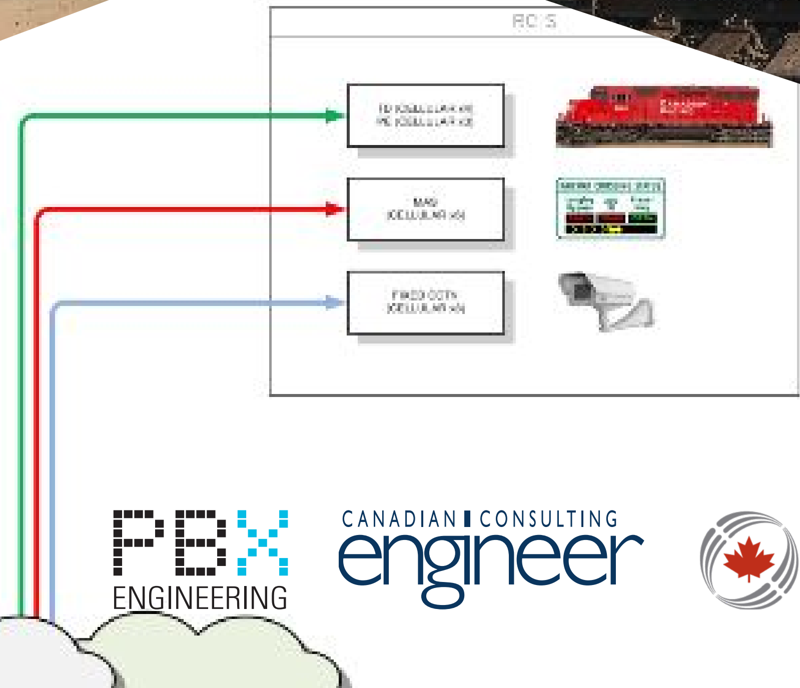

# Railway Crossing Information System

## PBX Engineering Ltd.



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# EXECUTIVE SUMMARY

The Roberts Bank Rail Corridor is a critical east-west link for the movement of goods by rail —connecting ports and facilities to the North American rail network. The railway runs through the City of Surrey, City of Langley, and the Township of Langley. Within the project area, this includes four at-grade rail crossings, where major roads intersect with the rail line.

When trains transit through the rail corridor, the at-grade intersections may be blocked for extended periods of time. As a result, motorists in the area often experience significant delays while the crossings are blocked, as well as delays due to residual traffic congestion that can take many minutes to clear once the train has passed. Blocked crossings result in a number of other impacts for the general public – including reduced commerce, increased emergency response times, and increased pollution levels.

Rail traffic is predicted to increase both in frequency and in length. Recognizing the need to address this growing issue, the Ministry of Transportation and Infrastructure initiated the Rail Crossing Information System (RCIS) project. The objective of the RCIS is to implement an Intelligent Transportation System (ITS) to mitigate the impact of rail traffic and optimize the use of the road infrastructure by providing motorists with information that will enable them to make informed route choices, reducing traffic congestion and its associated environmental, economic, and social costs. Information regarding the status of the crossings will encourage drivers to divert to alternate routes. PBX was engaged to plan, design, and implement the system.

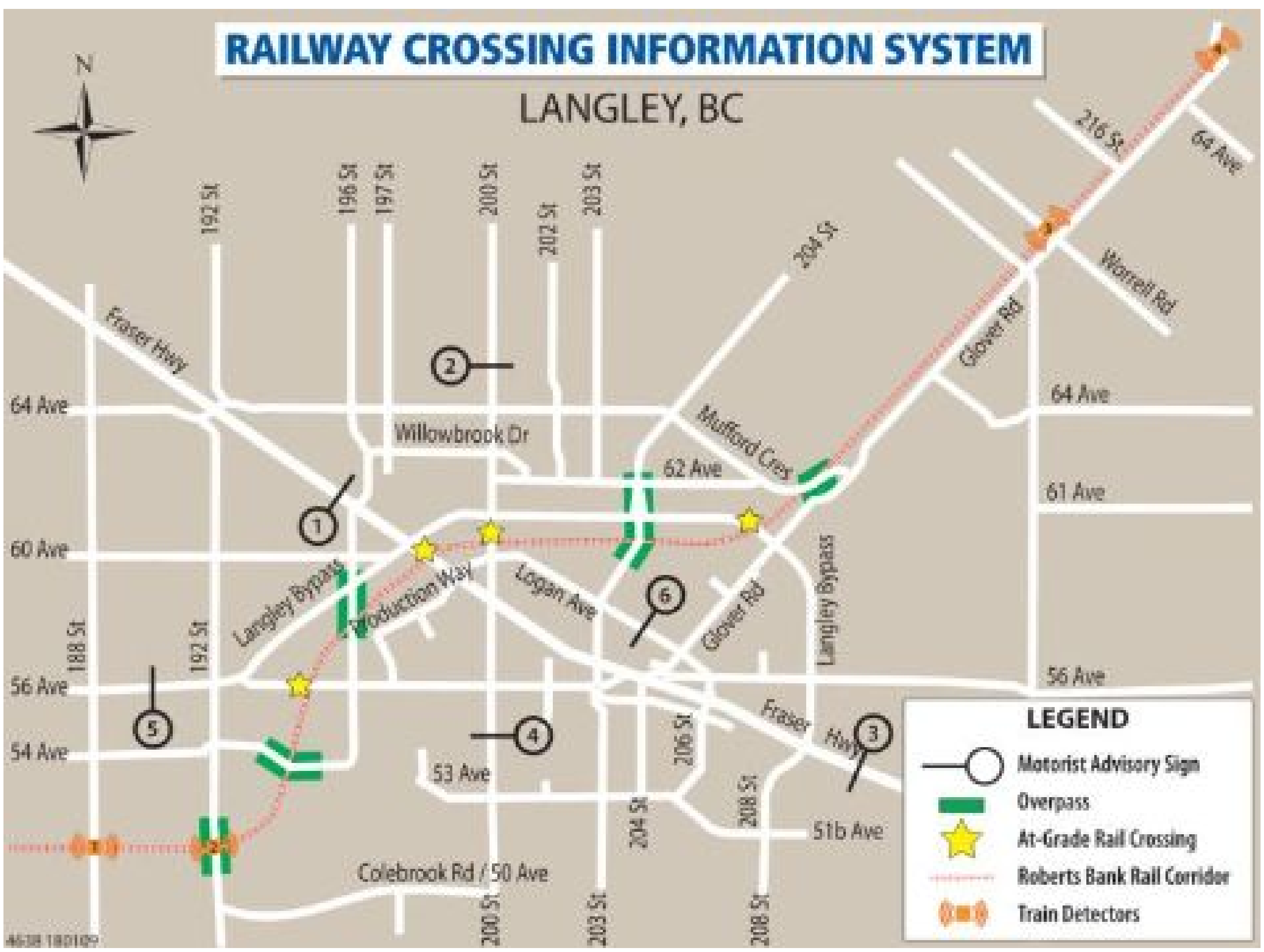



**Figure 1 - Project Area & Key Locations**

Figure 1 highlights each of the key locations throughout the project area, including:

- The Roberts Bank Rail Corridor;
- Overpasses currently bypassing existing crossings;
- At-grade crossings within the City of Langley;
- Each of the four Train Detector locations; and
- Each of the six Motorist Advisory Sign locations.

## PROJECT INCEPTION

The Roberts Bank Rail Corridor (RBRC) represents a critical east-west link for the movement of goods by rail—connecting ports, terminals, and other facilities to the larger North American rail network. Built prior to the densification of the Greater Vancouver Area, the railway now runs through the core of the "Langley's" comprised of the City of Surrey, City of Langley, and the Township of Langley. Within the project area, this includes four at-grade rail crossings, where major roads intersect with the rail line.

When trains transit through the "Langley's" area of the corridor, the at-grade intersections may be blocked for extended periods. As a result, motorists in the area often experience significant delays while the crossings are blocked, as well as delays due to residual traffic congestion that can take many minutes to clear once the train has passed. One of the busiest at-grade crossings within the City of Langley, located at 200th St. and Production Way, can be seen blocked by a passing train in Figure 2 below. Blocked crossings result in a number of other impacts for the general public – including reduced commerce, increased emergency response times, and increased pollution levels. A comprehensive study on global trade and its effect on the Pacific Gateway, led by Transport Canada, was conducted, which predicts significant increases in railway traffic volumes and train lengths in the near future to meet increasing demand.


**Figure 2 - Early Congestion at 200th Street & Production Way**

Recognizing the need to address this growing issue, the Ministry of Transportation and Infrastructure and other partner agencies initiated the Rail Crossing Information System (RCIS) project. PBX was engaged to plan, design, and implement the system, effectively managing a multi-disciplinary team that included traffic modelling, structural, civil, and geotechnical engineering.. PBX developed the Preliminary Design Report, tested different technologies, completed the full electrical and systems design, coordinated the inter-discipline design process, oversaw construction, programmed and configured the system operation, and undertook complete performance testing. PBX effectively managed a multi-disciplinary team that included traffic modelling, structural, and geotechnical engineering. The project was delivered on time and on schedule.

The objective of the RCIS is to implement an Intelligent Transportation System (ITS) to mitigate the impact of RBRC rail traffic and optimize the use of the road infrastructure by providing motorists with information that will enable them to make informed route choices, thereby reducing traffic delay and congestion and its associated environmental, economic, and social costs. Information regarding the status of the crossings will encourage drivers to divert to alternate routes, such as the recently constructed overpasses.

## SYSTEM DESIGN

### *System Overview*

The RCIS detects trains entering the “Langley’s” area of the RBRC corridor by utilizing multiple train detector checkpoints placed strategically along the corridor. Each train detector is comprised of an innovative suite of integrated sensors and field controllers that detect and measure train metrics. Gathered information is ingested by the system, processed by custom-developed adaptive algorithms within a sophisticated Advanced Transportation Management System, and relayed to the six Motorist Advisory Signs (MAS). The MAS are a unique hybrid of static and dynamic information elements.

The information displayed provides motorist with a predicted status of the four at-grade crossings relative to the motorist’s location, along with the train’s direction of travel and relative position. The MAS’s unique graphical format provides timely en-route status information that enables motorists to adjust their route choice and divert to nearby overpasses or unimpeded at-grade crossings to avoid travel delays.

Extensive traffic modelling of travel time savings was undertaken to validate the cost-benefit analysis and environmental benefits. The RCIS operates autonomously, without the need for operator intervention. Remote access to the devices is provided by the means of cellular modems so that the system can be monitored, remote alarms can be received, and data can be transmitted to the central system.

### *Environmental Considerations*

The RCIS will result in direct environmental benefits to the surrounding areas of the RBRC. As part of the RBRC Program, it was determined that major crossings currently typically remained occupied anywhere from 2-5 minutes during a rail event. To support increased international trade and the movement of goods through the Port of Vancouver, rail events are predicted to increase in both length and frequency in the coming years, resulting in longer and more frequent crossing closures. On average every 1 minute of blockage results in roughly 5 minutes of congestion. By reducing this congestion and corresponding unnecessary idle times, the RCIS will result in significant reductions in greenhouse gases. Additional environmental benefits from the RCIS include reduced noise pollution from excessive roadway congestion and improved air quality of the surrounding areas. Alleviating traffic delays will facilitate the movement of goods and services adjacent to the RBRC, reducing the ecological footprint of nearly all vehicles affected. Further, the reduction of traffic congestion helps optimize the use of the available roadway capacity, reducing the need to build additional road infrastructure in the area.

Extensive traffic modelling of travel-time savings was undertaken by the team to validate both the cost-benefit analysis and environmental benefits of the system.

## *TRAIN DETECTION*

The data to support the operation of the system is obtained by the four TD sites located along the rail corridor. These four detectors are strategically positioned along the rail corridor to the east and west of the City of Langley to detect trains entering the corridor from either direction. These detectors gather data, which is then transmitted to the central control system, analyzed, and used to formulate the appropriate sign status information. Figure 3 below shows the deployed Train Detector 01 monitoring a passing Canadian Pacific Railway train and relaying the information to the central control system.


**Figure 3 – Canadian Pacific Railway Train Passing Train Detector 01**

## *TECHNOLOGY PILOT STUDY*

The selection of an accurate and reliable train detection technology was pivotal in being able to display the appropriate information on the MAS that will allow motorists to make informed route choices based on reliable information. Standard transportation technologies were insufficiently capable for this challenge. As this system is the first of its kind in North America to employ this unique messaging, predictive algorithms, and integrated suite of sensors, a wide array of technologies and detection methods were researched and analyzed as part of a pilot test to evaluate and determine which had the greatest overall performance, reliability, and accuracy in gathering the necessary train metrics to support system operation. It was found that the following metrics would be required to realize the goals of the project:

- Presence of train (binary value: present, not present)
- Direction of travel (eastbound or westbound)
- Speed of train (km/h)
- Length of train (m)

With these metrics, a given train could be detected, tracked, and anticipated at each of the at-grade crossings. In order to ensure reliability of the system, adequate redundancy had to be designed into the sensor suite. To achieve this, various technologies provided overlap with one another, such that, if a sensor were to fail, the system could still determine the necessary metrics. With this in mind, the final configuration of sensors, as seen in Figure 4, was as follows:

- 1x Speed Radar
  - Speed
  - Direction
  - Duration
- 3x Beam Break Sensors
  - Speed
  - Presence
  - Direction
- 2x Presence Radars
  - Speed
  - Presence
  - Direction
  - Duration
- 2x Cameras
  - Event verification
  - Security

**Figure 4 – Sensor Configuration at Train Detector 02**

A requirement of the project was to install all infrastructure outside of the rail Right Of Way and independent of any rail equipment, which introduced significant complexities to system operation. The widely varying physical train configurations also posed significant challenges. This study was performed over a six-month period, allowing the candidate technologies to be tested for long-term reliability. Based on the results of the testing, an innovative combination of three different types of detection technologies were determined to provide the best performance.

## *Motorist Advisory Signs*

The RCIS utilizes unique messaging signs specific to each location they are installed. PBX developed a unique hybrid messaging strategy that combined static and dynamic graphical information elements. A number of options were designed, evaluated, and refined in order to arrive at an effective solution. The evolution of these test signs are depicted in Figure 5. Extensive human factors analysis and focus group testing were undertaken to optimize the specific details of the sign's graphical elements. These studies were performed to determine the most effective way of displaying the desired information to the general public. It was found that the highest level of comprehension included crossing statuses, as well as train direction and approximate length. From here, the signs were further refined from their initial concept to their final layouts as shown in Figure 5. The system is designed to provide the crossing status at the time the motorist would arrive at the

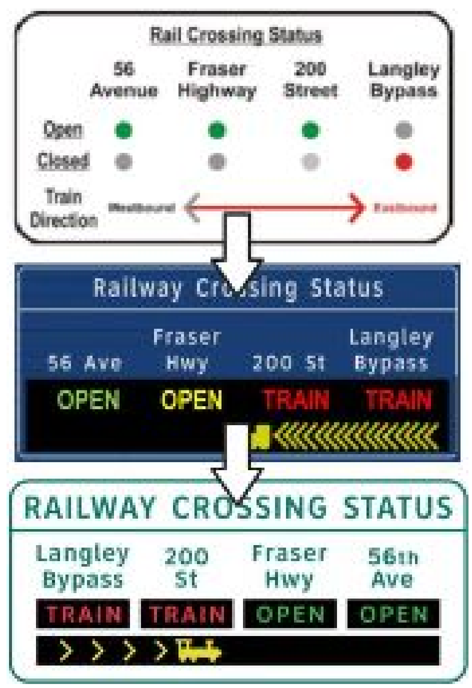



**Figure 5 - MAS Progression from Initial Concept Layout to Final Deployment**

respective crossing; however, should the traveller be delayed, they are able to roughly predict where the train will be.

As motorists approach the RBRC, they will see a hybrid static/dynamic sign indicating the various at-grade crossings accessible from their current location and the predicted status of the respective crossings. Once the system confirms the presence of a passing train, the system begins tracking the train and relaying predictive statuses to the signs as follows:

- **TRAIN –** Displayed in red, indicates the associated crossing will be closed due to the presence of a train at the time of the motorist's arrival.
- **OPEN –** Displayed in green, indicates the associated crossing will be clear at the time of the motorist's arrival.

Further to these crossing status messages, a simple graphic indicating the direction of the train is also displayed to provide an increased level of awareness. This graphic includes a small train engine followed by chevrons representing direction. As the train advances along the corridor, the train graphic advances from left-to-right (or right-to-left). The dynamic display of the signs can be seen in the graphic. The dynamic portion of the sign, as seen in Figure 6, also has the functionality to be overwritten to display a custom message in a range of colours. This allows for messages, such as amber alerts, to be displayed in the event of an emergency.


**Figure 6 - MAS Dynamic Portion Indicating Crossing Status & Train Direction/Length**

## *SYSTEM OPERATION*

In principle, the operation of the system is straightforward:

***Detect a train → Activate the signs → Deactivate the signs when the train passes***

However, in practice the operational details are far more complex. Significant data on rail movements were gathered through the pilot project. Rail operations on the corridor are unpredictable and complex: trains vary in length, speed (including speed changes while transiting the corridor), and configuration; trains may disappear from or reappear onto the corridor by using any of the numerous siding tracks; and multiple rail maintenance vehicles may be on the track in different locations at the same time. All of these conditions and exceptions need to be properly detected and accounted for in the system operation. A high-level description of the train detection and motorist notification cycle is as follows:

- As a train enters the project area from either the east or the west, train detectors detect the train.
- The system gathers data and calculates the speed, direction, and length of the train.
- The system estimates the train arrival and departure times at each at-grade crossing.
- Based on the estimated arrival time, and if the train length exceeds the minimum threshold, the system activates all MASs and updates the crossing status and train position information on each MAS to inform motorists of the status of each crossing.

- The status for each crossing, displayed on each MAS, takes into account the estimated driving time from each MAS to each crossing, so that the information provided to motorists reflects the state of each crossing from the motorists' perspective.
- As the train transits the corridor, the downstream train detectors and intersection pre-emption sites detect the train and transmit updated information to the system. The system updates the crossing status and train position information on each MAS, at regular intervals, using the most recent information.
- When the train clears the corridor, the system blanks each MAS.

PBX developed the data analysis and event response algorithms that drive the system operation. This involved an extensive software development process, including use case and requirements development for multiple integrated software modules, field controller programming, central system configuration, and systems integration. The system architecture utilizes distributed data analysis, such that field controllers perform significant pre-processing sensor data to create an efficient stream of train metrics data that is transported to the central control system. This architecture increases system responsiveness, improves system resiliency, decreases cellular data usage. Innovative adaptive exception processing is employed to ensure that only train events meeting the configured criteria activate the system. In the future, this system could interface with a variety of other applications to provide wider notification capabilities via web-based or app-based interfaces. An early simulation of the central control software can be seen below in Figure 7. As a train transiting the RBRC passes the various sensor checkpoints, the system predicts its location and conveys the anticipated crossing status to each of the MAS.

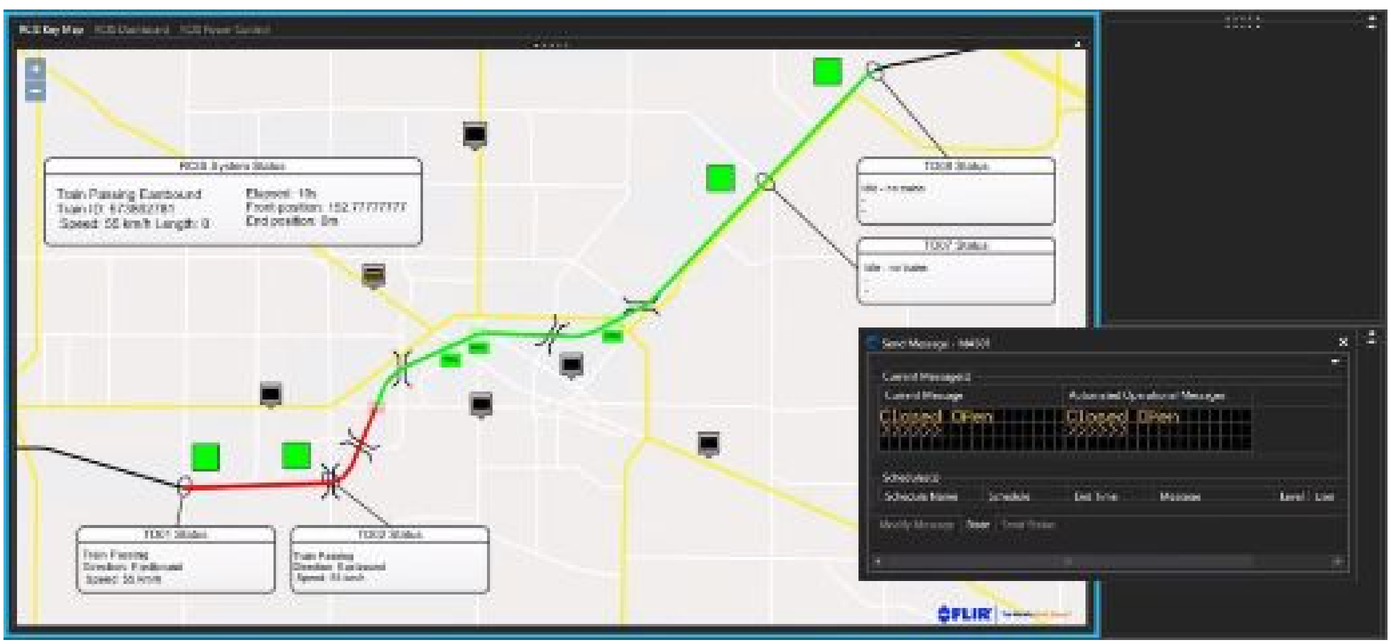


**Figure 7 – Simulation of Head-end Software Monitoring Transiting Train & Adjusting MAS Display**

## *SYSTEM TESTING & DATA VALIDATION*

It was critical to the project's success that the system is able to demonstrate and prove accurate performance of the system. A rigorous and systematic testing methodology was developed and applied over several test periods, in varying conditions, to ensure the system was capable of identifying trains and filtering out exceptions and invalid rail events.

## PROJECT CHALLENGES

The RCIS represented a complex undertaking, both from a technical perspective, as well as from a stakeholder coordination perspective. As the system is the first of its kind in North America to employ this unique messaging, predictive algorithms, and integrated suite of sensors, there was no reference on which to begin the design process, resulting in new and unexpected challenges. To mitigate this, it was necessary to clearly establish not only what the definition of performance would be, but how that performance would be measured and evaluated. As such, a clear set of performance metrics were established and tracked over the project lifecycle. Multiple iterations of various sensor configurations were tested during the pilot study before settling on the final design. The resulting setup would need to be resistant to factors such as inclement weather and vandalism, as well as reliably detect a vast array of physical train configurations.

Not only was the system required to detect trains of all configurations at varying speeds, it would need to be capable of determining whether or not a given rail event was a valid train. In order to do this effectively, it would need to be able to filter out any anomalies on the tracks to provide accurate and reliable results, including:

- Rail service vehicles and construction maintenance crews;
- Motorists using the at-grade crossings;
- Slow-moving/stopping trains;
- Trains routing to nearby siding tracks; and
- Obstructions on the tracks.

The data found in Figure 8 represents sensor detections for a passing rail event from three of the sensors on a given Train Detector.

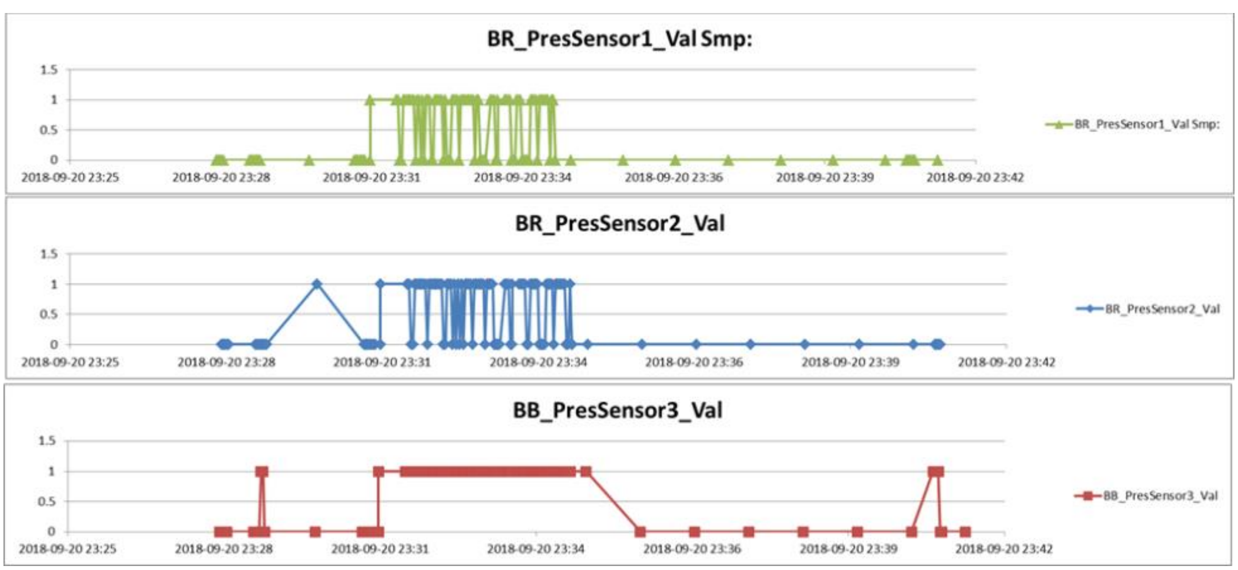



**Figure 8 - Sensor Triggers as Train Passes**

It is evident from the data gathered and depicted above that sensor detections are often intermittent due to variables such as gaps between rail cars and inconsistent railcar heights. Along with the factors listed previously, it is crucial to filter these results for the accuracy and reliability of the system.

The complexity and level of effort for the system programming and configuration was significant. PBX drew on our years of experience in systems integration in the ITS, security, and industrial process control application areas to create unique and highly effective system operational models, adaptive detection algorithms, and exception processing capabilities for the RCIS. The design and installation of the MAS involved significant civil and structural construction in dense urban environments. A unique helical pile design was used to minimize foundation size and construction time for the large signs.

The data on rail operations gathered by the RCIS has never been available before. The data will be shared with transportation agencies in the region to support long term planning activities and streamline the movement of goods, as well as to improve public transportation throughout the area.

MoTI relied on PBX's expertise to effectively coordinate and manage both the implementation, as well as the regional stakeholders. PBX collaborated closely with each of the neighbouring Municipalities to identify any planned projects or requirements that could affect the design of the RCIS, or impact municipal operations. PBX supported MoTI through challenging negotiations and coordination with the rail companies. Our team responded effectively to evolving stakeholder requirements, as well as rapidly addressing challenges that emerged during the complex construction process to ensure schedule adherence. By means of proactive status updates and engagement workshops, PBX was able to provide transparency to all stakeholders involved.

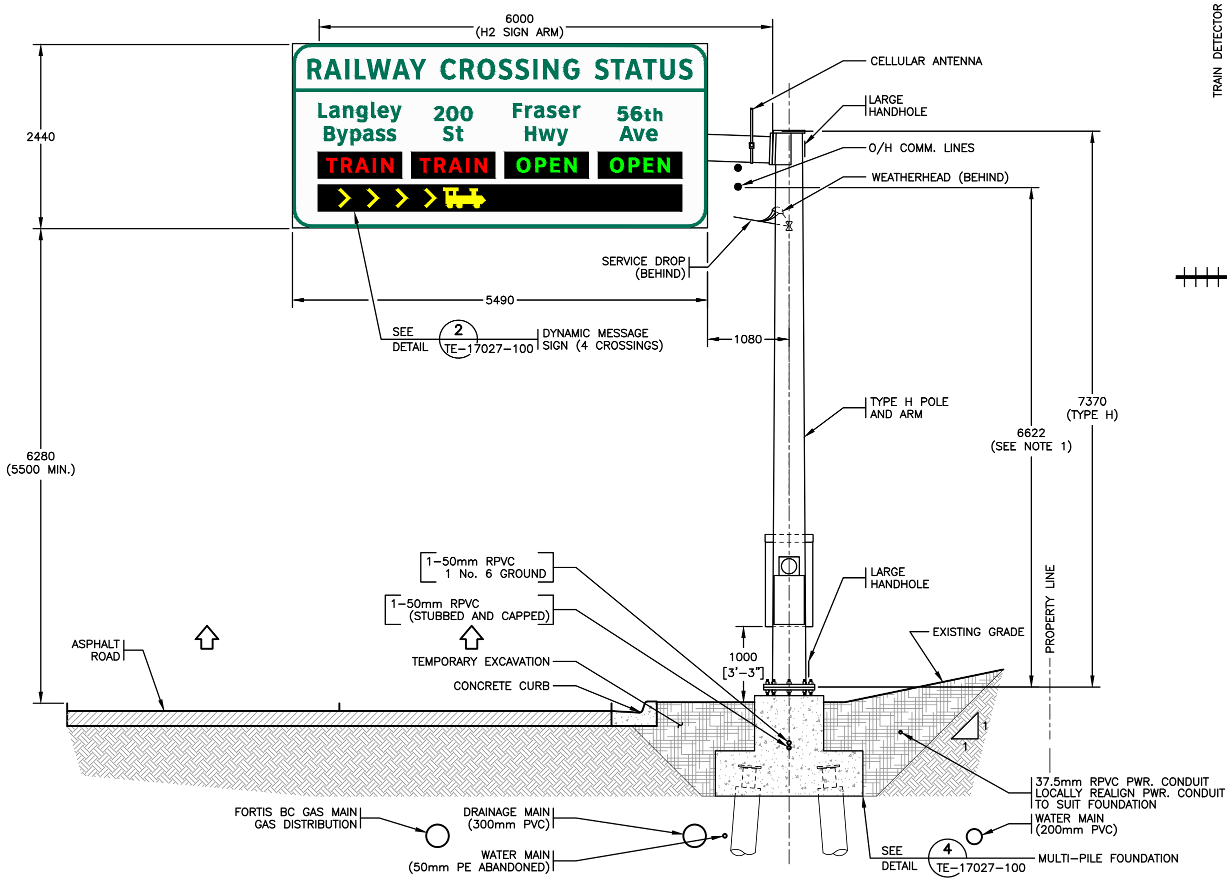
## CONCLUSIONS

PBX drew on our extensive experience with Intelligent Transportation Systems (ITS), software/systems integration, critical infrastructure security, and industrial process control to address this complex challenge. **The engineered solution represents a highly effective fusion of unique driver notification messaging with robust detection technologies and sophisticated data analysis and response algorithms**. The RCIS provides direct travel time savings benefit to the area residents who commute regularly. Additional benefits include:

- Reduced environmental pollution levels by reducing unnecessary idle time and shortening travel times.
- Improved information for emergency responders
- Improved movement of goods and services

This is an industry-leading, made-in-BC solution, applying locally developed technology and engineering expertise to overcome a difficult challenge, positively affecting the communities of BC.

The project is proceeding on schedule and on budget, meeting all of the client, stakeholder, and project-specific needs In recognition of its success and innovation, this project has recently won an Award for Engineering Excellence through ACEC-BC's annual awards program.




MOTORIST ADVISORY SIGN
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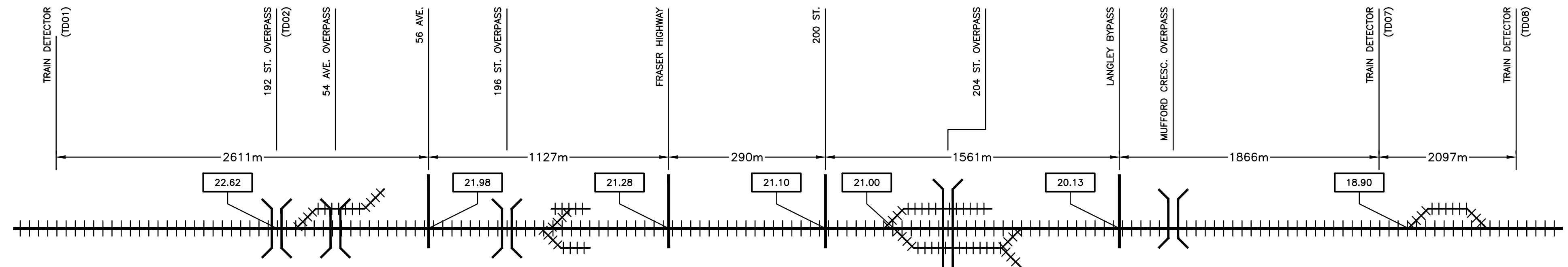
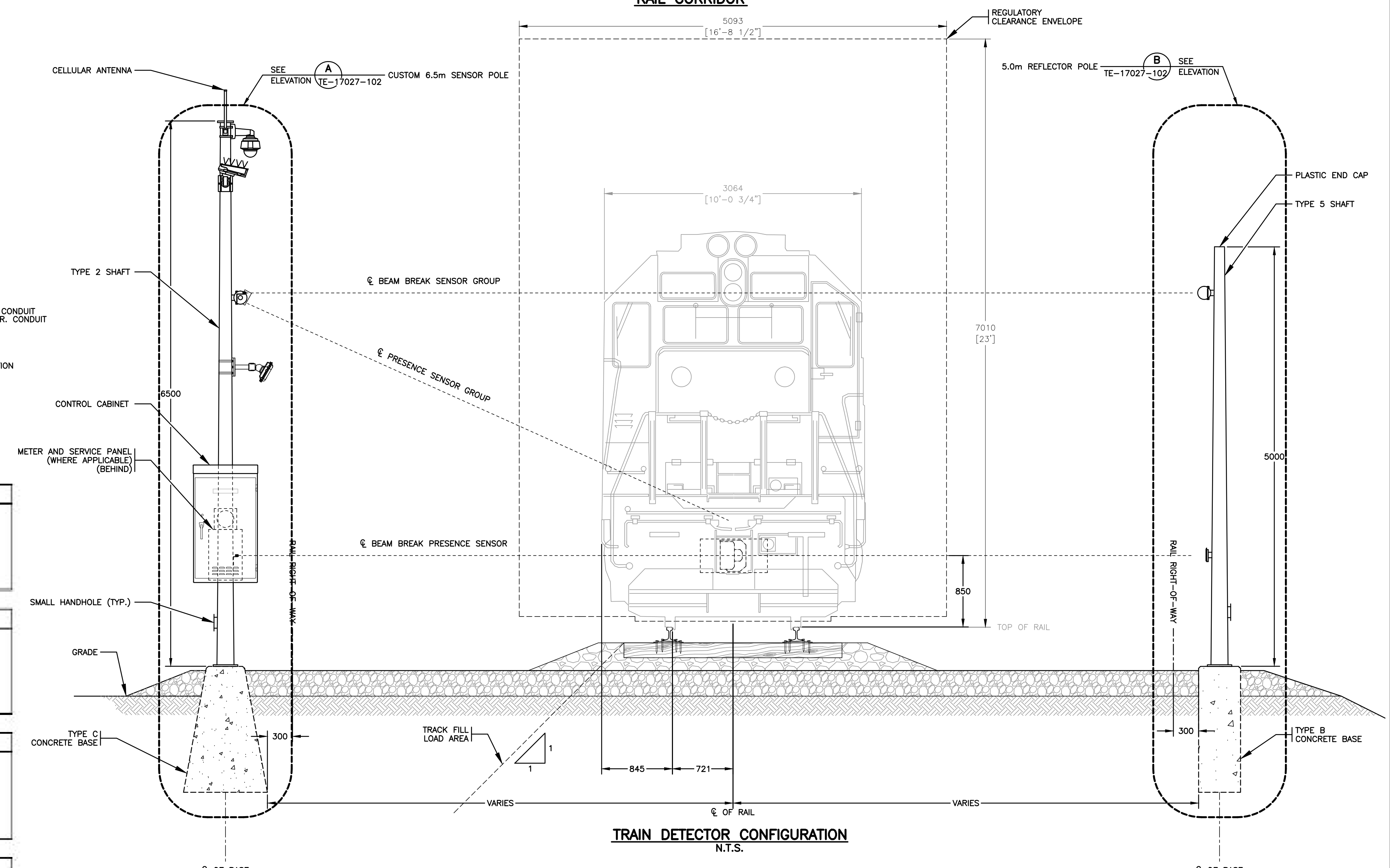
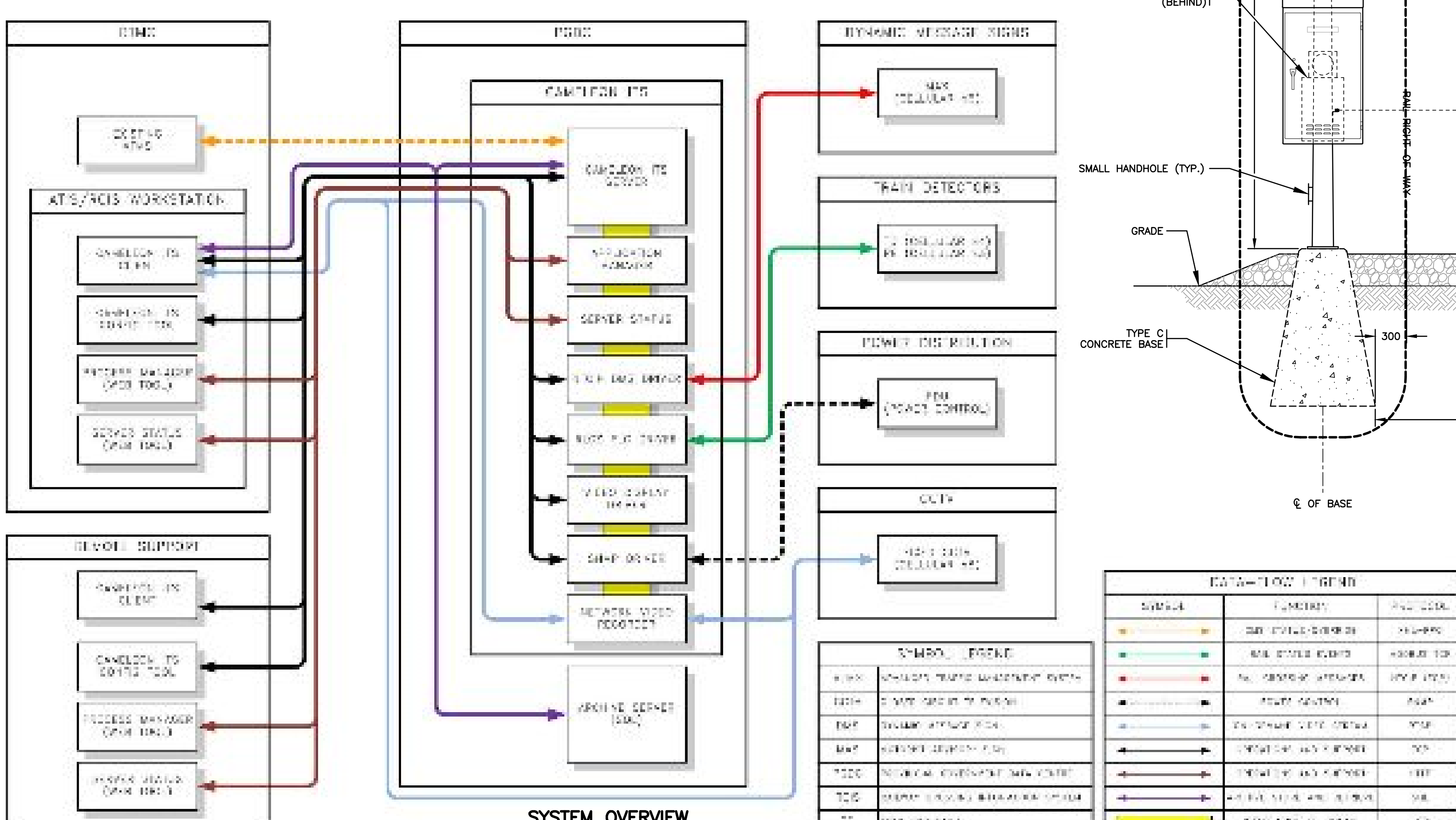



RAIL CORRIDOR




TRAIN DETECTOR CONFIGURATION
N.T.S.



SYSTEM OVERVIEW

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BRITISH COLUMBIA

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE
ELECTRICAL ENGINEERING CENTRE

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RAILWAY CROSSING INFORMATION SYSTEM
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CANCEL PRINTS BEARING PREVIOUS LETTER

# RAILWAY CROSSING INFORMATION SYSTEM

## IMPROVING TRAVEL TIMES & REDUCING CONGESTION THROUGH THE IMPLEMENTATION OF INNOVATIVE TRANSPORTATION TECHNOLOGIES

### THE CHALLENGE

The Roberts Bank Rail Corridor (RBRC) represents a critical east-west link for the movement of goods by rail. Built prior to the densification of the Greater Vancouver Area, the railway runs through the core of the "Langley's" comprised of the City of Surrey, City of Langley, and the Township of Langley. Four major at-grade rail crossings intersect with the rail line in this area.

When trains transit through the corridor, these major intersections may be blocked for extended periods of time. **Motorists often experience significant delays. Blocked crossings result in a number of other negative impacts – including reduced commerce, increased emergency response times, and increased pollution levels.**

Rail traffic is predicted to increase both in frequency and in length, which will result in greater impacts to the public. Recognizing the need to address this growing issue, the Ministry of Transportation and Infrastructure and other partner agencies initiated the Rail Crossing Information System (RCIS) project. PBX was engaged to plan, design, and implement the system.

### THE SOLUTION

The RCIS detects trains entering the "Langley's" area of the RBRC by utilizing multiple train detector checkpoints placed strategically along the corridor. Each train detector is comprised of an innovative suite of integrated sensors and field controllers that detect and measure train metrics. Gathered information is ingested by the system, processed by custom-developed adaptive algorithms within a sophisticated Advanced Transportation Management System, and relayed to six Motorist Advisory Signs (MAS). The MAS are a unique hybrid of static and dynamic information elements.

The information displayed provides a motorist with the predicted status of the four at-grade crossings relative to the motorist's location, along with the train's direction of travel and relative position.

**The MAS's unique graphical format provides timely enroute status information that enables motorists to adjust their route choice and divert to nearby overpasses or unimpeded at-grade crossings to avoid travel delays.**

### INNOVATION THROUGH IMPLEMENTATION

**The RCIS is the first of its kind in North America to employ this unique messaging, predictive algorithms, and integrated suite of sensors.** Extensive human factors analysis and focus group testing were undertaken to optimize the unique sign messaging strategy. PBX drew on extensive experience in other application areas, including industrial process control and critical infrastructure security, to identify, prototype, test, and apply leading edge detection technologies.

PBX developed the data analysis and event response algorithms. The system performs in a challenging operational environment where trains vary in speed, length, and physical configuration, or may exit onto siding tracks. Adaptive exception processing is employed for system activation to increase accuracy. Extensive multi-stage testing was performed to validate system performance.

**The engineered solution represents a highly effective fusion of unique driver notification messaging with robust detection technologies and sophisticated data analysis and response algorithms.**