Transportation Association of Canada

RURAL ITS

Technology & Design Primer

TABLE OF CONTENTS

RURAL ITS - GENERAL INFORMATION 4
Intro 4
System Planning 4
System Design 9
Implementation 10
Operations & Maintenance 11
Challenges 12
Supporting Technologies 13
RURAL ITS - SOLUTIONS 19
Overview 19
EXAMPLE: Overheight Warning Systems 22
Variable Speed Limit Systems 23
Intelligent Street Lights 25
Rural Variable Message Sign(VMS) Systems 27
Animal Detection & Warning Systems 29
Overheight Vehicle Detection & Warning Systems 32
Flood Detection & Warning Systems 33
Slow Moving Vehicle Detection & Warning Systems 35
Avalanche Detection & Warning Systems 38
Rural 511 Digital Services 39
Travel Time & Origin Destination Systems 40
Traffic Data Collection Systems 42
Subsurface Temperature & Moisture Monitoring 43
Air Quality & Green House Gas Monitoring 44
Road Weather Information Systems 45
Remote CCTV Monitoring Cameras 46
Weight in Motion Systems 47
Railway Crossing Advanced Warning & Detour Systems 48
Railway Crossings Conflict Analysis & Data Collection 49
RURAL ITS - CASE STUDIES 51
Overview 51
Template - System Title 52

ABSTRACT SUBMISSION

Dear ITS Canada Organizing Committee,

As a member of TACs ITS Committee, I, Michael McGuire, volunteered to lead the committee first working group which was we focused on the topic of Rural ITS. The group has approximately 12 members and our focused has been decided on developing a comprehensive primer on the subject of Rural ITS to assist agencies in the practical evaluation, design, and implementation of Rural ITS technologies.

Following on recent similar work on ITS architecture and Rural ITS applications this guide will focus on the practical aspects of implementation and include extensive examples of existing and soon to be deployed projects in Canada.

During the ITS Canada RITS Event it is my hope to discuss this initiative and bring awareness to the activity of our working group. By this point the primer will have been completed and will be available to share with any interested parties. The purpose of the primer is to de-mystify rural ITS deployments and provide inspiration to all those smaller agencies who are unsure how and if they can tackle certain problems.

Above is the draft title page and table of contents of the primer and below is the draft introduction to the document.

Kind regards,

Michael McGuire

RURAL ITS - GENERAL INFORMATION

Intro

The purpose of this primer is to provide insight into the world of rural ITS technologies. It will examine all aspects of these systems including the early planning stages, system design process, implementation, and maintenance. We will provide insight into the common challenges faced as well as many suggestions related to infrastructure and technology selection. In addition to this general information, we will provide specific details on a variety of rural ITS solutions in order to increase awareness about what is possible and to hopefully inspire rural agencies to pursue innovative approaches to their transportation challenges. For each solution we'll provide information on how and why they are typically implemented, how they operate, and specific challenges that will often be encountered. We will finish with a series of case studies highlighting real world deployments of innovative rural ITS systems across Canada and the relevant experiences and lessons learned from them.

System Planning

Planning Process Overview

The planning stage is critical to the successful implementation and long-term operation of rural ITS projects. ITS projects need to be at the appropriate scale that is manageable by the organization. For rural jurisdictions, ITS equipment is typically located in remote locations and is more costly to install and maintain. It is important to get the project right the first time to avoid costly iterations and to ensure that the outputs of the system are useful for the organization.

Rural jurisdictions typically have less infrastructure, funding, and operational capacity than urban jurisdictions. Determining whether an ITS system is feasible within your jurisdiction is an important step to understand if your system will deliver the desired outputs. Operational feasibility, financial feasibility, and technical feasibility should be assessed to determine the optimal plan for the ITS system in your rural jurisdiction. Long-term costs, including those associated with operating/maintenance, additional staffing resources, and technical support, need to be assessed to determine if the ITS system is feasible in your jurisdiction.

The planning process should not only determine the feasibility of the ITS system, but also if it is the most suitable system to address the business need. Other alternative approaches should be reviewed to determine if the ITS system can meet the objectives and deliver the desired outputs in a rural setting.

Determining the appropriate technologies to deliver an ITS project is a crucial step in the planning process. There are several different approaches that can be taken to research and investigate different technologies that can be integrated within the ITS system. Selecting the optimal technological components can be the difference between a feasible project and an infeasible project.

Over the course of the planning process, stakeholders need to be brought into discussions so that they can communicate what they expect from the outputs of the ITS system. Stakeholders can be either heavily involved in the project or just informed that the project is occurring. However, for all stakeholders, it is important that they understand what there role is in the project and what their expectations are when the project is delivered.

Selecting the appropriate site(s) is an important step in the planning process to ensure that the ITS system is able to deliver the expected outputs. There may be limitations to what the ITS system can deliver due to the limited infrastructure to power and provide network connectivity. Also, sites need to be accessible for maintenance and in some cases it may be necessary to locate equipment in remote locations with our road or trail access. Which will entail higher costs to maintain that equipment.

Lastly, the planning phase should incorporate all this information gathered into a realistic implementation plan that identifies the timelines, milestones and costs required to deliver the project. Funding sources need to be determined for not only the immediate capital costs, but over the course of the lifecycle of the ITS system.

The following sections are not sequential and each should be considered throughout the planning process. Several of these steps are connected to each other and these connections should be understood when planning an ITS project.

Needs Assessment and Identification

Needs for a project can originate from a number of sources, including an operational demand (e.g. to provide advanced traveller info to drivers), a public request, or as a component of a long-term strategic plan to build an ITS program. The following should be considered when completing a needs assessment for a project:

- Can the needs for a project be quantified with data and statistics (e.g. collision statistics, avalanche incidents)?
- Does the project fit within a network/system plan to meet long-term ITS program goals?
- Can the project be scaled over multiple years to account for funding availability and/or program maturity?

Technology Selection

For most ITS solutions, there is a wide range of possible technology options that can be suitable to meet your jurisdiction's needs. Finding the optimal technology to achieve the desired outputs may include scanning the available product offerings of different vendors and reaching out to vendors to learn about their products; however, some projects may require more work to select the appropriate technology to address the ITS need.

- Is it worth hiring a consultant to present options for different technologies to determine which meets the needs of the ITS program? Or can a Request for Information (RFI) be published to gather information about these technologies?
- A consultant can be helpful for examining technologies to meet your jurisdiction's more technical needs, whereas an RFI is a more cost-effective way of gathering information about different technology options.
- Are there other jurisdictions that have implemented these technologies to meet similar needs? Are there any relevant case studies for how these technologies have been used?
- If necessary, can the technology be further developed or customized to meet your jurisdiction's specific needs?
- Is the technology rapidly changing to meet the demands of customers? Do you need the solution now, or should you wait until the costs are lower and the technology is improved?
    - For instance, as of 2023, off-grid Level 2 EV chargers are high cost and require a large footprint. Since this technology is growing very quickly, it may make more sense to hold off on procuring these types of EV chargers until costs are lower and the technology improves (if there is not an immediate need to have off-grid EV charging).
- Does the technology have a decent expected lifecycle? Are there warranties and technical support services that come with the product, or should contracts related to these services be sought out and procured?

Operational and Financial Feasibility Requirements

Systems that may be feasible in an urban setting with additional infrastructure and resources might not be feasible in rural areas. Operational and financial limitations should be reviewed and assessed when determining if a project is feasible for your jurisdiction.

- Within your jurisdiction, is there a history of this ITS system (or a similar system) being built and operated in the past?
- Would a completely new system need to be constructed or can this ITS system be built as an addition/upgrade to an already existing system?
- Are there any required changes to legislation in order for this system to operate within the legal framework of your jurisdiction?
- Are there any privacy assessments required to implement this ITS system?
- Are there any other projects that should be prioritized ahead of this ITS project?
- Does your organization have the organizational capacity, business processes, and expertise to operate the ITS system?
- A new ITS system may require organizational changes to operate and realize potential of the system. This may be as simple as hiring new staff to operate or it may be complex in terms of implementing new or a change to organizational business processes.
- Does your organization have the financial capacity to operate and maintain the ITS system over its lifecycle (e.g. electricity fees, data plans, preventative maintenance, unscheduled maintenance)?

Technical Feasibility Requirements

When determining if an ITS system is technically feasible in rural areas, you should assess whether or not the power infrastructure and network connectivity is sufficient to meet the project's goals. Different ITS systems have different requirements for power capacity and data transfer rates, and there are many rural areas that are not able to accommodate these ITS systems due to limited infrastructure.

- Will the system require on-grid power, or can it be supplied power from off-grid solutions (e.g., solar, batteries, generators, etc.)?
- What are the bandwidth requirements for the data transferred from the ITS system? For the more remote sites, are satellite communications solutions feasible for the system?
- For instance, transmitting images from remote locations would have higher bandwidth requirements than basic data, particularly if they are high resolution images.
- Are there existing back-end systems (e.g. data warehouse) in place for support the ITS system?
- Is the system feasible with the current infrastructure? If not, is it feasible to build nearby infrastructure?
- For example, working with utility companies to install power drops may be necessary to make the system feasible.
- It may be more feasible to move the ITS system to another site if there is no nearby power infrastructure.

Suitability Considerations

The suitability of an ITS project should be assessed to determine if the project is appropriate for the rural jurisdiction. In areas with limited power and internet connectivity, the need to be addressed may have several alternative or complementary approaches, some of which are not ITS-related.

- Is the operating environment suitable to host an ITS solution, or will the environment limit the outputs to address the needs?
- Does the benefit of implementing an ITS solution outweigh the cost to build and maintain the ITS system?
- Can a non-ITS solution provide the same outputs as an ITS solution? Is there a solution that can include both ITS and non-ITS solutions?
- For example, wildlife/vehicle collisions may be addressed jointly by physical barriers and traffic calming measures along with complementary ITS solutions, including wildlife detection systems and digital message signs.

Site Selection

ITS systems typically include field devices built and installed along the sides of highways and roads. The information gathered with respect to suitability, feasibility and technology options can be used to build the criteria for determining optimal site(s) for the ITS system.

- Does the ITS equipment need to be in one specific location to serve its function or is there flexibility to move the equipment to a different location?
- If there is flexibility to move the equipment, what are the criteria to determine if the equipment is in the optimal location?
- Can the ITS equipment serve its function in a location with more accessible grid power and/or cell communications? Or does it have to be in an location without this infrastructure?
- Is the site able to be accessed safely if the ITS equipment needs to be worked on?
- Consider building/expanding shoulders or access roads, if necessary.

Stakeholder Consultation

ITS projects are typically delivered on behalf of separate end users or client groups. Part of the planning process should include seeking feedback from any stakeholders involved in installing, using, operating and maintaining the system. The purpose of this engagement is to gather requirements to development the system use case and design. It is critical to understand the end user requirements early on to design a system that will meet their business needs.

Who are the stakeholders of the ITS project? What degree of involvement do they need to have with the project?

Some stakeholders may only need to be notified that the project is taking place, whereas others need to be heavily involved in every step. Discuss the project with each stakeholder to determine what their level of involvement should be over the course of the project.

Some stakeholders may have limited interaction with the system, but they may have their own preferences that should be taken into account, if possible.

- Can the stakeholders provide input to suitability considerations, feasibility requirements, technology selection, or site selection?
- For instance, ITS projects in rural areas typically include project input from operational staff, who may have insights and preferences for site accesses, system placement, user interfaces, etc. that will help them to efficiently use and monitor the ITS system.
- What are each stakeholder's expectations for the outputs of the ITS system?
- What is each stakeholder going to use the outputs for? Do the outputs meet their business needs?
- How will you determine a solution if different stakeholders have different expectations about the outputs of the ITS system?
- Can you find a compromised solution, or do you need to take the input of one stakeholder group over another?
- Is this ITS project going to result in any changes to procedures, business processes, etc.? Who needs to be notified that this project is taking place?
- Some projects related to ITS systems can have a wide impact across an organization. It is important to communicate that these projects are taking place at the higher levels within your organization.

Implementation Plan

Plan out how the project will proceed from planning, to delivery and into operation by mapping out the key project milestones. This will help to determine realistic timelines and costs required to implement the system.

- What steps in the project do you anticipate taking the longest?
    - Identify any permits and permissions that may be required to implement and/or operate the system. This can include any legislative approvals (e.g. municipal Council), privacy impact assessments, security threat assessments, land use permissions, funding approvals and environmental permits and assessments if required.
- How are the project components going to be split into different contracts? What order should each of these contracts be completed? What is the appropriate funding source for each contract?
    - For example, a typical rural ITS project may include:
        - Engineering services contracts to design transportation, electrical, and structural components
        - Utilities contracts to provide power to the site
        - Goods/services contract to supply and install the ITS system
        - Technical support and maintenance contracts to provide support once the ITS system is operating
        - Subscriptions to services associated with the ITS system (e.g., DMS messaging software, data warehouse, software license fees, etc.)

Financial Considerations

Building a cost estimate for an ITS project requires assessing not only the capital costs, but a number of additional factors over the equipment's lifecycle.

- Are there funding sources that are available to finance the installation this ITS system? Are the operations and maintenance costs eligible to be financed by these funding sources?
- Does your jurisdiction have the resources to troubleshoot the ITS system, if necessary?
    - Consider procuring technical support for the ITS system.
- Are any additional staffing resources required to operate and maintain this ITS system? Is any training required for the staff to effectively utilize the system?
- What is the lifecycle of the ITS system's equipment? Has the replacement of equipment components been taken into account for your organization's financial forecasting?

System Design

- What is the problem we're trying to solve?
- What are the constraints?
    - Budget?
    - Locational?
    - Site conditions
    - Infrastructure availability (power/comms)
    - Etc
- Technology/Solution review.
    - Potential RFI to learn about more
- Solution Scoping
    - Functional requirements?
    - Technical requirements?
    - Contract structure? Iaas? Supply/Install, etc
- System architecture considerations
    - Cloud
    - On prem
    - Edge
- Site analysis
    - Accessibility
    - Traffic control requirements
    - Infrastructure available
- Prepare system overview doc
    - Site diagrams
    - Tech selection or shortlist
    - System architecture
    - Technical & functional requirements

Implementation

Project team engagement/kickoff

Review/Develop implementation plan

Site visits/surveys

Review identified challenges with sites/system architecture/technology

Equipment/product preparation

Software preparation/on-prem deploy (IT req's)

Operations & Maintenance

Challenges

Supporting Technologies

Power system options

General Considerations

Power availability is one of the greatest challenges in deploying ITS technology in rural areas. AC power is often not available and while renewable sources such as solar and wind are often great alternatives, they bring with them many limitations as well. In this section we will review the most common sources of electric power and the various advantageous and challenges which they carry with them. We will also discuss some more obscure and newer energy sources such as ethanol fuel which are becoming popular in artic regions where power options are extremely limited.

AC Power

AC power is the most common and reliable of all means of electric power available when deploying ITS equipment in remote and rural areas. AC power is provided by local utility companies which are responsible for ensuring the power is clean (ie correct voltage and frequency) and available (ie high up time, disruptions are repaired quickly) which heavily reduces the amount of maintenance required by clients which receive these power services. The other advantage to AC power is that it's nearly limitless in its ability to power ITS related equipment. While many ITS system components are low power and solar friendly, many others like CCTV cameras and Electronic Message Signs are extremely power hungry and much better suited to a hardwired AC power connection.

Probably the most challenging aspect of an AC power connection is the provisioning and commissioning of a new AC power line from the grid to your specific roadside location. Often a transformer is needed to condition the high voltage transmission lines down to a more useable 110V AC connection as one would be used to in their homes. In addition to the cost of the transformer of equipment is not able to be placed directly adjacent to a power line pole which requires underground conduit and trenching to route the power wires from the pole/transformer to the equipment being powered. This underground cable routing is often the most cost prohibitive aspect of an AC power system connection. In many cases renewable power systems become dramatically more attractive once the full cost of an AC power connection is evaluated and considered. However these often come at the expense of reliability and other factors mentioned above.

- Add comments about UPS systems

Solar Power Systems

Solar power has become extremely popular in the ITS industry in the past 10 years. While solar power technology has been around for over 20 years it's dramatic reduction in cost over the last 10 years has made it a much more viable solution within the ITS industry. It has enabled deployments of equipment in extremely remote locations which would never have been an option otherwise. It is by far the second most popular power source type used in this industry.

While in residential applications solar power is often installed to supplement or replace AC power as a means to reduce the environmental impacts and lower emissions, that is rarely the case in these deployments. Solar power is typically selected at a site due to the lack of available AC power or the prohibitive cost of running AC power to that site from the nearest power connection point. When AC power is readily available and nearby, it is extremely rare that a solar power system would be selected in its place, primarily because of the comparable reliability and maintenance requirements involved with solar systems (and as the systems being powered are often critical safety systems or infrastructure, reliability is crucial).

Solar systems at their core are fairly straightforward, they involve 3 major components:

- Solar Panel – Converts light into electrical power
- Batteries – Stores electrical power for later use
- Charge Controller – Manages power flows into and out of the battery during times of charging and discharging to ensure the most efficient operation

In the most basic sense, the solar panels provide power to charge the battery and power the electronics during the day and then at night the batteries take over full time and power the electronics through the night. In the morning when the sun comes back out the cycle repeats and the batteries are charged back up. If the system is sized correctly there will be sufficient capacity to accommodate all possible environmental conditions such as extended shady/overcast periods, snow covered solar panels, and excessive power consumption periods (Proper sizing also includes consideration for the deterioration of battery capacities over time and the impact which cold weather has on battery capacity).

The biggest challenges faced with the use of solar power systems in ITS is the correct sizing of the systems to accommodate the equipment it's used with. As ITS systems and their associated solar power systems are acquired through public procurement processes it is dependant on public agencies to write stringent specifications which ensure a reliable system is provided. As the sizing of solar systems is a somewhat complex operation, public agencies typically struggle to correctly write their tenders in such a way to ensure they receive reliable systems. Many of these bids are "low-bid" environments which also encourages suppliers to size these systems as small as possible in order to be the most competitive, resulting in sub standard performing systems when the specs are not written air tight. In the next section we will detail the key features and characteristics of a solar system which if properly required in the specs will ensure a reliable power system is provided and typically supplier cost-cutting strategies will be minimized/eliminated.

Add more detail:

- # days autonomy (ensure this can be achieved during winter with the reduced charge capacity of the battery banks. Per battery spec sheet)
- Designed for power consumption 20% greater than needed
- Supply solar panels which are 30% larger than needed to accommodate snow coverage and degradation over 10 years
- Supply battery banks which are 15% larger than what is needed to achieve the above autonomy to accommodate the capacity degradation experienced over it's 5 year life span.
- Ensure maximum discharge of the battery banks do not exceed 50% total capacity for wet lead acid batteries and no more than 80% total capacity of AGM and LiPO4 Batteries (note: LiPO4 batteries cannot manage temperatures lower than -20C). Above autonomy calculations must take this factor into consideration.

Wind Power Systems

Wind power systems are not very common in rural ITS applications due to their comparably higher cost compared to solar power as well as the unreliability of estimations of average wind speeds in a given location. Wind is highly variable and local conditions can have a dramatic effect on its viability from one location to the next (factors such as topography, height of the turbine, proximity to nearby structures and foliage, among many others). While average sun hour calculations for a given region/latitude are readily available and fairly reliable, the equivalent average factors for wind speed are much less reliable and highly dependant on site conditions. This makes system design & sizing extremely difficult. As a result wind power systems are often used to supplement solar power systems instead of being a dedicated power source. Wind power compliments solar power systems quite well because wind conditions typically improve in the winter and weaken in the summer while solar power experiences the opposite impacts. (ie during the summer solar is strong and during the winter, wind is strong)

Fuel Cell Power Systems

- Ethanol Fuel Generators – used in conjunction with solar and battery power systems in harsh conditions to extend the life and maintenance intervals. Very low power output but also it's liquid fuel is very dense and can last a full year without the need for refill.

Hybrid power systems

- Solar/Wind – As mentioned above very complimentary, best of both worlds
- Solar/AC – Similar to using a UPS system with an AC power connection but more reliable as the solar system can maintain the equipment even during very extended periods of outtages
- AC/Battery Street Light Powered – Similar to a UPS these systems run on AC power when available and then switch to battery power when the AC is turned off. This is a useful design strategy when powering your equipment on street lights which are powered only during the evening (street lights which are controlled from a central location and don't rely on a local photocell to turn on/off power)

Communication system options

General Considerations

Network communication is a critical aspect of any ITS system, both for local device communication as well as remote control and monitoring. While critical infrastructure and safety systems typically rely on dedicated local communication infrastructure for its normal operation, backhaul communication to centralized locations have traditionally been quite expensive.

Along urban roadways and freeways hardwired network infrastructure such as fibre optics is common place but in rural areas this is much too costly to be implemented. As such cellular LTE connections are most common to support rural ITS deployments.

With the advances in the cellular network coverage and the reduction in costs for LTE data plans, utilizing cellular modems for remote equipment monitoring & data collection has become common place. This has unlocked a wealth of new possibilities and efficiencies in regards to the types of systems a public agency can deploy as well as the ease at which it can monitor and maintain those facilities.

While LTE networks have enabled widespread connectivity it is not a silver bullet. There are still limitations in it's coverage areas and the affordability of high bandwidth data which require the consideration and use of other communication technologies. This is where other communication technologies, typically wireless, such as short range wireless, WISPs, and satellite communication service providers play a critical role in enabling rural ITS systems

Fibre

Fibre is the fastest communication medium currently available for extreme long distances. Fibre networks are the foundation of the internet and even stretch across oceans. They are extremely high speed and can communicate across vast distances, however their biggest downfall is their extreme cost both to install as well as maintain them. While still used in large municipalities and along urban highway networks, their use is beginning to diminish as newer wireless technologies such as 5G become adopted. While the fibre backbone which powers most critical infrastructure such as cell towers and the internet will not be going anywhere, use of this technology for last mile or near last mile communication is quickly being displaced by other more affordable technologies.

LTE

Cellular communication networks have expanded significantly over the past 10 years such that the majority of rural areas have near full coverage. Beneficial for rural ITS deployments is the fact that cellular tower deployments often follow along major road networks ensuring that cell connectivity is available along the vast majority of roadways, which means roadside equipment can leverage this connectivity as well.

With dramatic cost reductions in both cellular communication gateways (modems) as well as cellular data plans over the past few years, utilizing cellular LTE has become the dominant form of communication for rural technology deployments. The only remaining limitation on the applicable uses of LTE data plans are high bandwidth applications such as continuous video streaming which uses up too much data to be economical under existing pricing regimes. However over the past few years some cities and provincial agencies have been offered unlimited data rate/bandwidth SIM cards which unlocks this final limitation. While this type of plan is not yet available to private companies, it inevitably will be which will further drive adoption of this technology.

Cellular data services are provided under a number of schemas which each hold their advantages:

- Public Dynamic IP
- Public Static IP
- Private Static IP – The implementation of a private APN network by telecom companies on behalf of a third party such as a public agency or private company. In these schemas the provider segments their cellular network such that communication with these SIM cards is restricted using enterprise level network security. These segmented and private networks are then linked to the agency's municipal area network such that the devices behave as if they were part of the agencies private internal network.

LTE-M1 & NB-IOT

With the expansion of LTE networks, a number of providers have tried to leverage these networks to offer parallel services for IOT devices which require extremely low data rates and bandwidth. The most popular service focused on this market is the LTE-M1 network which is targeted to low cost, low bandwidth devices such as smart meters, smart tracking devices, and fleet services.

- Add more content

Wireless Internet Service Providers (WISPs)

As the cost of dedicated wireless radios operating in license free bands has reduced to costs approaching sub $100, internet providers are more and more utilizing this equipment to provide home internet to rural subscribers. In order to achieve this they deploy their own communication towers, or rent space on existing cellular towers to deploy their access points. From there point to multi-point networks are implemented to provide high speed connectivity to homes and businesses surrounding these communication towers.

While still not widely used for this purpose some ITS system integrators and public agencies have begun using these services to provide high speed, unlimited bandwidth connections to roadside assets. (with radios attached to traffic or light poles). As mentioned above unlimited LTE data plans are beginning to become available but until they become prolific, WISPs offer a very affordable option to perform continuous video stream from roadside locations. This can be used to provide connectivity to traffic signal equipment as well as dedicated CCTV. Speeds typically vary from 5-100mbps. As connections are typically limited to a single location a 5-10 mbps connection is sufficient to stream at 1080p and the associated monthly cost is approx. $100/month.

- Add more content

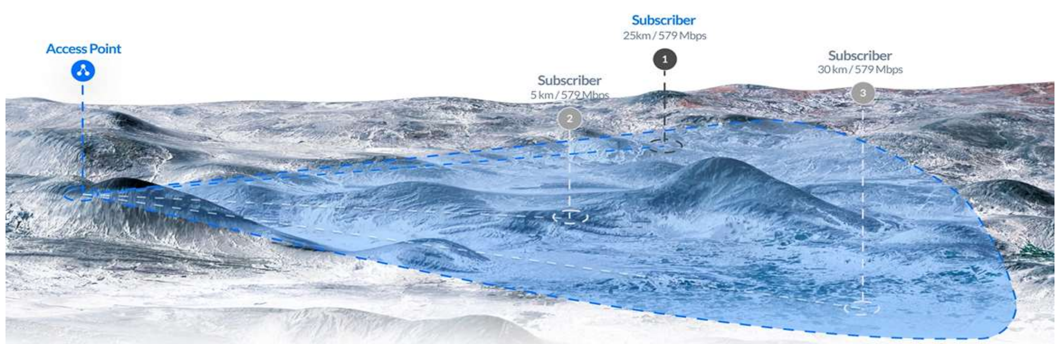
Dedicated Wireless Networks

While WISPs deploy and maintain wireless networks as a service, it's also possible for agencies to deploy their own wireless networks for more reliable and controllable infrastructure. This of course comes with its benefits and drawbacks.

Wireless network solutions typically fall into one of the two categories below:

- Point to Point networks (PTP) - long distance links typically using the 5GHz & 24GHz frequency bands at distances up to 150km. Typically backhaul connections.

- Point to Multi-Point Networks (PTMP) - Multiple medium to short distance links back to a single outdoor access point utilizing primarily the 5GHz band at distances up to 25km.



Traditional Satellite communication

Remote data communication using Satellite networks has been around for over 20 years and while the same technical limitations are still in place the costs for these services has dramatically decreased. They still do not compare to LTE pricing but in remote areas you are typically faced with not other options except for satellite.

The technical limitations of satellite involve the latency of the communications and the speeds on the upload portion of the communication. Often download speeds are comparable to LTE on the order of 5-25mbps while upload speeds are much slower in the 1-3mbps range. Latency is typically around 600-1000ms compared to less than 50ms for most terrestrial internet service providers. For ITS deployments which only require occasional sensor data uploads these limitations will not have a significant impact. Where these will impact ITS deployments are when high data upload usage is required such as the deployment of CCTV cameras. In these cases the 1-3mbps will only support a low resolution video stream reliably being uploaded, on the order of approx. 480p. Another challenge is if these are PTZ cameras then the commands to move and zoom the camera are often heavily delayed due to the connection latency which makes these tasks challenging as they take 3-5 seconds from time of command entry to actually seeing the camera move.

These systems involve two key components: (1) satellite dish and (2) modem/transceiver. These systems are fairly power hungry and sometimes include heaters to keep ice off the dish in winter conditions, as such they are not friendly to solar and other off-grid technologies and AC power is usually required (however higher power off-grid power systems like ethanol fuel cell systems are able to support them).

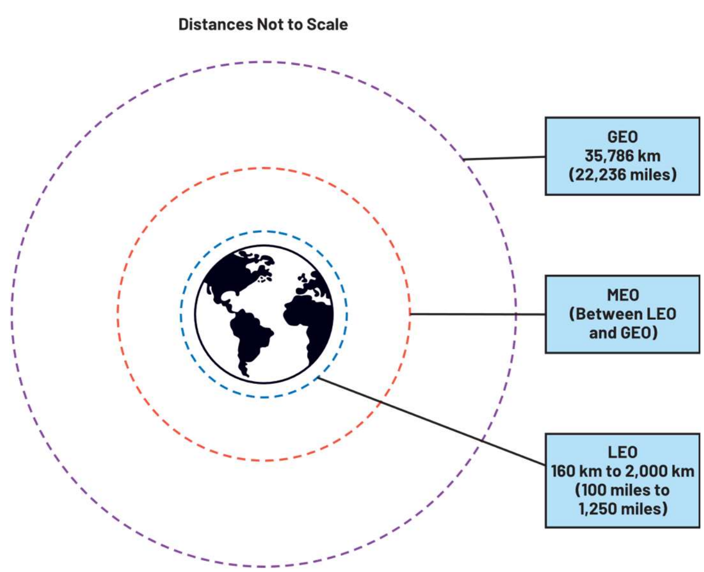
The costs related to these systems are on the order of $4000 - $7000 CAD for the hardware components while the service costs are on the order of $200-400/month for a 2GB/month data plan(including static IP).

Low Earth Orbit (LEO) Satellite Communication

Low Earth Orbit (LEO) Satellite services are a very new technology which is offering some very interesting use cases for the Traffic and ITS industry. While this technology had been around for some time it was really popularized by SpaceX through the launch of the StarLink constellation network with the promise of bringing highspeed home internet to users anywhere in the world (with a focus on Rural customers).

LEO satellites are distinguished from traditional satellite deployments by its much lower orbit around the earth. Traditional satellite based internet services are provided by satellites in Geo-Stationary orbit which is around 35,000km from the earths surface. Comparably, StarLink and other LEO satellites orbit at a distance of approax 1200km. This difference in distance results in much great latency and upload speeds being possible.

LEO services leverage many of the benefits of satellite communication (ie near ubiquitous coverage area) while seemingly resolving all its key detractions. (Latency and upload speeds). In addition to these benefits the hardware and subscription costs are also much lower for LEO services. On the order of $500-1000 for the hardware and $150-300/month for a 500GB/month service plan. There are likely IOT pricing models focused on the 1-2GB/month range discussed in the previous section but we could not locate specific costs to mention here, likely dramatically less.



It's expected that LEO communications will have a dramatic impact on the IOT market and in the ITS market particularly. The technology is so new that it has not been employed significantly but over the next 5-10 years I expect it to find it’s way into many rural ITS projects, especially any of them which have high bandwidth requirements.

RURAL ITS - SOLUTIONS

Overview

In this section we will provide a detailed list of rural ITS solutions. For each system we'll provide information on why they're used, how they work, relevant design considerations, and typical challenges.

- 1-3 page write up on each technology/solution. Confirmed solutions listed below, other potential topics listed in "other" section at end
- If you wish to volunteer for a specific system please highlight it's name and add a comment to the title something like: "I volunteer for this one". Similar to the comment added here.

List of systems to focus on:

General Technologies

- Variable Speed Limit systems
- Intelligent street lights (LEDs, LTE, sensors, etc)
- Rural VMS system applications – What's possible, challenges
    - With no AC, no LTE
    - Discuss data which feeds them
    - Applications, etc

Warning systems

- Animal Detection & Warning systems
- Overheight Detection Systems
- Flood Detection & Warning systems
- Slow moving vehicle warning systems – agricultural, school bus, Heavy Good Vehicle (HGV, targeted warning systems TC31A like, impacts on design, ie roundabouts)
- Avalanche Detection & Warning systems

Traveller info

- Rural 511 services – digital permitting, etc
- Travel time systems
- Road weather information systems

Data collection

- Traffic Count Stations – How are these used, what technologies, etc
- Subsurface Temperature Monitoring – use case, challenges, etc.

- Air quality & GHG monitoring
- RWIS – Road Weather Information Systems

Security & Compliance

- Remote CCTV

Commercial vehicles

- Weight in Motion
    - Tire sensors
    - Brake sensors

Rail

- Railway Crossings – advanced warning systems
- Railway Crossings - Near miss & Behavioural analysis

Other

This section includes a selection of suggested topics. They are left out from the primary list as they are too vague or a subject expert has not volunteered to write them. Included here for interested parties to adopt, review, ellaborate, inspire or adapt to more relevant/specific topics and then be added to the above lists.

- EV Charging
- Rest areas/Brake checks/chain-up/chain-off
  - Offering services at these facilities
  - parking occupancy detection (commercial vehicles)
- Border Crossings in Rural Areas – How can ITS assist?
  -
- Ice roads, etc
-
- Rural ITS conferences often focus on remote monitoring, road weather models & warning systems, road/bridge closures & detours, and autonomous, remote, self-sustaining technologies with minimal maintenance requirements.
- In many rural communities tourism is a main industry, as such they need to manage peak traffic from visitors only at specific times of year. Always a challenge.

Example:

EXAMPLE: Overheight Warning Systems

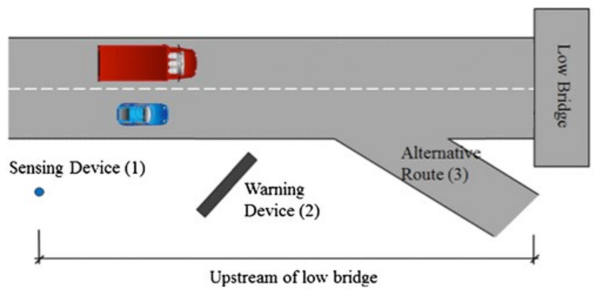
These systems involve the detection of overheight vehicles as they approach height-restricted obstacles such as bridges & tunnels in order to warn drivers and prevent a collision.

Warrant/Justification: Many rural communities have older bridges which do not meet minimum height clearance regulations. These can often be hit by overheight vehicles, causing significant damage to the infrastructure. Infrastructure repair costs are often many fold more than the cost of a warning system, thereby justifying their implementation in cases where bridge strikes are possible.

Operation: Once the sensor detects a vehicle is overheight a series of warning devices (such as beacons, LED signs, or VMS) warn the driver that they are overheight, and provide guidance on how to avoid the obstacle.

System Components: These systems involve two key elements

- The detection system includes a sensor, a controller, a power system, and a communication system to interface with the warning pole.
- The warning system includes a warning device, a controller, a power system & communications.



Design Considerations: Systems are installed on the approach towards an obstacle but positioned far enough in advance to provide a detour road for vehicles to take when they're detected as overheight.

Sensor types – Dual beam infrared sensors are the most common, however LIDAR sensors are beginning to be used as well

Operation/Maintenance Considerations: Sensors can get clogged by insects nesting in infrared tubes, system operation should be testing and maintained bi-annually. Remote monitoring highly recommended for solar powered systems (battery monitoring & system health)

Cost Considerations:

Typical Challenges:

- Lack of AC power – This is a common problem & while solar is a viable option it's important to highly oversize these systems for reliability as they are in remote conditions. (ie 10+ days autonomy)
- Difficult to monitor – add comms
- Difficult to catch violators – add cameras

Variable Speed Limit Systems

These systems involve the use of variable display systems, either electrical or mechanical, which allow agencies to dynamic change the speed limit on a roadway based on various set conditions. These conditions are usually detected by field sensors, processed by central software and then decisions made to change speeds automatically based on a decision matrix.

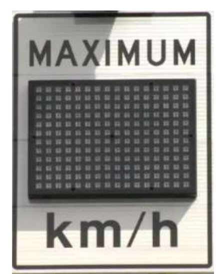
Warrant/Justification:

Speed is one of the more determinant factors in the severity and likelihood of a collision in almost all road conditions. As such controlling the speed more closely is the intent of these systems, especially when the driving conditions are not conducive to driving at the posted speed limit. These systems are often looking to detect poor driving conditions such as heavy rain, heavy snow, icy roads, or low visibility and using those to trigger reductions in the legal speed limit in order to force drivers to go slower. Triggering speed limit reductions based on heavy congestion conditions is also common as well.

Operation:

Typically involves sensors along the roadway measuring environmental conditions, road surface conditions, and congestion conditions. The data from these sensors are aggregated and analyzed by a software control system and under specific conditions this control system will make the decision to reduce the speed limit. The speed limit is reduced through the use of connected roadside devices, typically an electronic message sign, or prismatic mechanical sign.

System Components:



- Roadside Sensors deployed along the roadway, either existing or new
- Control Software deployed along the roadside, centrally based, or cloud based
- Display Systems deployed along the roadway, sometimes collocated with sensors

Design Considerations:

Key design considerations involve hardening the system such that it is highly redundant and will always fail safe. Displaying incorrect or especially conflicting speed limit information can be dangerous and confusing for drivers so ensuring a comprehensive monitoring & control system for each display device is critical. Including CCTV cameras for condition and system monitoring is highly recommended as an additional data source to ensure system operating correctly. Add more

Operation/Maintenance Considerations:

Regular preventative maintenance is critical especially for the sensors which drive the system. As the readings form these sensors typically drive speed limit changes automatically, it's important to ensure they're working properly. For example: Visibility sensor tubes are subject to being compromised by weather and insects nesting.

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Intelligent Street Lights

Intelligent street lights are streetlight mounted sensors that combine with an onboard LTE-M communication and robust cloud software to offer a turnkey traffic data collection solution. These sensors are easily mounted on streetlights on to the NEMA socket available on all streetlights in 5 minutes and start working immediately. The sensors are often offered as a service for traffic departments and provide dashboards and reports for traffic volumes, speeds, and classification. The intelligent streetlights also include sensors for pollution, noise, and camera sensors.

Warrant/Justification:

Traffic data collection is a necessary tool for providing valuable insights about traffic infrastructure, improving traffic systems, and identifying issues for traffic safety. The cost of implementing and managing a traffic data program is often prohibitive for smaller municipalities and townships in rural Canada. Intelligent streetlights are proven to be low cost and low-maintenance alternative for traffic data collection and are an attractive option for traffic data collection in rural areas with streetlights. Intelligent street light systems can provide insights about traffic volume, speed, and classification data.

Rural traffic departments often have lower annual budgets to spend on road infrastructure and safety. Correct traffic data can improve decisions of rural traffic departments to spend their budgets on the right problems.

Resident complaints are also a major factor in decisions of rural traffic departments. Traffic data collection can often validate the complaints using traffic sensors before taking the right actions to solve the complaints.

Operation:

Intelligent streetlights operate in a simple configuration, and includes the following components

1. NEMA Complaint base
2. Sensor
3. LTE Module
4. Data collection software

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Rural Variable Message Sign(VMS) Systems

Variable Message Signs (VMS) are electronic signs which utilize LEDs to provide information to the travelling public. These systems have been widely used in both permanent and temporary conditions for over 20 years. While viable in many rural ITS conditions there are limitations in certain areas typically based on power and communications infrastructure availability. In urban environments multi-lane large electronic signs mounted over the roadway are typical but in rural conditions it's much more common to see a "lollipop" signs mounted on the roadside on a single pole with an approximate size of the width of a lane (4-5m). This is also the typical size of a large sized Portable VMS trailer(PVMS). PVMS trailers are also very often used in rural environments.

The latest innovations in this space is the introduction of much higher resolution displays as well as the introduction of full colour LED displays. These features were often reserved for the very expensive multi-lane displays due to cost but they are now available and affordable for use in smaller lollipop style signs as well as PVMS trailers.

Warrant/Justification:

Use cases for VMS vary widely from standalone systems meant to provide general information to the driving p ublic to highly integrated systems which are only a component of a larger ITS system such as a travel time system or flood warning system. The most common use case is using them as general messaging platforms which display default safety messages until an incident occurs and operators of the roadway need to communicate information to the public such as a collision or lane closure ahead.

Operation:

These systems operate on either AC or Solar power in most cases and also always LTE communication due to the small amount of data needed to control and monitor them. VMS signs in North America are controlled using the NTCIP communication protocol which is a standardize protocol which was developed and released by the NEMA organization starting in the late 90s. These standards are almost universally adopted by all agencies in North America and allow many different central software control systems to control VMS signs from any manufacturer allowing for flexibility and competition.

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Animal Detection & Warning Systems

Animal detection and warning systems can detect large animals such as deers, bears, wolves, and moose as they approach the road and activate signs to warn drivers that large animals may be present on or near the road. One part of the system detects the animals as they approach the road, and the other part warns the drivers after the detection has occurred.

Warrant/Justification:

Traditional wildlife road signs, though frequently used and inexpensive, tend to be ignored by the drivers. Studies conducted by researchers show that 60% of the drivers do not even notice traditional wildlife warning signs.

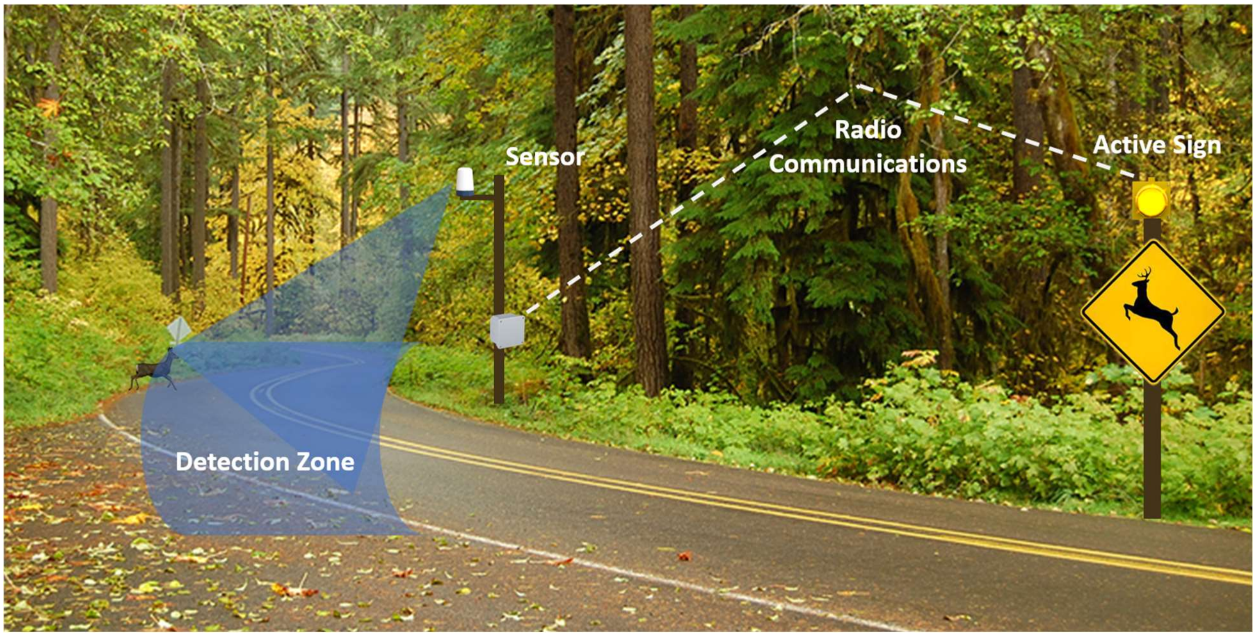
Flashing signs get higher attention from drivers, and can reduce the risk of both wildlife loss or severe accidents for road users. These systems shall be used in areas known for wildlife accidents on highways and high-speed roadways.

Operation:

The operation of animal detection and warning system could differ based on the frequency of animal related crashes, size of animals, road geometry, and road speeds. The size of animals and road geometry influence the animal detection technology that is more suitable, while the road speeds have an impact on the type of signage that is used to warn drivers.

System Components:

Animal detection and warning systems comprise of three major parts –



Animal detection systems: These systems are purpose built to detect animals as they approach the roadway. There are two main types of animal detection systems:

- Area coverage systems: These systems detect an animal within a certain area and range of a sensor through passive infrared technology, alterations in an electromagnetic field, 360-degree radars, LIDAR, or AI cameras.

- Break the beam systems: These systems detect an animal when the animal's body blocks or reduces an active infrared, laser or radar signal that is transmitted by one sensor and received by another sensor.

The durability and practicability of the system can be shown be a consistent performance over time, minimal monitoring, and maintenance requirements, size of the equipment, and the road length the sensors are able to cover.

Communications: The wired or wireless communications between the animal detection systems and the roadside warning signs.

Roadside animal warning signs: alerts animals and drivers through a range of audio and visual signals from signs or stations places neat the roadway.

Design Considerations:

The design considerations of an animal detection and warning system includes:

- Length of the conflict zone: The length of the conflict zone on the roadway could be estimated by the actual locations of the crashes on a given stretch on the roadway, locations of complaints by road users, or by conducting a study.
- Types of animals: The type and size of animals crossing the roadway at the location helps identify the right animal detection technology for the location. Radar or camera-based solutions are more suitable to fast moving animals such as deer or moose, while infrared or electromagnetic sensors are better for use when detecting slow moving animals.
- Road geometry and speed – Road geometry and speed influences the number of sensors (and coverage areas) and location of installation of animal detection systems. The placement of active warning signs is also influenced by the road geometry and posted speed on roadway.
- Weather – Weather conditions such as rain, snow, and fog can also have an impact on selection of sensing technology and type of active warning signs used at the location.

Operation/Maintenance Considerations:

The reliability of animal detection and warning systems is influenced by a range of weather conditions such as high winds, temperatures, rain, and snow. The animal sensors are often calibrated for optimal performance in the detection zones. Changes in sensor angles can have an impact on the reliability of animal detection.

Periodic cleaning of sensors such as cameras and IR sensors, and periodic recalibration of sensors shall be considered as part of maintenance operations for such systems.

Growth of trees or adding signage in the field of view of the sensors may occlude the sensors, and result in loss of detection of animals.

Cost Considerations:

Animal detection and warning systems can be expensive to purchase, install and commission. The municipality can apply for a range of federal and provincial programs to get funding for such systems.

Typical Challenges:

- Weather conditions – The reliability of animal detection systems can differ based on weather conditions. Choosing the right detection technology is important.
- Size of animals – Smaller animals such as rabbits, snakes, or skunks are difficult to detect.
- Speed of vehicles – Higher speed of vehicles on roadways limit the actions they can take when they see an animal. Posted speeds in conflict prone zones should be reduced to improve the impact of animal detection and warning systems.

Overheight Vehicle Detection & Warning Systems

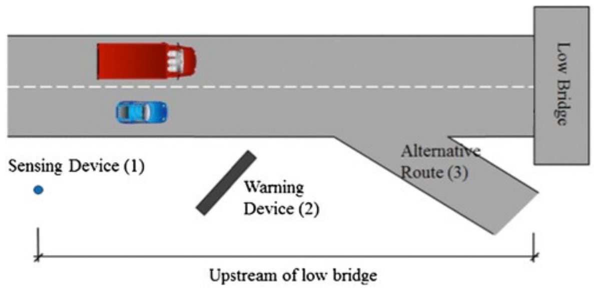
These systems involve the detection of overheight vehicles as they approach height-restricted obstacles such as bridges & tunnels in order to warn drivers and prevent a collision.

Warrant/Justification: Many rural communities have older bridges which do not meet minimum height clearance regulations. These can often be hit by overheight vehicles, causing significant damage to the infrastructure. Infrastructure repair costs are often many fold more than the cost of a warning system, thereby justifying their implementation in cases where bridge strikes are possible.

Operation: Once the sensor detects a vehicle is overheight a series of warning devices (such as beacons, LED signs, or VMS) warn the driver that they are overheight, and provide guidance on how to avoid the obstacle.

System Components: These systems involve two key elements

- The detection system includes a sensor, a controller, a power system, and a communication system to interface with the warning pole.
- The warning system includes a warning device, a controller, a power system & communications.



the

Design Considerations: Systems are installed on the approach towards an obstacle but positioned far enough in advance to provide a detour road for vehicles to take when they're detected as overheight.

Sensor types – Dual beam infrared sensors are the most common, however LIDAR sensors are beginning to be used as well

Operation/Maintenance Considerations: Sensors can get clogged by insects nesting in infrared tubes, system operation should be testing and maintained bi-annually. Remote monitoring highly recommended for solar powered systems (battery monitoring & system health)

Cost Considerations:

Typical Challenges:

- Lack of AC power – This is a common problem & while solar is a viable option it's important to highly oversize these systems for reliability as they are in remote conditions. (ie 10+ days autonomy)
- Difficult to monitor – add comms
- Difficult to catch violators – add cameras

Flood Detection & Warning Systems

Flooding can be a major hazard on roads in low lying areas and underpasses. Flood detection and warning systems detect rising water levels and provides automated warning / alerts for road maintenance managers and road users.

Warrant/Justification:

Rural areas in Canada may face water hazard on roads due to melting snow and heavy rainfall especially in low lying areas on roads. Even six inches of water can make a road dangerous, and a foot or more of flowing water can sweep a car off the roadway. Budgetary constrains do not often allow for elevated roadway construction for less used rural roads. A flood detection and warning system is a cost-effective alternative that provides the ability to warn road users through a flashing warning sign, and also provides the ability to inform the right public works personnel to call for action.

Operation:

The operation of the system involves installing an electronic water level sensor at the right location and warning road users via a flashing sign. Advanced systems have ability to send sms or electronic messages to the municipality's road and stormwater personnel. The system may use solar power options when AC power is not available at the location.

System Components:

These systems involve two key elements

- The detection system includes a sensor, a controller, a power system, and a communication system to interface with the warning pole. The detection system may also contain a cell modem configured to send automated messages to a list of cell numbers.
- The warning system includes a warning device, a controller, a power system, & communications. The warning system may also include a cell modem to communicate with the traffic control centre or with traffic operations personnel.

Design Considerations: The design can vary from one location to another depending on the road geometry and the speed of vehicles on the roadway. It is important to identify low altitude locations prone to flooding and installing the right sensor at the right location. The sensors shall be installed at location less prone to collecting debris or mud as it may activate a false alarm. For large locations multiple sensors may be installed activating signs on both sides of the roadway.

The speed on the roadway is a factor in deciding the distance at which the flashing sign is installed from the flood-prone location.

Operation/Maintenance Considerations:

There are three major operational considerations:

- Power supply: Solar powered systems are easier to operate and maintain. They also tend to be safer for flood-prone locations. Annual battery check for solar powered systems is recommended. Solar panels may also need periodic cleaning.
- AC powered systems may utilize a safety and disconnect switch to prevent shock hazard. These systems must be approved by a competent authority for safety.
- Sensor maintenance: Depending on the sensor selected for water level measurement, the sensor may need periodic cleaning to accurately detect flooding or to reduce false alarms. Water level detection may also be influenced by a range of environmental conditions such as freezing temperatures, high water flow rate, and high winds.

Cost Considerations:

Typical Challenges:

Typical challenges include

- Identification of locations: Flood prone locations near roadways are not easy to identify unless flooding has been recorded in recent past. The municipality’s planning department can help identify such locations.
- Selection of right level sensors: Most level sensors are designed for industrial environments where level is measured inside protected tanks. Adjustable water level sensors may be protected and installed in tubes to ensure these sensors only activate the warning signs when there is a rise in water level. The protection tubes often protect these sensors from flies and animals.

Slow Moving Vehicle Detection & Warning Systems

Slow moving vehicle detection and warning systems detect vehicles at accident prone zones and warn drivers about slow moving traffic at intersections or curves on roadway. Temporary slow moving vehicle detection and warning system may also be used at road construction work zones on rural highways.

Warrant/Justification:

During planning and harvesting seasons large, slow moving farm equipment may be on the highway. Similarly large mining trucks may be using highways around mining sites in rural areas. These large vehicles often create dangerous situations while crossing high-speed roadways. A slow-moving vehicle warning sign with activated beacons or blinker lights makes motorists aware of imminent slow-moving vehicle near the roadway and reduces the risk of conflicts and collisions.

These systems are especially appropriate at intersections with trees or structures reducing visibility of slow-moving cross traffic.

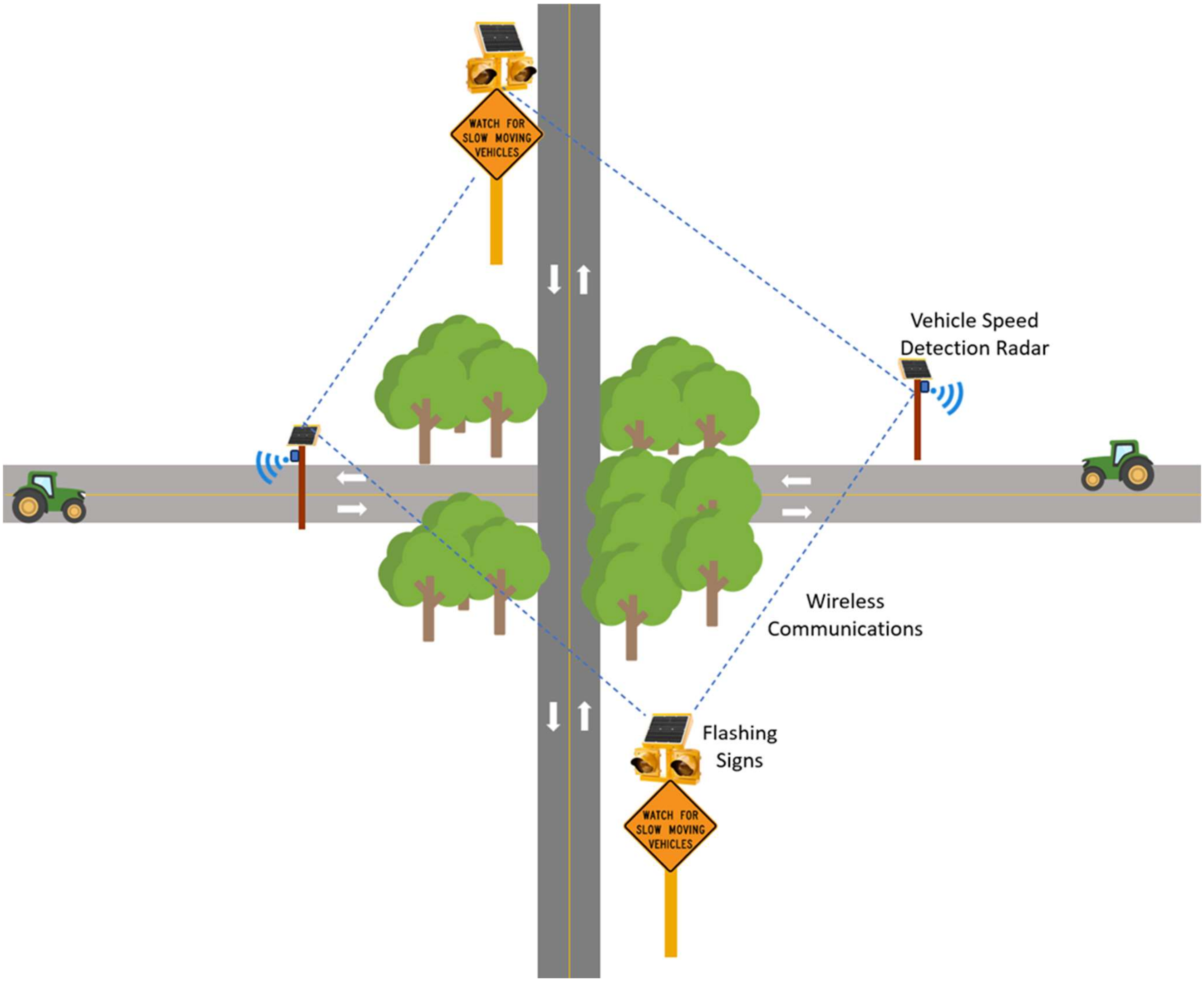
Operation:

The effective implementation of the system depends on the road geometry and the 85th percentile speed of vehicles operating on both roadways. Slow vehicle detection radars are installed and configured for detecting vehicles in the right speed range (typically 15 kmph to 40 kmph) at the right distance from the intersection. The sensor distance and the warning sign distance from the intersection in meters can be estimated from the intersection based on average speed of slow-moving vehicles and the average time taken by drivers to respond to warning signs. Distance (meters) = Average Speed (kmph) X 1000 ÷ 3600 X Average Response time

The radar detects the vehicles and send a radio signal to the warning signs to activate flashing. The warning signs then flash for approximately 20-30 seconds to warn drivers of possible slow-moving vehicles on the roadway.

Some systems may use a camera-based detection for a certain type of vehicles to warn road users.

System Components:



The system primarily has 3 major components:

- Vehicle speed detection system- The vehicle speed detection systems may use either a radar, which is more reliable during different weathers, or a camera system, capable of differentiating larger trucks or farm equipment from passenger cars, to detect the vehicles and their speeds. These systems can either be solar powered or AC powered. Solar powered system shall be adequately designed to accommodate for operations during winter.
- Communication system – Wireless radios are typically used for one-way communications between detection systems and warning systems. Wired systems may also be used but may need higher budget to accommodate additional cabling and ducting.
- Warning systems – The warning systems typically have a sign and beacons. Depending on severity of the conflicts, a single beacon, a dual beacon, or flashing LED signs can be used. Radio communications provides contacts for automated activation of these signs. These signs can be active for 15 seconds to 30 seconds depending on the traffic volumes on the roadway. Roadways with higher traffic volumes typically have more activation period for flashing beacons.
  - • Component 1 description 1
  - • Component 2 description 2

Design Considerations:

Typical design considerations vary depending on the road geometry, speed and conflicts observed on the roadway. Some intersections may need a slow vehicle detection on both the main road and the side road on the intersection to provide warning signs to both set of road users. Various design options are available as shown in figure below –

The design of the system shall also include the following considerations:

- Location of vehicle speed detectors – location of vehicle speed detectors shall be done at a suitable distance such that the oncoming vehicles on the other roadway can be made aware with ample time to react, if needed. These systems may be installed on existing poles to save costs.
- Location of warning signs – Warning signs should be installed at locations following local provincial or territorial guidelines about signs with respect to the speed on the roadway. The warning signs may be installed on existing poles to save costs.
- Radio communications distances – When the vehicle speed detection system and the warning signs are father than 200 meters or there are obstructions such as trees or houses in the line of sight, then a radio repeater can improve signal strength at longer distances.
- AC or Solar power – Providing AC power to locations can be costly and adds a monthly utility consumption at the site. Solar powered options are lower cost to install and operate, however they do have a disadvantage in northern rural areas with limited sunlight during winter. Solar powered systems can also be limited when there are tall trees or structures affecting the availability of sunlight at the install locations. Appropriate power systems shall be used based on the site.

Operation/Maintenance Considerations:

These systems are known to be low maintenance systems, and may need occasional maintenance to clean camera lens, or to change flasher lights.

Cost Considerations:

The systems are typically low cost and are available for purchase in the range of $10,000 to$20,000. Installation of posts and maintenance costs have not been considered.

Typical Challenges:

Typical challenges include

- • Selection of right detection technology – Reliability of detection and speeds during the right season is important. For mining sites it may be important for the system to work throughout the day. Radar systems are more reliable for such sites.
- • Radio communications range – The distances between the vehicle speed detection system and the flashing signs need to be considered while designing and specifying the system requirements. The radio signals may not work due to presence of trees or other structures, and may need a radio repeater.

Avalanche Detection & Warning Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Rural 511 Digital Services

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Travel Time & Origin Destination Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Poor Weather Advisory Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Traffic Data Collection Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Subsurface Temperature & Moisture Monitoring

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Air Quality & Green House Gas Monitoring

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Road Weather Information Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Remote CCTV Monitoring Cameras

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Weight in Motion Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Railway Crossing Advanced Warning & Detour Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Railway Crossings Conflict Analysis & Data Collection

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

Railway based Weight in Motion Systems

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3

RURAL ITS - CASE STUDIES

Overview

Two page write up for each case study. Target 4-6 case studies

- BC MOTI avalanche warning system
- GNWT Traffic monitoring & 511 system
- MTO Wildlife Detection System near North Bay, Hwy 11 – 360 Radar + Thermal
- Traveller information system – Yukon – DMS w/ EFOY

Content to include for each:

- Project location and implementation date
- Intro
- Operation
- System components
- Design considerations
- Maintenance & Operations challenges
- Operational Costs
    - Maintenance
    - Vandalism
    - Operating costs

Template - System Title

Summary of system purpose and operation

Warrant/Justification:

Operation:

System Components:

- Component 1 description 1
- Component 2 description 2

Design Considerations:

Operation/Maintenance Considerations:

Cost Considerations:

Typical Challenges:

- Challenge 1
- Challenge 2
- Challenge 3