ITS ARCHITECTURES

Benefit to Rural ITS Projects

Transport Canada Transports Canada

Canada

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INTRODUCTION

Intelligent Transportation Systems (ITS) combine different information and communications technologies, such as cameras, Bluetooth detection, and advanced data analytics. These systems can help make the transportation system safer and more efficient, and they're a key part of Canada's road transportation system.

While deploying ITS technologies is more challenging in rural areas[1], they can still be put in place and benefit road users.

HOW TO USE THIS GUIDE

This guide gives an overview of the unique challenges of deploying ITS technologies and applications in rural areas. It includes considerations for hardware and communications, and how you can use the US National ITS Reference Architecture, Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)[2], for rural ITS projects.

CONSIDERATIONS

Value of using ITS in rural areas

ITS can improve safety, mobility, and/or efficiency of road transportation. They also tend to save costs by reducing collisions, congestion, and the environmental impacts of transportation.

Although many ITS solutions focus on urban settings, there are options that can address some of the unique needs of rural transportation. For example:

- While there are fewer collisions on rural roads, a greater proportion of them are fatal. In 2020, more than half of all fatal collisions in Canada happened on rural roads[3].
- Emergency response times can be longer in rural areas compared to urban areas.

Challenges and solutions

Larger and less dense rural areas often have a lack of built infrastructure, which can pose unique challenges for planning and deploying ITS. Many of these challenges are related and could lead to higher costs for deploying, using, and maintaining a system.

To address these costs, you may be able to develop a cost sharing plan between agencies, reducing the cost per agency. A regional ITS architecture provides a good way of facilitating and encouraging these discussions and planning processes.

[1] While there are numerous definitions for "rural areas," unless otherwise noted this guide uses the term rural areas to mean those with low density and/or low distance to density, as used in the State of Rural Canada publication.
[2] Available in English only.
[3] Canada. Transport Canada. Canadian Motor Vehicle Traffic Collision Statistics: 2020. Available: https://tc.canada.ca/en/road-transportation/statistics-data/canadian-motor-vehicle-traffic-collision-statistics-2020

This section explains some of these challenges and how you can address or manage them.

Communications

In urban areas, public sector agencies are more likely to build dedicated physical communication infrastructure (like fibre networks) on their own right-of-way. These networks can provide easy access to connect central systems field devices.

An example of this would be a provincial government installing a fibre network along a highway network and using it for highway management applications. Telecommunications providers operate in rural areas, but for the most part their physical and/or wireless broadband networks are concentrated near the denser areas (like small cities), with limited availability and reliability outside of those.

While fibre and cellular networks are most common, other options like satellite and microwave technologies have been used for wide area and local network applications.

In an ideal situation, ITS should be used, if possible, with access to physical telecommunications infrastructure. Cellular wireless can be used as an alternative as long as bandwidth and connection issues are considered.

With cellular communications it's important to highlight the possibility of higher costs, and as such you should design your applications to limit the frequency of communications. This may include using less frequent polling cycles, larger batches of data (like 5-minute data instead of 20-second data), local/edge computing, and/or local storage and manual retrieval.

Power

Power isn't always available where devices will be used, and power supplies are usually more spread out in rural areas. Connecting ITS devices to a main power supply can be expensive and as such can limit use.

Alternative power source options exist, like solar panels or portable wind turbines and batteries. These alternative power sources come with other challenges, like the ability to provide enough power, parts that need extra maintenance, and they could be targets for theft or vandalism. It's also possible to have multiple power sources. For instance, a device may use solar power as its primary source but shift to battery as a back-up source as needed.

Another option for rural areas are alternative technologies and equipment that consume less power or equipment that has the ability to enter a "stand-by" mode to conserve power when needed.

In an ideal situation ITS devices should be placed alongside direct access to a main power supply. If that isn't possible then you must choose and design an appropriate alternative.

When you choose an alternative, you should consider:

- the size of device you will need;
- where the device will be placed – and what it will be exposed to (like weather); and,
- the device's cost over its entire lifecycle (including the initial capital, replacement, maintenance).

Design considerations should include making sure the system is designed such that lack of power as a probable state (like fallback state, fail over gracefully).

Maintenance

Maintaining field devices is another challenge in rural areas. It can be harder and more costly to detect and repair failures and requires trained staff to travel to the remote sites. Seasonal maintenance may be required to make sure that the system/equipment can be operated throughout winter.

In an ideal situation, ITS devices should be located close to maintenance resources and be easy for maintenance staff to access. In cases where this isn't possible, you may need more robust designs and specifications in order to obtain reliable devices that need less maintenance (for example devices with higher mean time between failure). If that isn't possible, then scheduled maintenance visits and remote diagnostics ahead of visits may be required.

Other considerations

Equipment must be placed so that it's easy for technicians and employees to access and physically connect to the network safely and securely.

Grouping equipment or systems means you can share access to power and communications and could save on maintenance costs.

Equipment may need to be modified to blend in with natural surroundings. This would most likely occur near a national or provincial park, where the equipment would either need to be painted or hidden behind other structures like roadway signs.

HOW ITS ARCHITECTURES CAN HELP

ITS architectures help transportation professionals plan, define, and integrate intelligent transportation systems into road transportation infrastructure and operations. An architecture gives planners and engineers a consistent way to develop and design systems using the same language.

The ITS Architecture for Canada was originally developed in 2000, by Transport Canada, and was based on the U.S. National ITS Reference Architecture (now called ARC-IT).

In early 2020 the ITS Architecture for Canada received a major update to Version 3.0, to align directly with the ARC-IT Version 8.3. In late 2020, ARC-IT was updated to Version 9.0. As part of this update, Canadian elements from the ITS Architecture for Canada were integrated into the ARC-IT.

Service Package Areas

Service packages represent slices of the Physical View that address specific services, like traffic signal control. A service package groups several different physical objects (systems and devices) and their functional objects and information flows that provide the desired service.[4]

The services in ARC-IT are organized into 12 Service Packages Areas that group similar or related services. As rural environments are unique, not all services defined in ARC-IT apply.

4 https://www.arc-it.net/html/servicepackages/servicepackages-areaspsort.html

The following subsections group the service package areas based on how well they apply to rural ITS deployments:

- **Strong use:** Most of these service packages apply directly rural areas
- **Some use:** Some of these service packages are either directly relevant or have some relevance to rural areas
- **Limited use**: Most of these service packages have little value for rural areas

Strong use

Generally, most service package areas have some use in rural areas by improving communication and awareness. Those with the most utility include:

- Commercial Vehicle Operations
- Maintenance and Construction
- Public Safety
- Traffic Management
- Vehicle Safety
- Weather

Commercial Vehicle Operations service packages offer benefits like improved safety monitoring, and increased awareness of potential hazards like Roadside CVO Safety (CVO07) and Road Weather Information for Freight Carriers (CVO10)

Maintenance and Construction service packages inform vehicles about expected roadway maintenance. For instance, the Winter Maintenance package (MC04) uses relevant environmental information to schedule winter maintenance activities like snow and ice control response.

Vehicle Safety and **Public Safety** service packages provide information to drivers about upcoming road hazards and changes to a highway (like speed, slopes, or curves). These features are offered through service packages such as Curve Speed Warning (VS05) and Reduced Speed Zone Warning/Lane Closure (VS09).

Public Safety service packages also include services that support public safety agencies and emergency management and can lead to reduced emergency response time and other benefits. These services are offered through service packages such as Emergency Response (PS02) and Roadway Service Patrol (PS08).

Traffic Management service packages focus on improving the movement of vehicles, travelers and pedestrians. For instance, the Variable Speed Limits (TM20) package provides roadway operators the ability to vary the speed to promote safer driving during poor driving conditions.

Weather service packages focus on collecting environmental data and providing warnings and information to drivers. For example, the Spot Weather Impact Warning (WX03) package will alert drivers of unsafe road conditions due to weather-related impacts.

Some use

Other Service Package Areas like **Data Management** and **Support** indirectly assist rural ITS deployments. Collecting data via detectors, sensors, and connected vehicles allows transportation officials to study and analyze safety and mobility-related measures, which could reduce the number of high speed or high collision roads in rural areas. The Performance and Monitoring (DM02) and Field Equipment Maintenance (SU11) packages can help you review and assess the performance of other service packages.

Public transportation in rural areas relate more to inter-city trips, and as such many individual service packages aren't relevant. Although there is a sub-set of **Traveler Information** packages that directly relate to rural areas, the content is likely different. For example, road closure information is very important as there are generally longer detour options in rural areas, so providing information on major incidents can be helpful before a driver travels too far.

Limited use

Finally, some Service Package Areas like **Parking Management** and **Sustainable** Travel have limited value for rural settings. Most rural areas don't have parking management issues, or consistent congestion issues. As such, the benefits of these packages likely don't justify the cost.

Developing project and regional architectures using ARC-IT

ARC-IT is accessed through two supporting tools[5] that are available for free through the ARC-IT homepage:

- **Systems Engineering Tool for Intelligent Transportation (SET-IT)** to create and maintain project architectures
- **Regional Architecture Development for Intelligent Transportation (RAD-IT)** to create and maintain regional ITS architectures

Project architectures

As a reference ITS architecture, ARC-IT can help you plan, design and deploy projects in both urban and rural areas. ARC-IT is technology and design agnostic in the framework it provides, and as such it can be adapted to either environment while also understanding each's limits.

For example, a weather warning system provides information to drivers on road and climate conditions. As shown in **Table 1**, rural areas present more limitations to how this system could be implemented when compared to urban areas.

[5] Available in English only

Table 1: Comparison of design considerations for a weather warning system in urban and rural environments

Urban area	Rural area
Able to use existing fibre network for communications.	Limited wireless connections for communications, which may be more costly to operate and/or less reliable than a fibre network.
Reliable broadband allows for real-time data collection. Central processing was a preferred option.	Given the limitations with communications, local processing was the preferred option, with periodic batch uploads to central for archiving purposes.
With easy access to power, and central processing, VMS variable message signs are used to advise motorists. The signs also provide other information and functionality options. For similar reasons, a CCTV camera could be used to stream video to a central location that could verify conditions.	With little access to power, a static sign equipped with flashers may be a better option. The sign can be paired with an appropriately sized solar panel and battery.

Figure 1 and **Figure 2** show possible implementation designs for a weather warning system, using ARC-IT**.**

Figure 1: Sample diagram for implementing a weather warning system in an urban area

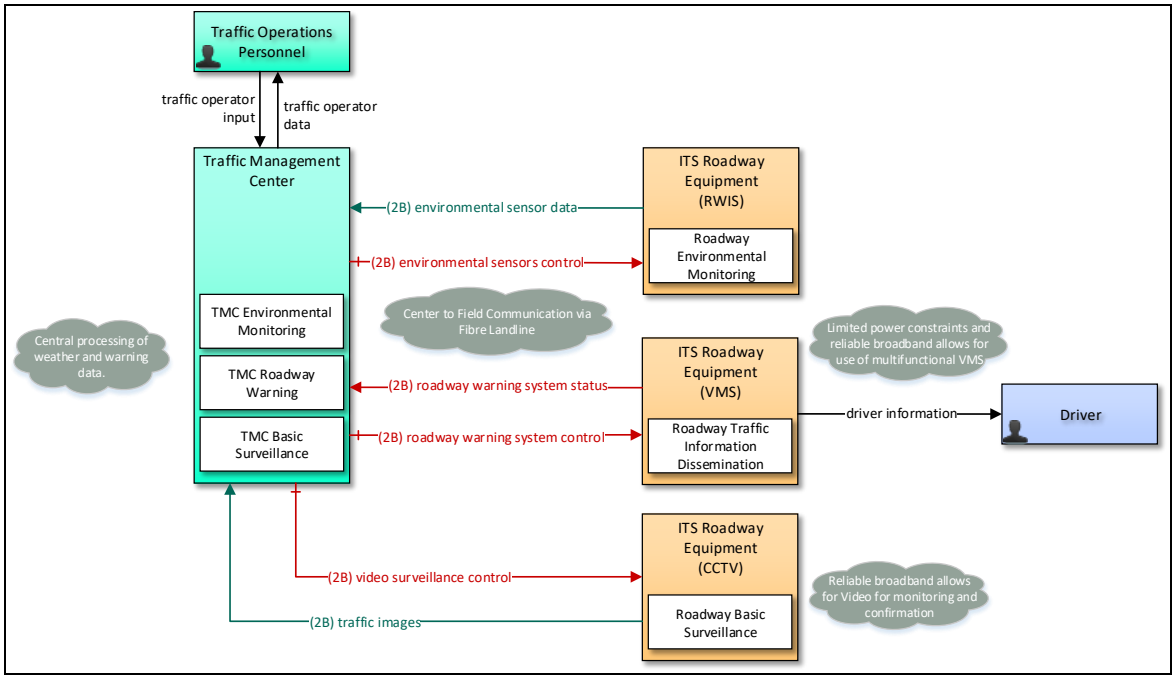
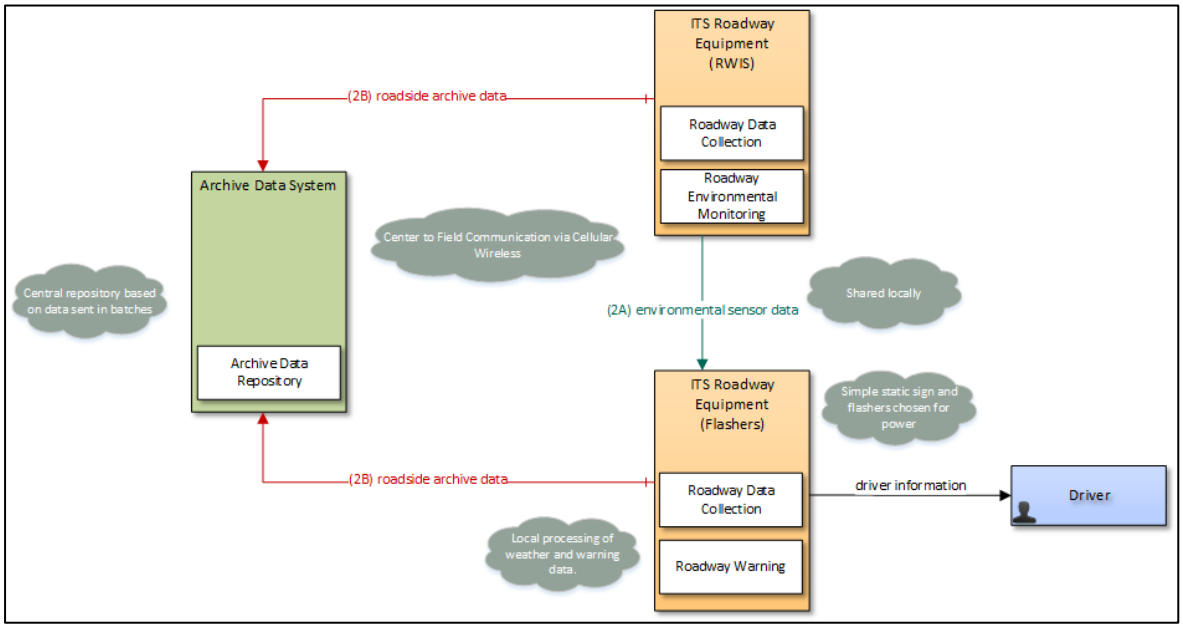


Figure 2: Sample diagram for implementing a weather warning system in a rural area



Regional architectures

A regional ITS architecture provides a foundation for local ITS planning and budgeting efforts, while facilitating interoperability. A region usually contains several municipalities or local administrations that are next to one another and that want to deploy ITS solutions.

A regional ITS architecture defines which parts of the system are linked to others, and the information that is exchanged between them. **Figure 3** shows the different elements that make up a regional ITS architecture. Regional architectures can be developed for urban areas, rural areas, or a mix of both.

Figure 3: Regional ITS architecture components

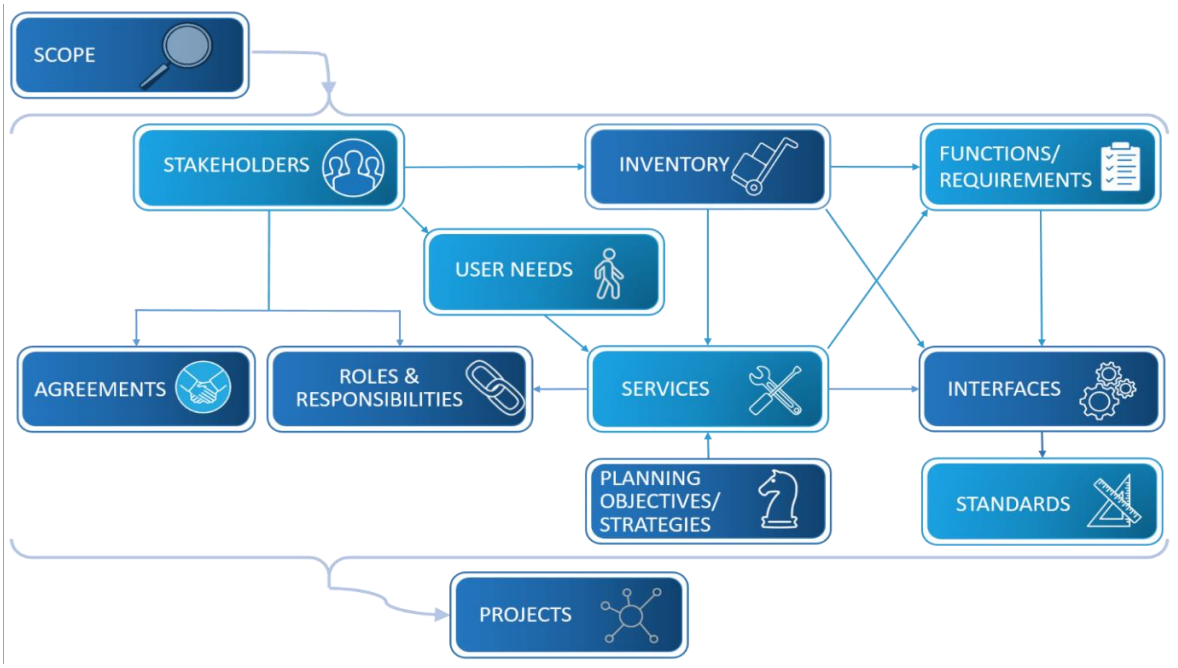


Image source: US DOT