REGIONAL ITS ARCHITECTURES – FROM POLICY TO PROJECT IMPLEMENTATION

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ABSTRACT

The ITS Architecture for Canada is a presentation of functional and physical ITS elements and how they are integrated. Transportation agencies in a particular region or area should use the ITS Architecture for Canada as a framework, a common vocabulary and a guide to develop an architecture that is tailored toward the unique features of the particular region. This "Regional Architecture" is a road map of the information flow between the various systems that are essential to the stakeholders of the region. It maps out how the various ITS components are ultimately tied together and integrated, both physically as well as institutionally.

Consultation with and the support by regional stakeholders are very important in the successful development and implementation of a regional architecture. In this context, stakeholders can be described as owners or operators of the existing and planned systems, parties that collect and disseminate the information as well as parties that use the information. To a large extent they are "terminators" which are described in the ITS Architecture for Canada as "representing the people, systems, and general environment that interface to ITS".

Stakeholders already deliver their activities within the prescribed polices of that region. Policies, particularly in the area of transportation, are guiding statements by which specific initiatives are undertaken. It makes sense then, that a regional architecture also reflects the policies of that region. Many jurisdictions have developed ITS strategic plans that discuss efforts to develop and expand ITS initiatives in support of transportation Master Plans. Although the ITS Architecture for Canada was first launched in 1999, "ITS Strategies" that have been developed since 1999, reference the ITS Architecture for Canada, but do not describe a regional architecture. In some cases the regional architecture is developed after the strategic plan and in other cases only the reference is made to the ITS Architecture for Canada, but a regional architecture is not developed.
The question is "Where does the regional architecture fit within the policy and planning process?"

This paper will discuss the development of regional ITS architectures that represent stakeholders' interests and meet the objectives of a transportation master plan. It presents a discussion of regional ITS architectures being developed as part of the strategic transportation planning process and conclude with the statement that the regional architecture, combined with prioritization, costing, and programming of future ITS initiatives into the short, medium and long term, is the ITS Strategic Plan.

1.0 INTRODUCTION

Intelligent Transportation Systems (ITS) provide the opportunity to integrate travellers, vehicles and infrastructure into a comprehensive system through a range of technologies. They are a set of tools based in information, communications and integration that serve to:

- Improve safety
- Increase operational efficiencies
- Reduce energy and environmental impact
- Enhance productivity and competitiveness
- Improve collection of data
- Enhance mobility
- Create opportunities for Canada's ITS Industry (1)

Stakeholders that benefit from ITS include:

- Owners and managers of transportation systems
- Vehicle drivers and fleet operators using the transportation system
- Travellers, Shippers and other transport companies
- Road Authorities (2)

ITS can be delivered as a collection of individual applications but this is likely to increase costs, duplicate data collection and use, and cause problems in the future for integration and sharing of information. An ITS Architecture is a tool that describes the "big picture" of the functions each application performs and how the applications work together. It illustrates the current system and the future needs. Looking at the "big picture" ensures that planners and engineers capture all the needs and the functions of the information users and providers that make up our transportation system.

ITS are information systems and are ultimately successful if delivered through a "Systems Engineering" approach. Since "Transportation Engineers" aren't "Systems Engineers", Transport Canada and ITS Canada have developed a guideline that can be used by Transportation Engineers and Planners to create an ITS Architecture that is unique to their region without spending a lot of time and money in developing the approach. This guideline, the ITS Architecture for Canada, will provide a blueprint for the integration of systems by providing a framework, creating a common vocabulary and providing guidance to facilitate deployment by Canadian transportation providers and to identify opportunities for integration.

Even given the known benefits of ITS to the operation of our transportation systems, the questions that remain are:

- Is it necessary to develop a regional ITS Architecture?
- Is it necessary to develop that regional ITS Architecture using the ITS Architecture for Canada? and
- Where does the regional ITS Architecture fit within the traditional transportation policy and planning process?

2.0 WHAT IS AN ITS ARCHITECTURE?

Before attempting to answer the questions outlined above, it is important to understand what an ITS Architecture is and how it represents the needs of the stakeholders, the functions of the systems and the institutional structure of the region.

ITS are information systems and to be successful, must be planned for and developed with a systems engineering approach. Systems engineering is a structured process for arriving at the final design of a system. The final design is selected from a number of alternatives that would accomplish the same objectives or functions and considers the total life-cycle of the project including not only the technical merits of the potential solutions but also the costs, relative value of alternatives, and how well the system fulfills the users or stakeholders needs. (3)

Systems engineering differs from a traditional transportation engineering approach in that it combines a high order planning component to understand the functions and needs of the region (What does the system do?) with the technical aspects of delivery (How does the system do it?). Architectures create a bridge or a transition between high order vision documents of conceptual plans and more definitive plans that are likely to be technology based.

An ITS Architecture:

"…defines an architecture of interrelated systems that work together to deliver transportation services. An ITS Architecture defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services." (3)

More specifically, a Regional ITS Architecture is a:

"…specific tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of ITS projects for a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them." (3)

ITS are interrelated systems where the largest benefits are provided if these systems work in an integrated manner. The benefits of integration are cost savings, data/information sharing, operational efficiencies and improved management productivity.(4) Integration of systems requires a framework or architecture to illustrate and gain consensus on the approach to be taken by a group of stakeholders regarding their particular systems. The ITS Architecture describes the interconnections and information exchanges between these systems. It defines the functions to be performed, the physical entity or subsystem where these functions reside, interfaces and information flows between the subsystems and communication requirements for the information flows.(4)

The most important aspects of an ITS Architecture is that it first, accurately represents the current or legacy systems that are in use in the transportation network today and second, accurately represents the integrated systems and functions that are required to meet the needs of the system users or stakeholders. Common themes can be identified within the various issues and needs expressed by system users of stakeholders in the initial stages of the architecture development process. These common themes can be used to identify relevant functional areas of ITS applications or the services that are required by the users.(5) These "User Services" are the initial step in describing functions and interconnects in an ITS Architecture. User Services document what ITS should do from a user's perspective. It allows the system or project definition to begin by establishing the high level services that will be provided to address the needs. The approach in an ITS Architecture is multi-modal with User Services representing the needs of the public and private sector, the individual traveller, commercial vehicle driver, infrastructure owner, public transportation manager, commercial fleet manager, etc. (5)

Once the User Services are identified, the ITS Architecture can be described in two inter-related components. The Logical Architecture provides details on the behaviour of the system or what the system will do.(6) What are the functions that the systems need to undertake to provide the services required by the users and what are the information flows? The Physical Architecture describes the data that must be exchanged between entities, the means of exchanging data and the interface (type of communication) requirements. Where the Logical Architecture details what the ITS systems will do based on User Services, the Physical Architecture describes how the ITS systems will do it and where in the overall transportation system the function will be provided. The relationship between the Logical and Physical Architectures is illustrated in Figure 2.1.

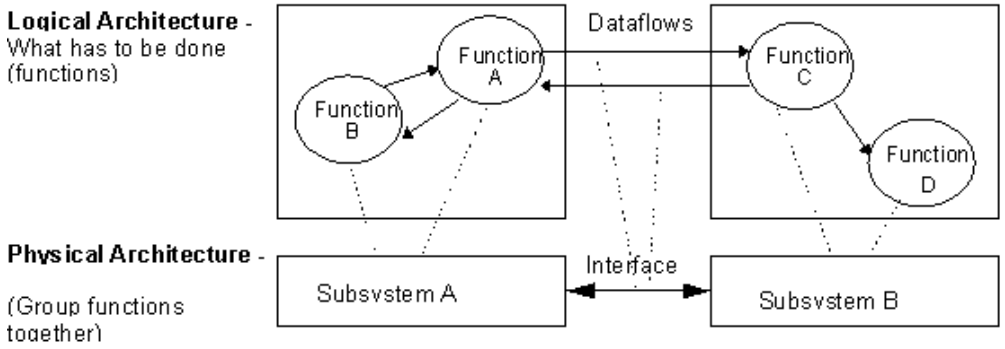

Figure 2.1 – Relationship between Logical and Physical Architectures (7)

Approaching ITS from a systems engineering perspective and developing a regional ITS Architecture is important because of the number of ITS elements, both existing and future, in a regional transportation network.(8) Integration of ITS applications is the key to successfully and efficiently providing the services required to meet the needs of the stakeholders or systems users. Integration allows for sharing of information and coordination of activities for efficient and effective operation of the transportation systems and has a synergistic effect on transportation systems (e.g., information from one

system may be used by another for a different purpose).(3) Many sources agree that the purpose of developing a regional ITS Architecture is to illustrate and document regional integration so that planning, design and deployment of ITS systems can take place in an organized and coordinated fashion. As well, the ITS Architecture:

- Defines the ITS that stakeholders wish to realize over a given time frame;
- Provides a framework or "Future Big Picture" to properly and efficiently define projects so that they build upon on another;
- Identifies opportunities for making ITS investments in a more cost effective fashion by using inter-agency cooperation during planning, implementation and operation of the projects; and
- Provides an opportunity for stakeholders to come together to discuss their transportation needs and plans. (3 & 8)

In the long term, a regional ITS Architecture is not a document to be "put on the shelf" once complete. A regional ITS Architecture is generally created with the use of planning information that has already been developed reflecting the policies and master plans of the region. It can be a powerful tool for further planning and operation of regionally integrated ITS throughout the transportation system and can be used by stakeholders in planning/designing individual ITS projects to support regional goals.(3 & 5)

3.0 WHERE DOES THE REGIONAL ITS ARCHITECTURE FIT WITHIN THE POLICY AND PLANNING PROCESS?

The systems that make up a regional transportation network, be they ITS or other, in general terms, deliver a series of integrated functions that support the services required to fulfill the stakeholders needs. Stakeholders include system operators as well as system users. At a higher level, the functions and the resulting services throughout the system are aimed at supporting the vision, goals and objectives of the road or regional authority within a set of defined policies.

The organizational tools that provide decision makers with the ability to meet overall objectives through individual decisions (e.g., take policy to project implementation), in order of hierarchy for a particular region are:

i) Transportation Policy – statements reflecting the objectives of the stakeholders and the government that are intended to guide decision making.

ii) Transportation Master Plan – outline of the efforts required given a growth target and a specified period of time, to achieve the stated goals with reference to the noted policies. The plan would include physical as well as procedural undertakings.

iii) ITS Strategic Plan – objective is to develop, program and communicate strategies for the development and deployment of a broad-based ITS program within a

jurisdiction. What will the system do and how will it do it? It includes project selection and prioritization, the project benefits and the costs of the ITS program.

iv) ITS Project Implementation - the design and implementation of a specific ITS project that has been previously identified in the ITS Strategy.(9)

The key aspects of the resulting ITS Architecture can be identified as impacts on the overall planning process. Generally, an ITS Architecture demonstrates the institutional integration or the structure around which discussions can take place among stakeholders to gain consensus on direction of ITS and it implies roles/responsibilities for each stakeholder involved to realize the benefits of ITS in the region.(3) The functional requirements described in the ITS Architecture and the rest of the system designs need to have a direct relationship with the vision, goals and objectives that are outlined in the Transportation Policy and Transportation Master Plan.(6)

The ITS Strategic Plan is a roadmap that sets the direction, pace and priorities of ITS investments over a long period in a coordinated manner.(10) It will identify ITS-related needs of the stakeholders, provide traceability to the higher order vision, goals and objectives, exploit opportunities for integration, establish a coordinating framework and processes for deployment.(10) The ITS Strategic plan will identify the roles and responsibilities of the participating agencies and stakeholders and define the institutional/technical vision for the region. It describes what the system will do and how it will do it. (3)

By definition, the ITS Architecture and the ITS Strategic Plan provide similar outcomes within the overall transportation planning process. The ITS Architecture provides the "Future Big Picture" of what the system will do and how it will do it, but does not prioritize future ITS initiatives into the short, medium and long term. The ITS Strategic Plan identifies user needs, provides traceability to higher order visions and goals, and assigns priority to specific initiatives, but cannot illustrate needs, functions and systems in an integrated and efficient manner without the inclusion of an ITS Architecture. A Regional ITS Architecture, therefore, is a core component of an overall ITS Strategic Plan. (2, 3, 4, 6, 8, & 9)

Many Canadian roadway authorities or government agencies at all levels (e.g., municipal, provincial or other) have developed ITS strategic plans that include efforts to develop and expand ITS initiatives in their region. The strategies focus on coordinated and controlled approach to delivery of ITS initiatives but until recently, did not include the development of a regional ITS Architecture. Roadway authorities and agencies that are preparing to embark on an ITS Strategic Planning initiative for their region are encouraged to include the core component of the ITS Architecture in the process. Roadway authorities and agencies that have recently completed an ITS Strategic Planning initiative but did not include the development of an ITS Architecture, do not need to stop design and deployment of individual applications and redo the strategic planning process. All that is required is a short step back using the detailed information in the initial ITS Strategic Plan (e.g., stakeholder needs, system functions) and placing it in an ITS Architecture

framework to illustrate the opportunities for integration and system efficiencies. Then as design and deployment proceeds, project level ITS Architectures can be developed for each initiative that fit within the framework or "Future Big Picture" of the Regional ITS Architecture.

4.0 THE ITS ARCHITECTURE FOR CANADA

One of the greatest challenges facing the transportation sector is the lack of familiarity amongst transportation professionals of the concept of an ITS Architecture. (9). In their publication on ITS Architectures, McQueen and McQueen have made the point that *"outside of a small core of highly involved people, the great majority of the transportation profession – certainly the majority of the public or stakeholders required to provide input to the process – are not familiar with ITS development processes or the issues involved in deploying a successful ITS".*(12) Tools such as the ITS Architecture for Canada are available to aid transportation professionals in the development of regional ITS Architectures. As well, such national architecture guidelines promote a common process that is likely to support integration within a region and interoperability between regions.

The ITS Architecture for Canada is a product of the 1999 Federal Government ITS plan for Canada entitled "En Route to Intelligent Mobility". In this document the architecture is described as the communication and information backbone that unites key ITS technologies, enabling them to communicate with each other and a framework that identifies the standards needed to support interoperability across technologies, modes and jurisdictions.(11) As illustrated in Figure 4.1, the ITS Architecture for Canada is a presentation of functional and physical ITS elements and how they are integrated. Transportation planners and engineers should not expect to deploy individual applications with strict adherence to the ITS Architecture for Canada but instead should use this tool as a framework, a common vocabulary and a guide to develop an architecture that is tailored towards the unique features of a particular region. (9).

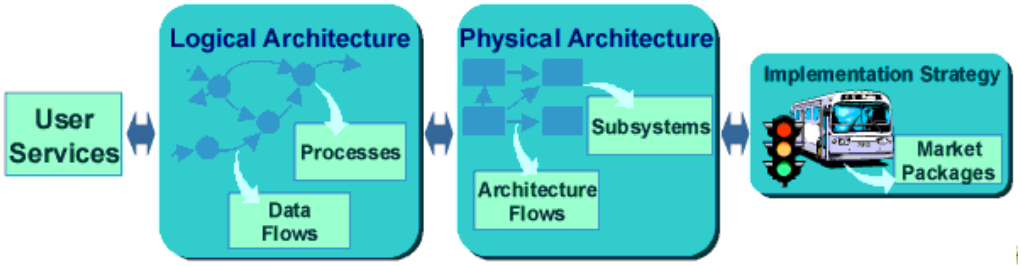

Figure 4.1 – Functional and Physical Elements of the ITS Architecture for Canada (7)

The intention is not to comply or conform to the ITS Architecture for Canada but to use it as a starting point from which to develop a regional ITS Architecture and this is important for the following reasons:

i) A Systems Engineer will likely be involved in the detailed design phase of a particular ITS initiative, however, Transportation Engineers and Planners need not undertake intense learning initiatives in development of systems architectures;
ii) Transportation Engineers and Planners need not waste already limited resources (e.g., time and funding) on developing an architecture procedure from scratch; and
iii) A national guideline for the development of ITS Architectures will support integration within a region and promote interoperability between regions and across jurisdictional borders.

The general steps to establishing an ITS Architecture can be outlined as follows:

i) Define the services required by the users
ii) Determine the functional requirements for providing these services
iii) Determine the information transfer or sharing at a detailed level of service (2)

With this in mind, the entry point for development of a regional ITS Architecture using the ITS Architecture for Canada is the "User Services". There are eight User Service Bundles that are described by 35 discrete User Services. Further detail is described by 90 User Subservices. Common themes to Stakeholder needs addressed earlier in this report can be described by User Service Bundles. These User Service Bundles include:

- Traveller Information Services
- Traffic Management Services
- Public Transport Services
- Electronic Payment Services
- Commercial Vehicle Operations Services
- Emergency Management Services
- Vehicle Safety and Control Services
- Information Warehousing Services (7)

Not all User Services and Subservices described under these bundles will be applicable to the specific region. Regional ITS Architecture development begins by specifying which of these best describes the services required by the users that have been identified through the needs assessment step of the overall strategic planning process.

Once the relevant list of User Services and Subservices have been identified, the services that are required can be described in functional terms by the processes and dataflows represented in the Logical Architecture. The Logical Architecture represents what the system will do and is defined as *"what has to be done to support the ITS user service. It defines the processes that perform ITS functions and the information or data flows that are shared between these processes."* (7)

Processes and data flows of the Logical Architecture can then be grouped together into like functions that are delivered by subsystems. Subsystems represent real or physical aspects of the transportation system where functions or activities are undertaken to deliver the processes that are required by the Logical Architecture. Common examples of subsystems are Traffic Management or Emergency Management. These collections of functions or subsystems are illustrated in the Physical Architecture. The Physical Architecture represents how the system will do what it needs to do and is defined *as "the physical representation (though not a detailed design) of the important ITS interfaces and major system components. It provides a high-level structure around the process and data flows defined in the Logical Architecture."*(7) The Physical Architecture guideline from the ITS Architecture for Canada is presented in Figure 4.2.

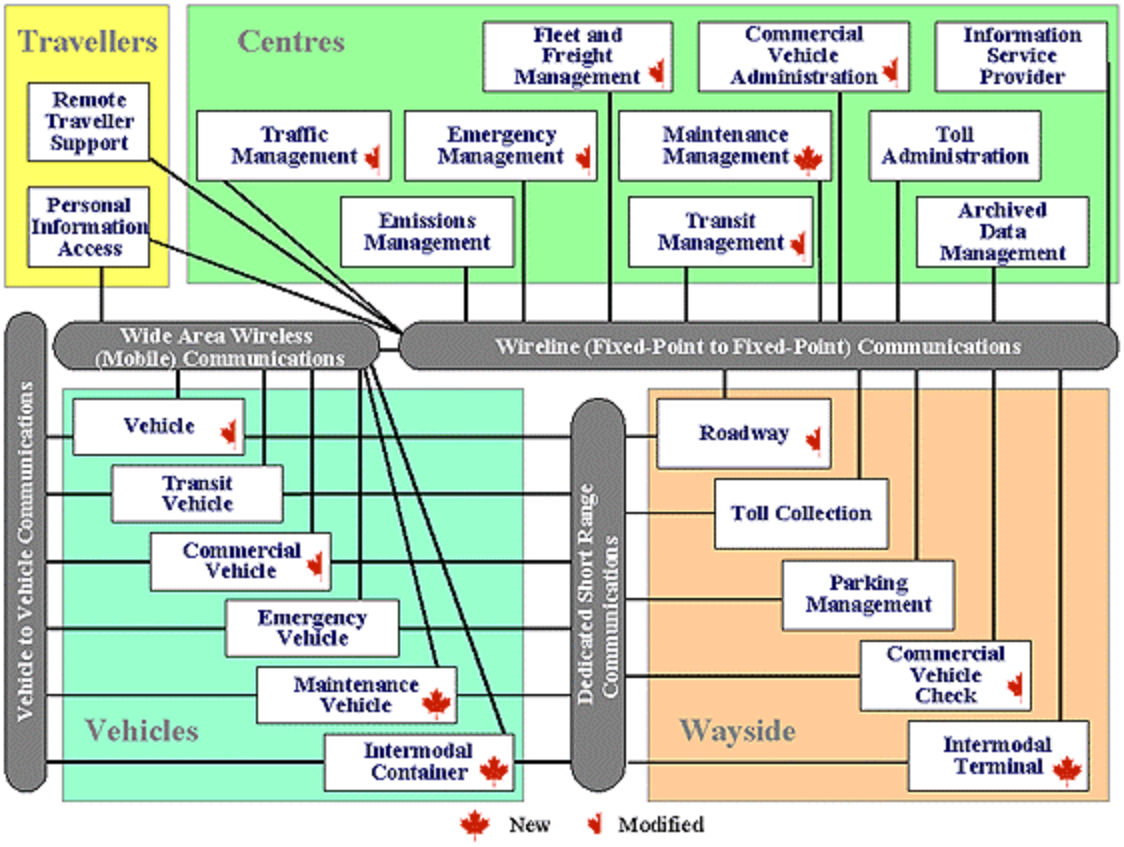

Figure 4.2 – Physical Architecture (7)

The Physical Architecture also represent the methods of communication between the subsystems, however, like the User Services and Subservices, the Physical Architecture is presented as a guideline or starting point and should be modified to represent the unique features of the region.

From the Physical Architecture, individual ITS Initiatives are described through Market Packages. Market Packages *"provide an accessible, deployment oriented perspective to*

the Architecture. They are tailored to fit - separately or in combination - real world transportation problems and needs. Market packages identify the pieces of the Physical Architecture that are required to implement a particular transportation service."(7) As they are individual ITS initiatives, Market Packages can be evaluated with respect to costs and benefits and prioritized in the overall ITS Strategic Plan.

5.0 THE IMPORTANCE OF USING A NATIONAL ITS ARCHITECTURE GUIDELINE

Although the ITS Architecture for Canada is a product of a Federal Government initiative, there is no legislative requirements to develop a regional ITS Architecture using the ITS Architecture for Canada, or to develop a regional ITS Architecture at all. In Canada, at the present time, it simply makes good planning and engineering sense to develop a regional ITS Architecture to support integration of systems throughout the ITS Strategic Planning Process and to use the ITS Architecture for Canada as a starting point to save time and money, and to promote future interoperability between regions and across jurisdictional boundaries.

The ITS Architecture for Canada is largely based on the U.S. National ITS Architecture due to our common transportation corridors. In the United States, there is a more significant reason to develop a regional ITS Architecture using the national guidelines and within a set of national standards. Significant U.S. federal funding is available for the design and implementation of ITS initiatives. However, the Transportation Equity Act for the 21st Century (TEA-21) requires federally funded ITS projects to conform to the National ITS Architecture.(4) Further to this, conformance with the National ITS Architecture is defined in the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) final rule and policy as using the National ITS Architecture to develop a regional ITS Architecture that would be tailored to address the local situation and the ITS investment needs, and subsequent adherence of ITS projects to the regional ITS Architecture.(3) In Canada, although current limited federal funding for ITS projects does not require conformance to the ITS Architecture for Canada, it is not unreasonable to think that conformance may be required in the future. Agencies currently developing regional ITS Architectures using the ITS Architecture for Canada as part of their overall ITS Strategic Planning Process may find that they have a distinct advantage in the future for federal funding should this become a legislated requirement.

6.0 CONCLUSIONS

Transportation professionals already understand that ITS is a valuable tool to maximize capacity and efficiency of the transportation system as well as improve safety. However, since ITS are information systems, planning, design, deployment and operation of ITS initiatives must be undertaken through a systems engineering approach. Unlike traditional transportation engineering, systems engineering combines aspects of the planning and development phases to obtain potential solutions that are based on

stakeholder needs and described in functional terms. Systems Engineering also provides the opportunity to represent the "Future Big Picture" of the transportation system in an ITS Architecture that promotes efficiencies of systems integration by describing what the system will do and how it will do it.

The development of an ITS Architecture that reflects the unique features of the region is not a stand alone exercise in the overall transportation planning process from policy to project implementation. The regional ITS Architecture, combined with prioritization, costing and programming of future ITS initiatives into the short, medium and long term is the ITS Strategic Plan.

Rather than starting from scratch in the development of a regional ITS Architecture, Transportation Engineers and Planners can utilized the ITS Architecture for Canada as a tool. Using this tool or guideline will save resources (e.g., time and money) in the development of the regional ITS Architecture, but will also support integration within a region and promote interoperability between regions and across jurisdictional border.

Roadway authorities and agencies that are preparing to embark on an ITS Strategic Planning initiative for their region are encouraged to include the core component of the ITS Architecture in the process. Roadway authorities and agencies that have recently completed an ITS Strategic Planning initiative but did not include the development of an ITS Architecture, are encouraged to continue with design and deployment but at the same time, develop a regional ITS Architecture using detailed information available in the ITS Strategic Plan, (e.g., stakeholder needs and system functions). Then as design and deployment proceeds, project level ITS Architectures can be developed for each initiative that fit within the framework or "Future Big Picture" of the Regional ITS Architecture.

It makes good engineering and planning sense to develop a regional ITS Architecture as part of the ITS Strategic Plan using the ITS Architecture for Canada. Also, agencies that have undertaken these planning initiatives may have a distinct advantage in accessing federal funding should the future requirement be to conform to the ITS Architecture for Canada.

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