kick-off Meeting Oct 25
Transit	Fleet Location GPS	Yes	-	GPS in Civic Vehicles and How's My Driving Decals Report.pdf
Transit	Public Transportation Management System (Novus ITS)	Yes	-	Novus ITS Functionality.docx
Transit	Social Media Channels for transit route information	Yes	-	Saskatoon.ca website
Transit	Transit Tracking App for Users, including Next Bus, Route Planning	No	Yes	http://www.cbc.ca/news/canada/saskatoon/city-nod-1-3m-software-future-brt-1.4430851
Telecom	Fibre Optic Corridors	Yes	-	2900057001r007_C98-Signal Location Map.dwg
Telecom	Encom Broadband Wireless Radios (Broadway Ave from 12th St to 8th St+ 8th St+east of Attridge Drive)	Yes	-	Currently Deployed ITS Devices and Components in Saskatoon.docx