Railroad Data Integration for Transportation Management Centers

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Innovative Surface Transportation Management

Texas Transportation Institute
The Texas A&M University System
College Station, Texas

Texas Department of Transportation

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16. Abstract

This report describes a project plan to communicate train information (i.e., train position, direction, speed, and length) to a transportation management center (TMC) for improved traffic operations. Several different approaches are discussed. The report recommends using a Highway-Railroad Intersection monitoring device on the railroad controller to gather train data. This data would be brought back to a TMC via a communications link such as cellular, radio-frequency based communication, or wireline. The report also recommends starting with a laboratory demonstration using the TransLink® laboratory facilities. Based on the finding from this laboratory demonstration, the most successful application could be moved forward to a more detailed field demonstration.

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IMPLEMENTATION STATEMENT

This report outlines a project plan to obtain railroad information (i.e., train position, direction, speed, and length) to be used for transportation management. The project plan will be used to develop a laboratory demonstration of integrating train data into a transportation management center. A railroad grade crossing monitoring device will be obtained for the laboratory demonstration to test the type of information that can be collected and to evaluate the effectiveness of that information. Based on the laboratory demonstration, the results will be used to move toward a field demonstration. A list of the specific recommendations is presented in Section 5.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and opinions presented herein. The contents do not necessarily reflect the official view or policy of the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation. The engineer in charge of this project was Mr. Christopher Poe, P.E. license number 70345.

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1.0 INTRODUCTION

Highway-railroad intersection (HRI) accidents are one of the most significant safety concerns of the railroad industry and the Federal Railroad Administration (FRA). In 1994, there were approximately 273,000 HRI accidents in the U.S. Of these accidents, 166,000 occurred near public at-grade crossings, and 107,000 occurred near private at-grade crossings. Accidents at HRIs occurred at a rate of about 4,900 each year, resulting in about 600 fatalities and 1,900 injuries annually. Besides the obvious safety concern, these accidents result in significant delays in operations for both the motoring public and railroad companies.

The application of advanced technology to transportation has significant opportunities to improve traffic operation and safety near highway-railroad intersections. Improved information about the location and arrival times of trains could alert highway users of trains and allow for use of alternate routes. Notification of train location could increase a driver's awareness of potential conflicts. Encouraging drivers to use alternate routes to avoid railroad grade crossing delays could eliminate some vehicle-train conflicts altogether.

1.1 Background

It is desirable to know the location of trains within a rail corridor for the purposes of traffic control device activation, preemption of traffic signals, and notification to traffic management centers[1] for emergency service and transit operations in and near rail corridors. Train operations cause significant vehicle delay nationwide each day, frequently disrupting emergency vehicle operations and transit service in many urban areas. Diverting to longer, but potentially faster, routes can significantly improve effectiveness of emergency services such as fire, police, and ambulance and transit operators capable of route diversion.

[1] For the purposes of this report, " traffic management center" is used to describe highway only operations, and "transportation management centers" is expanded to include multimodal operations such as transit, railroad, and emergency services.

Recent changes in railroad operations will only compound these problems, as recent mergers and consolidations in the rail industry will result in more frequent, longer, and higher speed trains operating in some of the nation's most congested rail corridors. As the highway systems become more crowded and air related environmental concerns more prevalent, trains potentially could be relied upon to carry more and more freight.

Operations and safety on the surface street system could be significantly improved if transportation agencies have advance knowledge that a train is approaching a highway-rail intersection. With this advance knowledge, transportation agencies could affect traffic control and diversion strategies that would minimize the disruption of vehicular traffic and transit operations.

The current level of highway-railroad information transfer is via an interconnection of highway traffic signals and railroad active warning systems, involving a simple two state electrical link between the railroad active warning system and the traffic signal controller assembly for the purpose of preemption. Generation of a preemption signal is directly coupled with the activation/deactivation of the warning systems. Occupancy determined by this method may be translated into train position. The precision of this method, however, is constrained by the block length, which is typically on the order of several hundred to several thousand feet. Most traffic management functions likely require a greater degree of precision than the preempt indication provides.

1.2 Objectives and Scope

Railroads are developing their equivalent of intelligent transportation systems. An opportunity exists to link highway and railway systems for the improvement of both systems. The focus of this research area is to establish a communications link between the railroad and traffic management centers. This communications link would permit traffic management centers to receive a variety of real-time information including train position, direction, speed and length.

An evaluation will be performed to determine the utility of this train information for use in transportation management. If deemed useful, this information can then be made available to other users of the transportation system, such as emergency services vehicles, transit providers, and commercial vehicle operators.

Also, through this communication link, information about the highway system could be disseminated back to the train control center. An evaluation is needed to determine the type of information that would be useful in a train control center. For example, information about the status of grade crossings can flow through this communication linkage. This information may indicate whether gates are down in the absence of a train at an active crossing or if a crossing is free of stopped or stalled vehicles. It is also important to evaluate how the railroad industry would handle this information and the response priorities that would be placed on the various types of signal system malfunctions and intersection traffic problems. The railroads would need to be given enough advanced notice to change train operation and reduce the potential or severity of a train-vehicle collision.

The desire is to monitor trains by *integrating* an existing source of data/information into the traffic management system. The first question that arises is: how can the grade crossing signal activation be detected and communicated to a traffic management center (TMC)? This challenge should not be insurmountable and, indeed, should not be difficult to overcome. The second question is how to use this information to determine the location of one or more trains within some pre-defined geographic region.

The geographic region of immediate interest is a linear corridor which includes: 1) the railroad track between two points, 2) all parallel roadways adjacent to the track, and 3) all roadways crossing that segment of rail at-grade or grade separated. The corridor is several kilometers in length and several hundred meters in width. (Consider the College Station/Wellborn Road corridor as an example.) The roadways that cut laterally across the corridor, intersect the track, the parallel roadway(s), or both the track and the parallel roadway(s). Two types of intersections may therefore exist within the corridor: highway/highway intersections (HHIs) and highway/rail intersection (HRIs). When these two intersection types are near one another (typically 60 meters per the Manual on Uniform Traffic Control Devices [MUTCD]), it is common practice to interconnect the traffic and railroad signal installations. This practice permits preemption (interruption) of the normal assignment of right-of-way at the highway/highway intersection during train approach and passage. Preemption has been utilized for traffic control at intersections whose proximities were 150 meters or greater from the highway/rail intersection.

1.3 Current Research

The Rail Research Center at TTI is currently conducting research on Positive Train Separation (PTS). The PTS project currently underway provides a non-vital safety overlay to existing railroad traffic control and signaling systems that enhances railroad safety by enforcing movement authority and speed restrictions for PTS-equipped trains. The system is based on networked data communications between locomotives, a central dispatching center and field monitoring and control installations. A sizeable ground and RF communication infrastructure has been put into place for the PTS pilot project along the test corridor near Seattle, Washington. To provide safe train distances, the PTS system server/computer continually monitors location and motion data from each train within the control the corridor. The central server computes a movement authority for each train and relays the authority to the locomotive via the data network. Each locomotive is equipped with an onboard computer which provides communications with the central server, maintains the current movement authority, calculates the locomotive's location from sensor inputs, and acts as a watchdog to intervene if an unsafe condition is detected. The locomotive computer will automatically bring the train to a stop short of its authority limit (enforcing the authority limit) if it is determined that under current operation actions have not been taken to safely stop at the end of the authority limit.

In addition, there is a project at TTI to develop a non-vital, research-oriented HRI control system to utilize the communications and control aspects of the PTS architecture. The goals of the new controller will be to enhance the capability and reliability of HRI motorist warning devices and to provide a foundation for future communication-based wayside warning systems. Interfacing with the PTS system will facilitate several new concepts at the HRI. Interaction with the PTS system will allow more accurate train status information to be calculated and delivered to the HRI independent of traditional electronic track circuitry and associated logic methods. This could enhance the efficiency of the HRI system and the preemption of highway/highway intersections at any distance from the HRI. The PTS-based HRI controller will have the ability to provide feedback from the grade crossing back into the PTS central system. Safety critical entrapment detection for high speed corridor applications and non-critical health monitoring data will be accessible by the PTS system.

One function of the HRI controller is to provide train arrival and departure time estimates for specific HRIs to a TMC. Current plans are for the data to arrive at the TMC via a commercial telephone line or leased line from the HRI controller in the field. Within the TMC, the information will be gathered and displayed, yielding a real-time view of the rail corridor under consideration.

The Railroad Data Integration (RDI) Project will face many of the same challenges at the TMC level as the PTS project. Knowledge, experience and software code can be shared, with a joint development effort being a possibility.

2.0 PROJECT DESCRIPTION

This report outlines a project plan to obtain train information (i.e., train position, direction, speed, and length) to be used for transportation management.

2.1 Proposed Approaches

2.1.1 HRI Control Box Monitoring

One proposed technique for train detection is outfitting the highway-rail intersection with a real-time monitoring device that can detect events other than the traditional preempt signal message provided to traffic signal controllers. At a typical active HRI, the railroad maintains train detection "blocks" on each side of the crossing and one that encompasses the roadway and the immediate area on either side of the crossing. The block functions as an electrical circuit, continually watching for an electrical "short" circuit between the rails. A rail car positioned anywhere within the electrical block provides the electrical path between the rails resulting in an "occupancy" indication. A major improvement in information content can be achieved by monitoring and reporting HRI track circuit occupancy within a railroad transportation corridor. With time-stamped occupancy information and known track circuit distance, train speed can be calculated from time measurements involving two adjacent track circuits within the confines of an HRI's track circuits. Additionally, a similar analysis of the track circuits associated with a single HRI can deduce a train direction of travel. Given train speed and direction information, downstream arrival projections can be made for simple rail corridor configurations (i.e., where there are no intervening routing options or undetectable operational obstacles between the train's current location and a given point of interest along the transportation corridor such as a switching track or speed restriction). The arrival projections become dynamic inputs to a TMC, providing a real-time view of railroad corridor activity.

Desirably, train controllers at each signalized grade crossing would be equipped with a monitoring device. Today there are companies that offer products that can be described as highway-railroad intersection monitoring devices. HRI monitoring devices can be configured to monitor certain events on the railroad through the use of various sensors. To gain access to HRI track circuits, the monitor must be physically located inside the railroad warning system control cabinet. With the monitor located in the railroad cabinet, other sensors could be configured to watch, record and/or report the action of the warning systems in real-time. The monitoring system can become a safety watchdog acting as an early warning device to communicate a failed gate motor, a broken gate arm, burned out light bulbs or a gate that is "stuck" down with no train detected.

Although these inputs do not directly affect the train's movement through the crossing, valuable information can be extracted for forwarding to a TMC for use in area traffic management. Proper operation and maintenance of field equipment at an HRI is important in maintaining the public's trust in the meaning of active control devices. Improper operation of devices due to maintenance problems can result in growing disrespect for the devices with motorists. Disrespect for the control devices can potentially increase the exposure of drivers to vehicle-train collisions.

2.1.2 Preemption

In the absence of HRI-equipped monitoring devices, it might be possible to utilize the preempt signal indications that are generated when a train approaches an interconnected highway-railroad grade crossing. The preempt signals would be a surrogate for grade crossing signal activation. Again, the signal activations/deactivations (deduced from preempt commands) could be time-stamped and communicated to a central office (traffic management center) via some communications medium (i.e., cellular link, dedicated land line, telephone line, RF communications) for recording and evaluation purposes.

2.1.3 Video Imaging

A third option would be to detect trains at the crossing by use of a video camera or other detection mechanism. This approach is a high-cost option requiring significantly larger capital outlays for the purchase and installation of video imaging technology, detectors, supporting hardware and software, and any associated supporting structures. There is also some concern over the reliability of this technology based on recent experience with video imaging in the *Smart Diamond Project* conducted by TTI through the ITS Research Center of Excellence.

2.1.4 Summary

All three of the options identified above will provide, with varying degrees of quality and quantity, approximate location, direction and speed of trains within the corridor. From this information, it becomes possible to estimate time of train arrival at any downstream location within the corridor.

2.2 Study Plan

In order for a TMC to monitor HRI control systems, the HRI must be able to communicate from the field to the TMC. The communications medium can be data radio, commercial dial-up telephone line, leased line, or through a cellular network. To develop the concepts for obtaining the desired information from the intersections and communicating this information to a control center, this project will be broken down into phases.

2.2.1 Phase I — Laboratory Evaluation

The first step is to perform a laboratory demonstration of the technology and railroad information integration application. This laboratory demonstration will allow researchers to become familiar with the device, communications medium, and technologies to be used for this study. By testing the proof-of-concept of this application in a laboratory environment, greater confidence will be gained in how the technology will perform in a field demonstration. The laboratory demonstration will include the following steps:

- Acquire one or more crossing monitor devices for initial evaluation.

- Set up the crossing monitor at the TransLink® laboratory facilities located on the Texas A&M University campus in College Station, Texas.

- Set up a personal computer in the lab (for simulating data, recording, testing, and display purposes) and establish a communications link between the HRI monitoring device and the personal computer. Several communications medium choices should be explored to determine the best option for the needs of the monitoring device and the TMC. RF communications and Cellular Digital Packaging Data (CDPD) are currently being explored on two other projects within TransLink®.

- Subject the device to a variety of inputs simulating the passage of a train through an HRI to verify proper generation, communication, reception, and interpretation of data messages.

- Develop software to log and process the raw data as well as to display the train speed and direction of travel derived information.

- Develop a graphical user interface to display the application in the TransLink® laboratory.

2.2.2 Phase II — Field Installation and Operation

By placing a few HRI monitoring devices at various locations throughout a small corridor and setting up communications between these monitors and a TMC, the necessary concepts can be developed and proven on a small scale. This can be done at a fraction of what it would cost to develop a full scale system. Steps for this phase include the following:

- Select an appropriate rail corridor, study the contained HRIs and associated track circuits, and propose an effective monitor outfitting plan.

- Equip identified HRI controller cabinets (exact number to be determined) with HRI monitoring devices.

- Establish communications between the crossing monitors at the HRIs and the "traffic management center." (For research purposes, the "traffic management center" will be the TransLink® facilities in College Station.)

- Collect and analyze data for transportation management purposes and measure system performance.

2.2.3 Phase III — Concept Application

The third phase of this project would be to apply the concepts developed in the first two phases to a larger network of HRIs. In this phase, the system can be studied with respect to its ability to predict train arrivals at HRIs in sufficient time for this information to be useful in determining minimum travel time routes for people and vehicles traveling in the corridor.

One important application to be explored is that of placing the information onto the Internet. Once information is on the Internet, individuals with a PC at the office or home can access information for route planning. A long-term goal would be to have a system that could be used to predict train arrivals over an entire network of HRIs, throughout an urban area. This application could be useful for freight rail or commuter rail in urban environments. It is important that the system developed have the potential to be used at a large portion of all HRIs. If the project does not have scalability, the utility will be limited in the future.

2.3 Test Location

Along with the multiple phases of this project, the locations will be phased to coincide with the application development.

2.3.1 Phase I

A computer and work space has been designated in the TransLink® laboratory for use in the initial phase of this project and for monitoring the devices in the field during subsequent phases. The laboratory demonstration can take advantage of the equipment and showcasing features of the TransLink® laboratory.

2.3.2 Phase II

The second phase of this project would, most desirably, use a section of Union Pacific track, along the Wellborn Road corridor, in College Station, Texas. This corridor, shown in Figure 1, is composed of a single rail line with several HRIs. There are between one and two dozen trains that travel the corridor each day. The northern section is in close proximity to Texas A&M University. The southern end of this corridor is in a rural environment, and the northern end, near Texas A&M University, is in a more urban setting.

2.3.3 Phase III

The goal of TransLink® research projects is to test devices and operating strategies in a laboratory environment and then deploy the successful applications to the field. Potential locations for a third phase of the project are San Antonio and Houston, Texas. Houston has nearly 1,200 HRIs, and San Antonio has several sites that impact traffic operations. Both of these cities have proposed integrating railroad operations into traffic management through the model deployment initiative in San Antonio and through a priority corridor project in Houston. The research findings may have direct impact on the effectiveness of these proposed deployment efforts.

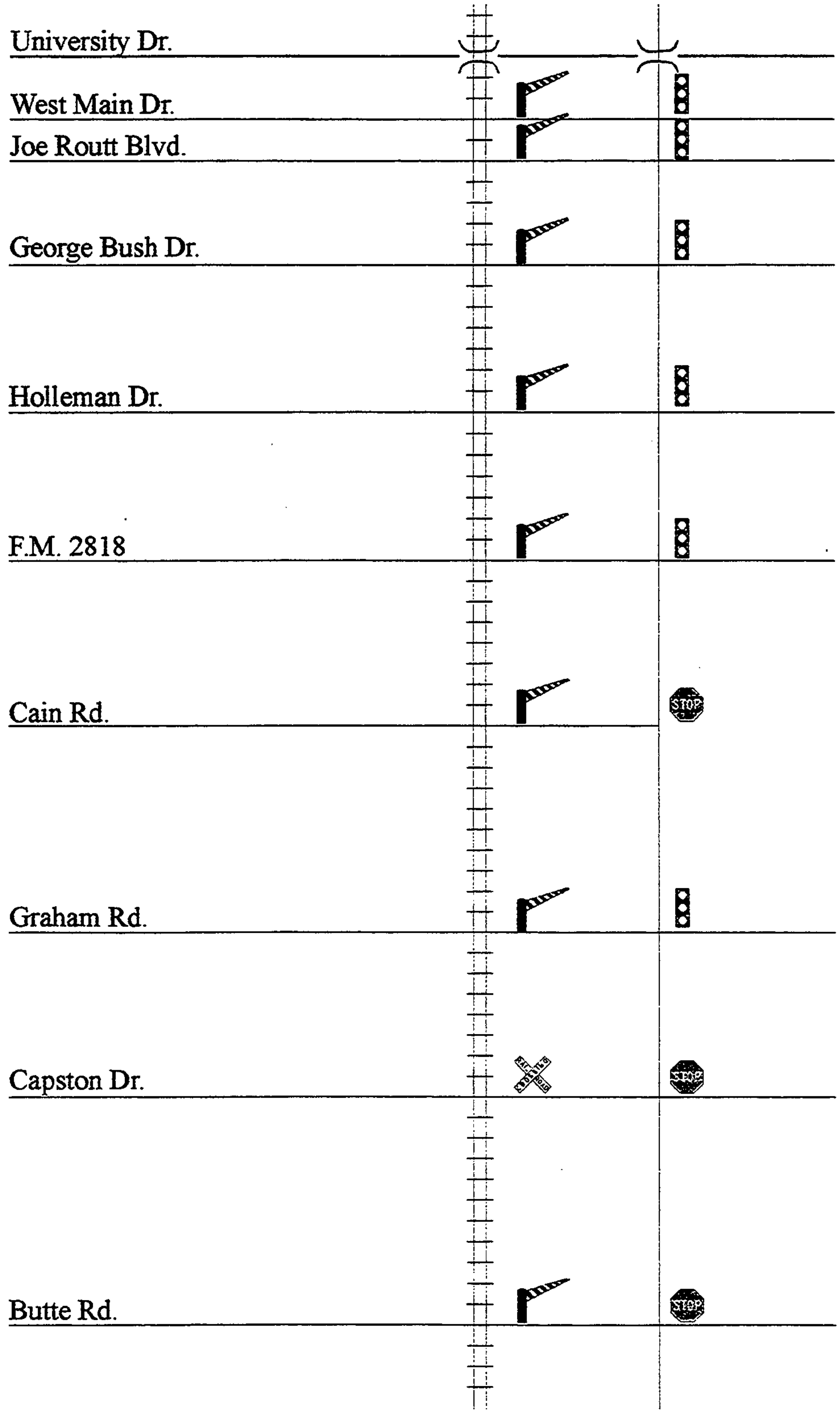

Figure 1. Wellborn Road Corridor

2.4 Roles of Those Involved

2.4.1 TTI / Rail Research Center

TTI's Rail Research Center will provide rail related technical assistance for this study. A study of each selected HRI site's associated track circuitry and control devices will be required. Identification of individual rail systems to be monitored and the associated sensors is also a necessary task.

Rail Research should make the initial contacts with railroad management to explore potential interest, as railroad support is fundamental to the railroad data integration project. Access to the railroad electrical cabinet is essential. The host railroad will likely appoint a project liaison toward whom further contact and support should be directed.

Since this railroad data integration project has significant tasks for both Rail Research and TransLink® personnel, a joint project management effort will be undertaken. Co-Principal Investigators, one from Rail Research and one from TransLink®, will form the project management team.

- Rail Research and TransLink® staff will interface with the product/service vendors and coordinate their efforts.

- Rail Research will coordinate with the host railroad to install and test the monitoring device(s).

2.4.2 TransLink®

TransLink® is a national, multi-modal, public/private program of research, development, and professional education designed to advance surface transportation system management. The Texas Transportation Institute, along with the Metropolitan Transit Authority of Harris County, Rockwell International, the Texas Department of Transportation, and the U.S. Department of

Transportation, have developed a research program that focuses on "linking" the various elements of the transportation system to maximize the value of the intelligent transportation infrastructure and create additional benefits for the users and operators of the system. The goal is to develop and deploy projects in urban areas that will form one intermodal surface transportation management system to be used in the next generation of transportation management centers (TMC).

TransLink® will bring the traffic management and signal operations expertise to the project. TTI staff, working through TransLink®, will be responsible for data simulation, data collection, communications, and application evaluation.

2.4.3 HRI Monitoring Device Vendors

The selected crossing monitor vendor will deliver the device as warranted by the project budget, that must be able to provide the identified functionality at the HRI. The vendor will provide detailed hardware/software support as required.

2.4.4 Railroad

In order to move forward toward a field implementation, it is essential that the host railroad agree to provide assistance in the following manner:

- Allow access to the HRI control systems and activation data within the electrical cabinet for our monitoring purposes.
- Coordinate system installation, setup and test with the required internal railroad departments.
- Install and setup the HRI monitoring device.
- Support any needed maintenance on the monitoring device.
- Supply train lineup/timing information if required.

3.0 PROJECT EVALUATION

3.1 HRI Monitoring Device

The use of an HRI monitoring device installed in the associated railroad's signal cabinet has several advantages. First and foremost, the monitor will be sensing inputs the grade crossing warning device control system uses. These inputs are derived from highly reliable all-weather train detection systems that are currently in place at active HRIs. No external detection mechanisms need to be employed as in the case of video monitoring. The capability to sense track circuit states will allow more information to be extracted from a single device. Preemption detection requires at least two sites to be monitored to derive any useable information. With a device installed in the railroad signal cabinet, segments of the HRI crossing control hardware can be monitored, yielding data for a TMC as well as a railroad signal department. A joint venture between the traffic agency and the associated railroad, each extracting information that is pertinent to their own needs, is a logical step for the future.

3.2 Preemption

The limitation of this approach is the requirement for interconnected highway/highway signal installations. Adjacent highway/highway intersections may not be signalized intersections, and those that are signalized may not be interconnected/preempted in all cases. This disadvantage is crucial if one desires to commence monitoring as trains approach the urban area from outlying rural regions, where adjacent signalized highway/highway intersections are rare or non-existent.

3.3 Video

Perhaps most important, from a conceptual standpoint, the video monitoring option violates the desire to monitor trains by *integrating* an existing source of data/information into the traffic management system.

3.4 Rail Monitoring vs. Preemption

An evaluation of the small scale system, phase II, will be performed to compare the usefulness of information obtained from the rail monitors to that provided by rail preemption of adjacent intersections. This evaluation will also look at the accuracy of predictions for train arrivals, made using the provided information, at HRIs upstream of the monitors. This will be done by comparing the predicted arrival times to those observed in the field.

4.0 EXPECTED BENEFITS

4.1 Technology to Estimate Train Arrival at HRIs

Key concepts and technologies, for use in predicting train arrivals at HRIs, will be developed and explored. These will include the following:

- Concepts for obtaining information from the HRI, such as train position, direction, speed and length. In addition, grade crossing device information, such as crossing activation, can be collected.

- Concepts for communicating this information with a TMC.

- Algorithms to predict train arrivals at HRIs in time to provide information useful in determining minimum travel time routes for private operators and motorists traveling in the corridor.

4.2 Transportation Management Center Applications

Transportation management centers are moving toward more integrated operation between agencies and modes. Emergency services and transit can use train operation information for more efficient operation.

Emergency services are traditionally given the highest priority in the transportation system. This is evident by the use of traffic signal precautions by many municipalities. Fire and ambulance service must be able to negotiate the transportation system in response to emergency situations. Notice of blocked highway-railroad intersections would allow emergency vehicle operators to avoid these delays and to take faster routes that avoid these HRI crossings. It is crucial that this information is delivered to the emergency management center in time for dispatchers to communicate the new routes to drivers before they encounter potential bottlenecks in the transportation system. The train information should be shared directly with dispatchers to give a more active view of the system and provide the information efficiently to a distribution point for the end users.

Transit agencies may also use train information for both fixed route service and may demand responsive service. Fixed route service does not necessarily have the flexibility to deviate from predetermined routes. There are some uses, however, for this information. Delays due to blocked railroad-highway intersections could be used to estimate schedule adherence. Significant delays could be communicated to transit passengers via advanced traveler information systems. In addition, as traffic signal control systems become more advanced to manage transit priority requests, train information could be used in signal timing to progress transit vehicles through signal systems reducing delay at these junctions.

Paratransit service has more flexibility in deviating from routes. Vehicle operators could use advance notice of highway-railroad intersection blockages to take alternate routes. This would help on-time performance in meeting scheduled pick-ups.

4.3 Rail Control Center Applications

HRI grade crossing monitors can equip railroads with an onsite watchdog delivering HRI warning system status information in a timely manner. The device's mission is to provide continuous real-time monitoring and recording of events at the HRI with the ability to communicate with a remote office. The communications capability of the device is particularly useful for immediate reporting of alarm events, delivering real-time sensor readings from the field and providing a remote download capability of logged events (not necessarily alarms but any change in sensor state). Sensors can measure commercial AC power integrity, low battery voltage, track circuit states, crossing gate bulb integrity, crossing gate status (broken gate, gate "stuck" down), ambient temperature and a host of other railroad definable inputs. Real-time reporting allows railroads to detect pending problems and yields a positive indication of actual problems. Given the information, problem detection time is greatly reduced, allowing maintenance personnel to be dispatched more quickly to a site. Train delays will be reduced by a more rapid maintenance force response time, when attending to malfunctioning HRI warning devices. This information can be prioritized for response by the railroad based on the urgency of the problem. Additionally, personnel will arrive at the site with advance knowledge of the problem, reducing costly diagnostic time.

4.4 Development of Technologies Useful for Other HRI Research

With this advanced knowledge, transportation agencies could affect traffic control and diversion strategies that would minimize the disruption of vehicular traffic and transit operations. Also, transportation agencies could check grade crossings to determine whether or not they were free of stalled or stopped vehicles and implement strategies to divert a catastrophe (such as clearing the tracks or requesting, through the railroad control center, that approaching trains slow down or stop before they reach the crossing). Furthermore, information about when and where trains will be blocking specific crossings in an area will be valuable to transportation users that depend on rapid response, such as commercial delivery services and emergency vehicles.

4.4.1 Improved HRI Safety

Highway-railroad grade crossings are a major safety concern (particularly crossings that have passive controls) for transit buses, school buses, and vehicles carrying hazardous or flammable materials. Projects in this problem area will test the application of existing and emerging devices for alerting drivers in their vehicles to the presence of a train. In vehicle warning devices, supplied with information from rail controllers, could inform drivers as they are approaching a passive crossing if a train is coming, how far away the train is from crossing, when it is expected to reach crossing, and from which direction the train is traveling.

4.4.2 Improved HRI Traffic Operations

Once a communication linkage has been established with railroad train control systems, improved railroad grade crossing operation is possible. Research in this problem area will examine alternative traffic control strategies for minimizing impacts on at-grade train crossings, given that a transportation control center has advance knowledge of when a train will reach the crossing. Research will focus on developing control strategies (other than the standard track clearance/preemption phase) that can be used to minimize disruption caused by a train. Research will also be performed to develop control strategies for minimizing the amount of disruption to progression along parallel and crossing arterials when a train interrupts flow across grade crossings.

5.0 IMPLEMENTATION RECOMMENDATIONS

The report makes recommendations on how to test, evaluate, and implement a highway-railroad monitoring device to obtain train information for transportation management centers. This plan is part of a TransLink® Research theme identified in the TransLink® Research plan. The following recommendations support the implementation of a train information project:

1) Conduct laboratory demonstration of monitoring devices to establish current capabilities.

2) Establish a railroad liaison to express the railroads needs, concerns, and share the railroad's current system capabilities.

3) Identify a communications link to be utilized between the HRIs and the TMC.

4) Evaluate proposed rail corridors for convenient implementation of a real-time monitoring system and the potential of the specific site to provide a variety of traffic management data (i.e., grade separation interchanges, highway/highway intersections, and highway/rail intersections).

5) Develop data processing procedures at the TMC to intergrade the information into the existing ITS systems.

6) Evaluate graphical means to display train information in a TMC.

6.0 FUTURE RESEARCH

In addition to train location, direction and speed, it is also desirable to know how the train is dispatched through the corridor (what it will do, how it will behave). In other words, one wishes to determine if the train will slow down, stop, enter a siding, take a diverging route, make a reverse movement, etc. This problem is more difficult, though not insurmountable. It would be technically possible to establish a common path between a traffic management center and the railroad's computer-assisted dispatch (CAD) system (housed within the railroad's centralized operations center). Such an architecture would also likely require modification of the railroad's CAD software and development/installation of specialized software at the TMC, in order that the two systems may communicate in a meaningful fashion. Such a problem is beyond the scope of any current study, though it represents a logical "next step" for future research.

7.0 REFERENCES

1. "TransLink® Research Plan: Phase I." Texas Transportation Institute, College Station, Texas. July 1996.