RFID Interoperability Best Practice Guideline

Prepared for: Metro Vancouver RFID Interoperability Working Group

2013 July

IBI GROUP

Transport Canada / Transports Canada

British Columbia — Ministry of Transportation and Infrastructure

TransLink

Port Metro Vancouver

Summary

The Metro Vancouver RFID Interoperability Working Group commissioned the RFID Interoperability Best Practice Guideline to provide a valuable resource for public and private transportation agencies in British Columbia and other Canadian provinces that are seeking to deploy applications based on vehicle identification technologies. The guideline includes information regarding existing RFID technologies, industry trends, and strategies for achieving interoperability. It also presents a case study of the Vancouver initiative between TransLink, Transportation Investment Corp., and BC Ministry of Transportation & Infrastructure which are working together to achieve multiple levels of interoperability between Golden Ears Bridge tolling, Port Mann Bridge tolling, and the Weigh2Go BC commercial vehicle program.

RFID is often used for vehicle identification in support of verifying commercial vehicle credentials, granting vehicle access to facilities, and assigning vehicle charges for use of facilities. The vehicle identification is used as a link to access other information needed by the application(s) such as vehicle owner, vehicle characteristics, safety and registration compliance status, and payment account status.

When customers of multiple agencies overlap, there are often opportunities for interoperability to increase overall customer convenience and satisfaction while reducing agency operating cost.

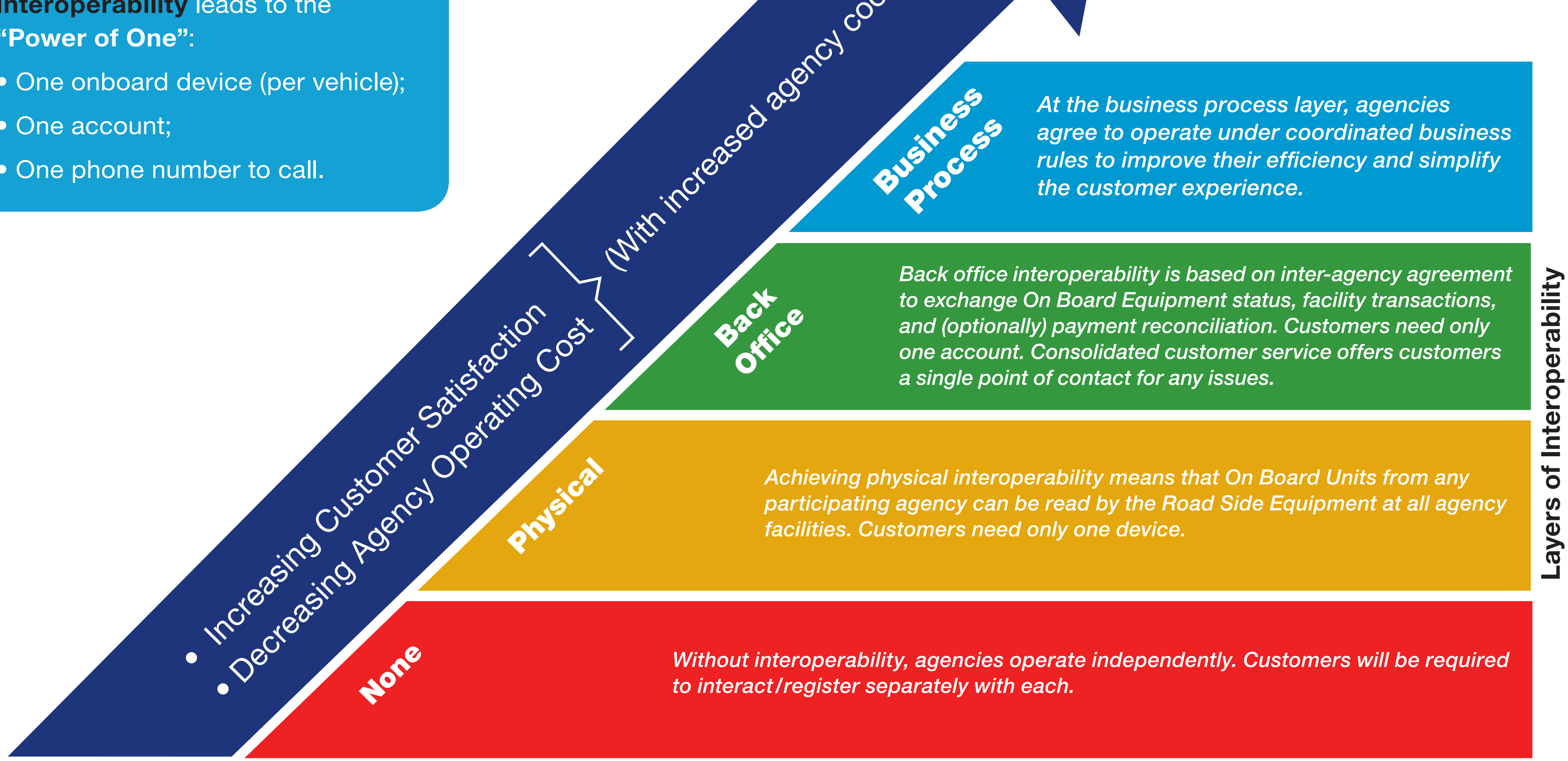
Interoperability can be implemented at the Physical level (using compatible On-Board Units and Road Side Equipment), the Back-Office level (sharing information to widen the base of known customers and sharing administrative resources), and at the Business Process level (coordinating policies or rules to reduce overall operations complexity). Proceeding with interoperability initiatives requires a significant commitment from management, finance, and operations personnel at all of the agencies involved.

Summary

Interoperability for Transportation Agencies Using Vehicle Identification

Interoperability leads to the **"Power of One"**:

- One onboard device (per vehicle);
- One account;
- One phone number to call.



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Glossary of Terms

AEI (ISO 10374)	A protocol for communication between RSE and OBU
ASTMv6	A protocol for communication between RSE and OBU
AVI	Automatic Vehicle Identification - Identification of vehicles without human intervention
AVL	Automatic Vehicle Location - Location of vehicles without human intervention
BC	Province of British Columbia
BC MoTI	British Columbia Ministry of Transportation and Infrastructure
BO	Back Office - The facilities and computer systems that process and store data from field (toll zone) equipment and enable the front, or customer facing, functions
CSV	Customer Service - The facilities and computer systems that enable customer service representatives to deal with customers
DSRC	Dedicated Short Range Communication
FAST	Free and Secure Trade - A border crossing pre-clearance program
GEB	Golden Ears Bridge
GPS	Global Positioning System
ISO 18000-6B	A protocol for communication between RSE and OBU
ISO 18000-6C	A protocol for communication between RSE and OBU

ITS	Intelligent Transportation Systems
LED	Light Emitting Diode
NorPass	A commercial vehicle weight monitoring program
OBU	On-Board Unit (also known as a transponder, tag, or decal) that communicates with RSE
PMB	Port Mann Bridge
PMV	Port Metro Vancouver
PrePass	A commercial vehicle weight monitoring program
RFID	Radio Frequency Identification - Provision of identifying data using radio frequency communication
RSE	Road Side Equipment that communicates with OBU and with a facility host or back-office.
TI Corp.	Transportation Investment Corporation - The entity that owns and operates Port Mann Bridge
Title 21	A protocol for communication between RSE and OBU
TransLink	The South Coast British Columbia Transportation Authority. It owns and operates the Golden Ears Bridge
TReO	Brand name for Port Mann Bridge 6C OBU or decal
Weigh2GoBC	A networked commercial vehicle weight monitoring program in BC
WIM	Weigh In Motion - Device that provides axle weight while vehicle is moving

1.0 Introduction

1.1 Background & Purpose

The development of these Radio Frequency Identification (RFID) Interoperability Best Practice Guidelines was led by the Metro Vancouver RFID Interoperability Working Group. This group was formed in the fall of 2010 as RFID applications for vehicle identification were becoming more widespread across British Columbia; particularly in Metro Vancouver, but also in Alberta and Washington State.

A group of representatives from Transport Canada, Port Metro Vancouver and TransLink began working together in 2008, preparing an environmental scan of RFID technology in the region and in North America. It was clear to these transportation agencies that there was a need for the various parties with an interest in RFID applications for vehicle identification to work together to form and implement a common approach to regional RFID practices. The Working Group's intent is to provide support and guidance to other organizations (public or private) that embark on an RFID project, leading to fewer independent, "stove-piped" technologies and operations.

Metro Vancouver RFID Interoperability Working Group Participants
Transport Canada – ITS Office / Pacific Region;
BC Ministry of Transportation and Infrastructure (BC MoTI);
Transportation Investment Corporation (TI Corp), operator of the Port Mann Bridge;
Weigh2GoBC Program, (within BC MoTI) Commercial Vehicle Safety Enforcement;
TransLink (operator of the Golden Ears Bridge and public transit systems);
Port Metro Vancouver (PMV) as the Port owner / administrator;
TSI Terminal on behalf of all Container Terminal Operators;
Vancouver Airport Authority;
BC Ferries;
BC Trucking Association;
US Customs and Border Protection;
Canada Border Services Agency.

1.0 Introduction

The Working Group convenes regularly to further its stated objectives:

"To develop a migration strategy to achieve RFID from all levels of functional requirements, such as technology and business processes;
To minimize the number of onboard devices as practically as possible, but to respect that individual agencies may have legitimate and compelling business justification to expand the deployment technology components;
To provide a convenient experience for the users/customers of the various systems, as practically and as commercially feasible as possible;
To ensure that each agencies' system complies with the Intelligent Transportation Systems (ITS) Architecture version 2 for Canada guidelines and standards to promote and facilitate interoperability".

On commissioning the RFID Interoperability Best Practice Guidelines project, the Working Group set out the following objectives.

To establish and promote a long term interoperability vision for the deployment of RFID systems in and around the Metro Vancouver region;
To provide guidance for other Canadian cities and regions facing similar interoperability issues when considering multiple RFID system deployments;
To help public and private transportation agencies understand the latest development in the field of RFID technology;
To prepare a Migration Strategy for those agencies interested in participating in an interoperable RFID environment for the Metro Vancouver region;
To provide input to the BC Regional ITS Strategic Plan update; and,
To promote RFID interoperability through this guideline regionally and nationally.

It is emphasized that this document is a guideline, not a mandate. The intent is to provide a resource for public and private organizations in British Columbia and other provinces that are seeking to deploy vehicle identification technologies and may be in need of straightforward information on the existing RFID technology inventory, industry trends, and strategies for achieving interoperability.

Port Mann Bridge, Coquitlam - Surrey, British Columbia

1.0 Introduction

1.2 What is Interoperability?

Interoperability can be defined as:

A common set of processes, procedures and equipment adopted by multiple providers, to support seamless usage for the customer and data acquisition / reimbursement for the provider.

In an interoperable system, a customer can move between similarly-functioned systems owned by different providers, with varying degrees of seamlessness. At the highest level of interoperability, the boundaries between the separately-owned systems are all but invisible to the customer. Various back-end processes and procedures work together to parse the customer's transactions, share appropriate data, provide a unified statement, collect funds, and distribute them to the correct provider. RFID interoperability refers to the ability for vehicles to be identified for various purposes at various locations using a single, but not necessarily common, On-Board Unit (OBU – also known as a transponder, tag, or decal) in each vehicle.

Interoperability is important within the transportation industry, as toll customers and commercial vehicles frequently travel between facilities owned or operated by different public or private entities. When neighbouring facilities are not interoperable, customers are required to have multiple OBU, maintain multiple accounts (for tolling each account may require a minimum pre-paid balance), and deal with multiple bills/statements. Without OBU interoperability, transportation agencies must identify more vehicles via the less dependable license plate method.

Beyond transportation, other examples of customer account interoperability include credit cards and cell phone networks. These industries became interoperable because of customer expectations, and similarly, transportation customers expect that they should be able to have a single account linked to a single onboard device.

Interoperability refers to the **"Power of One"**:

- One onboard device (per vehicle)
- One account
- One phone number to call

The "power of one" has commonly been applied within single applications, such as tolling. However, in British Columbia tolling and weigh scale operators have cooperated to achieve interoperability across applications. In Washington State, tolling and ferry operators are considering interoperability for fare collection. Additionally, many operators desire a more open and competitive vendor marketplace, and this is increasing the demand for standardized, interoperable systems.

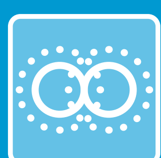
Interoperability is a significant technical, operational, and administrative undertaking. Its implementation should not be taken lightly.

1.0 Introduction

1.3 Who Should Read this Guideline?

You should be interested in this document if you have an operation that makes use of person identification, such as cross-border travel or validating eligibility for a reduced fare payment.

You should pay attention to this document if you have a standalone operation that makes use of vehicle identification, such as commercial vehicle credentialing, vehicle access control, or vehicle-based payment.



You should seriously review this document if you have an operation that makes use of vehicle identification and shares customers with other operations, within the same application or across applications.

2.0 Typical Agencies & Applications Using Vehicle RFID

The agencies and applications have been grouped by primary function as follows:

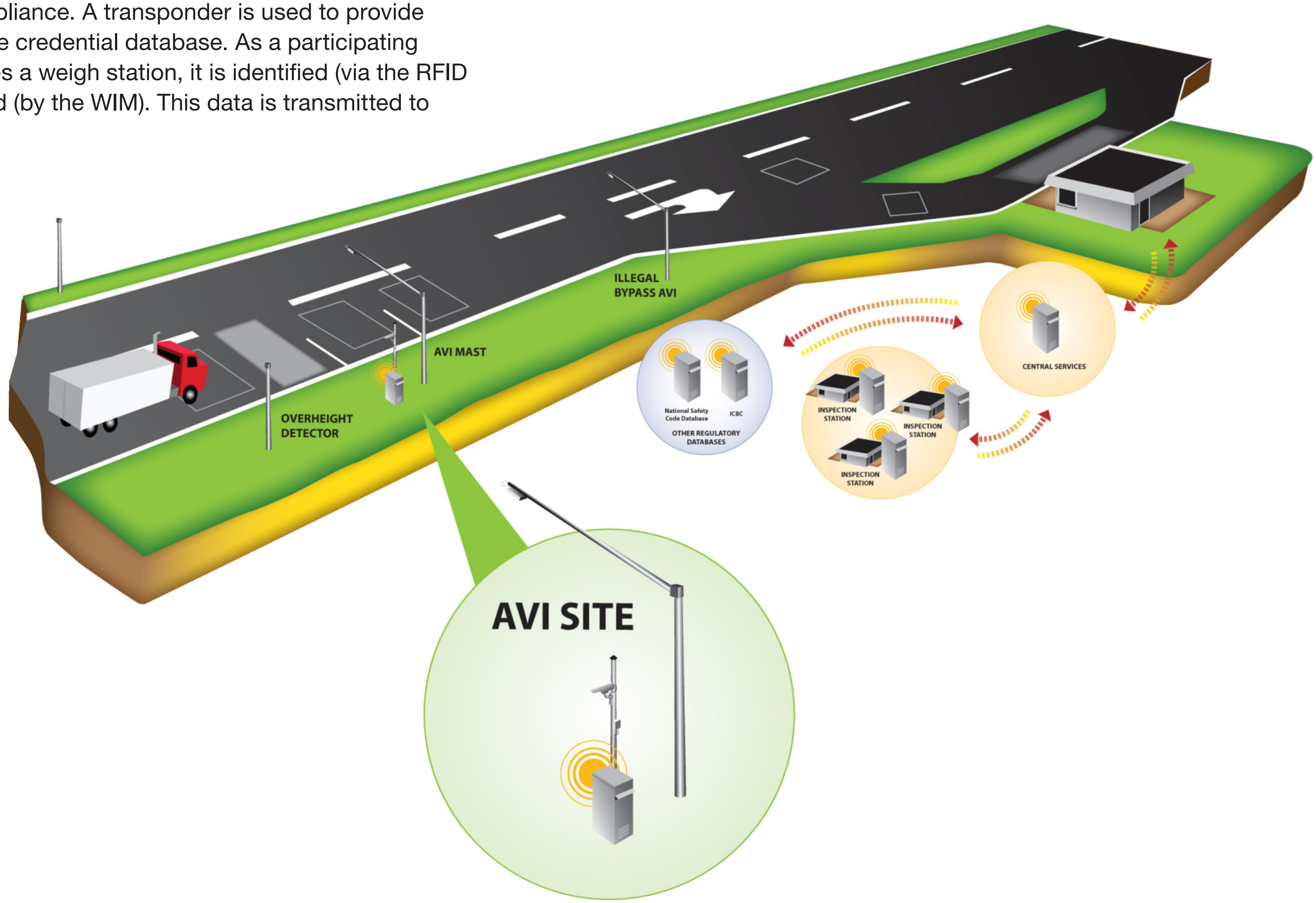
- ***Verifying Commercial Vehicle Credentials***
- ***Granting Vehicle Access to Facilities***
- ***Assigning Vehicle Charges for Use of Facilities***

Examples of agencies and applications within each of these functions are discussed in the remainder of this section.

2.0 Typical Agencies & Applications Using Vehicle RFID

2.1 Verifying Commercial Vehicle Credentials

An early use of RFID technology was related to monitoring compliance of heavy commercial vehicles with regulatory requirements. The combination of RFID vehicle identification and weigh-in-motion (WIM) sensors led to the deployment of weigh station bypass schemes for carriers with a good history of regulatory compliance. A transponder is used to provide a link to the vehicle credential database. As a participating vehicle approaches a weigh station, it is identified (via the RFID OBU) and weighed (by the WIM). This data is transmitted to the local system in the weigh station which checks the vehicle status and sends feedback via the transponder to inform the driver if approved for bypass. A second reader is used to validate the driver action. If a vehicle proceeds improperly, the violation is noted for future enforcement action.



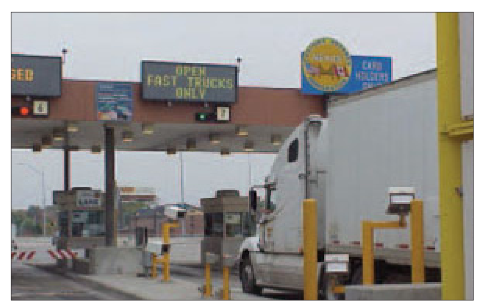
WIM Bypass Scheme

2.0 Typical Agencies & Applications Using Vehicle RFID

Weigh2GoBC, **NorPass** and **PrePass** are examples of programs that are operational. The PrePass program is a public-private partnership between carriers and state/provincial agencies. Carriers are charged a fee for bypassing and the use of a PrePass transponder is proprietary. Weigh2GoBC and NorPass and other similar programs are run by single agencies or groups of agencies that support the concept of interoperability. Each of the programs uses the ASTM version 6 transponder protocol. Weigh2GoBC has implemented back office interoperability with Alberta's PIC Program and Washington State.

W2G Transponder

Another major transportation application is at the border between Canada and the US. Under the **Free and Secure Trade (FAST) program**, three elements must come together – the driver, the vehicle, and the cargo. Each driver must enroll and be accepted. Each carrier/vehicle is also vetted and accepted into the program. The cargo for an individual passage is linked with the driver and vehicle and the vehicle is allowed to use a designated lane at the border crossing, generally with faster transit times. The program uses ISO 18000-6B transponders. Both Canadian and US border agencies operate this program. Given the nature of this application, there is interoperability between Canada and US at the transponder and back office levels.



FAST Program - U.S. Customs and Border Protection

2.0 Typical Agencies & Applications Using Vehicle RFID

2.2 Granting Vehicle Access to Facilities

Almost every vehicle access control scenario (barrier gate or garage door) has been implemented using the signal from a transponder to identify the approaching vehicle. The applications vary from low security and revenue situations like exiting a public garage, to more secure facilities such as airports and ports. Both public agencies and private companies have deployed and operate these types of systems. Generally they are standalone systems with the choice of technology based mostly on cost and not interoperability. Images of various deployments are provided below.

Access Control Systems

Gate Contactless entry and exit (Keytag)

Barrier Gate System

Wireless Gate (Schlage)

Access Control

2.0 Typical Agencies & Applications Using Vehicle RFID

2.3 Assigning Vehicle Charges for Use of Facilities

Tolling or road user charging is the largest application of RFID vehicle identification with millions of RFID OBU in service around the world. In these applications, the transponder is linked to an account which accumulates customer charges over time and possibly across multiple vehicles. Customers must pay their account according to the business rules of the issuing agency (ranging from mandatory pre-paid balance with pre-authorized credit card or bank replenishment to walk-in post-paid cash. Typical examples include:

Managed Lanes: *Some managed lane applications charge specific vehicles for use via RFID OBU. "Switchable transponders" that allow drivers to declare their HOV status in support of differential pricing have recently been introduced (Los Angeles on I-110 and I-10; Washington on I-495).*

Tolled Bridges and Highways: *Almost every toll bridge or highway in North America uses RFID technology to collect tolls. Vancouver area examples include the Port Mann and Golden Ears Bridges.*

Congestion Zones: *Singapore has implemented its cordon pricing program using RFID transponders.*

Variable Rate Toll Lanes, Los Angeles

FasTrak Transponder

Congestion Pricing, Singapore

2.0 Typical Agencies & Applications Using Vehicle RFID

Ports: *Pier Pass in Los Angeles and Long Beach are two examples of demand management by time of day for entry into a port to reduce emissions and traffic.*

Airport Ground Side: *Many airports, such as Sea-Tac, Portland International and Vancouver, use RFID to track taxi and shuttle access.*

Parking: *Several tolling programs (e.g. Halifax Harbour Bridges, North Texas Turnpike Authority, Atlantic City Express) allow the use of tolled highway program transponders as a means of parking payment, generally at airport facilities.*

Ferry Fare: *North Carolina is studying the integration of the ferry system with the road toll system so that transponder accounts will be valid for both. The Tamar Bridge and Torpoint Ferry in Plymouth England have integrated RFID transponder based charging.*

Golden Ears Bridge Tolling System, British Columbia

3.0 Vehicle Identification Alternatives

Once a public or private agency has recognized the need to identify vehicles as part of its business model, a decision must be made as to how vehicles will be identified and what types of information will be collected. This section describes identification alternatives.

3.0 Vehicle Identification Alternatives

3.1 Customer Declaration

Perhaps the simplest and oldest form of identification is self-declaration by each customer. The customer interacts with the application system via an attendant, a kiosk, telephone, internet, or a smart phone app in order to provide some identifying information. Examples include "pay-on-foot" parking, pay via phone parking (available in Vancouver), and traditional attended lane toll plazas. In general, self-declaration transactions are more complex and require more time than electronic transactions. Thus, they are typically limited to applications where the vehicle is not in motion.

There is a hybrid toll model in which customers self-declare their vehicle license plate and payment information; then proceed to use a toll facility with video or image identification (see next section).

3.2 License Plate Image

License plates are the original vehicle identification device. They are unique to each vehicle and are inherently interoperable as no electronic protocols are required to read them. Unfortunately, electronic identification of vehicles via license plate is a difficult process. Issues are:

Rear and/or front plate images may be required;
Plate must be visible – often obscured due to weather, bicycles, trailer hitches, other vehicle occlusion, or willful obstruction;
Unique identification requires primary alpha-numeric characters, jurisdiction, and often type (via background picture);
Background, font, colour, and contrast vary widely;
Owner registration databases may not be accessible or may require a fee for some jurisdictions. The data itself may be out of date.

When the electronic process fails, human intervention is applied. However, there are always vehicles that cannot be identified. As result, few agencies presently depend on license plates as the primary means of vehicle identification.

3.0 Vehicle Identification Alternatives

Ongoing initiatives that have the potential to improve license plate identification performance include:

A large bar code embedded on the plate and visible in the infrared spectrum only would be readable in more conditions and provide truly unique identification;

The Alliance for Toll Interoperability "Hub" concept aims to mitigate issues related to accessing the owner registration database across jurisdictions.

Typical License Plate Image

3.3 RFID On-Board Unit

The most common method of automatic vehicle identification (AVI) is via an on-board unit (OBU); also known as a transponder, tag, or decal, using radio frequency to transmit an identification code from the OBU to roadside equipment (RSE) consisting of antenna(s) and reader(s). In North America, these devices have historically operated in the 900 MHz radio frequency band using various dedicated short-range communication (DSRC) protocols. Unfortunately, each of these protocols is standalone and in some cases proprietary. Scenarios to support interoperability are presented in Section 5 of this document.

Many agencies wish to write and read additional information to/from the OBU. The amount of data that can be exchanged is constrained by the communication data rate (about 250 kilobits/sec at 900 MHz), the range of transmission (can be up to 100m, but is commonly limited to about 10m to facilitate mapping of tag read with detected vehicle), and the maximum vehicle speed (typically 140kph).

The 5.9GHz radio frequency band is now available for transportation applications and a few agencies have implemented RSE and OBU using it. It is likely to become more common as "Connected Vehicle" applications advance. This offers much greater communication bandwidth due to higher speed and longer range.

3.0 Vehicle Identification Alternatives

Beyond the different protocols, transponders have additional common characteristics:

Active or Passive – Various definitions exist, but in general "Active OBU" have a battery and an internal transmitter; "Passive OBU" have neither and depend on the reader's electromagnetic field for power. In-between is "Semi-active (sometimes called Semi-passive) OBU" which have a battery to power the processor and possibly the memory, but do not have an internal transmitter.

Write capability – Historically, it was considered that active OBU were suitable for accepting and storing information (often a location / time code) from a reader during a highway speed toll transaction, but passive OBU could only be written to in stopped or low speed environment. However, vendors are now testing passive OBU with stated highway speed read & write capability.

Feedback – Some OBU provide audible and/or visual feedback to drivers. Generally, a battery OBU is required for feedback capability.

Life – OBU with internal batteries are typically limited to the life of the battery which is defined by overall time and number of transactions; commonly 5 to 10 years. Batteries are not usually replaceable. Passive OBU can theoretically last forever, but in most cases they are destroyed when removed from a windshield due to windshield replacement or vehicle ownership transfer.

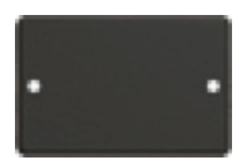
Cost (2013 values) – OBU purchase cost can range from $1 for passive types in large quantities to $60 for active types in smaller quantities. OBU incorporating GPS and other logic can be $100 or more.

3.0 Vehicle Identification Alternatives

The following table summarizes the various RFID protocols and applications in use in ***British Columbia***.

Protocol	Application	Example
ASTM v6	Weigh2GoBC transponders, consistent with use throughout North America. Port Mann Bridge and Golden Ears Bridge use tri-protocol readers that include ASTM v6. ASTM v6 transponders typically cost $30 to $60. They are presently provided to BC based carriers at no charge. Weigh2GoBC presently has a limited quantity of transponders available for BC based carriers at no charge.	Source: BC MoTI 
AEI (ISO 10374)	Rail car identification system used throughout North America.	Source: TransCore 
ISO 18000-6B	FAST border initiative between US-Canada, US-Mexico - enhances trade flow and security to identify low-risk commercial vehicles by using eGo tags and RFID embedded FAST ID cards. NEXUS border initiatives - enhance border crossing time for low-risk area residents/frequent travellers between US-Canada borders using ID cards embedded with ISO 18000-6B compliant RFID. 18000-6B tags purchased for toll collection applications have TYPICAL cost in the range of $5 - $7.	Source: CBSA FAST EXPRES CUSTOMS DOUANES NEXUS IMMIGRATION

3.0 Vehicle Identification Alternatives

Protocol	Application	Example
ISO 18000-6C	Port Mann Bridge TReO decals for toll collection. Readers are multi-protocol for Title 21 and ASTM v6 as well. There are also several applications in BC using 6C for identification of persons. 18000-6C tags can be purchased for less than $3 with large quantities as low as $1.	Source: TI Corp 
Title 21	Golden Ears Bridge Quickpass transponders for toll collection. Readers are multi-protocol for ISO 18000-6C and ASTM v6 as well.	Source: TransLink 
2.45GHz	Used by Vancouver Airport to record the number of taxi trips to the airport terminal.	Source: TagMaster 

3.0 Vehicle Identification Alternatives

The predominant RFID protocols used in the Metro Vancouver region are ISO 18000-6C (decals issued by Port Mann Bridge), Title 21 (transponders issued by Golden Ears Bridge, and ASTM v6 (transponders issued by Weigh2GoBC) with all three protocols being read on each bridge. Appendix A provides a detailed case study of the interoperability initiative between these three British Columbia agencies.

3.3.1 Infrared On-Board Unit

An additional form of OBU used for vehicle identification is based on infrared, rather than radio frequency communication. Some infrared OBU use a contactless smart card inserted in the unit to provide an identification number. Infrared has been used for toll collection, and also has applications for airport parking and vehicle-to-vehicle and vehicle-to-roadside communications. AVI using infrared is not currently used in British Columbia and is generally not common in North America.

Example IR OBU with Smart Card Source: EFKON

4.0 Vehicle Related Information

Vehicles are identified in order to look up related information. Interoperability concepts extend beyond vehicle identification to include which data are shared, the method of sharing, and the frequency of sharing. For the applications presented in Section 2, typical vehicle related information includes:

- *OBU (vehicle) status – eg. valid / invalid for specific application, on a security watch list;*
- *Vehicle characteristics – eg. size, axles: often mapped to a category;*
- *Vehicle license plate – for possible validation with images;*
- *Account – generally for accumulating data for multiple vehicles;*
- *Owner / operator / responsible person with contact details;*
- *Transaction record – location and time of each passage or access;*
- *Account balance and payment history when applicable;*
- *Commercial vehicle approval status – e.g. clearance certificates, last weigh station results;*
- *Goods / Trailer Manifest.*

4.0 Vehicle Related Information

When two agencies consider interoperability, they should review their respective information needs and balance these against the customer and agency privacy mandates. There will likely be information that falls under each of the following three approaches to sharing.

4.1 Private

In general, customers will desire, and agencies will be legally required, to keep most customer details private and confidential. This includes security applications such as border security agencies, commercial vehicle operators with sensitive cargo, secure facilities like the port, airport, etc. It also includes toll customer payment information such as credit card and banking data.

Other agencies may simply wish to maintain data privacy for competitive reasons. For example, a Commercial Vehicle Operator that uses in-vehicle RFID to identify their vehicles at their own facilities may not wish to share.

Secure facility check

Private Operator

4.0 Vehicle Related Information

4.2 Shared

This does not mean that information cannot be shared in the interest of interoperability. For tolling applications, it is common to keep the customer details private, but share registered OBU numbers, status, and possibly vehicle characteristics. Thus, when an agency sees an OBU not registered in its own database, it will know if it is an OBU registered with the interoperable agency. The OBU status can be used to determine how the vehicle passage is processed. The interoperable agency does not require the customer details such as account payment information. Similarly, commercial vehicle credential programs can share vehicle approval status without sharing underlying details.

If an agency determines that they want to share data with another partnering agency then typically both parties would enter into a formal agreement. The purpose of structuring a formal agreement is to flush out the policy, contractual terms and conditions and the financial terms and conditions for both entities. Customer agreements may also need to specify the inter-agency sharing that will occur. The agencies should also agree on data sharing format, method, and frequency. The OmniAir EPSNIS specification is a recent initiative to facilitate back-office data sharing.

There are benefits to both the customer and toll road operator when exchanging information with a partnering agency. For tolling, these include providing customers the convenience of registering their vehicle with one toll road agency and gaining access to multiple toll roads and facilities, all with a combined account billing. Agencies have fewer vehicle transactions to process via license plate identification reducing operation costs.

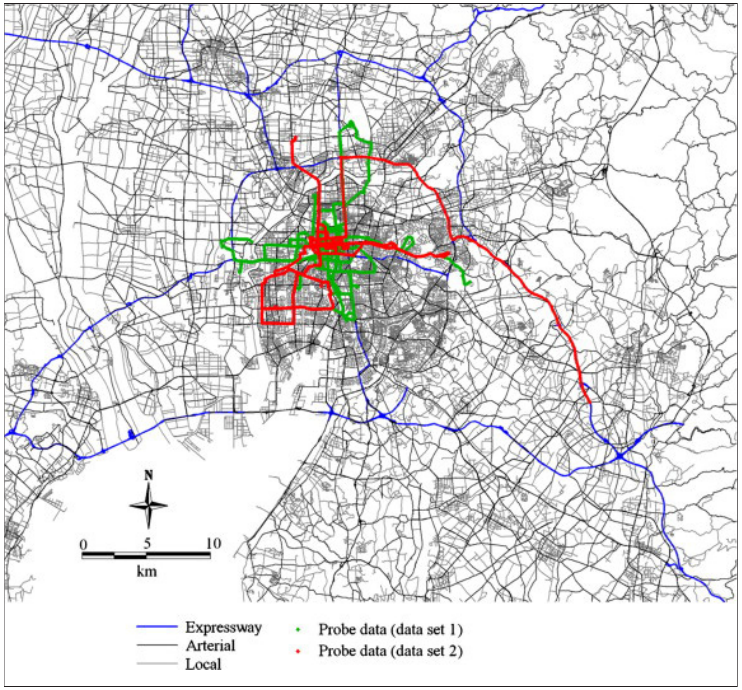
Data Form

4.0 Vehicle Related Information

4.3 Public Domain

There is not really any customer specific information that would typically be considered public. However, agencies may provide aggregate information / data to the public domain for the purpose of education, research, public use, data warehousing, and crowdsourcing.

An agency that chooses to publish aggregate information collected via RFID will have a business, operational, and/or public security, or safety reason. For example, a government agency such as the Ministry of Transportation may choose to share its vehicle probe data (tracking of automatic vehicle locator – AVL using RFID) to disseminate road network travel times to the public. The data from specific probe vehicles will not be directly available to the public, nor will any data points be tracked individually or linked to specific individuals. However, probe vehicle data can be used to influence the public's decision on routes travelled, assist businesses with their operations, and public agencies with monitoring and operating their road network.



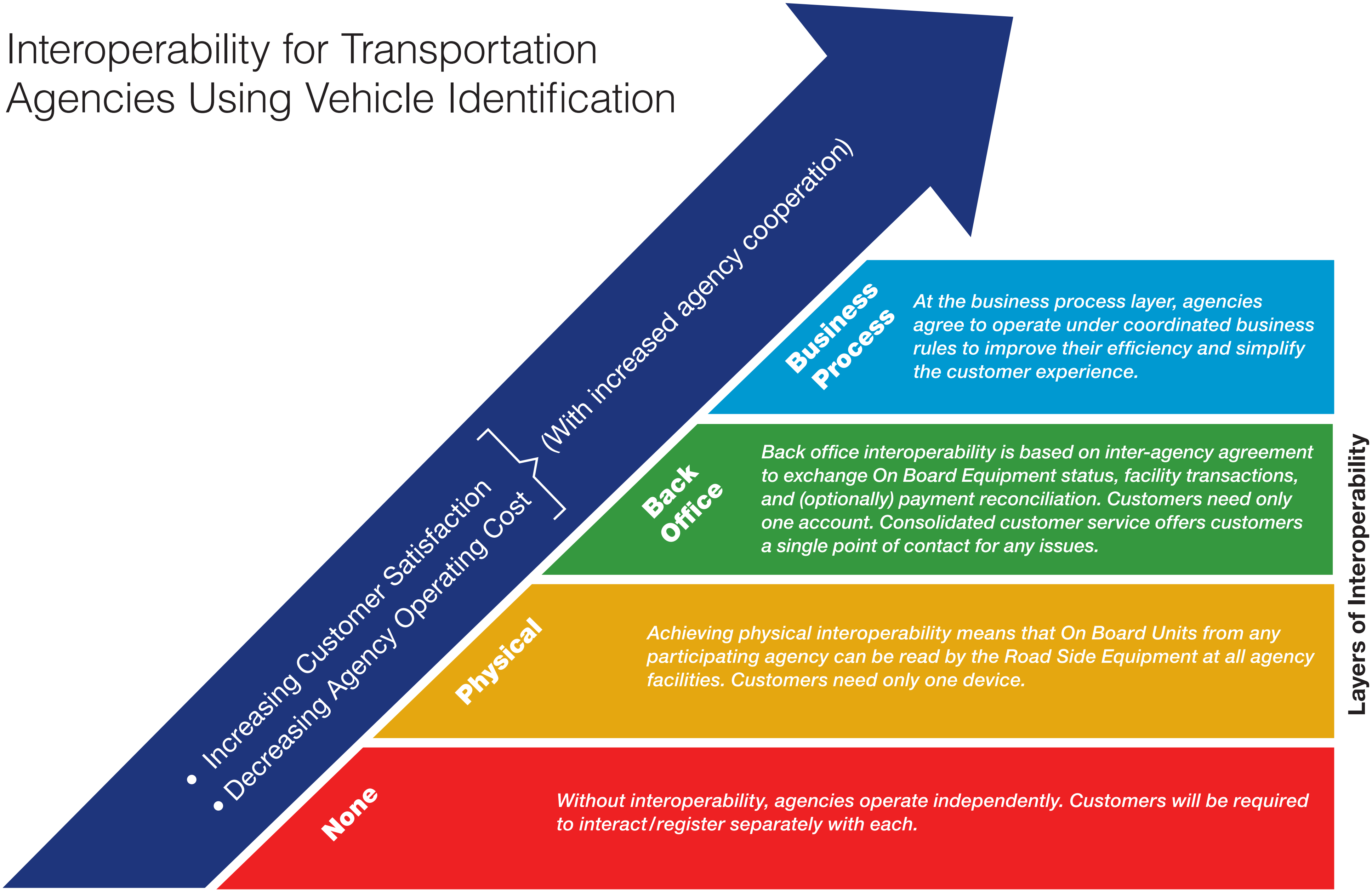
Aggregate Data

5.0 Interoperability Implementation Scenarios

The previous sections have described typical users of AVI technology, the technologies involved, and the data that can be collected and shared between partnering organizations. This section describes alternatives for implementation at each layer of interoperability.

5.0 Interoperability Implementation Scenarios

Interoperability for Transportation Agencies Using Vehicle Identification



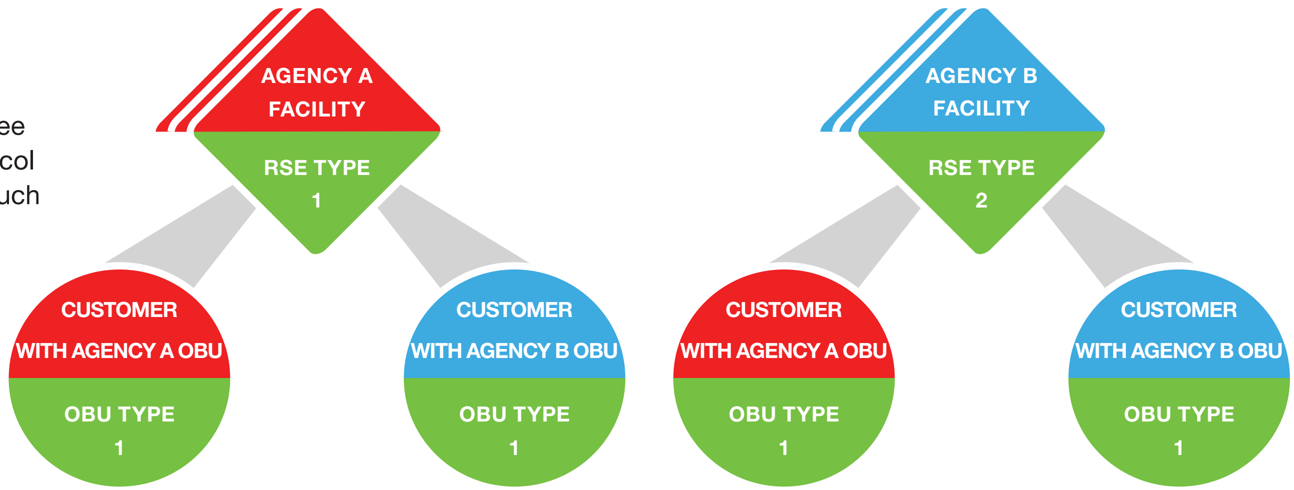
5.0 Interoperability Implementation Scenarios

5.1 Physical Interoperability

Four physical interoperability scenarios are presented. Schematics are shown for two agencies, but actual scenarios could be expanded to any number of agencies.

1. Single Protocol RSE and OBU

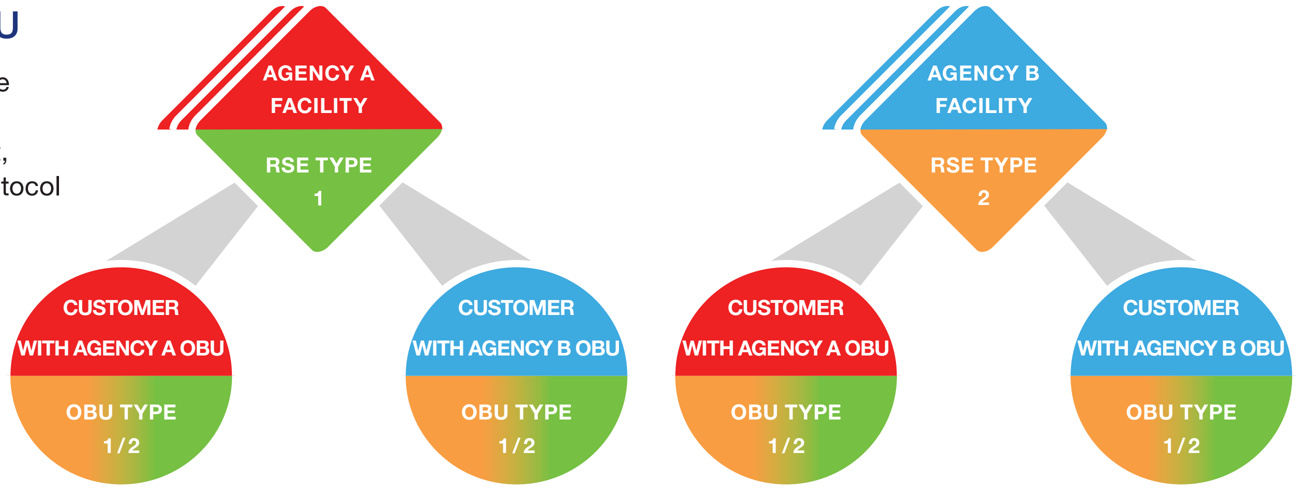
The partnering agencies agree to use the same single protocol OBU and RSE technology, such as 18000-6C.



5.0 Interoperability Implementation Scenarios

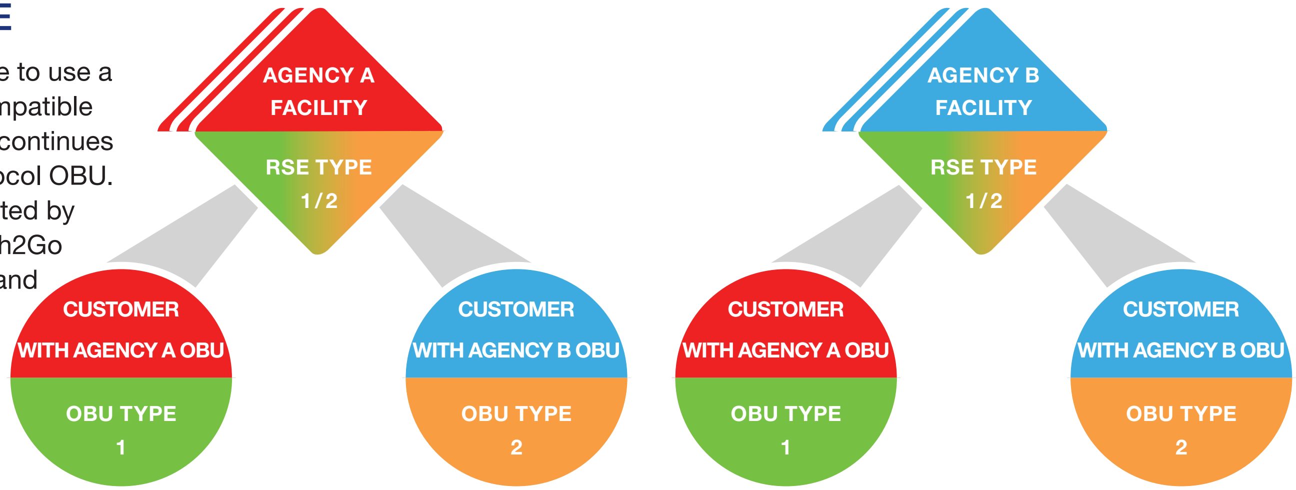
2. Multi-protocol OBU

The partnering agencies agree to use a multi-protocol OBU compatible with their different, single-protocol RSE. Dual protocol OBU are in use. Capability for more than two protocols in a programmable device (smart phone) may be coming.



3. Multi-protocol RSE

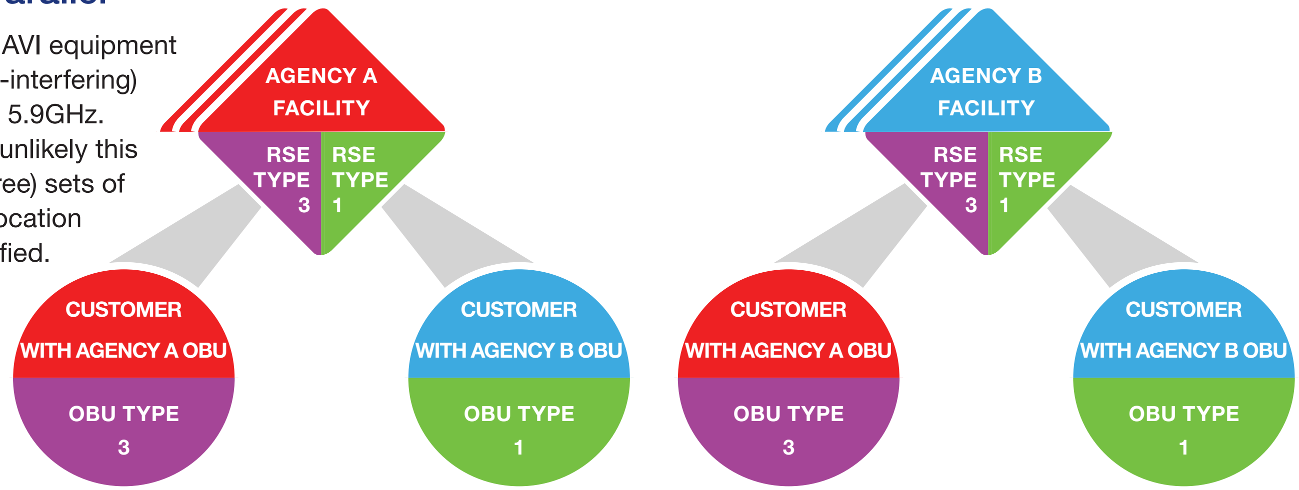
The partnering agencies agree to use a multi-protocol RSE that is compatible with each type of OBU. Each continues to use a different, single-protocol OBU. This is the scenario implemented by TI Corp., TransLink, and Weigh2Go BC for the Port Mann Bridge and the Golden Ears Bridge. It is an early implementation of triple-protocol capability. Three protocols is generally accepted as a present technological limit.



5.0 Interoperability Implementation Scenarios

4. Two Protocols in Parallel

Each agency agrees to install AVI equipment that operates at different (non-interfering) frequencies, e.g. 915MHz and 5.9GHz. They agree to install two (it is unlikely this would ever be extended to three) sets of roadside equipment at each location where vehicles must be identified. In a channelized lane environment, there could conceivably be separate lanes dedicated for each type of RSE with customers having to use the proper lane for their OBU.



Historically, multi-protocol equipment has been limited to two concurrent protocols. Recently, triple-protocol equipment has become available and the Vancouver Port Mann Bridge and Golden Ears Bridge are the first such implementation.

If interoperability is limited to physical only, customers must register for the applicable service with each agency independently. In the schematics for scenarios 1 to 4, all customers would become Agency A and Agency B customers. For tolling, there will be separate accounts with each agency, each requiring separate billing and in some cases, separate pre-paid account balances. If a customer does not register with an agency, then that agency has to process the customer via license plate identification, leading to extra cost and greater potential for lost revenue.

Achieving physical interoperability will often require at least one agency to migrate from its existing technology / protocol. In some cases, the migration impact on customers and/or the agency's facilities may be a major factor in the selection of physical interoperability scenario. Agencies with many facilities or facilities with many vehicle lanes should consider the impacts of allowing old and new technologies / protocols to co-exist during a migration period.

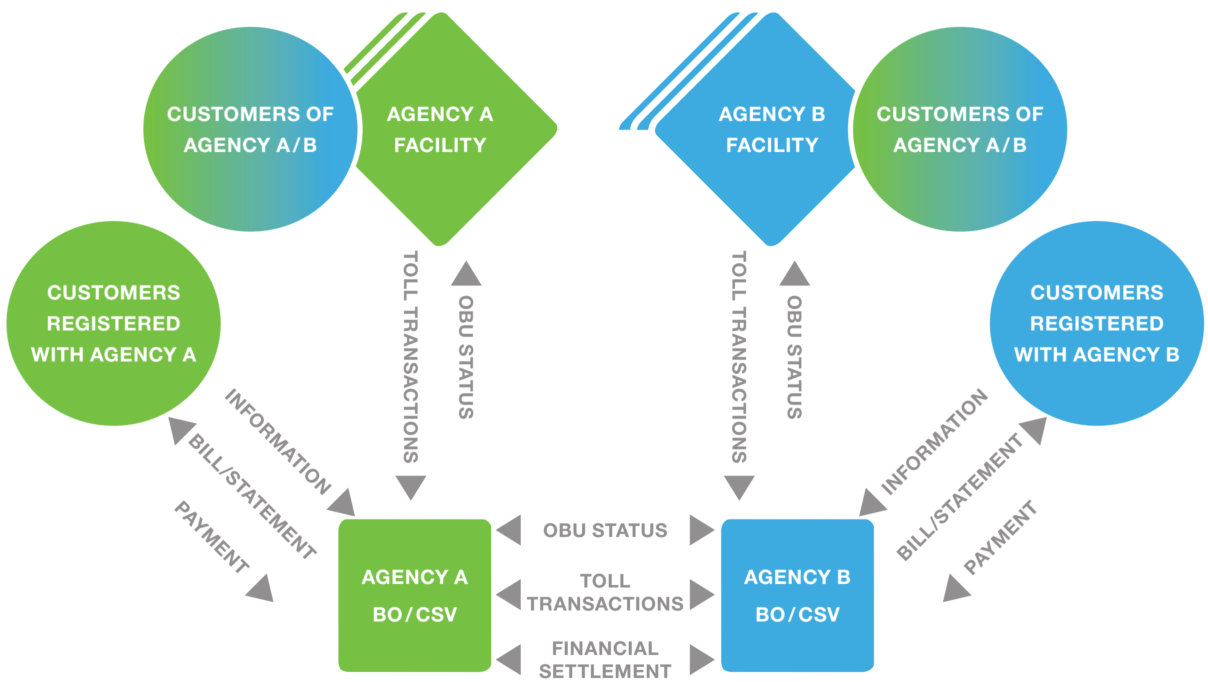
5.0 Interoperability Implementation Scenarios

5.2 Back Office Interoperability

Back office interoperability builds on physical interoperability to reduce the burden on both the agency and the customer by enabling automatic identification and charging of a customer that is registered at any facility, without the need for separate registration and accounts. There are three scenarios under which this may occur:

A. Multiple Back Office and Customer Service/ Peer-to-Peer Connection

Agencies each maintain their own back-office and customer service operation. They agree to share OBU status and transactions to enable identification and billing of customers from any agency at all facilities across all agencies. They also agree to a financial cross-agency settlement procedure. Data is exchanged through a customized request/response interface on a peer-to-peer basis between all agencies' systems. Customers receive one bill or statement from the agency they are registered with that includes transactions across all agencies. E-ZPass in the northeast United States is a major example of this type of back-office interoperability.



LEGEND:

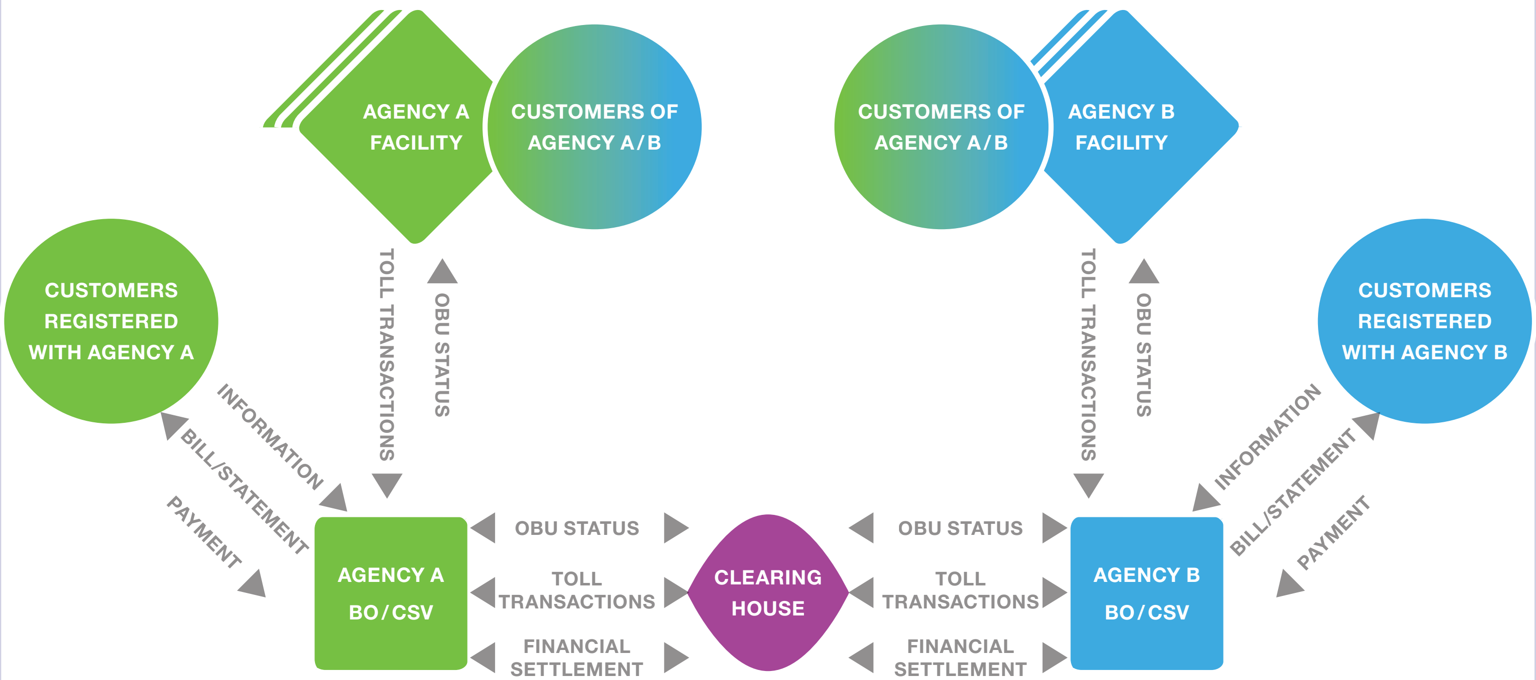
BO- BACK OFFICE

CSV- CUSTOMER SERVICE

5.0 Interoperability Implementation Scenarios

B. Multiple Back-Office and Customer Service / Clearinghouse Connection

As above, agencies each maintain their own back-office and customer service operation. Instead of the multiple interfaces required in a peer-to-peer exchange, agencies implement a clearinghouse that serves as a functionally independent entity for exchanging customer and transaction data. In some instances, the clearinghouse will also manage the exchange of funds between agencies. The clearinghouse is often provided by an independent company to maintain neutrality between agencies, but it can be provided by one of the partnering agencies. Customers receive one bill or statement from the agency they are registered with that includes transactions across all agencies. In Ireland, this scenario is used with an entity known as the Information Exchange Agent as the clearinghouse.

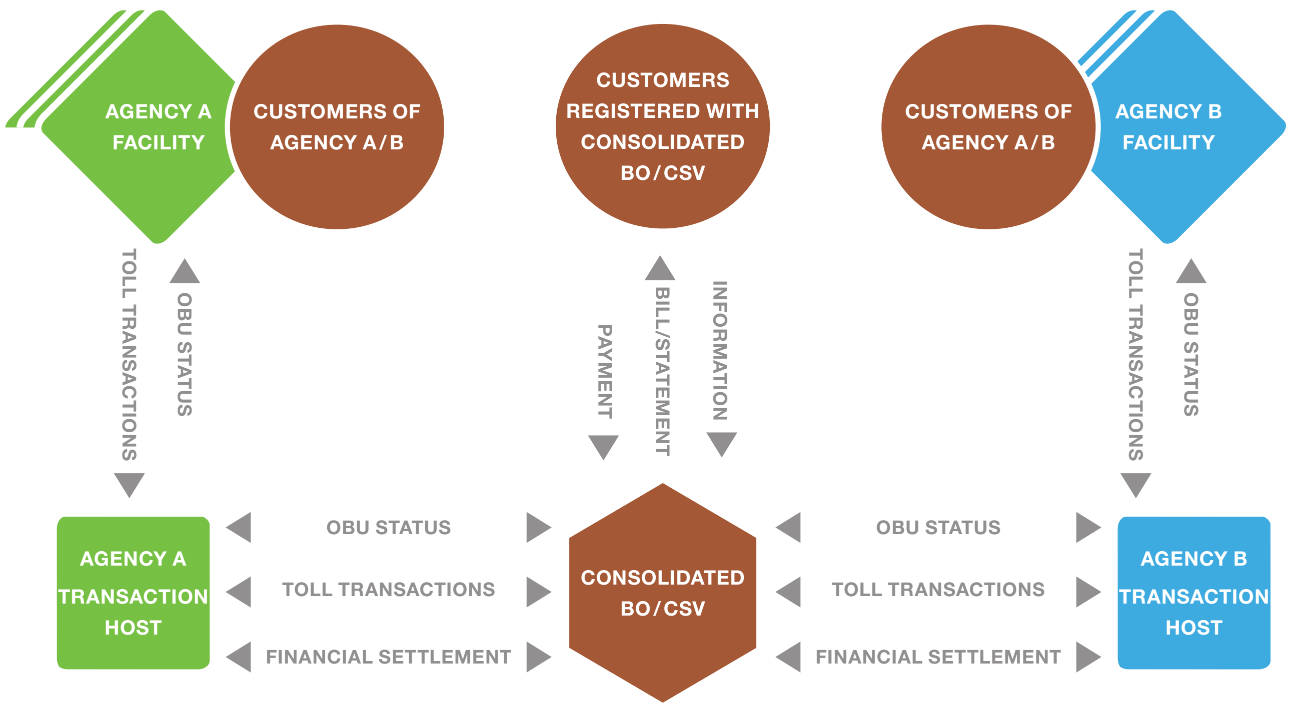


5.0 Interoperability Implementation Scenarios

C. Consolidated Back-Office and Customer Service

In this scenario, the agencies do not maintain independent back-office and customer service operations. Instead, all back-office and customer service functions are provided by a common, functionally independent, entity. Each agency will maintain a host system to aggregate data from its facilities and communicate with the consolidated system. Customers will register with, receive bills from, and make payments to the consolidated entity. The primary rationale for this scenario is the economies of scale available.

This is the model in Washington State where there is a single statewide customer service center (all facilities are owned by the state Department of Transportation) and in the State of Virginia where public and private facility owner/operators all use a state run back-office and customer service organization.



5.0 Interoperability Implementation Scenarios

5.3 Business Interoperability

The models of interoperability described in Sections 5.1 and 5.2 all have leeway for interoperable agencies to operate with individual policies, procedures, customer agreements, and fee structure. Although customers have a single device and a consolidated bill / statement, they must be familiar with the "fine print" of each agency, e.g. vehicle categories, pricing strategies, etc. Business interoperability is achieved when agencies move to common procedures and rules.

This may be relatively easy to attain in situations where a new facility is being deployed in a region with an established program, and the new facility can benefit from adopting already-successful and well-known rules. It is more difficult when two established agencies attempt to merge their rules. For example, some or all of the following may require intense customer interaction:

- Rationalizing different customer account types and definitions (public, private, commercial, etc.);
- Rationalizing different fees and discounts;
- Rationalizing different procedures for billing and collecting on delinquent accounts;
- Rationalizing different fees for OBU distribution.

5.4 Governance / Institutional Framework

Achieving cohesive interoperability between agencies requires good governance and a proper institutional framework. The process for adopting or establishing interoperability should be clear, consistent and transparent so that all agencies can understand the barriers and benefits.

Four key areas should be defined when structuring a governance/institutional framework. These include management and operations of the interoperability services, ongoing maintenance of the interoperability services, support changes to the operational rules of the interoperability agreement, and cost of the interoperability services. Each of these areas is described below.

5.4.1 Management and Operations

Each agency needs to consider how their management and operations will be affected by the establishment of an interoperability scheme. Each agency has to determine which of their services could be offloaded to a partner operation in order to provide savings through reduced operation costs. Along with these items, the agency also needs to determine if their decision will have any labour or institutional implications that need to be handled sensitively.

Interoperability between a public and private agency can have implications in terms of customer perception, and the possibility that a public agency exposes itself to risk by exchanging information with a private agency.

5.0 Interoperability Implementation Scenarios

If one agency handles the customer facing aspects of the interoperability service then the agency should determine how it will manage the additional revenue risks. For example, each operator will have to assess its revenue risk for allowing one agency to pursue customers for non-payment and breach of contract.

5.4.2 Maintenance

Each agency needs to carefully consider the implications on its own staffing and processes and what will be needed to support the ongoing maintenance of the interoperability services. These include third party software systems, hardware, established processes, staff for management, IT and day to day operations, consensus and policy building with partner agencies.

5.4.3 Support Changes to Interoperability Business Rules

There may be new business rules or changes to existing business rules during the life of the interoperability agreement. Each agency should be ready to participate in the development of new working agreements to reduce the potential for negative operational and cost impacts on their agency and customers.

5.4.4 Cost of Interoperability Services

Depending on the framework, costs related to interoperability may include capital costs for roadside equipment, service centres and back-office equipment, and/or per-transaction processing costs for a clearinghouse, as well as ongoing operations and maintenance costs. Depending on the agency's business model, the costs could be passed through to the customer or absorbed as part of their operation. The agency will need to assess these costs and determine the impact and value.

6.0 Benefits & Implications

The previous sections have described the various technologies and operational frameworks under which interoperability can be established between partnering agencies/operators who have overlapping customers and/or data sharing needs. The purpose of this section is to summarize the regional implications, benefits, and drawbacks associated with each layer of interoperability; recognizing that there are implementation complexities and costs, there are significant customer convenience and agency benefits.

6.0 Benefits & Implications

6.1 Independent Operation

Independent operation is essentially the "do nothing" option. The agencies have limited communication and opt to not pursue interoperability although it is recognized that they likely have some shared business objectives in terms of customer identification and data sharing.

Regional Implications	Benefits	Drawbacks
Number of incompatible AVI protocols and technologies in the region can continue to grow, limited only by the number of technologies in the marketplace.	No incurred cost of interoperability (Agency) Each agency maintains autonomy over technology selection and policy choices (Agency)	Negative public perception regarding agencies' ability to work together (Agency) Significant customer inconvenience as customer is required to activate and maintain multiple accounts and OBU (Customer) Agencies must independently pursue customers for account establishment and payment enforcement (Agency) Lost opportunities for knowledge transfer as a result of partnering with a "been there, done that" agency who has already deployed AVI. (Agency) Lost opportunities for cost savings through multi-agency joint equipment procurements. (Agency)

Multiple OBU

6.0 Benefits & Implications

6.2 Physical Interoperability

Physical interoperability refers to the OBUs and RSEs that communicate at the roadside to identify the customer's vehicle. Physical interoperability can be a relatively simple way for an agency that is "new" to AVI to quickly integrate with other existing operators in the region.

Regional Implications	Benefits	Drawbacks
As more agencies come online with AVI/RFID technologies, a critical mass towards certain preferred technologies begins to form.	A less-cluttered windshield, as customers need only one OBU for their vehicle. (Customers) Opportunity to piggyback on regional equipment procurements (Agency) Promotes good working relationships and demonstrates cooperation between agencies (Agency)	Can potentially result in an agency needing to swap out existing equipment before its useful lifecycle is up, in order to accommodate preferred regional technologies. (Agency) Customer will still need to maintain separate accounts with each operator. (Customer) Agencies must independently pursue customers for account establishment and payment enforcement (Agency)

6.3 Back Office/Customer Service Centre Interoperability

Back office interoperability refers to agencies exchanging data enabling automatic identification and charging of a customer that is registered at any facility, without further action by the customer. This is accomplished by either sharing information (peer-to-peer or clearinghouse) or consolidating into a single back-office. Back office interoperability builds on physical interoperability.

Regional Implications	Benefits	Drawbacks
Agencies recognize opportunities to increase customer convenience (single account) and agency automation by agreeing to exchange relevant data.	Customers need only one account. (Customer) Division between agencies is invisible to customer, their experience is not changed. (Customer) Agencies maintain autonomy implementing their own policies (unless consolidated back-office). (Agency) Reduce steps and increased accuracy in obtaining identifying information for customer which may reduce costs. (Agency) Opportunity to piggyback on regional equipment procurements (Agency) Promotes good working relationships and demonstrates a high level of cooperation between agencies (Agency)	Agreement required between agencies detailing data exchange requirements. (Agency) Depending on model selected, data exchange process can be cumbersome. (Agency) Additional costs for managing data exchange network and processes. (Agency)

6.0 Benefits & Implications

6.4 Business Process Interoperability

Business process interoperability refers to a single set of business rules, policies and procedures that applies across all agencies. Business process interoperability would generally only be implemented if a shared back office and customer service centre were already in place; however, it would also be possible for a new agency to "piggyback" on an existing business structure if the agency felt the benefits of interoperability would offset the loss of autonomy.

Regional Implications	Benefits	Drawbacks
A regional "standard" for AVI business rules is rare, and would put Metro Vancouver and the Working Group at the forefront of this area of interoperability. As business process interoperability is not a minor undertaking, the partnering agencies would want to pursue legislative support to ensure that future operators would be compelled to participate rather than "undoing" the effort by operating under their own rules and policies in the region.	Division between agencies is invisible to customer, their complete experience is streamlined and they can expect the same service from any agency. (Customer) Eliminates the sometimes endless back-and-forth of establishing rules and policies for a new operation if there is an accepted process baseline for the region. (Agency)	Requires a significant time investment in consensus-building and detailed process definition across agencies. (Agency) Agencies lose some autonomy and may be somewhat constrained in the types of accounts, penalties, discounts, etc., that they can offer. (Agency) Issues are magnified as number of disparate agencies attempting to merge their separate operations increases. (Agency)

7.0 Best Practices and Lessons Learned

Establishing and maintaining interoperability can be challenging. For established operations, this can be an onerous task of revamping every step of their customer management and collections processes, and also the surrender of some autonomy. For new operations, adhering to an existing interoperable framework is easier, but the framework must be clear and in-line with current technology as well as flexible to accommodate changes in operations policies and/or technology.

7.0 Best Practices and Lessons Learned

For interoperability, no single solution will fit each situation. Several agencies have worked through what they believe works best for them. Regardless of whether you are implementing a new RFID based vehicle identification system or migrating from an existing system, the following are important interoperability considerations:

a.	Do not underestimate the time/effort required to define and implement an interoperability strategy.
b.	A working group/committee/management team is required to define, implement and monitor the interoperability strategy/solution.
c.	For certain interoperability models, on-going management/oversight is required to ensure the desired performance is maintained at a reasonable cost (e.g. consolidated customer service operation).
d.	If legacy RSE/OBU infrastructure and inventory is involved, the migration path is a critical consideration.
e.	There are many operational and financial benefits to interoperability. However, many result from reduced staffing, which may contradict other regional/political mandates.
f.	Interoperable systems/networks are complex and a detailed interface specification is required.
g.	Current and future systems that may interact with the interoperable system/network should be factored into the model selected and the data elements being shared.
h.	Be realistic in frequency of data sharing activities. Understand the implications of receiving data later than expected (e.g. hours versus minutes).

i.	For models with cost sharing (e.g. each agency pays a fee per transaction for a clearinghouse), identify if one agency will be the dominant user and therefore the primary agency financing the interoperable operations component. In this case, identify the implications of the primary agency choosing not to participate.
j.	A government regulated or mandated interoperability strategy may ensure cooperation by existing and new operations.
k.	Establish a model/structure when none or only a few operations exist, therefore simplifying process to establish a model and agreement.
l.	Technical solutions may be considered complex; however, the majority of time & effort is typically spent on agencies coming to agreement on terms, policies, etc.
m.	Each participating agency should review existing or desired policies and determine where they can be modified/adjusted to meet interoperability goals (e.g. vehicle classification structure for tolling).
n.	Identify possible privacy related issues and ensure they are addressed in the data sharing solution selected.
o.	Review related legislation (e.g., can license plate information be legally shared between agencies).
p.	Strive to offer simplicity to customers and operations groups.
q.	Establish processes for introducing new agencies/facilities.

8.0 Getting Started

Interoperability is a cooperative endeavor between parties. For transport systems, this involves cooperation and agreement with technical, business and procedural components.

Reaching interoperability is not straightforward and may happen using different paths. For example, a region or country may enforce the concept of interoperability from the onset of an RFID related project. This was is the case for the Japanese toll road network, with a single OBU and consolidated back office processing. A similar approach was used in Ireland, with the government establishing the Information Exchange Agent (IEA), a central clearinghouse for RFID applications. Conversely, the E-ZPass network in the Northeast USA (25 agencies, 15 states, 14 million customers), established interoperability with a few participating agencies, and grew to the current size after an additional 15 years.

8.0 Getting Started

The steps presented here are a general guide in getting started with, or migrating to, an RFID program that has interoperability as the core objective. These steps are not a strict process, but instead reflect an understanding of the common activities performed by other interoperable groups.

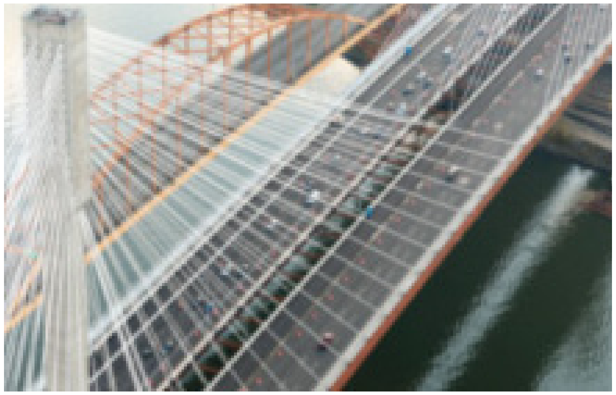
1.	Join, consult, or establish a **working group** of agencies with the same application (e.g. tolling) or similar applications with common requirements (e.g. transport systems – vehicle and / or customer identification).
2.	Identify **current and planned programs** with similar technical and business elements.
3.	Identify vehicle and customer **information types** that are required at field and back office levels for your application.
4.	Review the technical and data exchange solutions presented in this guideline, consult the working group, and then **develop a technical concept** of operations that, if possible, incorporates compatible AVI technology and existing interoperable data exchange networks.
5.	Develop **cost estimates** associated with deploying interoperable field and back office solutions. Consult working group on possible cost sharing or consolidation options.
6.	**Review desired policies** and see how they fit with interoperability requirements. Can you implement the policies needed?
7.	**Evaluate any trade-offs** between the desired policies and those available within the interoperable solution. Will the customer base have seamless experience between participating programs? Will customers receive customer service in line with your quality expectations?
8.	If an interoperable solution is selected, **present to working group** and other possible program partners.
9.	**Update concept of operations** for all elements (field, back-office, data exchange, and operations policies) and identify shared elements.
10.	Develop system functional requirements and **pursue procurements** of any new equipment.
11.	**Establish certification requirements.** What are the minimum requirements and how is a facility certified for inclusion with the interoperable network?
12.	**Establish agreements and terms** with participating agencies, including cost sharing arrangements.
13.	**Develop an implementation / migration strategy** that incorporates the transition timeline for each facility as well as any customer equipment swap-outs and education campaigns.
14.	**Deploy and test all elements.** If testing required with active systems, a test network will be required.
15.	The Transport Canada ITS Architecture is a good place to **start the design process.**

Appendix A: RFID Case Study

Introduction

TransLink, TI Corp., and BCMoTI are working together to achieve a degree of interoperability between Golden Ears Bridge tolling, Port Mann Bridge tolling, and the Weigh2GoBC commercial vehicle program. In this case study, the agencies present the activities that have occurred and offer best practice suggestions for others considering interoperability initiatives.

Appendix A: RFID Case Study



The Agencies and Facilities

TransLink (The South Coast British Columbia Transportation Authority) is Metro Vancouver's regional transportation authority dedicated to developing and operating an efficient and sustainable transportation network throughout the communities that it serves. This includes the Golden Ears Bridge (GEB) spanning the Fraser River; the first tolled facility in Western Canada to use All Electronic Tolling. Operation commenced in 2009 using the RFID Title 21 protocol and related devices common in western North America.

TI Corp (Transportation Investment Corporation) is a public Crown Corporation under the BC Ministry of Transportation & Infrastructure with a mandate to construct, operate, and maintain the Port Mann Bridge (PMB) and related Highway 1 improvements. PMB is the second toll facility in Western Canada to use All Electronic Tolling. Operation commenced in 2012 using the RFID ISO 18000-6C protocol and related devices.

BCMoTI (British Columbia Ministry of Transportation and Infrastructure) also operates Weigh2GoBC, a network of Weigh-in-Motion (WIM) and Automatic Vehicle Identification (AVI) technologies designed to enable more efficient movement of commercial vehicles through the province. Operation is based on the RFID ASTMv6 protocol and related devices.

Appendix A: RFID Case Study

Interoperability Synopsis

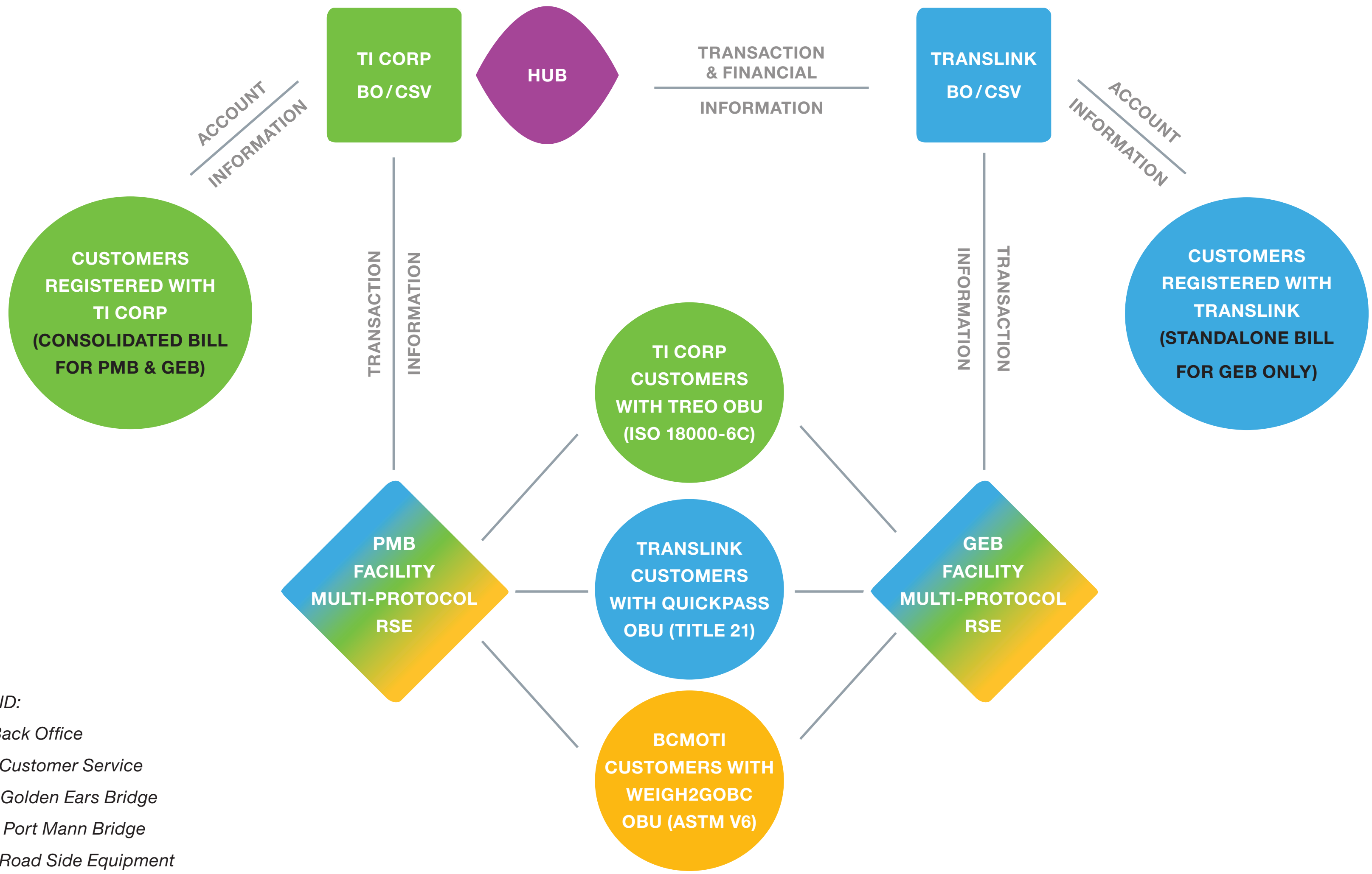
In conjunction with the opening of Port Mann Bridge in late 2012, TI Corp (PMB) and TransLink (GEB) agreed to install / change to multi-protocol Roadside Equipment (RSE) capable of reading three RFID protocols: ISO 18000-6C, Title 21, and ASTMv6; thus achieving device interoperability for trips over both toll bridges (customers do not require multiple OBU). They also agreed to implement back-office interoperability (commencing in 2013) to enable customers to receive a consolidated bill from TI Corp. that includes tolls for both PMB and GEB.

This was done to achieve the following interoperability objectives:

- Provide a seamless customer experience – customer gets one account, one OBU, and one invoice;
- Take advantage of economies of scale and efficiencies;
- Reduce revenue leakage and minimize costs;
- Provide a positive perception of government working together.

Appendix A: RFID Case Study

Interoperability Synopsis



LEGEND:

BO – Back Office

CSV – Customer Service

GEB – Golden Ears Bridge

PMB – Port Mann Bridge

RSE – Road Side Equipment

Appendix A: RFID Case Study

What led TransLink to adopt Title 21?

During the planning for GEB operation, TransLink assessed available RFID alternatives and determined that Title 21 was the best solution, in part because of its prevalence in western North America.

What led TI Corp to adopt 18000 6C?

During its initial toll system selection process in 2010, TI Corp considered dual-protocol readers for Title 21 and ASTM v6 protocols. Later field testing of ISO 18000 6C devices and protocol confirmed that its performance and accuracy met industry standards, while offering a significant cost advantage. Thus, TI Corp modified its RFID selection to use 6C with triple-protocol readers.

For both projects, who made the final decision on protocol?

TI Corp reached a decision to proceed with the 6C protocol. Both TI Corp and TransLink subsequently agreed to work together to achieve regional interoperability for seamless customer services.

Appendix A: RFID Case Study

What was the reason for continuing to support Title 21 concurrently with 6C?

TransLink determined that it would be more cost effective to upgrade the RSE but not to offer consolidated billing via GEB. This supported the decision to continue issuing T21 in order to encourage customers to register with PMB to receive full benefits of interoperability, and to reduce customer confusion in the event of both agencies deploying 6C decals at the same time.

What was the background on the decision to support Weigh2GoBC ASTM v6 protocol?

TransLink had previously agreed to a plan to include the ASTM v6 protocol the next time the RSE on GEB was upgraded. This would reduce the need for commercial vehicles to have a bridge OBU as well as a Weigh2GoBC OBU. When TransLink agreed to proceed with device interoperability with TI Corp, the previous commitment to ASTM v6 was included, resulting in a triple-protocol reader solution.

The region was the first to deploy triple-protocol Road Side Equipment. What has been the experience so far?

The initial field performance of the multi-protocol readers was reasonably on target, but further analysis with live traffic is on-going. Achieving standalone reader performance targets with three protocols is a much greater challenge than with one. The readers cycle through the different protocols as the vehicle passes through the read zone, which means that the read-time available for each protocol is reduced. However, system fine-tuning with careful consideration regarding protocol optimization and lane configuration, allows performance targets to be achieved.

Appendix A: RFID Case Study

What is the Back-Office structure?

There are independent Back-Office and Customer Service operations for each bridge. TI Corp. and TransLink are working towards back-office interoperability with integrated (single) billing for interoperable (TReO) customers when using both tolling facilities with a single OBU (planned for summer 2013 implementation). Existing GEB customers have the option of maintaining their GEB account without the benefits of being an interoperable (TReO) customer, or converting to a PMB interoperable (TReO) account customer to receive a single invoice.

Both agencies believed that this approach would reduce customer confusion that may have resulted if both agencies were perceived to be competing for customers. In British Columbia, many people assume that TransLink and TI Corp are the same entity.

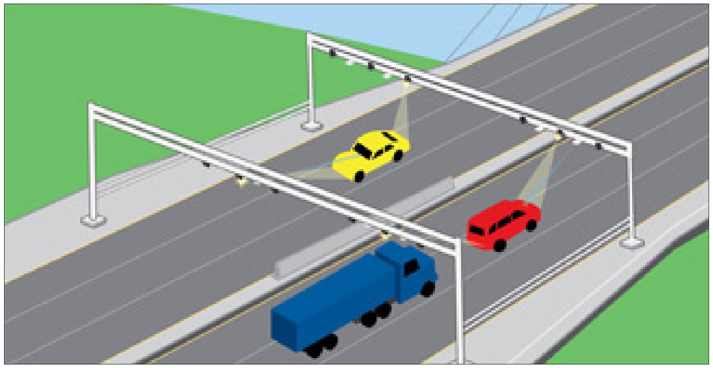
How is data exchanged between the agencies?

The back-office interoperability is achieved via a "hub" approach. A hub is deployed to process transactions from GEB on a real time basis and provides the flexibility for future opt-in from other regional tolling facilities.

Appendix A: RFID Case Study

Best Practices

- Need to establish common objectives at the beginning. The agencies should not be territorial or give the impression they are competing for customers; rather you should focus on providing a seamless customer experience and minimizing duplication of services and operations.
- Even when agencies work well together, interoperability still takes a long time and is a significant effort. Partners should get a good understanding of each other's objectives, budgets, schedules and operations up front to help streamline the process. A review of each other's business rules and gap analysis is an important task to identify the differences and develop a strategy to streamline redundant rules and encompass ones unique to each agency.
- Bring your developer into the process early on so they can hear firsthand what is planned and what the differences are between the two systems.
- Particularly in areas where there is not much tolling, go out and talk to the industry before making a decision on technology.
- Employ experienced technical personnel at each agency who are able to interact clearly with the developers, to ensure that requirements are clear, and to guide the development of technical specifications.



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