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A LOW-COST RAIL WARNING SYSTEM FOR PRIVATE AND FARM ROAD CROSSINGS

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A LOW-COST RAIL WARNING SYSTEM FOR PRIVATE AND FARM ROAD CROSSINGS

by

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NOTICES

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Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

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16. Abstract

Between 1993 and 2002, there was an average of 54 collisions per year at the approximately 28,500 private and farm grade crossings in Canada. The potential for significant human and material loss, particularly in the event of a collision between a passenger train and an industrial vehicle, has created a need for active warning systems at these low-volume crossings; however, the high cost of traditional active warning systems often prohibits their installation.

This report summarizes the identification, testing, and evaluation of a low-cost, active warning system for private and farm grade crossings. Following a review of suppliers across Canada, the U.S., and Europe, Ontrack Innovative Solutions Inc. was selected to provide a prototype solar-powered system with the potential of meeting the goals of this project.

Testing was carried out with the assistance of NB Southern Railway. The system was installed in April 2005 and evaluated until March 2007 to allow testing during two complete winter seasons. Once properly adjusted, the system proved to be capable of consistently detecting the presence of a train and providing adequate warning times to motorists.

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16. Résumé

De 1993 à 2002, 54 collisions sont survenues chaque année, en moyenne, aux quelque 28 500 passages à niveau de ferme et privés du Canada. Le potentiel de pertes de vie et de pertes matérielles importantes que représentent ces collisions, notamment lorsqu'elles mettent en cause un train de voyageurs et un véhicule industriel, a suscité le besoin de systèmes d'avertissement automatisés à ces passages à niveau peu fréquentés; mais le coût élevé des systèmes d'avertissement classiques est souvent un frein à leur installation.

Ce rapport résume les travaux de repérage, d'essai et d'évaluation d'un système d'avertissement automatisé à faible coût pour les passages à niveau privés et de ferme. Au terme d'un examen des produits de fournisseurs du Canada, des États-Unis et d'Europe, c'est le système de Ontrack Innovative Solutions Inc. qui a été choisi en tant que prototype de système à énergie solaire capable de répondre aux objectifs assignés au projet.

Les essais ont été réalisés avec l'aide de la NB Southern Railway. Le système a été installé en avril 2005 et l'évaluation s'est poursuivie jusqu'en mars 2007, de façon à s'étaler sur deux hivers complets. Une fois correctement réglé, le système s'est révélé capable de détecter de façon constante la présence d'un train et de donner des délais d'avertissement adéquats aux automobilistes.

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- New Brunswick Southern Railway
- Ontrack Innovative Solutions Inc.
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    - Mr. Raymond Bourque, Transport Canada, Rail Safety, Moncton
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    - Ms. Nancy Lynch, NBDoT, Fredericton
- New Brunswick Innovation Fund
- UNB research engineers:
    - Charles Roberts
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    - Karen Robichaud

EXECUTIVE SUMMARY

Between 1993 and 2002, there was an average of 54 collisions per year at the approximately 28,500 private and farm grade crossings in Canada. The potential for significant human and material loss, particularly in the event of a collision between a passenger train and an industrial vehicle, has created a need for active warning systems at these low-volume crossings; however, the high cost of traditional active warning systems often prohibits their installation.

The objective of this project was to identify, test, and evaluate a low-cost, active warning system for private and farm grade crossings. The New Brunswick Department of Transportation, in partnership with Transport Canada, retained the University of New Brunswick Transportation Group to identify and assess a low-cost grade crossing warning system. Following a review of suppliers across Canada, the United States, and Europe, Ontrack Innovative Solutions Inc. was selected to provide a prototype system with the potential of meeting the goals of this project. Ontrack has developed a low-cost solar-powered system that uses Doppler radar technology and ultrasonic presence detection to identify an approaching train and activate a set of LED lights to warn crossing roadway traffic.

Testing was carried out on a length of track in Westfield, New Brunswick, with the assistance of NB Southern Railway. The system was installed in April 2005 and evaluated until March 2007 to allow testing during two complete winter seasons. Early test results yielded a number of false detections, causing the system to activate in the absence of a train. Activation was triggered by vehicular traffic on an adjacent roadway. Initial adjustments were made to the system software, resolving the issue of false detections; however, interruptions in activations began occurring. Further adjustment to settings and refinement of system software corrected the vast majority of these issues.

Once properly adjusted, the system proved to be capable of consistently detecting the presence of a train and providing adequate warning times to motorists.

SOMMAIRE

De 1993 à 2002, 54 collisions sont survenues chaque année, en moyenne, aux quelque 28 500 passages à niveau de ferme et privés du Canada. Le potentiel de pertes de vie et de pertes matérielles importantes que représentent ces collisions, notamment lorsqu'elles mettent en cause un train de voyageurs et un véhicule industriel, a suscité le besoin de systèmes d'avertissement automatisés à ces passages à niveau peu fréquentés; mais le coût élevé des systèmes d'avertissement classiques est souvent un frein à leur installation.

Ce projet avait pour objectif de repérer, mettre à l'essai et évaluer un système d'avertissement automatisé à faible coût pour les passages à niveau privés et de ferme. Le ministère des Transports du Nouveau-Brunswick, en partenariat avec Transports Canada, a confié au Groupe des transports de l'Université du Nouveau-Brunswick la tâche de repérer et d'évaluer un système d'avertissement à faible coût pour passage à niveau. Au terme d'un examen des produits de fournisseurs du Canada, des États-Unis et d'Europe, c'est le système de Ontrack Innovative Solutions Inc. qui a été choisi en tant que prototype de système à énergie solaire capable de répondre aux objectifs assignés au projet. Ontrack a en effet développé un système solaire à faible coût qui utilise un radar Doppler et un détecteur de présence à ultrasons pour déterminer qu'un train arrive et déclencher des feux à DEL qui préviennent les conducteurs des véhicules routiers qui s'approchent du passage à niveau.

Les essais ont eu lieu sur un tronçon de voie situé à Westfield, au Nouveau-Brunswick, avec l'aide de la NB Southern Railway. Le système a été installé en avril 2005 et l'évaluation s'est poursuivie jusqu'en mars 2007, de façon à s'étaler sur deux hivers complets. Les premiers essais ont produit plusieurs fausses détections, qui faisaient que le système se déclenchait en l'absence d'un train. Ces déclenchements intempestifs étaient dus à la circulation de véhicules sur une route adjacente. Le logiciel du système a alors été mis au point, ce qui a résolu le problème des fausses détections; mais des coupures

dans l'activation des signaux ont commencé à se produire. D'autres mises au point et réglages ont corrigé la grande majorité des problèmes.

Une fois correctement réglé, le système s'est révélé capable de détecter de façon constante la présence d'un train et de donner des délais d'avertissement adéquats aux automobilistes.

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LIST OF SYMBOLS, NOMENCLATURE AND ABBREVIATIONS

AFO	Audio Frequency Overlay
AREMA	American Railway Engineering and Maintenance-of-Way Association
CN	Canadian National Railway
FHWA	Federal Highway Administration
GPS	Global Positioning System
HRI	Highway-Rail Intersections
ITS	Intelligent Transportation Systems
LED	Light Emitting Diode
MnDoT	Minnesota Department of Transportation
NBDoT	New Brunswick Department of Transportation
NCHRP	National Cooperative Highway Research Program
RTD10	Railway Technical Document 10
SDDoT	South Dakota Department of Transportation
TDC	Transportation Development Centre
TSB	Transportation Safety Board
TTCI	Transportation Technology Centre Inc.
UNB	University of New Brunswick
US DOT	United States Department of Transportation

m	metres
mph	miles per hour
km/h	kilometres per hour
AC/DC	Alternating Current/Direct Current
ft.	feet

1.0 INTRODUCTION

A low-cost active warning system was evaluated in this study for at-grade intersections of rail lines and private and farming roads. The evaluation was completed by the University of New Brunswick's (UNB) Transportation Group in coordination with the New Brunswick Department of Transportation (NBDoT), NB Southern Rail, the Transportation Development Centre (TDC) and the Intelligent Transportation Systems (ITS) Office of Transport Canada, and Ontrack Innovative Solutions Inc. The cost of a typical active warning system consisting of flashing lights and bells is currently in the order of $100,000 to $150,000. This cost precludes application for most private and farm crossings. A low-cost alternative is not currently market ready.

1.1 Problem Statement

According to Transport Canada statistics, there are approximately 28,500 private and farm crossings in Canada. Between 1993 and 2002, there has been an average of 54 accidents (4 fatal) per year at farm and private crossings (Direction 2006 website). While these statistics appear low, experts familiar with the movement of trains through these crossing types report that they do not capture close calls and the extensive human and material loss that would potentially occur if a passenger train collided with a large farm or industrial vehicle.

1.2 Background

This study was completed under the Rural ITS Research Program at UNB. The overall goal of the program is to provide a mechanism for evaluating promising technological solutions to rural transportation issues. It was established under UNB's Transportation Group through a funding contribution agreement from Transport Canada (under the Strategic Highway Infrastructure Program) and NBDoT.

The current ITS program includes five projects:

1. Work Zone Radar Speed Management
2. Remote Track Switch Position Indicator
3. Grade Crossing Warning System for Private and Farm Crossings
4. Development of an ITS/CVO Deployment Plan
5. New Brunswick Traveller Information System

Funding for the overall program was available from September 2004 until September 2006. TDC provided additional funding to extend the project into a second winter season of testing. NB Southern Railway agreed to partner with UNB's Transportation Group for the two rail projects by providing test sites, personnel, and expertise in developing and conducting the work plan.

1.3 ITS Architecture for Canada

The Intelligent Transportation Systems (ITS) Architecture for Canada (ITS Architecture for Canada, 2004) was developed to provide a common framework for planning, defining, and integrating ITS. It represents the contributions of the wide spectrum that is the ITS community, including transportation practitioners, systems engineers, system developers, consultants, etc. The architecture defines:

- the functions (e.g., gather traffic information or request a route) that are required for ITS,
- the physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle),
- the information flows that connect these functions and physical subsystems together into an integrated system.

The ITS Architecture for Canada is composed of a series of user services and sub-services. User services represent what the ITS system should do from the users' perspectives while user sub-services are focused on context and refined definition. A series of hierarchical requirements accompany each user sub-service and are essential to providing the final ITS service.

A summary of the user services and sub-services for warning systems at highway-rail intersections can be found in Table 1.1.

Table 1.1 - Summary of User Services and Sub-Services for Warning Systems at Highway-Rail Intersections

User Service/ Sub-Service		Description
2	Traffic Management Systems	Consists of user services designed to use advanced systems and technologies to improve the efficiency and operation of the existing surface transportation infrastructure and create safer conditions for travellers. This user service bundle includes Road Weather Systems and Services, as well as Automated Enforcement.
2.8	Multi-Modal Junction Safety and Control	The Multi-Modal Junction Safety and Control user service manages traffic at at-grade highway-rail intersections. The management functions can include warning systems, barrier systems, and co-ordination between railway operations and traffic management centres.

User Service/ Sub-Service	Description
2.8.1 Basic At-Grade Crossing Control	Manages highway traffic at highway-rail intersections (HRIs) where operational requirements do not dictate more advanced features (e.g., where rail operational speeds are less than 130 kilometres per hour). Both passive (e.g., the crossbuck sign) and active warning systems (e.g., flashing lights and gates) are supported…. These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalised intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported to both highway and railroad officials through wayside interfaces and interfaces to the Traffic Management Subsystem. Similar interfaces and services are provided for other types of multimodal crossings (e.g. drawbridges).

[Source: ITS Architecture for Canada, 2004]

The ITS Architecture for Canada is not intended to be technology- or implementation-specific; rather, it acts as a guide to ensure interoperability between various ITS deployments. User service requirements are used to maintain operability while remaining applicable to different system designs and encompassing a broad range of possibilities (IBI Group, 2004). Some requirements applicable to the warning system for private and farm road crossings project are listed below.

- Warning system shall provide interface between road users and rail operations.
- Warning system shall provide advance indication of train arrival.

1.4 Project Goals and Objectives

The overall goal of this project was to identify, test, and evaluate a low-cost active warning system for private and farm grade crossings of rail lines. Specific objectives were to:

- establish a Technical Steering Committee of stakeholders,
- identify potential products that meet the criteria for the program and have not yet been used or tested in the Canadian environment,
- select a product for installation and testing,
- develop evaluation criteria and performance thresholds,
- select a test site and install the equipment,
- collect data and analyze results,
- evaluate the product for use in Canada, and
- prepare a report.

Given the lack of a commercially available product, it was recognized that a prototype system would be evaluated. Furthermore, the testing program was meant to provide an initial proving ground where the product would likely require more robust testing if the results were promising.

1.5 Scope

The funding available under the Rural ITS Research Program limited the scope of the study to a period from September 2004 until September 2006. Given the leadtime required to identify a supplier, and acquire and install the equipment, the amount of field testing was initially limited to 18 months; however, TDC was able to provide enough additional funding to extend the test period to March 2007.

Study sites were located in New Brunswick because of NBDoT's role in the program and to allow access by UNB Transportation Group researchers. Funding for equipment acquisition and data collection efforts limited the number of product evaluations to one. Efforts were made to select test sites that would be representative of rural conditions in other parts of the country.

2.0 EXISTING WARNING SYSTEMS IN CANADA

Warning systems for highway-rail intersections (HRIs) in Canada are either passive or active. A passive warning system consists of pavement markings and signs such as a railway crossing sign, a railway advance warning sign, stop-ahead signs, and stop signs. Typical passive systems at a public and private crossing in New Brunswick are shown in Figures 2.1 and 2.2, respectively.

Figure 2.1 - Passive Warning System at a Public Crossing

Figure 2.2 - Passive Warning System at a Private Crossing

The purpose of passive traffic control devices is to identify and direct attention to the location of a crossing to allow drivers, pedestrians, and other users to take appropriate action (US DOT, 1986).

An active warning system includes flashing lights, bells and sometimes gates, depending on conditions. Its purpose is to give warning of the approach or presence of a train. A typical active warning system is shown in Figure 2.3.

Figure 2.3 - Active Warning System at a Public Crossing

2.1 Regulations for Private and Farm Crossings

Currently, Transport Canada has no regulations or standards for private and farm crossings. However, if an active warning system is installed, it must meet the requirements of the *Highway Crossings Protective Devices Regulations* (Government of Canada, 2005). These regulations apply to protective devices of the flashing light type that are installed by railway companies under the jurisdiction of Transport Canada. The regulations give standards for the installation, operation, and maintenance of the warning system.

Transport Canada also enforces its guideline on sightlines at passive and active crossings and uses Section 11 of the *Railway Safety Act* (Government of Canada, 1985), pertaining to engineering work related to railway works, to ensure that all crossings are well designed and maintained. Transport Canada is currently proposing new grade crossing regulations that include guidelines and standards for public as well as private and farm crossings.

2.2 Regulations for Active Crossings

Transport Canada has regulations for the design, operation and maintenance of warning systems (Government of Canada, 2005). Key points are noted below.

- Each signal shall have at least four light units.
- Signals shall operate for at least 20 seconds before a train travelling faster than 10 mph enters the crossing. This time is extended if the crossing is wider than usual.
- Signals shall continue to operate until the train has cleared the crossing.
- Signals, gates, operating mechanisms and control circuits shall be in accordance with American Railway Engineering and Maintenance-of-Way Association (AREMA) recommended practice.

Under the *Railway Safety Act*, Transport Canada is proposing new regulations for all grade crossings, both public and private (Transport Canada, 2002a). A draft set of standards for road/railway grade crossings, Railway Technical Document 10 (RTD10), is also being proposed as part of the regulations (Transport Canada, 2002b). Under the new regulations, a detailed safety assessment of a private or farm crossing will be required every 5 to 10 years if the crossing is a:

- recreation road maintained by a club, association, or other organization

- road of a commercial or industrial establishment, including a business operated from a residential or farm property that is used in connection with the establishment by persons other than the employees of the establishment
- road that serves three or more principal residences
- road that serves three or more seasonal residences access to which is not controlled by a gate equipped with a lock

Detailed safety assessments will also be required for private or farm roads if the owner of the road requests the railway company to make a change to the crossing. RTD10 will be the standard for the detailed safety assessments and for the installation of any signs, signals, or other equipment at grade crossings.

2.3 Components of a Warning System

A warning system at an HRI consists of:

- warning devices such as flashing light signals, a pedestrian bell, and possibly automatic gates,
- a system for detecting a train,
- communication between detectors and warning devices, and
- a power supply.

A low-cost system at a private or farm crossing would likely have one warning device, such as flashing light signals, plus the other components listed above. Warning systems in use today incorporate fail-safe design principles. For example, the system is designed to indicate an approaching train (i.e., operate in continuous flash mode) whenever the system has failed.

2.3.1 Warning Devices

Current warning systems have light signals consisting of two light units that flash alternately at a rate of 45 to 65 times per minute. “Thus, like its predecessor, the wigwag, it simulates a watchman swinging a red lantern. Wigwags consist of a single red light unit that sways back and forth.” (US DOT, 1986, p. 104).

Other warning systems, normally used to supplement flashing signals, include bells, automatic gates, active advance warning devices, and highway traffic signals.

2.3.2 Train Detection

Some form of train detection is required to activate warning devices at crossings. Generally, the method is automatic, although a small number of warning systems are operated under manual control. Automatic methods use the rails to conduct electricity and create a circuit. When a train enters the track circuit, the electricity is short-circuited (or shunted) through the wheels and axles of the train instead of the rails. The interruption in the flow of electricity triggers the warning system. This system is considered fail-safe because any shunt of the circuit, whether by a train, vandalism, or a broken rail, will trigger the warning device at the crossing.

There are five basic types of train detection systems in use (US DOT, 1986):

1. Direct current track circuit
2. AC-DC track circuit
3. Audio frequency overlay track circuit
4. Motion sensitive track circuit
5. Constant warning time track circuit

A simple DC track circuit is shown in Figure 2.4.

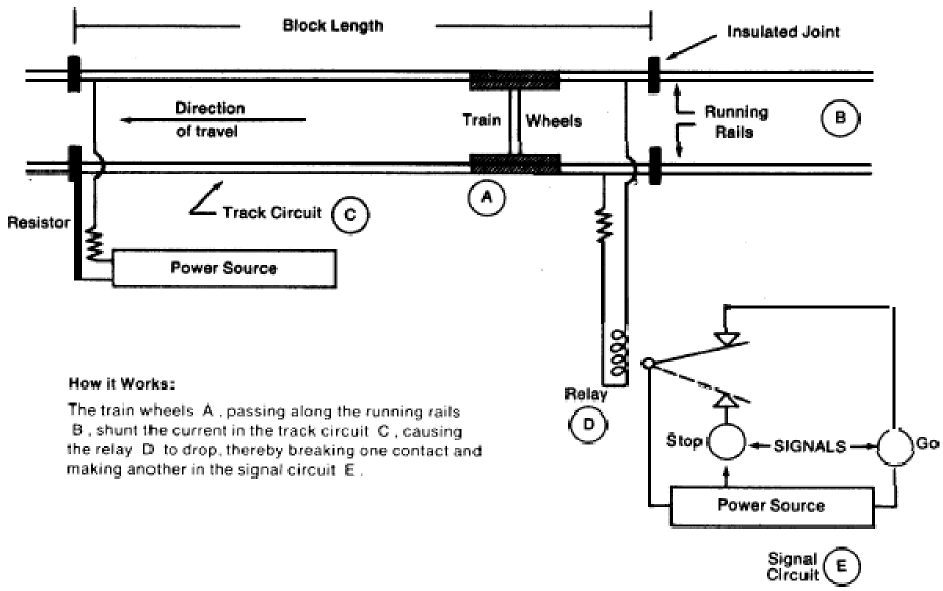

Figure 2.4 - Simple DC Track Circuit

[Source: United States Congress, 1976]

The track is divided into electrically isolated segments (called track circuits) by insulated joints placed at intervals in the running rails. This forms a circuit with a power source connected to the rails at one end of the block and a relay at the other. The relay is part of a second electrical circuit that has its own power supply (commonly a battery) and includes a signalling device (U.S. Congress, 1976).

Electricity from the track circuit flows through the relay and holds the movable element of the relay, or armature, up when a train is not present. When a train enters the block, the electricity is short-circuited from the relay through the train's wheels and axles. This weakens the electromagnetic force holding up the armature, allowing it to drop under the force of gravity. This action closes a contact in the signal circuit and activates the signals (U.S. Congress, 1976).

In order to provide a means for stopping the operation of the warning system after the train clears the crossing, three track circuits and associated logic elements are required. Two circuits are provided on the approaches to the crossing, and a third circuit, called the island circuit, overlaps the highway crossing. The logic elements are arranged such that as the train moves through the crossing, the crossing clears for highway traffic as soon as the rear end of the train leaves the island section (US DOT, 1986). The track circuits on the approaches must be long enough to provide a minimum warning time for the fastest train. Canadian regulations specify a minimum warning time of 20 seconds before a train travelling faster than 10 mph enters the crossing (the time is extended if the crossing is wider than usual). Approach sections may be divided into several short track circuits to permit more consistent warning times for trains travelling at various speeds. A "time-out" feature can also be used to deactivate the warning devices if a train stops in the approach section (US DOT, 1986).

An AC-DC track circuit (or Style C track circuit) is used quite extensively when approach distances are less than 3000 ft. and no other circuits are present on the rails. Advantages of this system are that all control equipment is located in a single housing at the crossing and shunting is improved because of higher voltages across the rails (US DOT, 1986). This type of circuit is often used to mitigate loss of shunt on tracks where foreign deposits tend to accumulate (Alcatel, 2005). Three circuits (i.e., two approach and one island) are usually used to establish train direction (US DOT, 1986).

The audio frequency overlay (AFO) track circuit is similar in application to the DC track circuit, except that it can be superimposed over other circuits that may exist on the rails. A transmitter and receiver are used instead of a battery and relay. No insulated joints are required with this type of circuit. As with the DC and AC-DC systems, three circuits are required to establish train direction (US DOT, 1986). AFO track circuits can also be used for the island circuit in combination with DC (or other types) of approach circuits because it can be used on top of the DC track circuits (Reiff et al., 2003).

A motion-sensitive track circuit uses audio frequencies, similar to an AFO track circuit, to detect the presence and direction of a train. The system continuously monitors the track impedance, which is relatively constant when a track is unoccupied or no train is moving within the approach. Decreasing track circuit impedance indicates that a train is moving toward the crossing and increasing impedance indicates that a train is moving away from the crossing. If the train stops on the approach or moves away from a crossing, the warning system is deactivated. This type of system is advantageous where trains stop or conduct switching operations within the normal approach limits of a particular crossing. A motion-sensitive track circuit can also be overlaid with other detection circuits (US DOT, 1986).

Constant warning time equipment can sense a train in the approach section, measure its speed and distance from the crossing, and activate the warning equipment to provide the selected minimum warning time. These systems should be considered for crossings on railway mainlines, particularly at crossings with variations in train speeds and at crossings with a number of switching movements on the approach sections (US DOT, 1986).

2.3.3 Fail-Safe Design

Active crossing warning systems used in Canada are designed to be fail-safe. This is because signals at a railway that are not flashing indicate that it is safe for a road user to cross the tracks, unlike highway traffic signals where dark signals tell the road user the system is not functioning. Rail crossing signals have to be designed to flash when a component of the warning system has failed. Otherwise, there could be a “wrong-side failure” where a road user crosses because the signals are dark even though a train is approaching. As noted in section 2.3.2, detection systems are based on activation by absence of an expected electric voltage or signal. In other words, if any part of a circuit fails, the warning system will be activated. Modern signal systems also include automatic equipment checks for transistors and microprocessors. The system will activate the warning devices at the crossing if the output of these checks is not acceptable (Reiff et al., 2003; Peterson, 2001).

3.0 COLLISIONS AT PRIVATE AND FARM CROSSINGS

Every year in Canada approximately 370 collisions and trespassing incidents occur at highway/railway crossings and along the railway tracks, resulting in the death or serious injury of nearly 170 people (Direction 2006 website). Collisions at private and farm crossings account for 15 percent of the total (or 54 per year) and 2 percent of the fatalities (or 4 per year) (Operation Lifesaver website). Although railway-related incident rates and crossing fatalities have reached their lowest levels in 10 years, improving safety at highway-railway crossings is one of the top priorities for Transport Canada and Canada's railways, as collisions at crossings account for half of the railway-related deaths and injuries each year. To help improve that situation, the Transport Canada Grade Crossing Improvement Program contributes an average of $7.5 million a year to improve safety at public highway-railway crossings (Direction 2006 website). However, farm and private crossings are not eligible for grants under this program because they must be in existence for public use for at least three years.

Traditional active warning systems are not an option for improving safety at farm and private crossings because of their high cost. There are approximately 28,500 private and farm crossings in Canada (Operation Lifesaver website). Active warning systems are installed where traffic volumes are high or where there is inadequate sight distance for a road user to see an approaching train in time to either cross safely or stop. An active warning system would rarely be warranted at any private or farm crossing on the basis of volume. However, a low-cost warning system may be warranted at selected private and farm crossings on the basis of inadequate sight distance, particularly if heavy vehicles such as farm equipment or trucks use the crossing, because they require longer sight distances than cars. Two examples of collisions at private crossings, where a low-cost warning system may have prevented the collision, are described in sections 3.1 and 3.2.

3.1 Collision and Derailment of VIA Rail Train No.603 in La Tuque, Quebec on August 30, 2000

(Source: Transportation Safety Board of Canada, 2000).

This collision occurred between a dump truck and a VIA Rail train at a private crossing near a gravel pit. The truck driver lost his life and a locomotive engineer was slightly burned. The 22 passengers and other 2 VIA employees were not injured.

Approximately 80 heavy vehicles per day used the narrow, winding, private road to cross the railway tracks and access the gravel pit. Given the characteristics of the road, loaded trucks travelled at a speed of approximately 7 km/h and required approximately 9 seconds to accelerate from the stop sign at the crossing and pass over the tracks. The available sightline for the driver was 120 m in one direction and 180 m in the other. The sightlines were inadequate for the maximum speed limit of 50 mph for passenger trains in the subdivision. The week preceding the accident, another driver had averted a collision with a train at the same crossing. Further investigation revealed that the mirrors on the dump trucks created a blind spot in the driver’s field of view along the tracks. Investigators concluded that the driver might not have seen the approaching train at all.

3.2 Collision of VIA Rail Train No.2 in Hornepayne, Ontario, on July 14, 1999

(Source: Transportation Safety Board of Canada, 1999a)

This collision occurred between an empty tractor-trailer and a VIA Rail train at a private crossing on a gravel road owned by a logging company. Three people – two passengers and one VIA employee – were seriously injured in the accident, and a total of eight were taken to the community hospital. There were 260 passengers and 26 employees on the train at the time of the accident.

The crossing had a passive warning system consisting of “maximum 30 km/h” signs, stop signs, and additional warning signs indicating “Danger High Speed Trains” on both approaches. The driver maintained a speed of 15 km/h because the road and crossing were rough. He elected not to stop at the stop sign, as he believed that his truck could stop if he saw a train approaching, and through habit, he never stopped at that crossing. He did look in both directions as he approached the crossing and did not see or hear the train.

Mostly large trucks servicing the logging company’s operation used the crossing. The sightline in the direction of the train was 365 m. The Transportation Safety Board of Canada (TSB) concluded that had the tractor-trailer driver stopped at the stop sign and looked for a train, he would have had at most two extra seconds to clear the crossing if a train had been approaching just outside the sightlines. A Transport Canada Regional Engineer determined that the safe time frame for a crossing where long, loaded trucks travel is 25 seconds. In this case, a sight distance of 686 m would be required to provide a 25 second clearance time because the maximum speed for the train was 60 mph.

3.3 Investigations of Farm Crossings

The TSB also addressed the issue of safety at farm crossings in a report on the investigation of a collision between a freight train, tractor-trailer, and VIA Rail train at a farm crossing in Ontario (Transportation Safety Board of Canada, 1999b). A westbound CN freight train collided with a vehicle abandoned on a farm crossing with two tracks. An eastbound VIA Rail train then struck the debris from the first collision, injuring six VIA employees and five passengers. Although an active warning system would not have made a difference in this case, the investigators did make the following observations regarding safety at farm crossings:

- The crossing under investigation was originally used as a farm crossing. However, its use changed around 1980 as the property was developed. At the time of the accident, it also provided a secondary entrance to both a cement plant and an Ontario Hydro property.

- The truck driver was not aware that the track on which his vehicle was immobilized was a double main line, i.e., a high-traffic main line. There were no signs warning drivers that high-speed trains operated on the track or signs listing an emergency number to call in case of impending danger.
- Most farm and private crossings are used almost exclusively by the landowner, although some are used for activities such as logging or resource extraction where use is less restricted. Where members of the public, who are unfamiliar with the crossings, deliberately or inadvertently use these crossings, they may be exposed to hazards. In these situations, more information and warning signage as well as a closed gate would deter a vehicle driver who wanted to use the crossing. In the absence of this deterrence, improved laneway and crossing approach designs would make these crossings easier to negotiate.
- Very few private or farm crossings across Canada have automated warning systems. No comprehensive review has been made of the level of warning systems at all private and farm crossings on high-speed corridors, and the current need for those crossings has not been examined.
- A small survey of 11 crossings in the same subdivision as the accident was completed for the investigation. All were below Transport Canada's existing regulatory requirements, which are significantly lower than the proposed requirements in RTD10.
- There were 12 accidents at farm and private crossings in the subdivision between 1990 and 2000 (compared to 41 crossing accidents in total). Typically, traffic using private or farm crossings and involved in accidents has been of the commercial type, suggesting that the probability of a train derailment may be proportionally higher at these crossing compared with public crossings.

4.0 RELEVANT STUDIES

Four studies from the United States were found on low-cost detection and warning systems for HRIs. Of the four, only two have been completed to date. The Transportation Technology Center Inc. (TTCI) and the John A. Volpe National Transportation Systems Center (Volpe Center) completed a report in February 2003 on five technologies for detecting trains and/or highway vehicles approaching and occupying HRIs (Reiff et al., 2003). Their methodology and results are reviewed in Section 4.1.

The Minnesota Department of Transportation, in cooperation with the Twin Cities and Western Railroad, conducted a study to assess the operation of a new low-cost active warning system for HRIs in the state (MnDoT website). The warning system was developed by C3Trans System LLC and costs about one-tenth of current systems. It was designed for use at low-volume public crossings. An evaluation report was published in December 2005 (URS Corp. & TranSmart Technologies, 2005). The Minnesota study's testing methodology is reviewed in Section 4.2.

The Texas A&M Research Foundation and the South Dakota Department of Transportation are currently conducting studies on low-cost detection and warning systems (NCHRP website, South Dakota Department of Transportation website).

The objective of the Texas A&M study is to identify and assess low-cost, viable active-warning-system and component designs for highway-rail grade crossings. It is being funded under the National Cooperative Highway Research Program (NCHRP) and was expected to be completed by December 31, 2006; however, at this time, it is still active.

Study tasks include:

- development of assessment criteria for active-warning-systems and component designs including, but not limited to, fulfillment of driver needs, reliability, fail-safe design, maintainability, training requirements, useful life and available technical support;
- identification of innovative active warning systems and component designs in use throughout the world. Collection of available information on the functionality and performance of the systems and ongoing evaluation efforts;
- identification of alternative technologies used in other industries applicable for use in low-cost active warning systems;
- assessment of potential systems based on the assessment criteria and recommendation of designs worthy of further testing;
- development of evaluation plans for further testing. (NCHRP website)

The South Dakota Department of Transportation (SDDoT) also initiated a project on low-cost active railroad crossing signals. Research objectives for the study included:

- identification and evaluation of candidate low-cost active rail crossing signal systems and components,
- evaluation of the potential for application of low-cost active rail crossing signals in South Dakota,
- recommendations for warrants and specification for deployment of low-cost active rail crossing signals in the state. (SDDoT Website)

The project has been postponed pending the NCHRP study results (Becker, 2007).

4.1 TTCI Evaluation of Detection Technologies at Highway Rail Intersections

4.1.1 Project Overview

The TTCI and the Volpe Center evaluated five non-track circuit based technologies for their ability to detect trains and/or highway vehicles approaching and occupying HRIs. The categories of evaluation included train approach detection, train island detection, static highway vehicle detection, and dynamic highway vehicle detection. The five technologies evaluated were as follows:

- System 1: A train presence detection system using a combination of magnetic anomaly and vibration detectors in a sensor module.
- System 2: An integrated train and vehicle detection system using double wheel sensors for train detection and a low-power laser and video imagery system for highway vehicle detection.
- System 3: A train detection system based on a low power module with vibration and magnetic anomaly sensors to detect the approach and departure of a moving train.
- System 4: An integrated train and vehicle detection system using inductive loops placed between the running rails to detect the train and a radar unit to detect highway vehicles.
- System 6: A combination of passive infrared and ultrasonic detectors for indicating a vehicle or obstacle within the HRI.

System 5 was not described or evaluated at the time the report was prepared because it was not installed in time for testing. Further information on the detection technologies is available in the final report (Reiff et al., 2003).

Findings were summarized as follows:

- Systems 2 and 4 exhibited no train approach failures.
- System 2 consistently matched the baseline system for accuracy in detecting train arrival/departure within the island limits.
- All technologies (Systems 2, 4, and 6) detected pedestrians and vehicles statically within the HRI.
- Systems 2 and 6 interpreted all combinations of vehicles moving properly and detected dropped loads.
- Only System 6 was able to discern an overhanging load on a flatbed truck within the HRI.

Results suggest that most systems using non-track circuit based detection systems did not always interpret train and highway vehicle presence within prescribed limits. Only System 2 successfully detected approaching trains and trains occupying the island in all 43 test scenarios. It should be noted that in some instances, differences were caused by placing sensors at or near detection limits used by conventional track circuit technologies. Alternative locations for certain sensors may improve performance. Details on the testing methodology and results follow in Sections 4.1.2 and 4.1.3.

4.1.2 Testing Methodology

Performance requirements included the following criteria:

- A minimum warning time of 20 seconds for an approaching train. The warning time did not have to be constant.
- Release of island detection within 2 seconds after the train departure.
- Functional for train speeds ranging from 5 to 125 mph.

Failures were categorized into three groups:

1. Critical failures, which were warning times of less than 20 seconds, deactivation before the train has cleared the island, or deactivation times greater than 10 seconds.
2. Missed detections.
3. Nuisance and false alarms, which are activations of the system by something other than a train or highway vehicle (e.g., pedestrians, bicycles, or birds) or a design flaw. This group also includes activation of the system before a train reaches the approach limits, and deactivation times greater than 2 seconds but less than 10 seconds.

Vendors were provided a two-week window to install and test their systems. TTCI staff then tested the ability of the systems to detect trains approaching at constant and variable speeds and trains occupying the island. The systems were also tested for their ability to detect highway vehicles or other obstacles within the island. The methodology for testing train detection on a single track is summarized below. Information on the approach for testing detection of highway vehicles and multiple trains on parallel tracks is provided in the final report (Reiff et al., 2003).

- Detections at constant speeds were tested using trains approaching the detectors from both directions at 5, 10, 20, 35, 50, 65, 80, 100, and 120 mph.
- Detections at variable speeds were tested using trains approaching at 30 mph, and then slowing to 5 mph. The test was repeated for approach speeds of 40 mph. Trains then approached at 5 mph and accelerated at their maximum rate through the test section.
- Detectors were tested for the following train switching moves:
  - Slow run, stop spine car over island for 5-10 minutes, then continue in the same direction. Repeat approaching from the other direction.

- Slow run, stop with wheel of rail car directly over island entrance for 5-10 minutes, then continue in same direction. Repeat approaching from the other direction.
- Slow run into island with at least three cars, stop. Uncouple last car, depart island. Leave lone car standing for 5-10 minutes, back onto car, couple and depart in original direction. Repeat approaching from the other direction.
- Back locomotive and six cars through island, stop for 3 minutes, pull forward two car lengths, stop 2 minutes, back through island. Repeat approaching from the other direction.
- Reverse three cars across island, stop, and move forward through island in same direction. Repeat approaching from the other direction.
- Kick single car through island. After car has departed island, follow with locomotive to capture. Repeat approaching from the other direction.

The detection systems were also tested to see whether a hi-rail maintenance vehicle would activate them. These vehicles are usually insulated to avoid activating any train detection or warning systems.

4.1.3 Results

Tables 4.1 and 4.2 summarize the train detection performance of Systems 1 to 4. As noted previously in Section 4.1.1, System 5 was not tested and System 6 was a vehicle and obstacle detection system only.

Table 4.1 - Frequency of Detecting Approaching Trains

Performance	System 1	System 2	System 3	System 4
Successful Detection	40	43	20	41
Critical Failure	1	0	0	0
Missed Detection	0	0	8	0
Nuisance or False Alarm	0	0	1	0

Table 4.2 - Frequency of Detecting Trains in the Island

Performance	System 1	System 2	System 3	System 4
Successful Detection	15	43	2	15
Critical Failure	20	0	37	9
Missed Detection	0	0	0	0
Nuisance or False Alarm	5	0	0	17

The only system that did not have any critical failures detecting trains both on approach and within the island was System 2. This system uses two sensors, one on each rail, at each approach limit to count the axles passing over the sensor. A sensor on each side of the HRI acts as the island circuit. When the number of axles counted at the approach matches the number of axles passing over the island in the same direction, the system indicates a clear circuit. Each sensor pair is hardwired to the control circuit located near the HRI.

4.2 Minnesota Testing Methodology

4.2.1 System Description

The warning system developed by C3 Trans Systems has the following features:

- Installation cost of 20 percent of traditional systems.
- Elimination of track-based detection. GPS and radio communication are used to send a signal when a train nears a crossing to activate a set of LED flashers warning vehicles not to cross.
- In-cab warning up to 1 mile in advance of the approach to crossings that are not working properly, giving the train crew time to stop safely.
- Solar power, eliminating the need for AC power at crossings.
- Continuous diagnostics, reducing service costs and increasing reliability.
- Dual redundant systems for continuous service when one unit fails.

The system was designed to provide 30 seconds' warning before a train enters an HRI and to deactivate 3 seconds after the train clears the intersection (MnDoT website). Detailed system requirements are summarized in Appendix A.

4.2.2 System Testing

The warning system was tested in three phases:

- Phase 1: Shadow-mode testing at a single HRI with one locomotive between March 2002 and May 2002. This test was successful.
- Phase 2: Shadow-mode testing at 10 contiguous intersections testing with eight locomotives from January 2003 to March 2003.
- Phase 3: Active-mode testing at 30 HRIs with eight locomotives from June 2005 through September 2005.

All system hardware was purchased and devices to allow the 10-intersection shadow-mode testing were installed. Testing activities with selected locomotives began on January 1, 2003, and data is currently being collected and analyzed to assess safety and operational performance, cost, reliability, and maintenance implications (MnDoT website).

Computers were installed on the locomotives to record time, position, speed, and heading of the locomotive in the "locomotive transmitted packet". The computer also records:

- activation and deactivation of the warning system, including:
  - warning time
  - island detection
  - clearance time
  - occurrence of false activations
  - occurrence of activation failures
- results of any error conditions, actual or simulated
- GPS lock loss and radio packet errors

Data is collected every 2 seconds at all crossing encounters and whenever GPS lock is lost. It is downloaded periodically via cell modem for analysis. Warning and deactivation times were measured in the field using stopwatches to validate the automated data collection system. All analysis will be completed using the data from the automated system.

The warning system was tested under the following scenarios:

1. Activation and deactivation from a moving train
    a. Trains travel at 5,10, 20 and 30 mph from each direction.
    b. Warning time is measured as the time from activation until the train is observed to enter the island (the area between the crossbucks).
    c. Deactivation time is measured as the time from when the train leaves the island until deactivation occurs.
2. Activation when a train stops on the approach
    a. Train travels from each direction until activation, then stops on the approach.
    b. Warning time is measured from train stoppage until deactivation.
    c. Train then resumes movement toward crossing and warning time is measured.
    d. Crossing activation is observed when the train moves away from the crossing after stopping.
    e. Warning time is measured when a train exceeding 40 cars backs into the crossing.
3. Continual activation during train presence
    a. Trains travel at 10, 20 and 30 mph from each direction.
    b. Trains stop on approach, then proceed toward the crossing.
    c. Trains stop on approach, then proceed away from the crossing.
    d. The test is successful if i) the crossing flashers say activated the entire time the train is in the crossing even if the train is moving at a constant speed, not moving, backing, decelerating, or accelerating; and ii) if the crossing deactivates when the train stops on the approach, and reactivates when the train resumes forward movement from a stop.

4. Continual activation during train acceleration and deceleration
    a. Train travels at 10 mph and then accelerates to 30 mph once the flashers begin. It is understood that a train that accelerates on the approach would likely yield a short warning time. This action would be against the operating rules when in normal operation.
    b. Train travels at 20 mph and then decelerates to 10 mph once the flashers begin (maintaining a safe braking profile).
    c. The test is successful if the crossing flashers stay activated the entire time the train is in the island even if the train is decelerating or accelerating.
5. Continual activation during train presence and switching moves
    a. Train with multiple cars travels at 10 mph.
    b. Train stops with locomotive beyond the island but with cars still fully in the island. Locomotive decouples and pulls away from the crossing, leaving at least one flat car in the island for 5 minutes. The team verifies that the crossing remains active this entire period.
    c. After 5 minutes, the locomotive re-couples and then proceeds out of the island. The team verifies that the system remains active until the train leaves the island.
    d. Train with multiple cars travels at 10 mph.
    e. Train stops with locomotive beyond the island but with cars still fully in the island.
    f. Train recedes and the team verifies that the system remains active until the train leaves the island.
6. Island protection
    a. Locomotive is pulled up to the crossing, aligning its nose with a crossbuck, and stopped. The crossing should activate within 4 to 6 seconds.
    b. Locomotive enters the crossing and stops. The warning system should continue flashing until the locomotive is pulled completely away from the crossing.

c. A mid-sized automobile and then a heavy truck (RR maintenance vehicle) pause on the tracks for 20 seconds from each direction. Crossing non-activation is verified visually.

d. Test is successful if train moving at 5 mph is detected in advance of the island, there is no deactivation while a train is in the island, and the a train is detected within a minimum of 10 ft. of either side of the crossbucks.

The following acceptance criteria were used for the tests:

- Warning times: target is 30 seconds
  between 20 and 40 seconds for 100% of tests
  between 24 and 36 seconds for 99.9% of tests

- Deactivation times: target is 6 seconds
  between 1 and 11 seconds for 100% of tests

Fail-safe features were also tested to ensure that the warning system faulted to flashing lights in the event of a system failure. It should be noted that other components of the system, such as an advance-warning flasher for highway traffic, radio performance, and an on-board indicator for the train crew, were also tested.

5.0 RESEARCH METHODOLOGY

The following sections describe the Transportation Group's approach for identifying the test site, and selecting and evaluating the warning system.

5.1 Test Site

The test site for the warning system was located on NB Southern's line in Grand Bay–Westfield, New Brunswick. Grand Bay–Westfield is a suburb of Saint John just northwest of the city. The site location is shown in Figure 5.1.

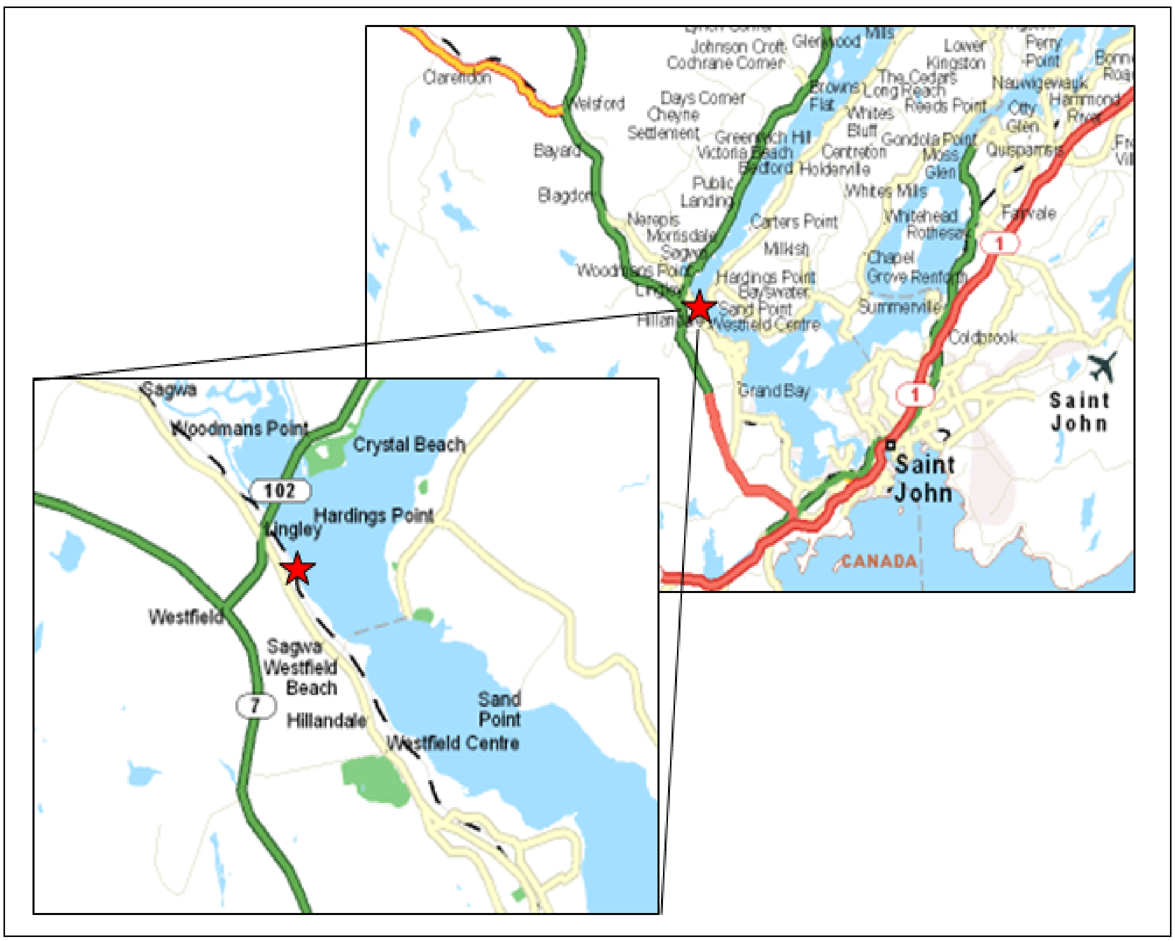

Figure 5.1 - Test Site Location

The site was chosen because:

- it was reasonably accessible for data collection,
- an existing concrete signal base could be used,
- adequate sightlines were available in both directions for radar detection,
- a highway running parallel to the railway line and a highway overpass north of the site provided an opportunity to test for interference from road traffic,
- there was less chance of vandalism due to its location in a community and visibility from the adjacent highway, and
- it was near another piece of equipment being tested by UNB, allowing for more frequent site visits and synergies in data collection.

There is no private or farm crossing at the test site. However, the warning system selected does not rely on highway vehicles for activation. It is based on train detection only, as described in the following sections. Therefore, the test site did not have to be located at a crossing. In fact, testing the equipment at a non-crossing location eliminated the risk of a highway user relying on the warning system before it was fully tested.

5.2 Equipment Selection

Potential suppliers of a grade crossing warning system were identified using existing contacts of the UNB Transportation Group and Steering Committee, and through a literature review. These contacts included the Volpe Center and the TTCI in the United States. Staff at TDC assisted in the search by:

- providing a list of potential suppliers,
- preparing a brief article describing the research program for submission to transportation periodicals, and
- providing a list of periodicals.

The resulting list of potential suppliers was reviewed and several were omitted because they had already been contacted or their products were not suitable. UNB prepared a brief description of the requirements for the warning system and distributed it to the remaining suppliers on the list (the description is attached as Appendix B). The suppliers were then contacted by telephone. The requirements description was also sent to ITS-Canada, which circulated it to its members as an industry opportunity. Three potential suppliers were identified – Carmanah Technologies, Ontrack Innovative Solutions Inc., and C3 Trans Systems. Ontrack's system was selected for testing because C3 Trans Systems' device is already being extensively tested in Minnesota and Carmanah Techologies did not yet have a fully functional prototype.

Ontrack's warning system is a self-contained, solar-powered unit that utilizes motion and presence detection of trains to control LED lights at the crossing. It provides an active warning system for a fraction of the cost of traditional systems. It is shown installed at the test site in Figure 5.2. The system components are listed in Table 5.1.

Table 5.1 - Warning System Components

• 1 control panel • 2 long-range motion detectors and mounts • 1 ultrasonic presence detector and mount • 4 – 12 in. red LED beacons with housings, visors, mounts, and wiring harnesses	• 3 – 80 W solar panels and mounts • 2 – 120 A batteries • 1 aluminum pole, including base and cap • 1 cabinet

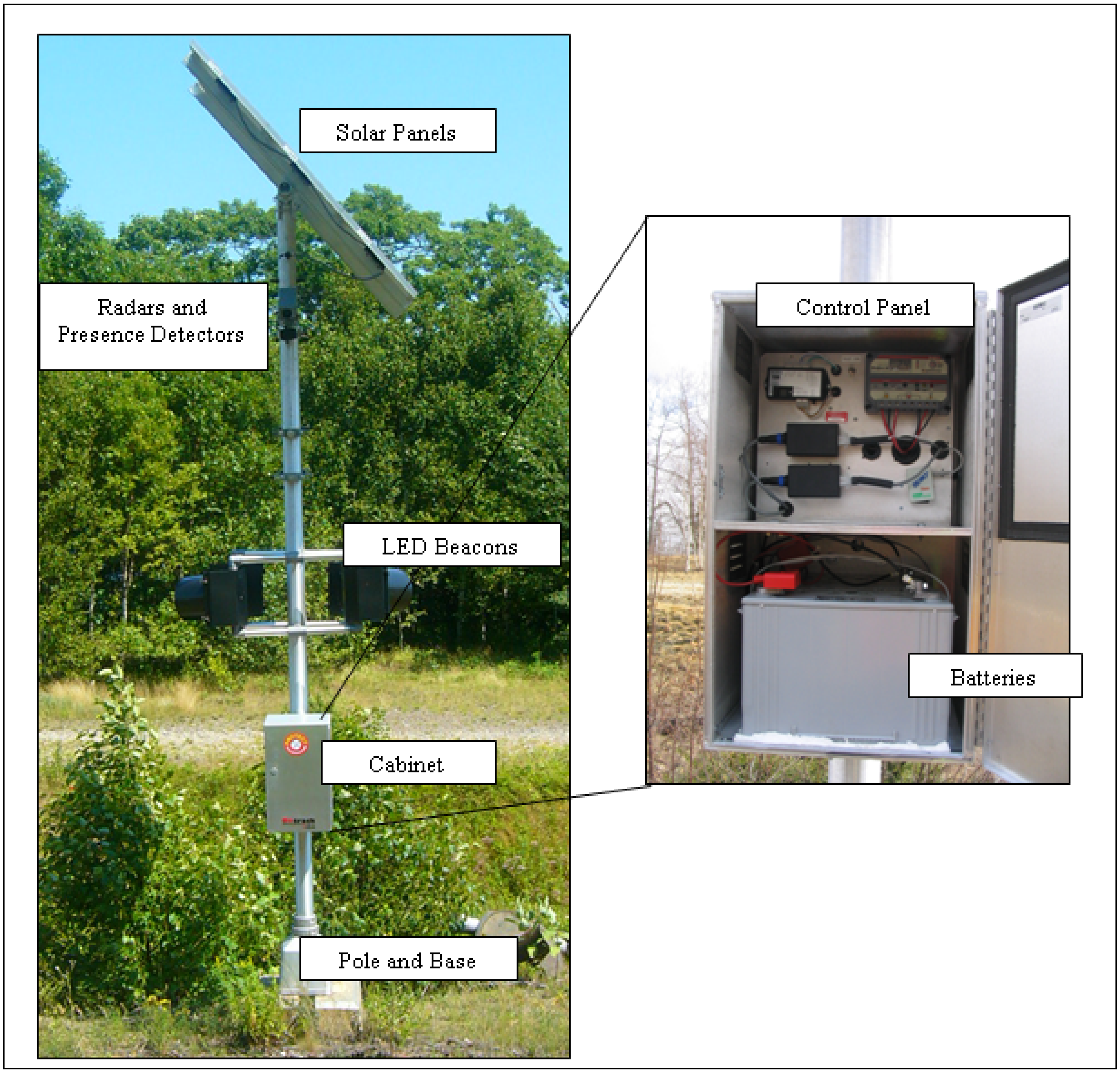

Figure 5.2 - Grade Crossing Warning System Components

Further information on the components is available from Ontrack's website (www.ontrackisi.com). The complete system includes a crossbuck sign and bell. These were removed for the test to avoid any confusion by the public. The beacons normally facing the road were rotated so that motorists could not see the flashing lights when the system was activated. Figure 5.3 provides an overview of how the system operates. Note that their complete system incorporates two signal units that in tandem can provide system redundancies. This study used a simplified one-unit system.

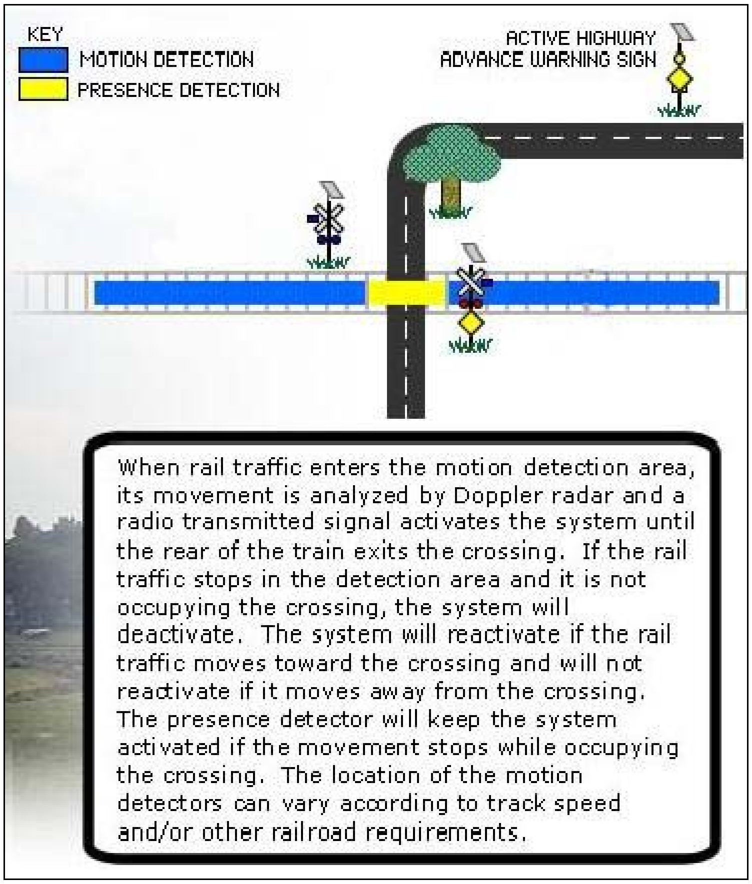

Figure 5.3 - Grade Crossing System Overview

5.3 Testing Methodology

Ontrack's system was tested for its ability to consistently detect the presence of a train and communicate this information to road users through the use of flashing signals. The system was tested in "shadow mode" by preventing road users from seeing the flashing signals and all tests were conducted in compliance with regulatory requirements. The testing methodology followed the guidelines below:

1. In early April 2006, the system was supplied, installed, and tested by Ontrack Innovative Solutions Inc. until it was working to their satisfaction.
2. The system was tested in the field until the end of September 2006.

3. Data was collected on the number of times the system was activated and the duration of warning and clearance times. The acceptable limits of these times were set in consultation with the Steering Committee and NB Southern Railway.
4. TTCI's approach was used to categorize failures, i.e., critical failures that do not comply with regulatory requirements, missed detections, and nuisance and false alarms.
5. The system was tested in "shadow mode" by covering the flashing lights.
6. An automated data logging system was used to record the date, time, and duration of all activations. These data were compared to NB Southern Rail's schedule to determine whether there were any activation failures or false activations. Weather conditions were noted each day.
7. A sample of warning and clearance times for normal train operations were collected manually through field observations. Weather conditions were noted each time.
8. The battery reserve was periodically measured to evaluate the effectiveness of the solar panel.
9. The warning system was also periodically tested under the following scenarios:
   a. Low approach speeds such as 5 and 10 mph.
   b. Accelerating and decelerating approach speeds.
   c. Switching moves that would cause a train to stop on an approach, then proceed toward the crossing; stop on an approach and recede from the crossing; stop within the island for 5-10 minutes.
   d. Vehicles crossing tracks and travelling parallel such as a mid-size automobile, a heavy truck, and a hi-rail vehicle (these vehicles should not activate the system).

Following the testing phase, this final report was prepared, including a project summary and recommendations regarding future use of warning systems at farm and private at-grade railway crossings.

6.0 DATA ANALYSIS AND SYSTEM PERFORMANCE

Ontrack's grade crossing warning system was evaluated for its ability to consistently detect the presence of a train approaching a grade crossing and provide adequate warning time. Data was collected on the number of times the system was activated, duration of activations, missed detections, and clearance times. The data logging capabilities of the system were used to capture and record detections and activation times. The following sections discuss the results of the data collection process as well as other issues that were dealt with during the course of the testing period.

6.1 Equipment Installation and Calibration

The installation of the grade crossing warning system occurred over a two-day period, from April 5 to April 6, 2005. The system arrived on site pre-assembled (se Figure 6.1), with only the solar panel needing to be installed. An existing concrete base, with pre-installed leg bolts, was used to mount the pole. The simplicity of the system and its relatively low weight enabled the pole to be raised without any mechanical assistance. A hi-rail equipped with a boom was used to install the solar panel after the pole was secured in place. The installation of the solar panel is shown in Figures 6.3 and 6.4. The fully installed system is pictured in Figure 6.5.

Figure 6.1 - Pre-assembled Unit before Installation of Solar Panel

The calibration process took place following the installation of the system. The initial calibration of the unit involved having a hi-rail repeatedly travel toward the unit from both the eastbound and westbound directions. The aim was to direct the radar units, shown in Figure 6.2, so they would detect the hi-rail and activate the system at a distance that would provide approximately 20 seconds of warning. A speed of 30 mph was used to calibrate the system. It was felt that this speed was a fair representation of a typical train travelling through the area. The horizontal and vertical orientation of the radars were adjusted to provide the appropriate warning time and to ensure no false activations resulted from traffic travelling on the roadway adjacent to railway. Numerous passes were required before the radar units were set to the appropriate position.

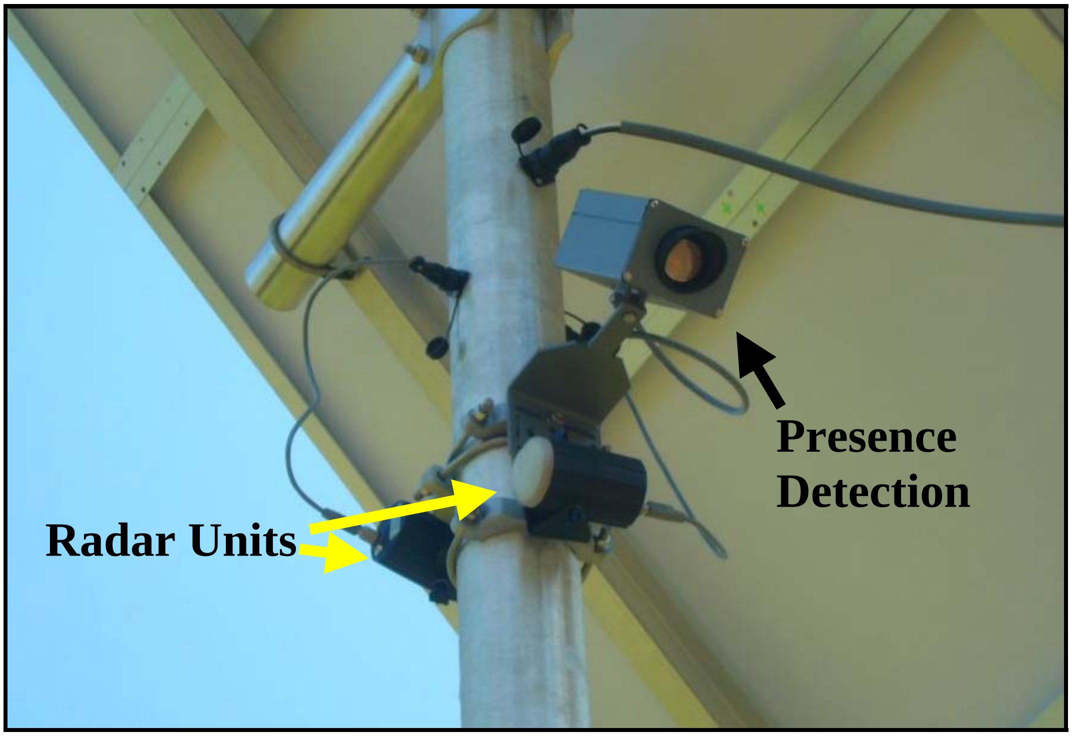

Figure 6.2 - Radar Units and Presence Detection

The default system parameters and sensitivity settings were used for the first calibration process. The system has four base sensitivity settings (1 through 4) with 1 being the least sensitive and 4 the most sensitive. The Max Sensitivity setting (13 through 16) allows for further refinement of the sensitivity level by providing intermediate settings for each base sensitivity level (e.g., 1.13, 1.14…, 2.13, 2.14…). The initial setting for testing was 1.13.

Figure 6.3 - Installation of Solar Panel

Figure 6.4 - Installation of Solar Panel

The other key parameter requiring adjustment is Target Quality Acquisition. The radars are constantly monitoring motion within their range by sending out buffers that are returned to the unit and provide either a positive (motion detected) or negative (no motion detected) reading. The radar units emit 22 buffers per second. The Target Quality Acquisition setting defines how many consecutive positive buffers must be received before activating the system. The setting works on a scale of 1 to 10 where a 1 of 10 setting indicates that the previous buffer must be positive in order for the system to activate and a 10 of 10 setting would require 10 of the previous buffers to be positive. Target Acquisition Quality was initially set to require 2 of 10 positive buffers before activating the system.

Figure 6.5 - Fully Installed Ontrack Grade Crossing Warning System

6.2 System Calibration

Initial Results

Following the initial installation on April 6, 2006, the system was allowed to operate and collect data for a few weeks to evaluate the initial system settings. Data indicated a number of false detections as a result of radar settings that were too sensitive. The high sensitivity caused the system to be activated by motion other than trains.

In order to eliminate the false detections, a series of changes were made to the radar settings. Following consultation with the radar manufacturer, an adjustment was first made to the Target Acquisition Quality setting. Target Acquisition Quality was set to 5 of 10, requiring 5 positive buffers before the system would activate. Data were collected for a week following this change. Results showed that the false detections had been eliminated but the system had become too insensitive. The system would initially detect the train but would experience an interruption in the activation; subsequently, the LED lights would shut off for a varying amount of time before the train was redetected.

May 27, 2005

To eliminate the periodic loss of detection, the Target Acquisition Quality setting was adjusted again, upon recommendation of the manufacturer. This time an 8 of 10 setting was used. There was no change noted from previous results; no false detections were experienced, but the system continued to periodically lose detection of the train.

June 16, 2005

One final adjustment was made to the Target Acquisition Quality, adjusting the setting from 8 of 10 to 2 of 10. The change corrected the issue of the lost detections; however, the false detections returned again. It was apparent that the problem extended beyond adjustment of the basic radar settings and that a more technical solution to the problem was required.

The original software was deemed to be too coarse for this particular application and refinement was required. There are two important criteria that need to be addressed when detecting the presence of the train. First, to avoid false detections, the system must be able to detect the train and only the train, avoiding the detection of other sources of motion. Secondly, the radars must be sensitive enough to maintain detection and keep the system activated until the train passes the presence detection zone. The original software was able to address only one of these criteria at a time; settings were either too sensitive, which resulted in a number of false detections, or too insensitive and unable to sustain detection of the train. System Engineers at Applied Concepts, Inc. determined that the only solution to such a problem was to create a two-tier system that began with a very insensitive setting to ensure that only trains were being detected and then switched to a sensitive setting that prevented the link from being lost.

6.2.1 Software Adjustments

Throughout the course of this system evaluation, several software updates were required to allow the system to function in the capacity it was intended.

Initial Software Update

The first software update, a new configuration file, was installed on July 19, 2005, with the recommended settings uploaded. The initial Target Acquisition Quality setting was 8 of 10, as was the secondary setting. Results following the installation of the new software were a vast improvement. There were no false activations and there was no loss of signal following initial detection.

It was noticed that after a few weeks, with the new settings in place, trains in the westbound direction were no longer being detected. The settings were checked for accuracy and when no problems were found, the eastbound and westbound radars were switched on July 28, 2005. After a week of further testing, data indicated the detection issue was now in the eastbound direction, indicating an issue with the radar unit. A new radar was installed on August 18, 2005 and data collection recommenced.

Second Software Update

The system appeared to be working quite well after the initial software update and replacement of the defective radar. However, in late September 2005 there was a reappearance of the false detections that were experienced earlier in the testing phase. To correct this problem, another new software filter was created. This new software provided additional settings for Target Acquisition Quality. The original 1 to 10 scale was expanded to a 1 to 30 scale, allowing for more refined adjustment. A setting of 28 of 30 was used for both the initial and secondary portions of Target Acquisition Quality. There were no false detections following the installation; however, there was an appearance of periodic interruptions in activations after the trains were detected. This was believed to have been caused by sensitivity settings that were too stringent. To compensate, the basic sensitivity setting was changed from 1 to 2. A week of data collection indicated the false activations had returned. It was decided that further improvements to the software were required.

Third Software Update

The previous version of the software had one sensitivity setting (Sensitivity = 0, 1, 2, or 3). The third software update provided two sensitivity settings (Sen), each serving a unique purpose. For this application, sensitivity was set to Sen = 1 when the unit was trying to acquire a target. At Sen = 1 the radars were very insensitive to motion and would only detect objects that were very large – in this case, a train. The issue with only using Sen = 1 was that, after detecting the train, it was so insensitive that it would often lose detection and therefore the LED lights would stop flashing. To compensate for this, a second sensitivity setting, Sen = 2, was added, which was much more sensitive to any motion, regardless of object size. The second setting ensured the target would not be lost until the train passed the crossing. Once the target was dropped, the unit reverted back to Sen = 1 and waited for the next train to arrive. This alleviated the dropouts that were present before with Sen = 1, and eliminated the false detections that occurred with Sen = 2. The new software was installed on December 22, 2005.

Final Software Update

Data were much improved following the installation of the software in December 2005. False detections were virtually eliminated; however, there was still the occasional activation interruption.

A final software update was made on April 12, 2006. When a train was detected with the previous software, the sensitivity level was increased one level. It was decided that this increase was insufficient and the system was still too insensitive, leading to the dropping of the signal and subsequent activation interruption. The new software increased the sensitivity two levels after initial activation.

False activations continued and increased significantly from April 12, 2006, until April 15, 2006. From April 15, 2006, to May 31, 2006, the east facing radar unit no longer detected trains coming from Saint John. These problems were attributed to a faulty radar unit. The faulty radar unit was replaced on May 31, 2006, but the new unit was initially aligned toward the road, resulting in highway vehicles activating the unit. The radar unit was re-aligned June 21, 2006, to eliminate activations due to vehicles. The false detections due to the faulty radar unit were eliminated; however, there was still the occasional activation interruption. No further adjustments to the system’s configuration were made from this point forward.

6.3 Overview of Train Detection

This section provides an overview of the data pertaining to train detection. The number of activations, length of activations, and issues encountered are discussed, with a breakdown made for each month of testing. Exemplary activation summaries for each month of testing can be seen in Appendix C.

The train volumes along this particular section of track are relatively consistent, with one train travelling eastbound and one westbound each day. Typically, trains run seven days a week, resulting in approximately 50 to 60 trains per month and, subsequently, an equivalent number of activations. In addition to the activation of the system by the trains, there was also periodic activation by hi-rail travelling along the track. Depending on the sensitivity of the system and the speed of the hi-rail, the number of these additional activations fluctuated quite substantially.

The movement of hi-rails is not recorded by NB Southern, making it difficult to discern whether an activation was legitimate or a false detection. It was mentioned in section 6.2 that, at times, there were numerous false detections recorded. It is quite possible that some of these short activations were the result of the intermittent detection of a hi-rail passing along this section of track. However, although some of these activations might have been attributed to hi-rails, the large number of activations and the times at which they occurred indicate activation by other means. Most hi-rail activity occurs between the hours of 8 a.m. and 5 p.m., typically with one pass of the hi-rail in the morning and another in the afternoon. Many of these false activations occurred at hours well outside this period. In other cases, there were too many activations throughout the day to be considered hi-rail activity.

When the system was properly adjusted, a reasonable number of activations could be expected to be anywhere from 60 to 90 per month. Figure 6.2 shows how the number of activations fluctuated from month to month. July, October, November and December

2005 all showed an excessively high number of activations. As was explained in section 6.2, these resulted from improper calibration of the system and deficiencies in the software. Following the installation of the last software updates in December 2005 and April 2006, there was a significant decrease in the number of false activations, as seen in Figure 6.6. An increase was noted from April until June 2006. This was partially a result of a faulty radar unit that was replaced on May 31, 2006. The large spike in activations for the month of June 2006 was a result of aligning the radar unit initially toward the road, resulting in highway vehicles activating the unit. The radar unit was realigned on June 21, 2006, to eliminate activations due to highway vehicles. From this point forward, no changes were made to the system configuration.

It must be noted that the data logger failed from February 12 through to March 22, 2007, so a complete picture of the system performance is not possible. The data in subsequent graphics reflect this void in coverage.

The number of activations provides a rough indication of system performance, but gives little insight into how well the system is truly working. A better description is given by the distribution of activation lengths. A combination of a low number of activations and long activation times is an indication that the system is working properly. There is a balance, however, as too few activations may signify that there are missed activations occurring; in other words, some trains are passing undetected. Figure 6.6 shows the distribution of activation times by month. Activations are divided into three ranges: less than 10 seconds, 11 to 60 seconds, and greater than 60 seconds. Most, but not all, train activations are in the range of one to two minutes. The total time the system remains activated is a function of the following relationship:

$$\boxed{\textit{Total Activation Time} \approx 20\,\text{sec} + \left(L \div V\right) + LT}$$

where:

20 sec =	Acceptable amount of warning time before train reaches crossing
L =	Length of train (m)
V =	Speed of Train (m/s)
LT =	Lag time; time system remains active after train passes ~ 3 seconds

Example:

A 750 m long train travelling 30 mph (48 km/h) approaches the crossing. After converting the speed (48 km/h = 13.3 m/s), the total activation time would be:

$$20 + 750/13.3 + 3 = 79.3 \text{ seconds} \quad (1)$$

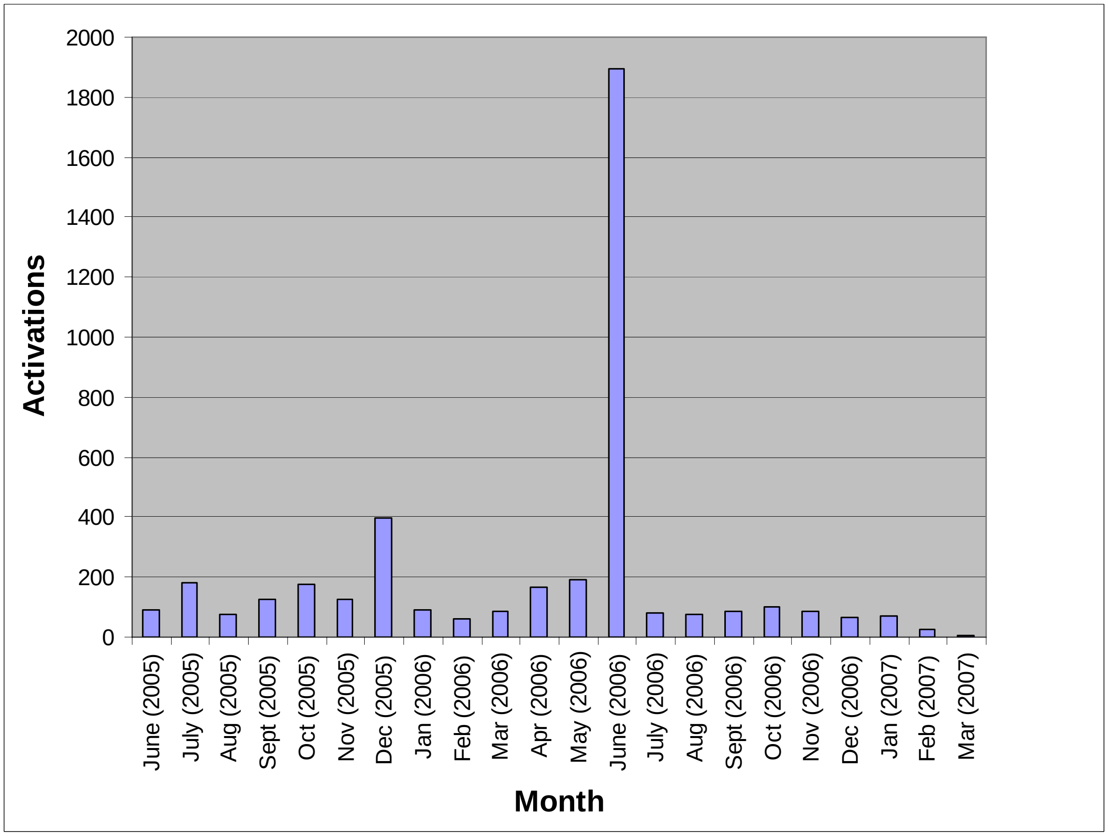

Figure 6.6 - Number of Activations by Month

As can be seen in Figure 6.7, prior to the installation of the software update in late December 2005, there were typically a greater number of smaller activations. In the months prior to the update, activations less than 10 seconds accounted for at least 20 percent of the total in each month. In June, July, October, and December 2005, activations less than 10 seconds accounted for over 50 percnet of the total. Following the December 2005 software update, these figures were much improved and the percentage of activations less than 10 seconds was below 20 percent. The percentage of activations over a minute was in excess of 40 percent for January to March 2006. Once the faulty radar unit was replaced and properly aligned (June 2006), the data settled into a consistent pattern with relatively few short duration activations and proportionately more activations over 60 seconds.

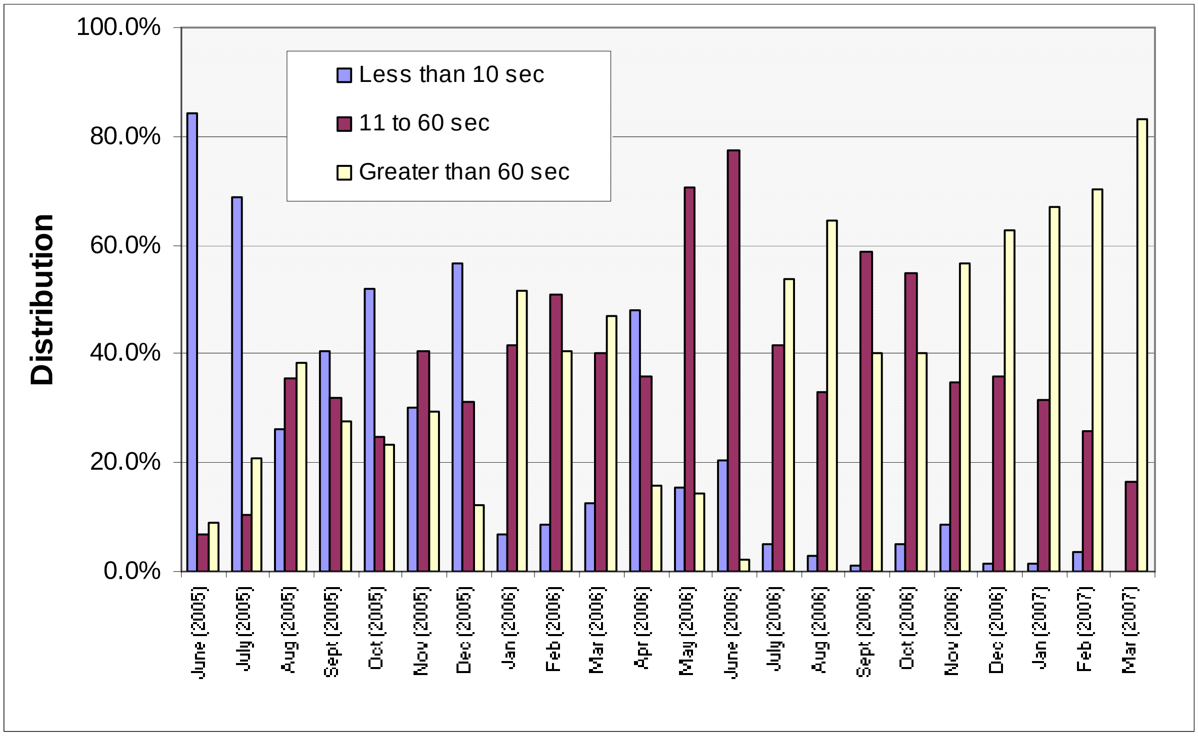

Figure 6.7 - Distribution of Activation Lengths (Seconds) by Month

The data in Figure 6.8 provide a comparison of observed total activation times compared to “estimates” of what would be expected. The expected activation times were determined based on the *Total Activation Time* calculated using Formula 1. Note that these are only estimates because exact train speed is not known (although they consistently operate at 30 mph through this area). Furthermore, total train lengths were estimated based on the known number of cars. An average car length of 60 ft. was used based on NB Southern data; however, car lengths can vary depending on load composition. These expected activation times were estimated because of the difficulties associated with observing high volumes of train approaches at this particular site.

The data in Figure 6.8 show that over 53 percent of actual activation lengths were within 10 percent of those expected based on train length and speed. Over 83 percent of all observations were within a tolerance of ±20 percent. Approximately 8 percent of logged activation times exceeded that which was expected by ±30 percent. A more accurate measure of the system's reliability with respect to activation times is presented in Section 6.4, which describes actual clearance times recorded in the field.

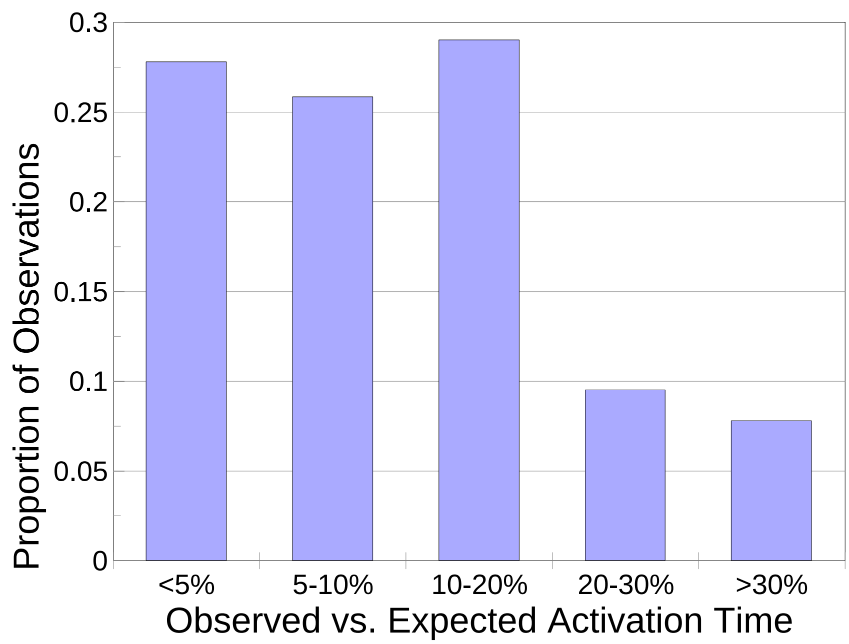

Figure 6.8 - Difference Between Observed & Expected Activation Time Durations

A crosscheck was made between system activations noted on the internal data logger and manually kept schedules of train activity to confirm whether the system was working properly. There were only four months in which any missed activations were noted. The dates and direction in which the missed activation occurred are summarized in Table 6.1.

Table 6.1 - Missed Activations by Month and Direction

Count	Date					
	July (2005)	Aug (2005)	Apr (2006)	May (2006)	Feb (2007)	Mar (2007)
1	19 (W)	4 (E)	13 (W)	1(W)		
2	20 (W)	5 (E)	15 (W)	2 (W)	missing data	missing data
3	21 (W)	6 (E)	17 (W)	3 (W)		
4	22 (W)	10 (E)	20 (W)	4 (W)		
5	23 (W)	11 (E)	19 (W)	5 (W)		
6	24 (W)	12 (E)	20 (W)	6 (W)		
7	29 (E)	14 (E)	21 (W)	8 (W)		
8		15 (E)	22 (W)	9 (W)		
9		16 (E)	24 (W)	10 (W)		
10		17 (E)	25 (W)	11 (W)		
11		17 (E)	26 (W)	13 (W)		
12			27 (W)	17 (W)		
13			28 (W)	18 (W)		
14			30 (W)	19 (W)		
15				20 (W)		
16				22 (W)		
17				25 (W)		
18				26 (W)		
19				27 (W)		
20				29 (W)		
21				30 (W)		

(W) – Westbound; (E) – Eastbound

In the month of July 2005, there were seven missed activations, the majority in the westbound direction. There were 11 missed activations in August 2005, all occurring in the eastbound direction. It was determined that all missed detections were the result of a faulty radar detector and not an issue with the basic system or its settings. After the December 22, 2005, software update, no missed activations were noted until April 13, 2006, indicating the reduction in smaller activations was related to an improvement in the system settings. There were 14 missed activations in April 2006, all occurring in the westbound direction. There were an additional 21 missed activations in May 2006, all occurring in the westbound direction. It was determined that all missed detections were the result of a faulty radar detector and not an issue with the system or its settings.

No missed activations were noted following the replacement of the faulty radar unit on May 31, 2006. Note, however, that the data logger failed from February 12 to March 22, 2007, so data were not available for this time period.

Another concern that arose during testing was that of activation interruptions. Interruptions are of particular concern because it means the LED lights are no longer flashing and therefore not providing any warning of the presence of a train. On a number of occasions, the system would detect a train and would then experience an intermittent interruption in the activation before resuming. These interruptions varied in length and appeared to show no pattern in terms of when they occurred or the direction in which they occurred. The number of interrupted activations is shown in Figure 6.9, while Figure 6.10 shows the average length of interruption by month and train direction.

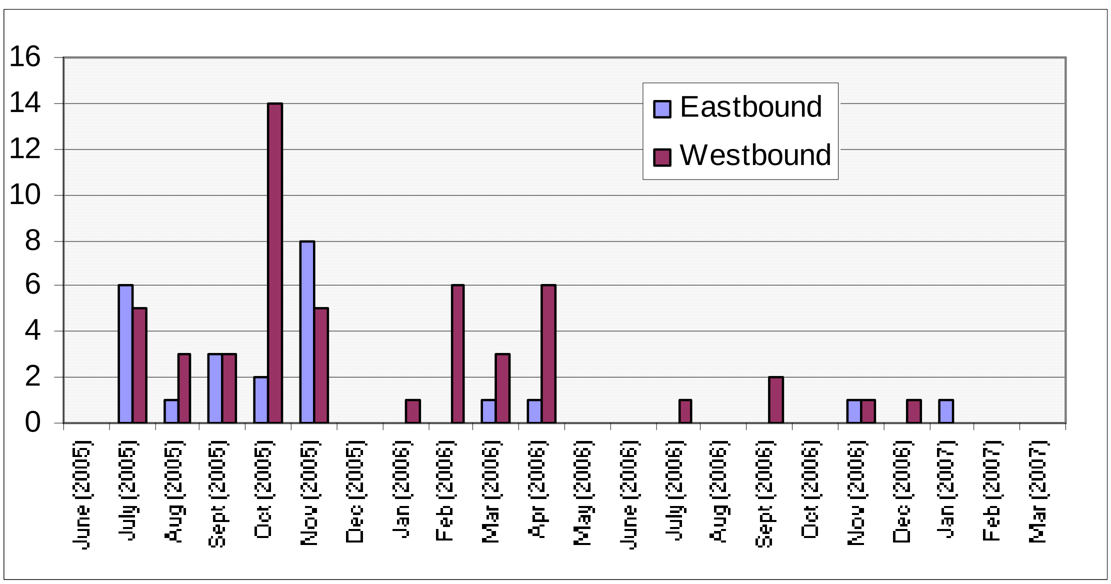

Figure 6.9- Number of Interrupted Activations by Month

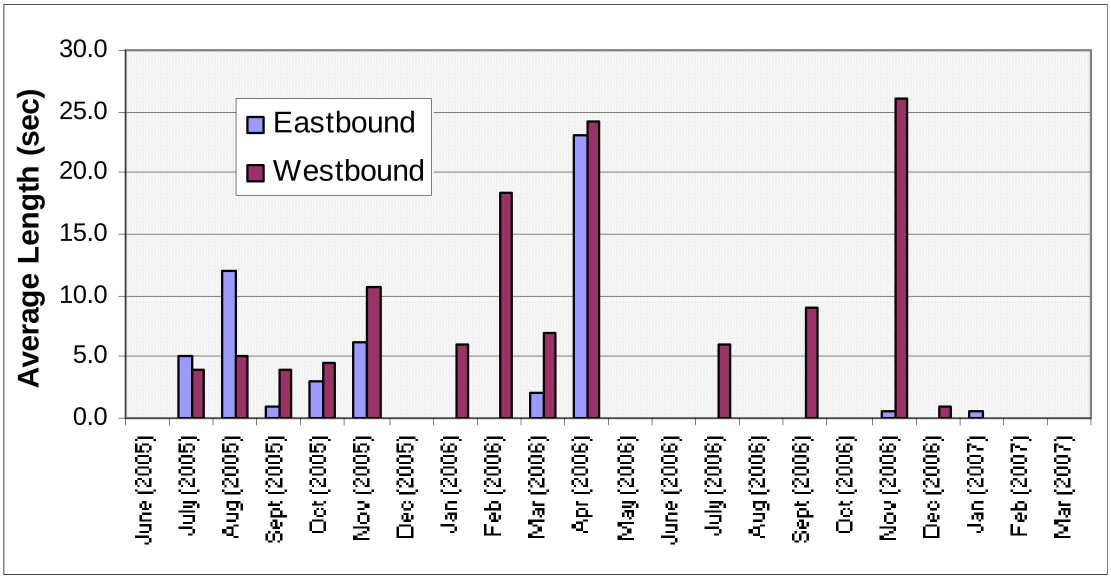

Figure 6.10 - Average Length of Activation Interruption by Month

Initial System Performance

There were 16 interruptions in October 2005 and 13 interruptions in November 2005. These were due mainly to settings that were too insensitive and unable to maintain a connection between the train and radars. The majority of these interruptions occurred in the westbound direction.

System Performance after December 22, 2005, Software Update

As can be seen in Figure 6.8, there were still interruptions following the December 22, 2005, software update, the majority of which occurred in February 2006. To determine if weather was a possible factor in these interruptions, weather logs were examined to see whether any correlation existed. The key months were those following the last software update: January, February, and March 2006, as well as part of April 2006. There were a total of 15 interruptions during this period. The longest average length of interruption, 26 seconds, was also found in April 2006. On six of the days in which an interruption occurred, flurries were noted. There were three days of rain recorded and sunny conditions on the remaining six days. Since some of the interruptions occurred on clear days, it is impossible to say with any certainty that weather was a contributing factor. It is most likely that these interruptions were the result of further setting issues.

System Performance after April 12, 2006, Software Update

As can be seen from Figure 6.8, there were only seven interruptions following the April 12, 2006, software update. To determine if weather was a possible factor in these interruptions, weather logs were examined to see whether any correlation existed. Interestingly, fog was present during five of the seven events. During these foggy conditions, it was raining three times. The weather during the other two events was raining (without fog) and overcast. The weather during the dropped activation in November 2006 that lasted 26 seconds was foggy with drizzle.

6.4 Clearance Times

Clearance times were observed to measure the amount of time that elapsed between the point at which the LED lights began to flash and when the train passed the system. A large sample was difficult to obtain due to the fact that train schedules were not known ahead of time and because trains often left late at night or early in the morning. The test site was nearly an hour's drive from the University of New Brunswick, thereby precluding daily visits. Table 6.2 contains a list of sample clearance times. The desired clearance time is 20 seconds. The radar units are adjusted for a fixed position and do not take into account the speed of the train (although speed is typically constant through this area); consequently, the warning times can vary quite a bit depending on train speed and when the radar first detects it.

The data presented in Table 6.2 summarize the field observations. Actual clearance times were found to average 21.9 seconds and ranged from 18 to 26 seconds. Realigning the radar unit or adjusting the radar sensitivity settings can adjust the actual clearance times the system provides.

Table 6.2 - Sample of Clearance Times

Date	Direction	Clearance Time (seconds)
14-Oct-05	Westbound	25
31-Jan-06	Westbound	24
3-Mar-06	Eastbound	26
10-Mar-06	Eastbound	23
12-Mar-06	Westbound	19
13-Mar-06	Eastbound	18
19-Mar-06	Eastbound	21
26-Jan-07	Eastbound	20
21-Mar-07	Eastbound	21
	average	**21.9**
	standard deviation	**2.8**

6.5 Power Source

The grade crossing warning system's power source is a solar recharging unit with three 80 W solar panels charging two 12 V batteries. It is imperative that batteries be able to keep the system operational under any conditions. If the power source fails, the system has no way of warning motorists of the presence of a train. Furthermore, the solar panels must be capable of keeping the batteries charged, regardless of the draw on them or the prevailing weather conditions.

The batteries were tested periodically to monitor voltage levels. A summary of these measurements is found in Table 6.3. Generally, the power supply operated without issue during the two-year test period. The voltage measurements were made with the system under full activation mode (LED signals activated). The three solar panels provided more than ample charge, especially considering the low train volumes in the area. A two-panel system would probably have worked equally as well. No issues were noted with regard to the power source of this system.

Table 6.3 - Battery Voltage Levels

Date	Battery Level (Volts)
December 21, 2005	14.20
December 31, 2005	14.21
January 9, 2006	12.56
February 6, 2006	13.53
March 6, 2006	13.78
April 10, 2006	13.80
May 8, 2006	13.80
June 14, 2006	14.10
July 18, 2006	14.00
August 9, 2006	13.35
September 12, 2006	13.55
October 10, 2006	13.50
November 8, 2006	12.74
December 4, 2006	12.58
January 8, 2007	12.50
February 7, 2007	14.85
March 13, 2007	13.72
March 27, 2007	14.26

6.6 Train Approaches

Given the difficulties that were initially experienced with system calibration, it was neither possible nor practical in the early stages to undertake some of the more advanced tests (see section 5.3) involving approaching trains accelerating/decelerating and stopping within the detection zones.

Three separate field tests involving hi-rail vehicles were conducted following the final calibration of the system in June 2006. These tests were undertaken to ensure the logic of the system in dealing with slowing or accelerating trains within the detection zones on either side of, and within, the crossing. Once the system was activated, an approaching hi-rail was required to decelerate to a speed below the minimum threshold speed (5 mph). On all occasions, this successfully deactivated the system. If the hi-rail came to a stop or reversed, the system would not activate. If, after slowing, the hi-rail then accelerated up to a speed greater than the minimum threshold, the system reactivated. The hi-rail was also stopped on the crossing to test the functionality of the ultrasonic presence detector. In all instances, the system operated as it should. One issue that was identified was that if the hi-rail dropped below the minimum threshold speed of 5 mph on the approach to the crossing before entering the detection area of the ultrasonic presence detector, the system would not activate while the hi-rail occupied the crossing.

6.7 Other Issues

Besides issues with detection and system calibration, only a couple of other problems were experienced with the system components. Two radar units malfunctioned during the course of the testing program. One was replaced in June 2006, and another unit failed right at the end of the study in March 2007. It is unknown at the time of writing whether the units failed due to a mechanical issue or a software problem. Ontrack also markets a full system with signal units on alternate sides of the crossing (Figure 5.3). Such a configuration would provide redundancy (two radar units) but drive up overall system costs.

Another problem arose with respect to the base holding the pole in place. The aluminum base was attached to a concrete pad with leg bolts and the pole rested within a three-inch sleeve in the base, fixed in place by a pre-cast aluminum collar. On January 19, 2006, a combination of high winds and the large area of solar panel being supported by the pole caused the collar to crack; consequently, the pole leaned heavily to one side. The pole was righted and hose clamps were used to hold the collar in place (Figure 6.11). This same scenario was repeated two or three times in the following week, at which time it was decided that the base was inadequate and needed to be replaced. The over-sized solar panel was a contributing factor in this failure.

On January 31, 2006, a replacement base was installed. The new base, as seen in Figure 6.12, was a much more rigid design that allowed for the insertion of approximately 12 inches of the pole into the base.

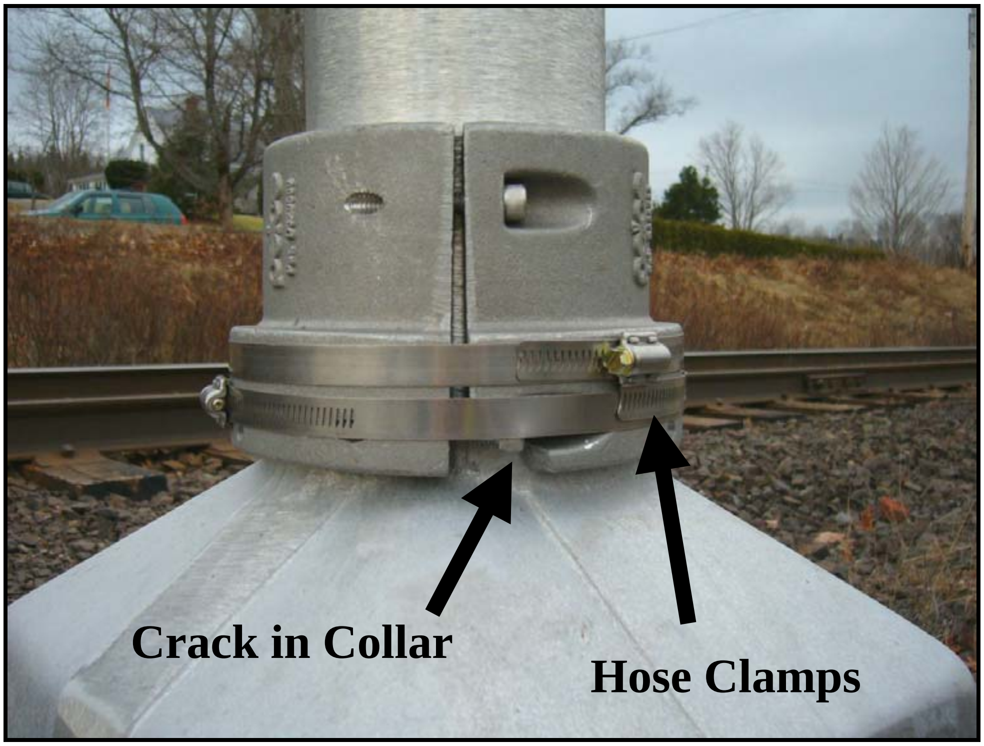

Figure 6.11 - Crack in Collar and Hose Clamps to Secure Base in Place

Figure 6.12 - Replacement Base

Weather is another factor affecting operation of the system. The ability to withstand extreme weather conditions is a good indication of system robustness. This is particularly true during winter months where cold temperatures, snow and freezing rain can create a number of issues.

In comparison to past winters, the first winter of testing (2005/06) was relatively mild. The average temperature from December 2004 to March 2005 was -6.5°C, while the average for the same period in 2005-06 was -3.9°C. Snowfall amounts were lower as well, with a monthly average of 43.6 cm and 25.1 cm for the same periods, respectively.

The winter of 2006-07 was more representative of a typical New Brunswick winter. The average temperature was -6.1°C from December 2006 to March 2007. The average monthly snowfall was 36.8 cm over the same period. The month of February 2007 provided a series of particularly cold nights with lows reaching into the -20s for 12 different days throughout the month. The coldest temperatures were recorded in early March 2007: -26°C for two consecutive nights. Despite these cold temperatures, the power system performed without incident. Unfortunately, as noted in section 6.3, the data logger used to collect information for this study failed during this time period.

The components of the system were not affected in any way by either extreme heat or cold that was experienced during summer and winter months. No issues or failures of any of the components were reported throughout testing.

7.0 CONCLUSIONS

The system tested was a prototype; as a result, a series of adjustments were made to accommodate unexpected operational challenges. Most of the adjustments relate to the radar units' sensitivity, aim and software algorithms that interpret the return radar signature. Initial study results yielded numerous false detections due to settings in the above parameters. The initial field experience lead to a fundamental change in the software designed to interpret the radar readings. This change was made to the system in April 2006 and results were markedly improved following the replacement of a faulty radar unit in June 2006. The system shows potential to meet required objectives, but further, more robust testing is desirable.

In the period from June 2006 to project completion, all train movements through the test site successfully activated the warning system. During the same period, there were seven instances where the system was activated for an oncoming train and the signal was temporarily interrupted for periods typically under six seconds (three were a second or less). It was foggy and or raining for all but one of these interruptions.

Observed clearance times averaged 21.9 seconds (and ranged from 18 to 26 seconds). Clearance interval durations were appropriate, given the approaching train lengths and speeds. Power supply was not an issue and it is felt that the solar supply is over-specified, given the low volume of activations at this site.

The system's logic was shown to handle different scenarios of changes in speed/direction of approaching trains appropriately. One issue identified resulted when an approaching train slowed to a speed below the minimum threshold (5 mph) before entering the detection zone of the presence detector. This deactivated the warning system before the ultrasonic detector had a chance to extend the signal activation if the train stopped at the crossing.

8.0 RECOMMENDATIONS

From the time the system was properly calibrated and adjusted in June 2006, test results have indicated that the system performance holds much promise. Although a few minor glitches have arisen in the interim, the positive performance to date warrants a wider-scale series of more robust testing. Multiple units should be installed at various sites and monitored for a period of at least one year. Longer-term testing should alleviate any concerns over the durability of radar units. Sites selected should have much higher train volumes and be more readily accessible than the current site.

Future versions of this system should incorporate the following features:

- Adjustment of clearance times to reflect approaching train speeds
- Ability to adjust software settings within the radar units from the cabinet (rather than having to remove the radar units)
- Consideration of a dual-unit system to provide fail-safe features
- Draw upon solar experience of western Canada’s rail industry:
    - size solar capacity
    - cover solar panels with lexan to mitigate vandalism concerns
    - use black coloured frame to enhance melting of snow/ice

Future testing of this system should incorporate variations in train approaches (acceleration, deceleration, and stopping within the detection zones) to ensure operating characteristics meet requirements.

A final issue exists regarding the detection of hi-rail vehicles. Since the system tested was calibrated to recognize the radar signature of a train, system activation was inconsistent when hi-rail vehicles approached the crossing. The system will need to be further refined to either eliminate or include system activation for an approaching hi-rail vehicle.

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APPENDIX A – *Detailed System Requirements for C3 Trans System*

Low-Cost Highway-Rail Intersection Active Warning System Field Operational Test

Evaluation Report

Prepared for:

MINNESOTA DEPARTMENT OF TRANSPORTATION

Minnesota Guidestar

December 2005

5. EVALUATION METHODOLOGY

This section presents the approach to evaluating the Low-Cost HRI Active Warning System Project, including the specific measures of effectiveness (MOEs), data, and analyses that were employed. This section also describes how this project and its evaluation goals and objectives relate to the goals and MOEs that have been established by the U.S. DOT for advanced technology projects.

5.1 Evaluation Goals and Objectives

5.1.1 National ITS Goals and Measures

The U.S. DOT has identified a set of goals and associated measures of effectiveness for use in evaluating advanced technology, or ITS projects. The U.S. DOT recommends that these goals and measures be considered for use in all ITS evaluations, and that evaluators "relate the purpose of the project to the overall ITS goal areas." (ITS Evaluation Resource Guide, USDOT)

Table 5-1 presents the National ITS goal areas and the associated MOEs, or "few good measures." The shaded portions of the table indicate the goals and MOEs that are relevant to the Low-Cost HRI Active Warning System Project. It is intended that relative to existing passive signage and pavement markings at the six operational test sites, the low-cost HRI active warning system will improve safety (although not necessarily demonstrably during the FOT due to short time period and low volumes and crash rates) and elicit positive responses from travelers, indicating a perceived improvement in mobility. It is also intended that the low-cost system be more cost-effective than the traditional, higher cost active warning systems.

5.1.2 Evaluation Goals and Objectives

As indicated in the overall project mission statement presented in Section 1.1, the purpose of the Low-Cost HRI Active Warning Project, and therefore the evaluation effort as well, is to determine whether the system can perform as well or better at low-volume crossings than the more costly traditional active warning systems. To the extent that the low-cost system is found lacking, the evaluation must provide information that will support future refinement of the system.

The determination of whether the low-cost HRI active warning system will "perform as well as" traditional systems will require documentation and comparison of both types of systems in terms of their ability to function as intended (i.e., performance), impacts on travelers, costs and "deployability". The evaluation goals and objectives that have been identified by the project participants are organized around these determinations and are presented in Table 5-2.

Table 5-1. National ITS Program Goal Areas and ITS Evaluation Measures

(shaded) = Intended impact of low-cost HRI active warning system

National ITS Goal Area	Measures of Effectiveness (Few Good Measures)
Safety	Reduction in overall crash rate
	Reduction in the rate of crashes resulting in fatalities
	Reduction in the rate of crashes resulting in injuries
	Improvement in surrogate measures
Mobility	Reduction in travel time delay
	Reduction in travel time variability
	Improvement in surrogate measures
Efficiency	Increase in throughput or effective capacity
Customer Satisfaction	Difference between users' expectations and experience in relation to a service or product: −Product awareness −Expectations of product benefits −Product use −Response – decision-making and/or behavior change −Realization of benefits −Assessment of value
Productivity	Cost savings
Energy and Environment	Reduction in emissions
	Reduction in fuel consumption

Table 5-2. Evaluation Goals and Objectives

Goal	Objective
1. Assess system performance	Assess system capabilities Assess system reliability Assess system maintainability Assess system integratability Assess system usability Assess system transferability Assess system national compatibility
2. Assess system impacts	Assess safety impacts Assess motorist perception Assess locomotive engineer perception Assess TC&W management perception Assess local transportation agency perception
3. Document system costs	Document system costs Document personnel training costs Document participant contributions Determine expansion costs Determine cost-effectiveness Determine maintenance costs
4. Identify deployment issues	Identify technical deployment issues Identify institutional deployment issues

5.2 Data Collection and Validation

5.2.1 System Data Collection

The majority of the data used to assess system performance was collected by the computers installed on the locomotives and transmitted via cellular telephone directly to the Evaluator on a daily basis. Each locomotive moving through the system records all communications with each crossing it encounters. The collected data indicates the time, date, location in latitude/longitude of the crossing, computed distance from locomotive to crossing, estimated locomotive time of arrival, status of GPS information, status of radio communications, status of the crossing (i.e. activated or not), status of the advanced warning flashers, status of the batteries, status of the magnetometers, status of the ultrasonic sensors, and number of times the crossing entered a fail-safe state. This data is captured and logged every 2 seconds. The locomotive logs up to 43,200 records each 24-hour period. A sample of the logged data is shown in Table 5-3.

5.2.2 Field Observations and Data Verification

Data verification and validation was conducted during the 10-intersection shadow mode test in spring 2003 as well as during the one-day filed test in July 2004. Independent field observations and data collection at selected crossings were conducted to verify the accuracy of the system data that was collected from computers that were installed on the locomotives. Field observations were recorded from the cabins of instrumented locomotives using a handheld GPS device and an antenna temporarily mounted to the front of the locomotive. The crossing times recorded in the field with the handheld GPS device were compared with the crossing times reported by the system.

In addition, system data were compared to the TC&W Standard Train Delay Reports (STDR). The STDRs recorded the movement of a train based on their stops and places where unusual delays occurred. The movements of the locomotives described in the STDRs were compared to the GPS latitude/longitude coordinates obtained from the system data. Using a mapping tool, the appropriate latitude/longitude coordinates from the system data were mapped to locations identified in the STDRs to determine the similarities between where the locomotive engineer reported stopping and the actual location of the train as recorded by the system.

Based on the above analyses, it was confirmed that the on-board computers accurately recorded train movements and, without fail, transmitted the data to the Evaluator on a daily basis.

Table 5-3. Sample Locomotive Log Data

Date	7/2/2005	7/2/2005	7/2/2005	7/2/2005
Time	7:51:24	7:51:26	7:51:28	7:51:30
Xing Latitude	44.727373	44.727373	44.727373	44.727373
Xing Longitude	-94.396417	-94.396417	-94.396417	-94.396417
Comm Data Quality	240	235	240	240
Zone ID	4	4	4	4
Xing Index	9	9	9	9
Xing Name	Tagus	Tagus	Tagus	Tagus
Distance to Xing	650	626	602	579
Xing Time of Arrival	54	52	51	49
Xing Status	tracking	tracking	armed_on_approach	armed_on_approach
Failsafe Count	0	0	0	0
Activation Count	5	5	5	5
On Time Delay	20	18	16	15
Slave Status	SP	SP	SP	SP
Advance 1 Status	A1P	A1P	A1P	A1P
Advance 2 Status	A2P	A2P	A2P	A2P
Island Magnetometer Status	off	off	off	off
Master Magnetometer Status	off	off	off	off
Slave Magnetometer Status	off	off	off	off
Master Sonic Sensor Status	Ok	Ok	Ok	Ok
Slave Sonic Sensor Status	Ok	Ok	Ok	Ok
Master Battery Status	Nom	Nom	Nom	Nom
Slave Battery Status	Nom	Nom	Nom	Nom
A1 Battery Status	Nom	Nom	Nom	Nom
A2 Battery Status	Nom	Nom	Nom	Nom
Master Charger Status	Ok	Ok	Ok	Ok
Slave Charger Status	Ok	Ok	Ok	Ok
A1 Charger Status	Ok	Ok	Ok	Ok
A2 Charger Status	Ok	Ok	Ok	Ok
Master Flasher Status	Ok	Ok	Ok	Ok
Slave Flasher Status	Ok	Ok	Ok	Ok
A1 Flasher Status	Ok	Ok	Ok	Ok
A2 Flasher Status	Ok	Ok	Ok	Ok
Master GPS Status	Lock	Lock	Lock	Lock
Slave GPS Status	Lock	Lock	Lock	Lock
A1 GPS Status	Lock	Lock	Lock	Lock
A2 GPS Status	Lock	Lock	Lock	Lock
Master GPS Solution Quality	Good	Good	Good	Good
Slave GPS Solution Quality	Good	Good	Good	Good
A1 GPS Solution Quality	Good	Good	Good	Good
A2 GPS Solution Quality	Good	Good	Good	Good
XDelta	7	6	6	6
Locomotive Pack Status	Solo	Solo	Solo	Solo

5.2.3 Interviews

Interviews were conducted to gather additional information for the evaluation of system impacts, costs, and institutional and deployment challenges. Interviews were conducted with individuals involved in the project after the completion of the FOT. The goal of the interviews was to gather input from key stakeholders on their perceptions of the effectiveness of the project and of the technical and institutional challenges that were experienced. Individuals from Mn/DOT, C3 Trans Systems, TC&W, SRF Consulting Group, Inc., FHWA, and FRA were interviewed either in person or by telephone during October and November 2005. Interviews with residents living near the crossings were also conducted to assess public perceptions and reactions to the system. Interview questionnaires were developed for each of the stakeholder groups and were reviewed by Mn/DOT prior to the interviews.

The interview questionnaires were designed to gather the following perceptions from the project stakeholders:

- Overall project success and effectiveness, including:
    - Overall success
    - Satisfaction with the system performance
    - Impact of the system on safety
    - Value of further deployment
    - Level of effort required for further deployment
    - Benefits
    - Costs
    - Strengths and weaknesses of the system
- Technical and institutional challenges
    - Integration with roadside environment
    - Deployment on the locomotives
    - Hardware and software development
    - Testing and calibration
    - Operations and maintenance
    - Training
    - Maintaining project schedule and milestones
    - Level of stakeholder involvement and contributions
    - Stakeholder coordination
    - Other issues and challenges

5.3 Methodology

For the evaluation of the system performance, an “encounter” was defined as the train moving continuously toward a crossing, beginning at 2000 meters from the crossing and ending as the locomotive enters the crossing.

The primary focus of system capability evaluation was to verify that the active warning system performed without any system failures and provided adequate active-warning times before a train entered the highway-rail island. The system data were analyzed to determine the occurrence and frequency of communication failures. The MOEs were the ability for the system to meet both the technical and functional requirements of the system as well as FRA requirements. It was required that the system would provide warning times of at least 20 seconds before the train enters the island. It was also expected that the crossing status would be displayed correctly on the in-locomotive indicator panel.

The assessment of the overall system reliability measured the frequency of communication losses/failures, roadside equipment failures, in-locomotive indicator failures, false activations, activation failures, and fail-safe conditions. System performance measurements included metrics such as mean time between failures (MTBF) and mean outage time (MOT). The MOEs were the type, severity, and frequency of communication losses, system failures, roadside equipment failures, in-locomotive system failures, false activations, and activation failures. It was expected that the system would perform reliably, performing without any system failures, during the duration of the FOT period.

Methodologies for evaluating the system capability and reliability are described in the following:

Calculated and verified that activation times meet FRA/System requirements

1. Activation Time - the duration of time the two main, crossbuck-mounted flashers were active before the train arrived in the island.
2. Computed individual activation times for each train encounter recorded in system data

Calculated and verified that advanced warning activation times met System requirements

1. Advanced Warning Activation Time - the duration of time the advanced warning flashers were active before the train arrived in the island.
2. Computed individual advanced warning activation times for each train encounter recorded in system data

Train to Crossing Communication Failures

1. Detected locomotive to crossing communication failures by analyzing Crossing Status data field during encounters
2. Reported failures by type, severity, and frequency of occurrence
3. Examined individual encounters to verify that data transmitted by the crossing to the locomotive showed successful communication
4. Crossing Status:
   - Looked at the progression of crossing status from tracking, armed, active on approach, active on departure, and deactivated
   - Verified correct progression took place during encounters
5. Documented any system failures caused by an inability of a locomotive to successfully communicate to a crossing device

Communication between Crossing Equipment

1. Detected communication failures between crossing equipment by analyzing recorded system data on the following components:
   - Advanced Warning Status – reported whether the master crossbuck designates the equipment as present, missing, or failed

- Slave Status – reported the status of the slave crossbuck as present, missing, or failed

2. Investigated the Failsafe Counter to determine the number of times the device switched to failsafe mode due to a communication problem.

Fault Notification Failures

1. Examined fault notifications to document occurrences of problems in:
   - Communications Error
   - Crossing Status
   - Device Status
   - Failsafe Activation
2. Analyzed notifications by day and by individual crossing

Roadside Equipment Failures

1. Analyzed Battery Status – examined condition of the batteries for the main flashers and advanced warning flashers.
2. Determined if any change in Battery Status caused any system performance or reliability issues.
3. Analyzed Crossing and Advanced Warning Status – examined reported condition of both advanced warning flashers and slave crossbuck to see if device was reported as present, missing, or failed.
4. Reported percentage each condition was recorded and highlighted any performance or reliability issues.

Magnetometer Equipment Failure

1. Examined the system data to determine when the magnetometer had a “false on” when no train was present at the crossing
2. Verified that the magnetometer status changed to off after the entire train had cleared the island
3. For occurrences of magnetometer errors, investigated and determined the potential causes of the incorrect reading
4. Documented the frequency of magnetometer errors

Sonic Sensor Equipment Failure

1. Examined the system data to determine when the ultrasonic sensor had a “false on” when no train was present at the crossing
2. Verified that the ultrasonic sensor status changed to off after the entire train had cleared the island
3. For occurrences of ultrasonic sensor errors, investigated to determine the potential cause of the incorrect reading
4. Documented the frequency of ultrasonic sensor errors

In-Locomotive System Failures

1. Obtained failure reports of the in-locomotive device that were recorded by TC&W locomotive engineers
2. Documented any occurrence of failures recorded by locomotive engineers
3. Documented corrective action taken

Non-Locomotive Activations

1. Examined crossing status counts in the recorded data
2. Found non-sequential jumps in the crossing activation counts. These jumps mean that sometime between successive trains, the crossing was activated either falsely or by high rail or maintenance equipment.
3. Correlated the occurrence of non-locomotive activations with TC&W work orders for high-rail and maintenance equipment movements.
4. Documented the frequency and occurrence of such events.

Activation Failures

1. Any critical failure at the crossing that led to an activation failure would be immediately reported to the crew on the in-locomotive device as a problem with the crossing. Activation failures require a credible witness to report that the system did not activate flashers. However, it was difficult to observe activation failures of the 21 crossings operated in shadow mode. The flashers at those crossings were not visible during the FOT duration, making it impossible to have a credible witness report seeing an activation failure.
2. To address this issue, the following analyses were performed:
   - Compared train delay reports with data generated by locomotive. Train movements recorded in the train report without corresponding recorded system activations would be considered activation failures
   - Documented and investigated any reports of activation failures by analyzing recorded system data during the reported time of the failure.

APPENDIX B – *Requirement Description for Supplier*

The University of New Brunswick has partnered with Transport Canada and the New Brunswick Department of Transportation to establish a research program for testing intelligent transportation system (ITS) products in rural environments. Researchers in the University's Transportation Group are currently seeking ITS technology that could be used to improve rail safety in two areas: 1) highway-rail intersections and 2) switch positions. At least one ITS product will be selected for each problem area by January 31, 2005 and then tested over the following 12-month period. Successful suppliers are expected to provide input to the research effort.

Potential products must be suitable for the Canadian environment and cost less than traditional systems in use today while providing equal or greater safety benefits. Further details on the product requirements are provided below for each problem area. For more information, please contact Dr. Eric Hildebrand, Transportation Group Coordinator at the UNB Department of Civil Engineering.

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Highway Rail Intersections

A low-cost ITS-based warning system is being sought for intersections between railways and private roads and farm crossings. Typically, these crossings are equipped only with warning signs. Potential warning systems should cost much less than the $100,000 required for existing warning systems, operate independently of train and rail company equipment, have a stand-alone power supply, and have a failure reporting feature.

Switch Position Indicator

Researchers also want to test an ITS-based product that would give train crews advance warning of the position of hand-operated switches along non-signalled sections of track. Potential systems should be relatively low-cost, have a stand-alone power supply, and have a failure-reporting feature.

APPENDIX C – *Sample of Activation Logs*

JULY (2006)

Date Time	State	Activation Time	Notes	# of Cars
07/01/2006 14:08:52	on	00:01:28	Train from McAdam (Dep @ 11:15)	58
07/01/2006 14:10:20	off			
07/01/2006 19:03:49	on	00:00:31	Train from SJ (Dep @ 15:40)	4
07/01/2006 19:04:20	off			
07/02/2006 20:33:33	on	00:01:51	Train from SJ (Dep @ 19:35)	68
07/02/2006 20:35:24	off			
07/03/2006 16:47:17	on	00:01:16	Train from McAdam (Dep @ 13:35)	52
07/03/2006 16:48:32	off			
07/03/2006 21:37:09	on	00:01:04	Train from SJ (Dep @ 20:10)	42
07/03/2006 21:38:13	off			
07/04/2006 6:26:59	on	00:00:12	HI RAIL	N/A
07/04/2006 6:27:11	off			
07/04/2006 16:27:35	on	00:01:24	Train from McAdam (Dep @ 13:00)	54
07/04/2006 16:28:59	off			
07/04/2006 20:10:36	on	00:01:40	Train from SJ (Dep @ 18:45)	59
07/04/2006 20:12:16	off			
07/05/2006 10:12:38	on	00:00:18	HI RAIL	N/A
07/05/2006 10:12:57	off			
07/05/2006 10:44:49	on	00:00:33	HI RAIL	N/A
07/05/2006 10:45:22	off			
07/05/2006 20:34:59	on	00:00:34	Train from SJ (Dep @ 19:05)	21
07/05/2006 20:35:33	off			
07/06/2006 3:07:38	on	00:00:30	Train from McAdam (Dep @ 00:01)	5
07/06/2006 3:08:08	off			
07/06/2006 21:01:37	on	00:01:53	Train from SJ (Dep @ 19:30)	69
07/06/2006 21:03:30	off			
07/07/2006 20:09:50	on	00:03:05	Train from McAdam (Dep @ 16:50)	114
07/07/2006 20:12:55	off			
07/07/2006 23:18:15	on	00:01:09	Train from SJ (Dep @ 21:55)	69
07/07/2006 23:19:25	off			
07/08/2006 16:33:15	on	00:01:32	Train from McAdam (Dep @ 13:25)	55
07/08/2006 16:34:48	off			
07/08/2006 16:50:08	on	00:00:10	HI RAIL	N/A
07/08/2006 16:50:18	off			
07/09/2006 21:26:32	on	00:01:10	Train from SJ (Dep @ 20:05)	50
07/09/2006 21:27:42	off			
07/10/2006 13:02:31	on	00:00:32	HI RAIL	N/A
07/10/2006 13:03:02	off			
07/10/2006 17:29:06	on	00:01:31	Train from McAdam (Dep @ 14:27)	44
07/10/2006 17:30:37	off			
07/11/2006 1:50:35	on	00:01:41	Train from SJ (Dep @ 00:25)	46
07/11/2006 1:52:17	off			
07/11/2006 8:22:46	on	00:00:11	HI RAIL Dropped signal for 13 seconds	N/A
07/11/2006 8:22:57	off			
07/11/2006 8:23:10	on	00:00:10		
07/11/2006 8:23:20	off			
07/11/2006 11:51:05	on	00:00:32	HI RAIL	N/A
07/11/2006 11:51:37	off			
07/11/2006 11:52:30	on	00:00:49	HI RAIL	N/A
07/11/2006 11:53:18	off			
07/11/2006 23:37:31	on	00:02:23	Train from McAdam (Dep @ 20:15)	83
07/11/2006 23:39:54	off			
07/12/2006 4:34:59	on	00:01:25	Train from SJ (Dep @ 03:10) Dropped signal for 6 seconds	61
07/12/2006 4:36:24	off			
07/12/2006 4:36:30	on	00:00:17		
07/12/2006 4:36:46	off			
07/12/2006 12:28:56	on	00:00:37	HI RAIL	N/A
07/12/2006 12:29:33	off			
07/12/2006 15:54:06	on	00:00:09	HI RAIL	N/A
07/12/2006 15:54:15	off			
07/12/2006 19:41:03	on	00:01:02	Train from McAdam (Dep @ 16:50)	31
07/12/2006 19:42:05	off			
07/13/2006 0:21:54	on	00:02:03	Train from SJ (Dep @ 22:20)	59
07/13/2006 0:23:56	off			
07/13/2006 8:56:16	on	00:00:13	HI RAIL	N/A
07/13/2006 8:56:29	off			
07/13/2006 10:26:57	on	00:00:40	HI RAIL	N/A
07/13/2006 10:27:37	off			
07/13/2006 15:57:13	on	00:01:07	Train from McAdam (Dep @ 12:50)	42
07/13/2006 15:58:20	off			
07/13/2006 22:20:47	on	00:02:12	Train from SJ (Dep @ 21:00)	
07/13/2006 22:23:00	off			
07/14/2006 12:53:42	on	00:00:35	HI RAIL	N/A
07/14/2006 12:54:17	off			
07/14/2006 17:02:08	on	00:01:14	Train from McAdam (Dep @ 14:05)	55
07/14/2006 17:03:22	off			

07/14/2006 20:13:16	on	00:01:38	Train from SJ (Dep @ 18:50)	41
07/14/2006 20:14:54	off			
07/15/2006 12:24:48	on	00:00:53	Train from McAdam (Dep @ 09:15)	
07/15/2006 12:25:41	off			
07/16/2006 21:49:11	on	00:01:11	Train from SJ (Dep @ 20:25)	37
07/16/2006 21:50:23	off			
07/17/2006 13:33:26	on	00:00:29	HI RAIL	N/A
07/17/2006 13:33:55	off			
07/17/2006 16:36:18	on	00:01:33	Train from McAdam (Dep @ 13:30)	61
07/17/2006 16:37:51	off			
07/17/2006 20:33:28	on	00:01:09	Train from SJ (Dep @ 19:10)	
07/17/2006 20:34:37	off			
07/18/2006 14:53:02	on	00:01:54	HI RAIL	N/A
07/18/2006 14:54:55	off			
07/18/2006 19:32:34	on	00:01:34	Train from McAdam (Dep @ 14:35)	59
07/18/2006 19:34:08	off			
07/18/2006 22:43:54	on	00:01:55	Train from SJ (Dep @ 21:20)	74
07/18/2006 22:45:48	off			
07/19/2006 14:10:16	on	00:00:38	HI RAIL	N/A
07/19/2006 14:10:54	off			
07/19/2006 15:21:15	on	00:00:40	HI RAIL	N/A
07/19/2006 15:21:54	off			
07/19/2006 15:34:10	on	00:00:52	Train from McAdam (Dep @ 11:45)	32
07/19/2006 15:35:02	off			
07/19/2006 20:46:16	on	00:01:20	Train from SJ (Dep @ 19:20)	48
07/19/2006 20:47:36	off			
07/20/2006 17:27:06	on	00:01:35	Train from McAdam (Dep @ 14:25)	53
07/20/2006 17:28:41	off			
07/20/2006 22:29:42	on	00:00:58	Train from SJ (Dep @ 21:10)	30
07/20/2006 22:30:40	off			
07/21/2006 10:24:45	on	00:00:10	HI RAIL	N/A
07/21/2006 10:24:55	off			
07/21/2006 13:16:31	on	00:00:27	HI RAIL	N/A
07/21/2006 13:16:59	off			
07/21/2006 17:28:46	on	00:01:24	Train from McAdam (Dep @ 14:30)	57
07/21/2006 17:30:11	off			
07/22/2006 1:20:44	on	00:01:39	Train from SJ (Dep @ 23:59)	58
07/22/2006 1:22:23	off			
07/22/2006 17:55:50	on	00:00:30	Train from McAdam (Dep @ 14:50)	8
07/22/2006 17:56:20	off			
07/23/2006 10:26:11	on	00:00:14	HI RAIL	N/A
07/23/2006 10:26:25	off			
07/23/2006 20:53:13	on	00:01:26	Train from SJ (Dep @ 19:30)	55
07/23/2006 20:54:39	off			
07/24/2006 11:06:22	on	00:00:20	HI RAIL	N/A
07/24/2006 11:06:42	off			
07/24/2006 11:43:58	on	00:00:15	HI RAIL	N/A
07/24/2006 11:44:13	off			
07/24/2006 16:20:08	on	00:01:11	Train from McAdam (Dep @ 13:20)	46
07/24/2006 16:21:19	off			
07/24/2006 21:02:22	on	00:01:07	Train from SJ (Dep @ 19:40)	39
07/24/2006 21:03:28	off			
07/25/2006 17:46:41	on	00:01:59	Train from McAdam (Dep @ 14:40)	74
07/25/2006 17:48:40	off			
07/25/2006 21:07:11	on	00:01:26	Train from SJ (Dep @ 19:40)	52
07/25/2006 21:08:37	off			
07/26/2006 10:58:53	on	00:00:43	HI RAIL	N/A
07/26/2006 10:59:36	off			
07/26/2006 13:39:21	on	00:00:19	HI RAIL	N/A
07/26/2006 13:39:41	off			
07/26/2006 16:30:19	on	00:01:40	Train from McAdam (Dep @ 13:30)	70
07/26/2006 16:31:58	off			
07/26/2006 21:26:05	on	00:01:15	Train from SJ (Dep @ 20:00)	47
07/26/2006 21:27:20	off			
07/27/2006 15:38:17	on	00:01:02	Train from McAdam (Dep @ 12:30)	29
07/27/2006 15:39:19	off			
07/27/2006 20:58:50	on	00:01:08	Train from SJ (Dep @ 19:35)	47
07/27/2006 20:59:58	off			
07/28/2006 11:49:20	on	00:00:02	HI RAIL (dropped signal for 5 seconds)	N/A
07/28/2006 11:49:22	off			
07/28/2006 11:49:27	on	00:00:10		
07/28/2006 11:49:38	off			
07/28/2006 17:10:34	on	00:00:45	Train from McAdam (Dep @ 14:20)	25
07/28/2006 17:11:19	off			
07/28/2006 21:23:53	on	00:01:38	Train from SJ (Dep @ 20:00)	54
07/28/2006 21:25:31	off			
07/29/2006 9:05:42	on	00:00:14	HI RAIL	N/A
07/29/2006 9:05:56	off			
07/29/2006 15:22:25	on	00:00:49	Train from McAdam (Dep @ 12:23)	22

07/29/2006 15:23:14	off	00:00:49	Train from McAdam (Dep @ 12:25)	22
07/31/2006 0:17:50	on	00:01:40	Train from SJ (Dep @ 22:45)	59
07/31/2006 0:19:30	off			
07/31/2006 10:12:30	on	00:00:21	HI RAIL	N/A
07/31/2006 10:12:52	off			
07/31/2006 18:25:44	on	00:01:55	Train from McAdam (Dep @ 15:20)	76
07/31/2006 18:27:39	off			
07/31/2006 22:49:47	on	00:01:16	Train from SJ (Dep @ 21:25)	44
07/31/2006 22:51:03	off			

AUGUST (2006)

Date Time	State	Activation Time	Notes	# of Cars
08/01/2006 17:20:16	on	00:01:28	Train from McAdam (Dep @ 14:20)	47
08/01/2006 17:21:44	off			
08/01/2006 23:21:24	on	00:01:23	Train from SJ (Dep @ 21:55)	14
08/01/2006 23:22:47	off			
08/02/2006 18:06:14	on	00:01:24	Train from McAdam (Dep @ 15:10)	62
08/02/2006 18:07:39	off			
08/02/2006 23:04:17	on	00:01:37	Train from SJ (Dep @ 21:40)	58
08/02/2006 23:05:53	off			
08/03/2006 14:36:58	on	00:00:51	Train from McAdam (Dep @ 11:40)	27
08/03/2006 14:37:49	off			
08/03/2006 23:00:18	on	00:01:06	Train from SJ (Dep @ 21:40)	55
08/03/2006 23:01:24	off			
08/04/2006 16:18:13	on	00:00:50	Train from McAdam (Dep @ 13:30)	23
08/04/2006 16:19:02	off			
08/04/2006 21:46:49	on	00:01:12	Train from SJ (Dep @ 20:25)	61
08/04/2006 21:48:02	off			
08/05/2006 16:18:57	on	00:01:23	Train from McAdam (Dep @ 13:20)	53
08/05/2006 16:20:20	off			
08/06/2006 23:13:15	on	00:02:03	Train from SJ (Dep @ 21:45)	74
08/06/2006 23:15:18	off			
08/07/2006 9:51:53	on	00:00:25	HI RAIL	N/A
08/07/2006 9:52:18	off			
08/07/2006 17:34:15	on	00:01:42	Train from McAdam (Dep @ 14:30)	68
08/07/2006 17:35:58	off			
08/07/2006 21:25:07	on	00:01:11	Train from SJ (Dep @ 20:00)	44
08/07/2006 21:26:19	off			
08/08/2006 15:24:46	on	00:01:35	Train from McAdam (Dep @ 12:25)	69
08/08/2006 15:26:21	off			
08/08/2006 20:47:08	on	00:00:59	Train from SJ (Dep @ 19:25)	29
08/08/2006 20:48:07	off			
08/09/2006 7:19:51	on	00:00:11	HI RAIL	N/A
08/09/2006 7:20:02	off			
08/09/2006 11:03:41	on	00:02:12	HI RAIL	N/A
08/09/2006 11:05:53	off			
08/09/2006 17:13:21	on	00:00:58	Train from McAdam (Dep @ 14:15)	40
08/09/2006 17:14:19	off			
08/09/2006 20:52:34	on	00:01:28	Train from SJ (Dep @ 19:25)	51
08/09/2006 20:54:02	off			
08/10/2006 16:48:00	on	00:00:56	Train from McAdam (Dep @ 13:55)	30
08/10/2006 16:48:56	off			
08/10/2006 23:14:36	on	00:01:34	Train from SJ (Dep @ 21:45)	56
08/10/2006 23:16:10	off			
08/11/2006 16:41:55	on	00:01:01	Train from McAdam (Dep @ 13:45)	40
08/11/2006 16:42:56	off			
08/11/2006 20:58:26	on	00:00:44	Train from SJ (Dep @ 19:35)	49
08/11/2006 20:59:09	off			
08/12/2006 16:48:53	on	00:01:10	Train from McAdam (Dep @ 14:00)	46
08/12/2006 16:50:04	off			
08/13/2006 20:30:48	on	00:01:21	Train from SJ (Dep @ 19:05)	44
08/13/2006 20:32:10	off			
08/14/2006 14:22:43	on	00:00:06	HI RAIL	N/A
08/14/2006 14:22:49	off			
08/14/2006 18:40:05	on	00:01:04	Train from McAdam (Dep @ 15:40)	49
08/14/2006 18:41:09	off			
08/14/2006 22:21:40	on	00:01:06	Train from SJ (Dep @ 20:55)	44
08/14/2006 22:22:46	off			
08/15/2006 10:34:25	on	00:01:04	HI RAIL	N/A
08/15/2006 10:35:29	off			
08/15/2006 14:09:30	on	00:00:50	HI RAIL	N/A
08/15/2006 14:10:20	off			
08/15/2006 15:51:38	on	00:01:13	Train from McAdam (Dep @ 12:45)	58
08/15/2006 15:52:52	off			
08/15/2006 20:30:23	on	00:01:18	Train from SJ (Dep @ 19:10)	46
08/15/2006 20:31:41	off			
08/16/2006 9:20:12	on	00:00:35	HI RAIL	N/A
08/16/2006 9:20:47	off			

08/16/2006 11:34:24	on	00:00:42	HI RAIL	N/A
08/16/2006 11:35:06	off			
08/16/2006 18:09:56	on	00:00:51	Train from McAdam (Dep @ 15:10)	30
08/16/2006 18:10:46	off			
08/16/2006 23:24:06	on	00:01:34	Train from SJ (Dep @ 22:00)	61
08/16/2006 23:25:39	off			
08/17/2006 7:48:54	on	00:00:39	HI RAIL	N/A
08/17/2006 7:49:33	off			
08/17/2006 11:04:43	on	00:01:06	HI RAIL	N/A
08/17/2006 11:05:49	off			
08/17/2006 11:49:31	on	00:00:26	HI RAIL	N/A
08/17/2006 11:49:57	off			
08/17/06 13:50:10.0	on	00:00:38	HI RAIL	N/A
08/17/06 13:50:48.5	off			
08/17/06 16:15:43.5	on	00:00:56	Train from McAdam (Dep @ 13:15)	29
08/17/06 16:16:39.0	off			
08/17/06 21:07:19.5	on	00:01:40	Train from SJ (Dep @ 19:45)	59
08/17/06 21:09:00.0	off			
08/18/06 16:10:21.0	on	00:01:43	Train from McAdam (Dep @ 13:15)	63
08/18/06 16:12:03.5	off			
08/18/06 20:44:17.0	on	00:01:33	Train from SJ (Dep @ 19:20)	65
08/18/06 20:45:50.5	off			
08/19/06 15:23:08.0	on	00:01:42	Train from McAdam (Dep @ 12:15)	52
08/19/06 15:24:50.5	off			
08/20/06 21:15:08.5	on	00:01:11	Train from SJ (Dep @ 19:55)	46
08/20/06 21:16:19.5	off			
08/21/06 07:55:52.5	on	00:00:38	HI RAIL	N/A
08/21/06 07:56:31.0	off			
08/21/06 11:40:19.0	on	00:00:19	HI RAIL	N/A
08/21/06 11:40:38.0	off			
08/21/06 18:10:46.0	on	00:02:28	Train from McAdam (Dep @ 14:55)	78
08/21/06 18:13:14.0	off			
08/21/06 21:24:13.5	on	00:01:13	Train from SJ (Dep @ 19:55)	46
08/21/06 21:25:27.0	off			
08/22/06 17:08:04.5	on	00:01:51	Train from McAdam (Dep @ 13:55)	66
08/22/06 17:09:55.5	off			
08/22/06 21:56:28.0	on	00:01:05	Train from SJ (Dep @ 20:35)	47
08/22/06 21:57:32.5	off			
08/23/06 07:39:39.5	on	00:00:07	HI RAIL	N/A
08/23/06 07:39:46.5	off			
08/23/06 16:24:58.0	on	00:00:55	Train from McAdam (Dep @ 13:20)	25
08/23/06 16:25:52.5	off			
08/23/06 22:27:00.0	on	00:01:39	Train from SJ (Dep @ 21:00)	50
08/23/06 22:28:39.5	off			
08/24/06 14:12:43.0	on	00:00:51	Train from SJ (Dep @ 12:45)	12
08/24/06 14:13:34.0	off			
08/24/06 17:33:40.0	on	00:01:39	Train from McAdam (Dep @ 14:15)	62
08/24/06 17:35:19.5	off			
08/24/06 20:56:50.5	on	00:01:05	Train from McAdam (Dep @ 18:30)	15
08/24/06 20:57:56.0	off			
08/24/06 23:22:02.0	on	00:00:37	Train from SJ (Dep @ 19:35)	39
08/24/06 23:22:39.0	off			
08/25/06 17:41:02.0	on	00:01:32	Train from McAdam (Dep @ 14:00)	43
08/25/06 17:42:33.5	off			
08/25/06 23:01:02.5	on	00:01:55	Train from SJ (Dep @ 21:30)	63
08/25/06 23:02:57.0	off			
08/26/06 17:24:08.5	on	00:01:04	Train from McAdam (Dep @ 14:10)	37
08/26/06 17:25:12.5	off			
08/27/06 22:41:22.5	on	00:01:14	Train from SJ (Dep @ 21:15)	55
08/27/06 22:42:36.5	off			
08/28/06 20:17:21.5	on	00:02:17	Train from McAdam (Dep @ 17:05)	99
08/28/06 20:19:39.0	off			
08/28/06 23:55:25.5	on	00:00:58	Train from SJ (Dep @ 22:30)	55
08/28/06 23:56:24.0	off			
08/29/06 12:18:39.0	on	00:00:10	No Record from NB Southern	
08/29/06 12:18:49.5	off			
08/29/06 17:09:07.0	on	00:01:18	No Record from NB Southern	
08/29/06 17:10:24.5	off			
08/29/06 20:43:30.5	on	00:01:39	No Record from NB Southern	
08/29/06 20:45:09.5	off			
08/30/06 11:03:16.0	on	00:00:22	No Record from NB Southern	
08/30/06 11:03:38.0	off			
08/30/06 14:40:57.5	on	00:01:05	No Record from NB Southern	
08/30/06 14:42:03.0	off			
08/30/06 21:23:52.5	on	00:01:24	No Record from NB Southern	
08/30/06 21:25:16.5	off			
08/31/06 16:19:12.0	on	00:01:30	No Record from NB Southern	
08/31/06 16:20:42.0	off			
08/31/06 20:46:47.5	on	00:01:19	No Record from NB Southern	

08/31/06 20:48:06.5	off	00:01:19	No Record from NB Southern	

SEPTEMBER (2006)

Date Time	State	Activation Time	Notes	# of Cars
01/09/2006 9:52:24	on	00:00:24	HI RAIL	N/A
01/09/2006 9:52:48	off			
01/09/2006 10:47:07	on	00:00:17	HI RAIL	N/A
01/09/2006 10:47:24	off			
01/09/2006 16:55:15	on	00:01:23	Train from McAdam (Dep @ 13:41)	50
01/09/2006 16:56:38	off			
01/09/2006 22:28:36	on	00:01:32	Train from SJ (Dep @ 21:00)	51
01/09/2006 22:30:07	off			
02/09/2006 17:01:59	on	00:01:53	Train from McAdam (Dep @ 13:55)	63
02/09/2006 17:03:51	off			
03/09/2006 20:46:56	on	00:01:09	Train from SJ (Dep @ 19:25)	42
03/09/2006 20:48:05	off			
04/09/2006 16:56:06	on	00:01:35	Train from McAdam (Dep @ 13:50)	64
04/09/2006 16:57:42	off			
04/09/2006 20:54:05	on	00:00:44	Train from SJ (Dep @ 19:30)	20
04/09/2006 20:54:49	off			
05/09/2006 6:08:18	on	00:00:21	Train from SJ (Dep @ 04:45)	2
05/09/2006 6:08:38	off			
05/09/2006 13:51:57	on	00:00:43	Train from McAdam (Dep @ 09:10)	2
05/09/2006 13:52:40	off			
05/09/2006 16:17:04	on	00:00:12	HI RAIL	N/A
05/09/2006 16:17:16	off			
05/09/2006 17:16:53	on	00:01:40	Train from McAdam (Dep @ 14:20)	64
05/09/2006 17:18:32	off			
05/09/2006 21:12:05	on	00:00:52	Train from SJ (Dep @ 19:50)	30
05/09/2006 21:12:57	off			
06/09/2006 17:24:11	on	00:00:46	Train from McAdam (Dep @ 14:15)	23
06/09/2006 17:24:57	off			
06/09/2006 21:01:00	on	00:01:10	Train from SJ (Dep @ 19:40)	33
06/09/2006 21:02:10	off			
09/07/2006 15:15:15	on	00:00:30	HI RAIL	N/A
09/07/2006 15:15:45	off			
09/07/2006 15:16:30	on	00:00:31	HI RAIL	N/A
09/07/2006 15:17:01	off			
09/07/2006 16:14:38	on	00:00:42	Train from McAdam (Dep @ 13:15)	19
09/07/2006 16:15:19	off			
09/07/2006 22:26:30	on	00:01:28	Train from SJ (Dep @ 21:00)	51
09/07/2006 22:27:58	off			
09/08/2006 17:52:29	on	00:01:21	Train from McAdam (Dep @ 14:55)	52
09/08/2006 17:53:50	off			
09/08/2006 21:15:53	on	00:00:36	Train from SJ (Dep @ 19:55) Dropped signal for 15 seconds	66
09/08/2006 21:16:29	off			
09/08/2006 21:16:44	on	00:00:49		
09/08/2006 21:17:34	off			
09/09/2006 17:15:40	on	00:00:56	Train from McAdam (Dep @ 14:15)	27
09/09/2006 17:16:35	off			
09/10/2006 22:00:10	on	00:01:32	Train from SJ (Dep @ 20:30)	74
09/10/2006 22:01:42	off			
09/11/2006 10:16:01	on	00:00:32	HI RAIL	N/A
09/11/2006 10:16:33	off			
09/11/2006 13:05:24	on	00:01:53	HI RAIL	N/A
09/11/2006 13:07:17	off			
09/11/2006 17:43:52	on	00:02:30	Train from McAdam (Dep @ 14:25)	114
09/11/2006 17:46:22	off			
09/11/2006 22:57:18	on	00:01:00	Train from SJ (Dep @ 21:35)	41
09/11/2006 22:58:17	off			
09/12/2006 10:42:47	on	00:00:24	HI RAIL	N/A
09/12/2006 10:43:11	off			
09/12/2006 15:12:56	on	00:00:36	HI RAIL	N/A
09/12/2006 15:13:32	off			
09/12/2006 16:05:47	on	00:00:57	Train from McAdam (Dep @ 13:06)	31
09/12/2006 16:06:44	off			
09/12/2006 22:41:26	on	00:00:51	Train from SJ (Dep @ 21:20)	23
09/12/2006 22:42:17	off			
09/13/2006 8:15:10	on	00:00:19	HI RAIL	N/A
09/13/2006 8:15:28	off			
09/13/2006 15:34:54	on	00:00:33	Train from McAdam (Dep @ 12:35)	10
09/13/2006 15:35:26	off			
09/13/2006 17:11:21	on	00:00:32	HI RAIL	N/A
09/13/2006 17:11:52	off			
09/13/2006 22:25:06	on	00:00:48	Train from SJ (Dep @ 21:00) Dropped signal for 3 seconds	55
09/13/2006 22:25:53	off			
09/13/2006 22:25:56	on	00:00:42		
09/13/2006 22:26:38	off			
09/14/2006 8:32:16	on	00:00:24	HI RAIL	N/A

09/14/2006 8:32:40	off	00:00:24	HI RAIL	N/A
09/14/2006 12:04:48	on	00:00:12	HI RAIL	N/A
09/14/2006 12:05:00	off			
09/14/2006 14:58:03	on	00:00:31	HI RAIL	N/A
09/14/2006 14:58:34	off			
09/14/2006 16:46:30	on	00:01:16	Train from McAdam (Dep @ 13:40)	48
09/14/2006 16:47:46	off			
09/14/2006 21:43:51	on	00:00:56	Train from SJ (Dep @ 20:25)	41
09/14/2006 21:44:47	off			
09/15/2006 12:54:17	on	00:00:21	HI RAIL	N/A
09/15/2006 12:54:38	off			
09/15/2006 17:16:51	on	00:02:12	Train from McAdam (Dep @ 14:05)	79
09/15/2006 17:19:03	off			
09/15/2006 22:10:01	on	00:01:18	Train from SJ (Dep @ 20:45)	64
09/15/2006 22:11:19	off			
09/16/2006 14:57:35	on	00:01:23	Train from McAdam (Dep @ 11:50)	45
09/16/2006 14:58:57	off			
09/17/2006 21:19:15	on	00:01:05	Train from SJ (Dep @ 19:50)	32
09/17/2006 21:20:21	off			
09/18/2006 9:21:11	on	00:00:25	HI RAIL	N/A
09/18/2006 9:21:35	off			
09/18/2006 15:00:48	on	00:01:07	Train from McAdam (Dep @ 11:55)	37
09/18/2006 15:01:56	off			
09/18/2006 21:12:50	on	00:01:30	Train from SJ (Dep @ 19:45)	58
09/18/2006 21:14:21	off			
09/19/2006 16:20:42	on	00:01:24	Train from McAdam (Dep @ 13:15)	59
09/19/2006 16:22:06	off			
09/19/2006 21:31:51	on	00:01:00	Train from SJ (Dep @ 20:05)	57
09/19/2006 21:32:51	off			
09/20/2006 17:10:36	on	00:00:57	Train from McAdam (Dep @ 14:15)	33
09/20/2006 17:11:33	off			
09/20/2006 22:37:14	on	00:00:51	Train from SJ (Dep @ 21:15)	53
09/20/2006 22:38:06	off			
09/21/2006 7:41:19	on	00:00:33	HI RAIL	N/A
09/21/2006 7:41:53	off			
09/21/2006 13:09:26	on	00:00:18	HI RAIL	N/A
09/21/2006 13:09:43	off			
09/21/2006 14:19:34	on	00:00:04	HI RAIL	N/A
09/21/2006 14:19:38	off			
09/21/2006 15:04:48	on	00:00:32	HI RAIL	N/A
09/21/2006 15:05:19	off			
09/21/2006 16:57:50	on	00:01:48	Train from McAdam (Dep @ 13:50)	80
09/21/2006 16:59:38	off			
09/21/2006 21:05:30	on	00:01:17	Train from SJ (Dep @ 19:40)	40
09/21/2006 21:06:47	off			
09/22/2006 12:44:37	on	00:00:41	HI RAIL	N/A
09/22/2006 12:45:18	off			
09/22/2006 16:29:43	on	00:00:45	Train from McAdam (Dep @ 13:35)	23
09/22/2006 16:30:28	off			
09/22/2006 21:36:08	on	00:01:24	Train from SJ (Dep @ 20:10)	50
09/22/2006 21:37:32	off			
09/23/2006 16:29:55	on	00:01:34	Train from McAdam (Dep @ 13:25)	63
09/23/2006 16:31:29	off			
09/24/2006 22:16:01	on	00:01:10	Train from SJ (Dep @ 20:50)	53
09/24/2006 22:17:11	off			
09/25/2006 16:11:27	on	00:00:13	HI RAIL	N/A
09/25/2006 16:11:40	off			
09/25/2006 16:24:28	on	00:00:24	HI RAIL	N/A
09/25/2006 16:24:51	off			
09/25/2006 18:47:06	on	00:02:56	Train from McAdam (Dep @ 15:45)	90
09/25/2006 18:50:02	off			
09/25/2006 22:40:59	on	00:01:04	Train from SJ (Dep @ 21:15)	30
09/25/2006 22:42:02	off			
09/26/2006 8:47:49	on	00:00:38		
09/26/2006 8:48:27	off			
09/27/2006 20:16:06	on	00:01:07	Train from McAdam (Dep @ 15:55)	32
09/27/2006 20:17:14	off			
09/27/2006 23:07:07	on	00:00:54	Train from SJ (Dep @ 21:15)	44
09/27/2006 23:08:01	off			
09/28/2006 17:17:00	on	00:01:35	Train from McAdam (Dep @ 14:15)	55
09/28/2006 17:18:34	off			
09/28/2006 21:27:40	on	00:01:15	Train from SJ (Dep @ 20:05)	41
09/28/2006 21:28:56	off			
09/29/2006 8:57:29	on	00:00:24	Train from McAdam (Dep @ 07:30)	5
09/29/2006 8:57:52	off			
09/29/2006 18:04:50	on	00:00:53	Train from SJ (Dep @ 15:17)	36
09/29/2006 18:05:43	off			
09/29/2006 20:01:01	on	00:00:32	Train from McAdam (Dep @ 17:00)	5
09/29/2006 20:01:33	off			

09/29/2006 21:27:19 09/29/2006 21:29:23	on off	00:02:04	Train from SJ (Dep @ 20:05)	71
09/30/2006 11:13:06 09/30/2006 11:13:43	on off	00:00:37	Train from McAdam (Dep @ 09:50)	5
09/30/2006 12:07:17 09/30/2006 12:07:53	on off	00:00:35	Train from SJ (Dep @ 10:50)	5
09/30/2006 15:09:28 09/30/2006 15:09:56	on off	00:00:29	Train from SJ (Dep @ 13:55)	35
09/30/2006 15:45:33 09/30/2006 15:46:44	on off	00:01:11	Train from McAdam (Dep @ 12:45)	5
09/30/2006 16:16:07 09/30/2006 16:16:44	on off	00:00:37	Train from McAdam (Dep @ 14:50)	5

NOVEMBER (2006)

Date Time	State	Activation Time	Notes	# of Cars
11/01/2006 0:22:55 11/01/2006 0:24:26	on off	00:01:31	Train from SJ (Dep @ 22:00)	59
11/01/2006 21:19:16 11/01/2006 21:21:11	on off	00:01:56	Train from McAdam (Dep @ 17:00)	68
11/02/2006 6:27:59 11/02/2006 6:28:44	on off	00:00:45	Train from SJ (Dep @ 04:05)	57
11/02/2006 19:49:23 11/02/2006 19:50:32	on off	00:01:09	Train from McAdam (Dep @ 16:45)	41
11/03/2006 1:00:14 11/03/2006 1:01:23	on off	00:01:09	Train from SJ (Dep @ 23:40)	28
11/03/2006 10:27:17 11/03/2006 10:27:30	on off	00:00:13	HI RAIL	N/A
11/03/2006 18:08:30 11/03/2006 18:10:05	on off	00:01:35	Train from McAdam (Dep @ 15:10)	47
11/03/2006 22:00:52 11/03/2006 22:02:29	on off	00:01:37	Train from SJ (Dep @ 20:40)	48
11/04/2006 16:48:39 11/04/2006 16:50:26	on off	00:01:47	Train from McAdam (Dep @ 13:50)	47
11/05/2006 21:21:08 11/05/2006 21:22:37	on off	00:01:30	Train from SJ (Dep @ 20:00)	62
11/06/2006 20:12:47 11/06/2006 20:15:46	on off	00:02:58	Train from McAdam (Dep @ 16:00)	107
11/07/2006 0:32:40 11/07/2006 0:34:28	on off	00:01:48	Train from SJ (Dep @ 23:05)	52
11/07/2006 17:10:41 11/07/2006 17:12:04	on off	00:01:23	Train from McAdam (Dep @ 14:10)	50
11/07/2006 21:31:50 11/07/2006 21:33:12	on off	00:01:22	Train from SJ (Dep @ 20:12)	52
11/08/2006 9:41:41 11/08/2006 9:43:19	on off	00:01:39	HI RAIL	N/A
11/08/2006 18:12:09 11/08/2006 18:13:33	on off	00:01:25	Train from McAdam (Dep @ 14:45)	50
11/08/2006 23:04:22 11/08/2006 23:05:55	on off	00:01:34	Train from SJ (Dep @ 21:45)	56
11/09/2006 14:48:56 11/09/2006 14:50:09	on off	00:01:13	Train from McAdam (Dep @ 11:55)	55
11/09/2006 15:25:20 11/09/2006 15:25:50	on off	00:00:30	HI RAIL	N/A
11/09/2006 21:14:19 11/09/2006 21:15:31	on off	00:01:12	Train from SJ (Dep @ 19:50)	38
11/10/2006 8:16:18 11/10/2006 8:16:19 11/10/2006 8:16:21 11/10/2006 8:16:26 11/10/2006 8:16:28 11/10/2006 8:16:32	on off on off on off	00:00:02 00:00:06 00:00:05	HI RAIL (dropped signal for 2 seconds and 5 seconds)	N/A
11/10/2006 15:40:54 11/10/2006 15:41:32	on off	00:00:38	Train from McAdam (Dep @ 12:50)	12
11/10/2006 23:08:57 11/10/2006 23:10:34	on off	00:01:37	Train from SJ (Dep @ 21:40)	52
11/11/2006 17:21:09 11/11/2006 17:22:26	on off	00:01:17	Train from McAdam (Dep @ 13:30)	35
11/12/2006 22:55:15 11/12/2006 22:56:39	on off	00:01:24	Train from SJ (Dep @ 21:30)	35
11/13/06 19:20:52.5 11/13/06 19:22:23.0	on off	00:01:31	Train from McAdam (Dep @ 16:10)	56
11/13/06 23:37:24.0 11/13/06 23:38:15.0	on off	00:00:51	Train from SJ (Dep @ 22:05)	33
11/14/06 17:43:39.0 11/14/06 17:45:08.5	on off	00:01:29	Train from McAdam (Dep @ 14:45)	57
11/14/06 23:13:44.0 11/14/06 23:14:59.5	on off	00:01:16	Train from SJ (Dep @ 21:50)	43
11/15/06 12:59:16.5	on	00:00:54		

11/15/06 13:00:10.5 11/15/06 13:00:36.0 11/15/06 13:00:40.0	off on off	00:00:34 00:00:04	Train from SJ (Dep @ 10:15) Dropped signal for 26 seconds	4
11/15/06 16:28:22.5 11/15/06 16:28:58.5	on off	00:00:36	Train from McAdam (Dep @ 13:15)	13
11/15/06 18:51:22.0 11/15/06 18:51:51.5	on off	00:00:29	HI RAIL	N/A
11/15/06 22:15:31.0 11/15/06 22:16:56.0	on off	00:01:25	Train from SJ (Dep @ 20:50)	43
11/16/06 18:48:39.0 11/16/06 18:50:31.5	on off	00:01:52	Train from McAdam (Dep @ 15:25)	63
11/16/06 22:28:09.0 11/16/06 22:29:35.5	on off	00:01:27	Train from SJ (Dep @ 21:05)	49
11/17/06 10:52:30.0 11/17/06 10:52:48.0	on off	00:00:18	HI RAIL	N/A
11/17/06 17:46:58.0 11/17/06 17:48:34.0	on off	00:01:36	Train from McAdam (Dep @ 14:40)	29
11/18/06 09:45:44.0 11/18/06 09:48:03.0	on off	00:02:19	Train from SJ (Dep @ 08:20)	73
11/19/06 01:14:25.5 11/19/06 01:15:40.0	on off	00:01:15	Train from McAdam (Dep @ 22:10)	33
11/19/06 22:01:48.5 11/19/06 22:03:04.0	on off	00:01:16	Train from SJ (Dep @ 20:40)	37
11/20/06 13:25:41.0 11/20/06 13:26:14.5	on off	00:00:33	HI RAIL	N/A
11/20/06 13:51:04.0 11/20/06 13:51:47.0	on off	00:00:43	HI RAIL	N/A
11/20/06 18:39:12.5 11/20/06 18:41:03.5	on off	00:01:51	Train from McAdam (Dep @ 22:10)	33
11/20/06 23:11:26.5 11/20/06 23:12:58.5	on off	00:01:32	Train from SJ (Dep @ 21:50)	47
11/21/06 18:21:03.5 11/21/06 18:23:02.5	on off	00:01:59	Train from McAdam (Dep @ 15:05)	66
11/21/06 22:07:44.0 11/21/06 22:08:52.5	on off	00:01:08	Train from SJ (Dep @ 20:45)	36
11/22/06 08:42:43.0 11/22/06 08:42:52.0	on off	00:00:09	HI RAIL	N/A
11/22/06 14:33:00.0 11/22/06 14:33:20.0	on off	00:00:20	HI RAIL	N/A
11/22/06 14:59:27.0 11/22/06 15:00:04.0	on off	00:00:37	HI RAIL	N/A
11/22/06 15:14:11.5 11/22/06 15:14:18.0	on off	00:00:06	HI RAIL	N/A
11/22/06 16:58:37.0 11/22/06 16:59:51.5	on off	00:01:14	Train from McAdam (Dep @ 14:00)	45
11/22/06 21:04:44.5 11/22/06 21:05:19.0	on off	00:00:34	Train from SJ (Dep @ 19:45)	36
11/23/06 01:48:53.5 11/23/06 01:49:19.0	on off	00:00:25	Train from McAdam (Dep @ 22:56)	1
11/23/06 09:53:48.5 11/23/06 09:54:25.5	on off	00:00:37	HI RAIL	N/A
11/23/06 12:18:15.5 11/23/06 12:18:55.0	on off	00:00:40	HI RAIL	N/A
11/23/06 13:36:33.5 11/23/06 13:37:11.0	on off	00:00:38	HI RAIL	N/A
11/23/06 14:56:08.5 11/23/06 14:56:53.5	on off	00:00:45	HI RAIL	N/A
11/23/06 15:03:23.5 11/23/06 15:04:04.0	on off	00:00:40	HI RAIL	N/A
11/24/06 10:16:02.0 11/24/06 10:16:42.0	on off	00:00:40	Train from SJ (Dep @ 08:55)	14
11/24/06 10:46:35.0 11/24/06 10:47:02.5	on off	00:00:27	HI RAIL	N/A
11/24/06 11:24:01.0 11/24/06 11:24:26.5	on off	00:00:25	HI RAIL	N/A
11/24/06 12:55:25.0 11/24/06 12:55:53.5	on off	00:00:28	HI RAIL	N/A
11/24/06 17:50:26.5 11/24/06 17:51:58.5	on off	00:01:32	Train from McAdam (Dep @ 14:00)	53
11/24/06 22:36:30.5 11/24/06 22:38:42.0	on off	00:02:12	Train from SJ (Dep @ 21:15)	92
11/25/06 16:16:00.5 11/25/06 16:17:18.0	on off	00:01:17	Train from McAdam (Dep @ 13:10)	32
11/26/06 20:41:26.5 11/26/06 20:42:20.0	on off	00:00:53	Train from SJ (Dep @ 19:20)	28
11/27/06 13:19:00.0 11/27/06 13:19:17.0	on off	00:00:17	HI RAIL	N/A
11/27/06 13:22:13.0 11/27/06 13:23:04.0	on off	00:00:51	HI RAIL	N/A

11/27/06 16:44:01.5 11/27/06 16:45:46.5	on off	00:01:45	Train from McAdam (Dep @ 13:38) Dropped signal for 0.5 seconds	59
11/27/06 16:45:47.0 11/27/06 16:45:49.0	on off	00:00:02		
11/27/06 23:04:55.5 11/27/06 23:06:18.0	on off	00:01:23	Train from SJ (Dep @ 21:40)	52
11/28/06 08:42:05.5 11/28/06 08:42:26.0	on off	00:00:21	HI RAIL	N/A
11/28/06 17:05:56.0 11/28/06 17:07:23.5	on off	00:01:28	Train from McAdam (Dep @ 14:00)	51
11/28/06 22:25:43.5 11/28/06 22:27:28.0	on off	00:01:45	Train from SJ (Dep @ 20:45)	49
11/29/06 08:53:17.5 11/29/06 08:53:48.5	on off	00:00:31	HI RAIL	N/A
11/29/06 09:27:12.5 11/29/06 09:28:18.0	on off	00:01:06	HI RAIL	N/A
11/29/06 15:23:11.0 11/29/06 15:24:48.0	on off	00:01:37	Train from McAdam (Dep @ 12:20)	56
11/29/06 23:39:03.0 11/29/06 23:40:32.5	on off	00:01:30	Train from SJ (Dep @ 22:20)	50
11/30/06 16:14:24.5 11/30/06 16:15:35.5	on off	00:01:11	Train from McAdam (Dep @ 13:15)	54
11/30/06 20:38:35.5 11/30/06 20:39:59.0	on off	00:01:24	Train from SJ (Dep @ 19:20)	36

DECEMBER (2006)

Date Time	State	Activation Time	Notes	# of Cars
12/01/2006 16:44:06 12/01/2006 16:45:20	on off	00:01:14	Train from McAdam (Dep @ 13:43)	38
12/01/2006 22:12:55 12/01/2006 22:13:53	on off	00:00:58	Train from SJ (Dep @ 20:50)	57
12/02/2006 16:42:40 12/02/2006 16:44:01	on off	00:01:21	Train from McAdam (Dep @ 13:23)	38
12/03/2006 20:52:44 12/03/2006 20:53:58	on off	00:01:14	Train from SJ (Dep @ 19:30)	40
12/04/2006 18:48:53 12/04/2006 18:50:47	on off	00:01:54	Train from McAdam (Dep @ 15:05)	62
12/05/2006 0:07:51 12/05/2006 0:08:56	on off	00:01:05	Train from SJ (Dep @ 22:50)	36
12/05/2006 17:34:57 12/05/2006 17:36:42	on off	00:01:44	Train from McAdam (Dep @ 14:40)	64
12/05/2006 21:28:12 12/05/2006 21:29:36	on off	00:01:25	Train from SJ (Dep @ 20:05)	55
12/06/2006 14:50:22 12/06/2006 14:51:00	on off	00:00:39	HI RAIL	N/A
12/06/2006 18:07:33 12/06/2006 18:08:57	on off	00:01:23	Train from McAdam (Dep @ 15:06)	49
12/06/2006 22:13:39 12/06/2006 22:14:53	on off	00:01:13	Train from SJ (Dep @ 20:50) Dropped signal for 1 second	42
12/06/2006 22:14:54 12/06/2006 22:15:05	on off	00:00:12		
12/07/2006 8:21:40 12/07/2006 8:22:17	on off	00:00:38	HI RAIL Dropped signal for 20 seconds	N/A
12/07/2006 8:22:37 12/07/2006 8:22:50	on off	00:00:13		
12/07/2006 11:19:39 12/07/2006 11:20:12	on off	00:00:33	HI RAIL	N/A
12/07/2006 13:57:37 12/07/2006 13:57:55	on off	00:00:19	HI RAIL	N/A
12/07/2006 16:45:52 12/07/2006 16:46:38	on off	00:00:46	Train from McAdam (Dep @ 13:50)	14
12/07/2006 22:03:58 12/07/2006 22:05:44	on off	00:01:47	Train from SJ (Dep @ 20:45)	62
12/08/2006 14:22:27 12/08/2006 14:22:45	on off	00:00:18	HI RAIL	N/A
12/08/2006 15:51:07 12/08/2006 15:52:17	on off	00:01:10	Train from McAdam (Dep @ 12:36)	31
12/08/2006 21:43:03 12/08/2006 21:44:36	on off	00:01:33	Train from SJ (Dep @ 20:20)	52
12/09/2006 13:54:13 12/09/2006 13:54:19	on off	00:00:06	HI RAIL	N/A
12/09/2006 18:16:22 12/09/2006 18:18:14	on off	00:01:51	Train from McAdam (Dep @ 14:55)	71
12/10/2006 21:49:32 12/10/2006 21:51:17	on off	00:01:45	Train from SJ (Dep @ 20:00)	56
12/11/2006 9:26:49 12/11/2006 9:27:24	on off	00:00:35	HI RAIL	N/A
12/11/2006 18:25:29	on	00:01:58	Train from McAdam (Dep @ 15:00)	72

12/11/2006 18:27:27	off	00:01:58	Train from McAdam (Dep @ 15:00)	72
12/11/2006 22:16:42 12/11/2006 22:17:52	on off	00:01:10	Train from SJ (Dep @ 20:55)	43
12/12/2006 14:35:29 12/12/2006 14:36:17	on off	00:00:49	HI RAIL	N/A
12/12/2006 15:46:14 12/12/2006 15:47:14	on off	00:01:00	Train from McAdam (Dep @ 12:55)	32
12/12/2006 22:06:23 12/12/2006 22:07:36	on off	00:01:13	Train from SJ (Dep @ 20:45)	39
12/13/06 13:55:53.5 12/13/06 13:56:40.5	on off	00:00:47	HI RAIL	N/A
12/13/06 14:10:11.5 12/13/06 14:10:48.5	on off	00:00:37	HI RAIL	N/A
12/13/06 16:04:12.5 12/13/06 16:05:17.0	on off	00:01:04	Train from McAdam (Dep @ 12:55)	30
12/13/06 22:20:18.0 12/13/06 22:21:33.0	on off	00:01:15	Train from SJ (Dep @ 21:00)	39
12/14/06 09:34:42.0 12/14/06 09:37:40.5	on off	00:02:58	HI RAIL	N/A
12/14/06 14:02:27.0 12/14/06 14:02:43.5	on off	00:00:16	HI RAIL	N/A
12/14/06 18:32:28.5 12/14/06 18:33:59.0	on off	00:01:31	Train from McAdam (Dep @ 15:30)	60
12/14/06 23:11:23.0 12/14/06 23:12:57.0	on off	00:01:34	Train from SJ (Dep @ 21:35)	49
12/15/06 10:27:26.0 12/15/06 10:28:15.5	on off	00:00:49	HI RAIL	N/A
12/15/06 12:58:03.5 12/15/06 12:58:43.5	on off	00:00:40	HI RAIL	N/A
12/15/06 16:11:00.5 12/15/06 16:12:01.0	on off	00:01:00	Train from McAdam (Dep @ 13:10)	30
12/15/06 21:32:03.5 12/15/06 21:33:25.5	on off	00:01:22	Train from SJ (Dep @ 20:10)	52
12/16/06 16:38:11.5 12/16/06 16:38:56.5	on off	00:00:45	Train from McAdam (Dep @ 13:45)	20
12/17/06 22:02:34.5 12/17/06 22:04:00.5	on off	00:01:26	Train from SJ (Dep @ 20:40)	58
12/18/06 08:40:33.5 12/18/06 08:41:23.5	on off	00:00:50	HI RAIL	N/A
12/18/06 19:11:51.0 12/18/06 19:13:39.0	on off	00:01:48	Train from McAdam (Dep @ 16:06)	51
12/18/06 23:03:39.0 12/18/06 23:04:59.5	on off	00:01:21	Train from SJ (Dep @ 21:40)	54
12/19/06 20:03:41.0 12/19/06 20:06:22.5	on off	00:02:42	Train from McAdam (Dep @ 16:35)	100
12/19/06 23:46:09.0 12/19/06 23:47:26.5	on off	00:01:18	Train from SJ (Dep @ 22:25)	47
12/20/06 13:07:16.5 12/20/06 13:07:57.5	on off	00:00:41	HI RAIL	N/A
12/20/06 16:36:04.0 12/20/06 16:37:25.0	on off	00:01:21	Train from McAdam (Dep @ 13:35)	43
12/20/06 21:51:32.0 12/20/06 21:53:05.5	on off	00:01:34	Train from SJ (Dep @ 20:30)	60
12/21/06 14:05:27.0 12/21/06 14:05:57.5	on off	00:00:30	HI RAIL	N/A
12/21/06 15:57:26.0 12/21/06 15:58:14.5	on off	00:00:48	HI RAIL	N/A
12/21/06 17:26:19.5 12/21/06 17:28:13.0	on off	00:01:53	Train from McAdam (Dep @ 14:15)	74
12/21/06 21:01:41.5 12/21/06 21:02:44.5	on off	00:01:03	Train from SJ (Dep @ 19:45)	34
12/22/06 17:06:22.0 12/22/06 17:07:46.5	on off	00:01:24	Train from McAdam (Dep @ 14:05)	45
12/23/06 00:17:40.5 12/23/06 00:19:38.0	on off	00:01:58	Train from SJ (Dep @ 22:55)	75
12/23/06 15:43:51.0 12/23/06 15:44:37.0	on off	00:00:46	Train from McAdam (Dep @ 12:24)	20
12/26/06 21:21:50.5 12/26/06 21:53:45.5	on off	00:31:55	Train from SJ (Dep @ 19:34)	48
12/27/06 21:38:20.5 12/27/06 21:40:56.5	on off	00:02:36	Train from McAdam (Dep @ 17:50)	72
12/28/06 00:19:04.0 12/28/06 00:20:17.0	on off	00:01:13	Train from SJ (Dep @ 23:00)	37
12/28/06 18:04:58.5 12/28/06 18:07:08.0	on off	00:02:09	Train from McAdam (Dep @ 14:30)	78
12/28/06 21:31:48.5 12/28/06 21:33:07.5	on off	00:01:19	Train from SJ (Dep @ 20:10)	45
12/29/06 16:30:57.5 12/29/06 16:32:03.0	on off	00:01:05	Train from McAdam (Dep @ 13:40)	34

12/30/06 00:10:49.0 12/30/06 00:12:45.5	on off	00:01:56	Train from SJ (Dep @ 22:45)	62
12/30/06 14:32:31.5 12/30/06 14:33:31.0	on off	00:01:00	Train from McAdam (Dep @ 11:35)	28

JANUARY (2007)

Date Time	State	Activation Time	Notes	# of Cars
01/02/2007 14:10:26 01/02/2007 14:10:51	on off	00:00:25	HI RAIL	N/A
01/02/2007 21:40:31 01/02/2007 21:42:11	on off	00:01:40	Train from SJ (Dep @ 20:20)	63
01/03/2007 19:47:49 01/03/2007 19:50:17	on off	00:02:28	Train from McAdam (Dep @ 16:50)	77
01/03/2007 23:20:34 01/03/2007 23:22:21	on off	00:01:47	Train from SJ (Dep @ 21:55)	61
01/04/2007 16:54:53 01/04/2007 16:56:07	on off	00:01:14	Train from McAdam (Dep @ 13:55)	36
01/04/2007 22:06:47 01/04/2007 22:08:13	on off	00:01:26	Train from SJ (Dep @ 20:40)	53
01/05/2007 19:02:24 01/05/2007 19:04:31	on off	00:02:07	Train from McAdam (Dep @ 16:40)	79
01/05/2007 22:58:21 01/05/2007 22:59:52	on off	00:01:31	Train from SJ (Dep @ 21:40)	48
01/06/2007 14:24:53 01/06/2007 14:25:08	on off	00:00:15	HI RAIL	N/A
01/06/2007 16:00:20 01/06/2007 16:01:40	on off	00:01:20	Train from McAdam (Dep @ 13:00)	37
01/07/2007 22:23:49 01/07/2007 22:25:17	on off	00:01:28	Train from SJ (Dep @ 21:00)	53
01/08/2007 10:30:50 01/08/2007 10:33:25	on off	00:02:35	HI RAIL	N/A
01/08/2007 14:27:36 01/08/2007 14:27:55	on off	00:00:19	HI RAIL	N/A
01/08/2007 17:51:48 01/08/2007 17:53:10	on off	00:01:23	Train from McAdam (Dep @ 15:00)	51
01/08/2007 21:45:43 01/08/2007 21:47:08	on off	00:01:24	Train from SJ (Dep @ 20:25)	38
01/09/2007 18:42:48 01/09/2007 18:45:51	on off	00:03:03	Train from McAdam (Dep @ 15:00)	99
01/09/2007 22:41:18 01/09/2007 22:42:50	on off	00:01:33	Train from SJ (Dep @ 21:20)	41
01/10/2007 10:23:14 01/10/2007 10:23:27	on off	00:00:13	HI RAIL	N/A
01/10/2007 17:50:17 01/10/2007 17:51:43	on off	00:01:26	Train from McAdam (Dep @ 15:00)	60
01/10/2007 21:45:50 01/10/2007 21:47:33	on off	00:01:43	Train from SJ (Dep @ 20:20)	58
01/11/2007 15:49:54 01/11/2007 15:50:43	on off	00:00:49	Train from McAdam (Dep @ 12:51)	26
01/11/2007 22:28:24 01/11/2007 22:30:00	on off	00:01:36	Train from SJ (Dep @ 21:05)	53
01/12/2007 16:41:30 01/12/2007 16:42:49	on off	00:01:18	Train from McAdam (Dep @ 13:40)	51
01/12/2007 21:20:43 01/12/2007 21:22:38	on off	00:01:55	Train from SJ (Dep @ 20:00)	62
01/13/07 16:20:58.0 01/13/07 16:22:44.5	on off	00:01:46	Train from McAdam (Dep @ 13:05)	62
01/14/07 22:03:06.5 01/14/07 22:05:05.0	on off	00:01:59	Train from SJ (Dep @ 20:40)	63
01/15/07 09:25:11.0 01/15/07 09:25:27.5	on off	00:00:16	HI RAIL	N/A
01/15/07 17:14:52.5 01/15/07 17:16:33.0	on off	00:01:40	Train from McAdam (Dep @ 14:20)	66
01/15/07 21:29:45.0 01/15/07 21:31:09.5	on off	00:01:24	Train from SJ (Dep @ 20:10)	41
01/16/07 17:13:00.0 01/16/07 17:14:34.0	on off	00:01:34	Train from McAdam (Dep @ 14:15)	45
01/16/07 21:14:26.0 01/16/07 21:15:28.0	on off	00:01:02	Train from SJ (Dep @ 19:55)	25
01/17/07 13:35:23.0 01/17/07 13:35:40.0	on off	00:00:17	HI RAIL	N/A
01/17/07 17:41:11.0 01/17/07 17:42:14.5	on off	00:01:04	Train from McAdam (Dep @ 14:45)	32
01/18/07 00:20:48.0 01/18/07 00:22:13.5	on off	00:01:26	Train from SJ (Dep @ 23:00)	41
01/18/07 14:10:21.0 01/18/07 14:10:40.0	on off	00:00:19	HI RAIL	N/A
01/18/07 18:03:50.5	on	00:01:09	Train from McAdam (Dep @ 15:05)	38

01/18/07 18:05:00.0	off	00:01:09	Train from McAdam (Dep @ 15:05)	58
01/18/07 23:39:17.0 01/18/07 23:40:45.0	on off	00:01:28	Train from SJ (Dep @ 22:00)	55
01/19/07 16:05:38.5 01/19/07 16:05:57.5	on off	00:00:19	Train from McAdam (Dep @ 15:05) Dropped signal for 0.5 seconds	52
01/19/07 16:05:58.0 01/19/07 16:06:56.5	on off	00:00:59		
01/19/07 22:15:20.0 01/19/07 22:17:17.0	on off	00:01:57	Train from SJ (Dep @ 20:50)	56
01/20/07 20:07:44.5 01/20/07 20:09:17.5	on off	00:01:33	Train from McAdam (Dep @ 17:10)	57
01/21/07 21:46:03.0 01/21/07 21:47:29.0	on off	00:01:26	Train from SJ (Dep @ 20:20)	55
01/22/07 10:38:34.0 01/22/07 10:38:48.0	on off	00:00:14	HI RAIL	N/A
01/22/07 15:17:15.0 01/22/07 15:17:54.5	on off	00:00:40	HI RAIL	N/A
01/22/07 18:00:09.5 01/22/07 18:01:23.5	on off	00:01:14	Train from McAdam (Dep @ 15:10)	40
01/22/07 23:14:47.0 01/22/07 23:15:50.5	on off	00:01:04	Train from SJ (Dep @ 21:45)	30
01/23/07 16:43:46.0 01/23/07 16:45:36.0	on off	00:01:50	Train from McAdam (Dep @ 13:45)	63
01/23/07 22:00:04.0 01/23/07 22:01:54.0	on off	00:01:50	Train from SJ (Dep @ 20:35)	59
01/24/07 13:37:42.5 01/24/07 13:37:56.5	on off	00:00:14	HI RAIL	N/A
01/24/07 18:30:10.5 01/24/07 18:31:08.0	on off	00:00:57	Train from McAdam (Dep @ 15:10)	24
01/24/07 21:45:08.0 01/24/07 21:46:33.0	on off	00:01:25	Train from SJ (Dep @ 20:25)	50
01/25/07 13:20:31.0 01/25/07 13:20:45.5	on off	00:00:14	HI RAIL	N/A
01/25/07 13:30:57.5 01/25/07 13:31:37.5	on off	00:00:40	HI RAIL	N/A
01/25/07 13:46:09.0 01/25/07 13:46:40.5	on off	00:00:31	HI RAIL	N/A
01/25/07 13:47:05.0 01/25/07 13:47:16.5	on off	00:00:11	HI RAIL	N/A
01/25/07 14:02:29.5 01/25/07 14:03:13.0	on off	00:00:43	HI RAIL	N/A
01/25/07 17:02:53.0 01/25/07 17:04:17.0	on off	00:01:24	Train from McAdam (Dep @ 14:05)	45
01/25/07 22:09:23.0 01/25/07 22:11:07.5	on off	00:01:45	Train from SJ (Dep @ 20:45)	31
01/26/2007 16:41:14 01/26/2007 16:42:00	on off	00:00:46	Train from McAdam (Dep @ 13:50)	16
01/26/2007 21:50:03 01/26/2007 21:51:45	on off	00:01:42	Train from SJ (Dep @ 20:30)	55
01/27/2007 17:24:49 01/27/2007 17:27:00	on off	00:02:11	Train from McAdam (Dep @ 14:25)	68
01/28/2007 22:42:28 01/28/2007 22:44:07	on off	00:01:39	Train from SJ (Dep @ 21:20)	57
01/29/2007 17:39:46 01/29/2007 17:41:16	on off	00:01:29	Train from McAdam (Dep @ 14:45)	52
01/29/2007 21:23:03 01/29/2007 21:24:26	on off	00:01:23	Train from SJ (Dep @ 20:05)	34
01/30/2007 9:52:20 01/30/2007 9:52:24	on off	00:00:04	HI RAIL	N/A
01/30/2007 16:53:01 01/30/2007 16:54:19	on off	00:01:18	Train from McAdam (Dep @ 14:45)	52
01/30/2007 21:43:52 01/30/2007 21:45:05	on off	00:01:13	Train from SJ (Dep @ 20:05)	34
01/31/2007 14:06:39 01/31/2007 14:07:16	on off	00:00:38	HI RAIL	N/A
01/31/2007 15:37:04 01/31/2007 15:37:44	on off	00:00:40	HI RAIL	N/A
01/31/2007 20:02:59 01/31/2007 20:04:04	on off	00:01:05	Train from McAdam (Dep @ 17:05)	35

FEBRUARY (2007)

Date Time	State	Activation Time	Notes	# of Cars
02/01/2007 0:17:37 02/01/2007 0:19:07	on off	00:01:31	Train from SJ (Dep @ 22:59)	50
02/01/2007 9:20:14 02/01/2007 9:20:33	on off	00:00:19	HI RAIL	N/A
02/01/2007 18:44:53 02/01/2007 18:46:37	on off	00:01:43	Train from McAdam (Dep @ 15:50)	62

02/02/2007 0:03:25 02/02/2007 0:04:56	on off	00:01:31	Train from SJ (Dep @ 21:55)	61
02/02/2007 17:56:13 02/02/2007 17:57:11	on off	00:00:58	Train from McAdam (Dep @ 15:00)	35
02/03/2007 0:41:45 02/03/2007 0:43:24	on off	00:01:39	Train from SJ (Dep @ 23:20)	61
02/03/2007 17:21:08 02/03/2007 17:22:27	on off	00:01:19	Train from McAdam (Dep @ 14:20)	43
02/05/2007 1:12:37 02/05/2007 1:13:58	on off	00:01:21	Train from SJ (Dep @ 23:20)	50
02/05/2007 19:51:02 02/05/2007 19:52:39	on off	00:01:37	Train from McAdam (Dep @ 16:50)	58
02/06/2007 0:01:42 02/06/2007 0:03:14	on off	00:01:31	Train from SJ (Dep @ 22:40)	47
02/06/2007 9:30:56 02/06/2007 9:31:37	on off	00:00:41	HI RAIL	N/A
02/06/2007 11:45:16 02/06/2007 11:45:58	on off	00:00:41	HI RAIL	N/A
02/06/2007 18:13:54 02/06/2007 18:15:19	on off	00:01:25	Train from McAdam (Dep @ 15:15)	46
02/06/2007 21:32:14 02/06/2007 21:33:10	on off	00:00:56	Train from SJ (Dep @ 20:10)	23
02/07/2007 5:10:43 02/07/2007 5:11:06	on off	00:00:23	HI RAIL	N/A
02/07/2007 9:28:05 02/07/2007 9:31:14	on off	00:03:08	HI RAIL	N/A
02/07/2007 18:05:40 02/07/2007 18:06:42	on off	00:01:02	Train from McAdam (Dep @ 15:10)	35
02/07/2007 22:21:10 02/07/2007 22:22:39	on off	00:01:29	Train from SJ (Dep @ 21:00)	53
02/08/2007 18:24:10 02/08/2007 18:25:06	on off	00:00:56	Train from McAdam (Dep @ 15:15)	22
02/08/2007 22:33:39 02/08/2007 22:35:00	on off	00:01:20	Train from SJ (Dep @ 21:12)	53
02/09/2007 20:03:37 02/09/2007 20:05:15	on off	00:01:38	Train from McAdam (Dep @ 17:00)	65
02/10/2007 0:50:47 02/10/2007 0:52:14	on off	00:01:27	Train from SJ (Dep @ 23:30)	47
02/10/2007 17:06:24 02/10/2007 17:07:55	on off	00:01:32	Train from McAdam (Dep @ 14:15)	45
02/11/2007 21:54:42 02/11/2007 21:55:54	on off	00:01:12	Train from SJ (Dep @ 20:35)	36
02/12/2007 18:54:40 02/12/2007 18:56:10	on off	00:01:30	Train from McAdam (Dep @ 16:00)	51
02/12/2007 19:15:56 02/12/2007 19:16:06	on off	00:00:10	HI RAIL	N/A
02/12/2007 23:48:41 02/12/2007 23:50:04	on off	00:01:23	Train from SJ (Dep @ 22:30)	47

MARCH (2007)

Date Time	State	Activation Time	Notes	# of Cars
03/22/2007 17:32:57 03/22/2007 17:34:38	on off	00:01:40	Train from McAdam (Dep @ 14:40)	73
03/23/2007 17:48:13 03/23/2007 17:49:16	on off	00:01:03	Train from McAdam (Dep @ 14:50)	36
03/24/2007 17:42:02 03/24/2007 17:43:42	on off	00:01:41	Train from McAdam (Dep @ 13:55)	64
03/26/2007 15:18:42 03/26/2007 15:19:11	on off	00:00:29	HI RAIL	N/A
03/26/2007 18:33:15 03/26/2007 18:35:11	on off	00:01:56	Train from McAdam (Dep @ 15:35)	64
03/27/2007 18:21:04 03/27/2007 18:22:48	on off	00:01:44	Train from McAdam (Dep @ 00:00)	0

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
11/01/2006 0:22:55 11/01/2006 0:24:26	Train from SJ (Dep @ 22:00)	on off	91	59	1,078.99	30	103	-12	-11.6
11/01/2006 21:19:16 11/01/2006 21:21:11	Train from McAdam (Dep @ 17:00)	on off	116	68	1,243.58	30	116	0	-0.2
11/02/2006 6:27:59 11/02/2006 6:28:44	Train from SJ (Dep @ 04:05)	on off	45	57	1,042.42	30	101	-56	-55.3
11/02/2006 19:49:23 11/02/2006 19:50:32	Train from McAdam (Dep @ 16:45)	on off	69	41	749.81	30	79	-10	-12.6
11/03/2006 1:00:14 11/03/2006 1:01:23	Train from SJ (Dep @ 23:40)	on off	69	28	512.06	30	61	8	12.8
11/03/2006 18:08:30 11/03/2006 18:10:05	Train from McAdam (Dep @ 15:10)	on off	95	47	859.54	30	87	8	9.1
11/03/2006 22:00:52 11/03/2006 22:02:29	Train from SJ (Dep @ 20:40)	on off	97	48	877.82	30	88	8	9.1
11/04/2006 16:48:39 11/04/2006 16:50:26	Train from McAdam (Dep @ 13:50)	on off	107	47	859.54	30	87	20	23.4
11/05/2006 21:21:08 11/05/2006 21:22:37	Train from SJ (Dep @ 20:00)	on off	90	62	1,133.86	30	108	-18	-16.8
11/06/2006 20:12:47 11/06/2006 20:15:46	Train from McAdam (Dep @ 16:00)	on off	178	107	1,956.82	30	169	10	5.7
11/07/2006 0:32:40 11/07/2006 0:34:28	Train from SJ (Dep @ 23:05)	on off	108	52	950.98	30	94	14	14.5
11/07/2006 17:10:41 11/07/2006 17:12:04	Train from McAdam (Dep @ 14:10)	on off	83	50	914.40	30	91	-8	-9.0
11/07/2006 21:31:50 11/07/2006 21:33:12	Train from SJ (Dep @ 20:12)	on off	82	52	950.98	30	94	-12	-12.7
11/08/2006 18:12:09 11/08/2006 18:13:33	Train from McAdam (Dep @ 14:45)	on off	85	50	914.40	30	91	-6	-6.8
11/08/2006 23:04:22 11/08/2006 23:05:55	Train from SJ (Dep @ 21:45)	on off	94	56	1,024.13	30	99	-6	-5.9
11/09/2006 14:48:56 11/09/2006 14:50:09	Train from McAdam (Dep @ 11:55)	on off	73	55	1,005.84	30	98	-25	-25.5
11/09/2006 21:14:19 11/09/2006 21:15:31	Train from SJ (Dep @ 19:50)	on off	72	38	694.94	30	75	-2	-3.1
11/10/2006 15:40:54 11/10/2006 15:41:32	Train from McAdam (Dep @ 12:50)	on off	38	12	219.46	30	39	-1	-3.5
11/10/2006 23:08:57 11/10/2006 23:10:34	Train from SJ (Dep @ 21:40)	on off	97	52	950.98	30	94	3	2.8
11/11/2006 17:21:09 11/11/2006 17:22:26	Train from McAdam (Dep @ 13:30)	on off	77	35	640.08	30	71	6	8.9
11/12/2006 22:55:15 11/12/2006 22:56:39	Train from SJ (Dep @ 21:30)	on off	84	35	640.08	30	71	13	18.8
11/13/06 19:20:52.5 11/13/06 19:22:23.0	Train from McAdam (Dep @ 16:10)	on off	91	56	1,024.13	30	99	-9	-8.9
11/13/06 23:37:24.0 11/13/06 23:38:15.0	Train from SJ (Dep @ 22:05)	on off	51	33	603.50	30	68	-17	-25.0
11/14/06 17:43:39.0 11/14/06 17:45:08.5	Train from McAdam (Dep @ 14:45)	on off	89	57	1,042.42	30	101	-11	-11.2
11/14/06 23:13:44.0 11/14/06 23:14:59.5	Train from SJ (Dep @ 21:50)	on off	76	43	786.38	30	82	-6	-7.5
11/15/06 16:28:22.5 11/15/06 16:28:58.5	Train from McAdam (Dep @ 13:15)	on off	36	13	237.74	30	41	-5	-11.6
11/15/06 22:15:31.0 11/15/06 22:16:56.0	Train from SJ (Dep @ 20:50)	on off	85	43	786.38	30	82	3	4.1

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
11/16/06 18:48:39.0 11/16/06 18:50:31.5	Train from McAdam (Dep @ 15:25)	on off	112	63	1,152.14	30	109	4	3.3
11/16/06 22:28:09.0 11/16/06 22:29:35.5	Train from SJ (Dep @ 21:05)	on off	87	49	896.11	30	90	-3	-3.7
11/17/06 17:46:58.0 11/17/06 17:48:34.0	Train from McAdam (Dep @ 14:40)	on off	96	29	530.35	30	63	33	53.5
11/18/06 09:45:44.0 11/18/06 09:48:03.0	Train from SJ (Dep @ 08:20)	on off	139	73	1,335.02	30	123	16	13.4
11/19/06 01:14:25.5 11/19/06 01:15:40.0	Train from McAdam (Dep @ 22:10)	on off	75	33	603.50	30	68	6	9.6
11/19/06 22:01:48.5 11/19/06 22:03:04.0	Train from SJ (Dep @ 20:40)	on off	76	37	676.66	30	73	2	2.8
11/20/06 18:39:12.5 11/20/06 18:41:03.5	Train from McAdam (Dep @ 22:10)	on off	111	33	603.50	30	68	43	63.2
11/20/06 23:11:26.5 11/20/06 23:12:58.5	Train from SJ (Dep @ 21:50)	on off	92	47	859.54	30	87	5	5.6
11/21/06 18:21:03.5 11/21/06 18:23:02.5	Train from McAdam (Dep @ 15:05)	on off	119	66	1,207.01	30	113	6	5.3
11/21/06 22:07:44.0 11/21/06 22:08:52.5	Train from SJ (Dep @ 20:45)	on off	68	36	658.37	30	72	-4	-5.0
11/22/06 16:58:37.0 11/22/06 16:59:51.5	Train from McAdam (Dep @ 14:00)	on off	74	45	822.96	30	84	-10	-11.7
11/22/06 21:04:44.5 11/22/06 21:05:19.0	Train from SJ (Dep @ 19:45)	on off	34	36	658.37	30	72	-38	-52.1
11/23/06 01:48:53.5 11/23/06 01:49:19.0	Train from McAdam (Dep @ 22:56)	on off	25	1	18.29	30	24	1	4.7
11/24/06 10:16:02.0 11/24/06 10:16:42.0	Train from SJ (Dep @ 08:55)	on off	40	14	256.03	30	42	-2	-5.0
11/24/06 17:50:26.5 11/24/06 17:51:58.5	Train from McAdam (Dep @ 14:00)	on off	92	53	969.26	30	95	-3	-3.4
11/24/06 22:36:30.5 11/24/06 22:38:42.0	Train from SJ (Dep @ 21:15)	on off	132	92	1,682.50	30	148	-17	-11.4
11/25/06 16:16:00.5 11/25/06 16:17:18.0	Train from McAdam (Dep @ 13:10)	on off	77	32	585.22	30	67	11	16.3
11/26/06 20:41:26.5 11/26/06 20:42:20.0	Train from SJ (Dep @ 19:20)	on off	53	28	512.06	30	61	-8	-12.6
11/27/06 16:44:01.5 11/27/06 16:45:49.0	Train from McAdam (Dep @ 13:38) Dropped signal for 0.5 seconds	on off	107	59	1,078.99	30	103	4	3.9
11/27/06 23:04:55.5 11/27/06 23:06:18.0	Train from SJ (Dep @ 21:40)	on off	83	52	950.98	30	94	-11	-12.2
11/28/06 17:05:56.0 11/28/06 17:07:23.5	Train from McAdam (Dep @ 14:00)	on off	88	51	932.69	30	93	-5	-5.5
11/28/06 22:25:43.5 11/28/06 22:27:28.0	Train from SJ (Dep @ 20:45)	on off	105	49	896.11	30	90	15	16.3
11/29/06 15:23:11.0 11/29/06 15:24:48.0	Train from McAdam (Dep @ 12:20)	on off	97	56	1,024.13	30	99	-2	-2.4
11/29/06 23:39:03.0 11/29/06 23:40:32.5	Train from SJ (Dep @ 22:20)	on off	90	50	914.40	30	91	-2	-1.9
11/30/06 16:14:24.5 11/30/06 16:15:35.5	Train from McAdam (Dep @ 13:15)	on off	71	54	987.55	30	97	-26	-26.5
11/30/06 20:38:35.5 11/30/06 20:39:59.0	Train from SJ (Dep @ 19:20)	on off	84	36	658.37	30	72	11	15.8
12/01/2006 16:44:06 12/01/2006 16:45:20	Train from McAdam (Dep @ 13:43)	on off	74	38	694.94	30	75	-1	-1.1

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
12/01/2006 22:12:55 12/01/2006 22:13:53	Train from SJ (Dep @ 20:50)	on off	58	57	1,042.42	30	101	-43	-42.4
12/02/2006 16:42:40 12/02/2006 16:44:01	Train from McAdam (Dep @ 13:23)	on off	81	38	694.94	30	75	6	8.3
12/03/2006 20:52:44 12/03/2006 20:53:58	Train from SJ (Dep @ 19:30)	on off	74	40	731.52	30	78	-4	-5.2
12/04/2006 18:48:53 12/04/2006 18:50:47	Train from McAdam (Dep @ 15:05)	on off	114	62	1,133.86	30	108	6	5.5
12/05/2006 0:07:51 12/05/2006 0:08:56	Train from SJ (Dep @ 22:50)	on off	65	36	658.37	30	72	-7	-9.8
12/05/2006 17:34:57 12/05/2006 17:36:42	Train from McAdam (Dep @ 14:40)	on off	104	64	1,170.43	30	110	-6	-5.7
12/05/2006 21:28:12 12/05/2006 21:29:36	Train from SJ (Dep @ 20:05)	on off	85	55	1,005.84	30	98	-13	-13.3
12/06/2006 18:07:33 12/06/2006 18:08:57	Train from McAdam (Dep @ 15:06)	on off	83	49	896.11	30	90	-6	-7.0
12/06/2006 22:13:39 12/06/2006 22:15:05	Train from SJ (Dep @ 20:50) Dropped signal for 1 second	on off	86	42	768.10	30	80	6	7.1
12/07/2006 16:45:52 12/07/2006 16:46:38	Train from McAdam (Dep @ 13:50)	on off	46	14	256.03	30	42	4	10.5
12/07/2006 22:03:58 12/07/2006 22:05:44	Train from SJ (Dep @ 20:45)	on off	107	62	1,133.86	30	108	-1	-1.0
12/08/2006 15:51:07 12/08/2006 15:52:17	Train from McAdam (Dep @ 12:36)	on off	70	31	566.93	30	65	4	6.5
12/08/2006 21:43:03 12/08/2006 21:44:36	Train from SJ (Dep @ 20:20)	on off	93	52	950.98	30	94	-1	-1.0
12/09/2006 18:16:22 12/09/2006 18:18:14	Train from McAdam (Dep @ 14:55)	on off	111	71	1,298.45	30	120	-8	-6.9
12/10/2006 21:49:32 12/10/2006 21:51:17	Train from SJ (Dep @ 20:00)	on off	105	56	1,024.13	30	99	5	5.2
12/11/2006 18:25:29 12/11/2006 18:27:27	Train from McAdam (Dep @ 15:00)	on off	118	72	1,316.74	30	121	-4	-3.0
12/11/2006 22:16:42 12/11/2006 22:17:52	Train from SJ (Dep @ 20:55)	on off	70	43	786.38	30	82	-12	-14.3
12/12/2006 15:46:14 12/12/2006 15:47:14	Train from McAdam (Dep @ 12:55)	on off	60	32	585.22	30	67	-7	-10.0
12/12/2006 22:06:23 12/12/2006 22:07:36	Train from SJ (Dep @ 20:45)	on off	73	39	713.23	30	76	-3	-4.2
12/13/06 16:04:12.5 12/13/06 16:05:17.0	Train from McAdam (Dep @ 12:55)	on off	64	30	548.64	30	64	1	0.9
12/13/06 22:20:18.0 12/13/06 22:21:33.0	Train from SJ (Dep @ 21:00)	on off	75	39	713.23	30	76	-1	-1.6
12/14/06 18:32:28.5 12/14/06 18:33:59.0	Train from McAdam (Dep @ 15:30)	on off	91	60	1,097.28	30	105	-14	-13.7
12/14/06 23:11:23.0 12/14/06 23:12:57.0	Train from SJ (Dep @ 21:35)	on off	94	49	896.11	30	90	4	4.6
12/15/06 16:11:00.5 12/15/06 16:12:01.0	Train from McAdam (Dep @ 13:10)	on off	60	30	548.64	30	64	-3	-5.3
12/15/06 21:32:03.5 12/15/06 21:33:25.5	Train from SJ (Dep @ 20:10)	on off	82	52	950.98	30	94	-12	-12.7
12/16/06 16:38:11.5 12/16/06 16:38:56.5	Train from McAdam (Dep @ 13:45)	on off	45	20	365.76	30	50	-5	-10.5
12/17/06 22:02:34.5 12/17/06 22:04:00.5	Train from SJ (Dep @ 20:40)	on off	86	58	1,060.70	30	102	-16	-15.8

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
12/18/06 19:11:51.0 12/18/06 19:13:39.0	Train from McAdam (Dep @ 16:06)	on off	108	51	932.69	30	93	15	16.7
12/18/06 23:03:39.0 12/18/06 23:04:59.5	Train from SJ (Dep @ 21:40)	on off	81	54	987.55	30	97	-16	-16.7
12/19/06 20:03:41.0 12/19/06 20:06:22.5	Train from McAdam (Dep @ 16:35)	on off	162	100	1,828.80	30	159	2	1.3
12/19/06 23:46:09.0 12/19/06 23:47:26.5	Train from SJ (Dep @ 22:25)	on off	78	47	859.54	30	87	-10	-11.0
12/20/06 16:36:04.0 12/20/06 16:37:25.0	Train from McAdam (Dep @ 13:35)	on off	81	43	786.38	30	82	-1	-0.8
12/20/06 21:51:32.0 12/20/06 21:53:05.5	Train from SJ (Dep @ 20:30)	on off	94	60	1,097.28	30	105	-11	-10.8
12/21/06 17:26:19.5 12/21/06 17:28:13.0	Train from McAdam (Dep @ 14:15)	on off	113	74	1,353.31	30	124	-10	-8.4
12/21/06 21:01:41.5 12/21/06 21:02:44.5	Train from SJ (Dep @ 19:45)	on off	63	34	621.79	30	69	-6	-9.2
12/22/06 17:06:22.0 12/22/06 17:07:46.5	Train from McAdam (Dep @ 14:05)	on off	84	45	822.96	30	84	0	0.2
12/23/06 00:17:40.5 12/23/06 00:19:38.0	Train from SJ (Dep @ 22:55)	on off	118	75	1,371.60	30	125	-8	-6.2
12/23/06 15:43:51.0 12/23/06 15:44:37.0	Train from McAdam (Dep @ 12:24)	on off	46	20	365.76	30	50	-4	-8.5
12/26/06 21:21:50.5 12/26/06 21:53:45.5	Train from SJ (Dep @ 19:34)	on off	1915	48	877.82	30	88	1827	2064.8
12/27/06 21:38:20.5 12/27/06 21:40:56.5	Train from McAdam (Dep @ 17:50)	on off	156	72	1,316.74	30	121	35	28.7
12/28/06 00:19:04.0 12/28/06 00:20:17.0	Train from SJ (Dep @ 23:00)	on off	73	37	676.66	30	73	0	-0.6
12/28/06 18:04:58.5 12/28/06 18:07:08.0	Train from McAdam (Dep @ 14:30)	on off	129	78	1,426.46	30	129	0	0.1
12/28/06 21:31:48.5 12/28/06 21:33:07.5	Train from SJ (Dep @ 20:10)	on off	79	45	822.96	30	84	-5	-6.4
12/29/06 16:30:57.5 12/29/06 16:32:03.0	Train from McAdam (Dep @ 13:40)	on off	65	34	621.79	30	69	-4	-5.6
12/30/06 00:10:49.0 12/30/06 00:12:45.5	Train from SJ (Dep @ 22:45)	on off	116	62	1,133.86	30	108	9	8.3
12/30/06 14:32:31.5 12/30/06 14:33:31.0	Train from McAdam (Dep @ 11:35)	on off	60	28	512.06	30	61	-2	-2.8
01/02/2007 21:40:31 01/02/2007 21:42:11	Train from SJ (Dep @ 20:20)	on off	100	63	1,152.14	30	109	-9	-8.6
01/03/2007 19:47:49 01/03/2007 19:50:17	Train from McAdam (Dep @ 16:50)	on off	148	77	1,408.18	30	128	20	15.6
01/03/2007 23:20:34 01/03/2007 23:22:21	Train from SJ (Dep @ 21:55)	on off	107	61	1,115.57	30	106	1	1.2
01/04/2007 16:54:53 01/04/2007 16:56:07	Train from McAdam (Dep @ 13:55)	on off	74	36	658.37	30	72	2	2.6
01/04/2007 22:06:47 01/04/2007 22:08:13	Train from SJ (Dep @ 20:40)	on off	86	53	969.26	30	95	-9	-9.2
01/05/2007 19:02:24 01/05/2007 19:04:31	Train from McAdam (Dep @ 16:40)	on off	127	79	1,444.75	30	131	-4	-2.9
01/05/2007 22:58:21 01/05/2007 22:59:52	Train from SJ (Dep @ 21:40)	on off	91	48	877.82	30	88	3	2.9
01/06/2007 16:00:20 01/06/2007 16:01:40	Train from McAdam (Dep @ 13:00)	on off	80	37	676.66	30	73	7	8.9

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
01/07/2007 22:23:49 01/07/2007 22:25:17	Train from SJ (Dep @ 21:00)	on off	88	53	969.26	30	95	-7	-7.6
01/08/2007 17:51:48 01/08/2007 17:53:10	Train from McAdam (Dep @ 15:00)	on off	83	51	932.69	30	93	-10	-10.9
01/08/2007 21:45:43 01/08/2007 21:47:08	Train from SJ (Dep @ 20:25)	on off	84	38	694.94	30	75	10	12.9
01/09/2007 18:42:48 01/09/2007 18:45:51	Train from McAdam (Dep @ 15:00)	on off	183	99	1,810.51	30	158	25	15.8
01/09/2007 22:41:18 01/09/2007 22:42:50	Train from SJ (Dep @ 21:20)	on off	93	41	749.81	30	79	14	17.8
01/10/2007 17:50:17 01/10/2007 17:51:43	Train from McAdam (Dep @ 15:00)	on off	86	60	1,097.28	30	105	-18	-17.5
01/10/2007 21:45:50 01/10/2007 21:47:33	Train from SJ (Dep @ 20:20)	on off	103	58	1,060.70	30	102	1	1.4
01/11/2007 15:49:54 01/11/2007 15:50:43	Train from McAdam (Dep @ 12:51)	on off	49	26	475.49	30	58	-9	-16.2
01/11/2007 22:28:24 01/11/2007 22:30:00	Train from SJ (Dep @ 21:05)	on off	96	53	969.26	30	95	1	0.8
01/12/2007 16:41:30 01/12/2007 16:42:49	Train from McAdam (Dep @ 13:40)	on off	78	51	932.69	30	93	-14	-15.2
01/12/2007 21:20:43 01/12/2007 21:22:38	Train from SJ (Dep @ 20:00)	on off	115	62	1,133.86	30	108	7	6.9
01/13/07 16:20:58.0 01/13/07 16:22:44.5	Train from McAdam (Dep @ 13:05)	on off	106	62	1,133.86	30	108	-1	-1.0
01/14/07 22:03:06.5 01/14/07 22:05:05.0	Train from SJ (Dep @ 20:40)	on off	119	63	1,152.14	30	109	10	8.8
01/15/07 17:14:52.5 01/15/07 17:16:33.0	Train from McAdam (Dep @ 14:20)	on off	100	66	1,207.01	30	113	-13	-11.1
01/15/07 21:29:45.0 01/15/07 21:31:09.5	Train from SJ (Dep @ 20:10)	on off	84	41	749.81	30	79	6	7.1
01/16/07 17:13:00.0 01/16/07 17:14:34.0	Train from McAdam (Dep @ 14:15)	on off	94	45	822.96	30	84	10	11.4
01/16/07 21:14:26.0 01/16/07 21:15:28.0	Train from SJ (Dep @ 19:55)	on off	62	25	457.20	30	57	5	8.6
01/17/07 17:41:11.0 01/17/07 17:42:14.5	Train from McAdam (Dep @ 14:45)	on off	64	32	585.22	30	67	-3	-4.7
01/18/07 00:20:48.0 01/18/07 00:22:13.5	Train from SJ (Dep @ 23:00)	on off	86	41	749.81	30	79	7	8.3
01/18/07 18:03:50.5 01/18/07 18:05:00.0	Train from McAdam (Dep @ 15:05)	on off	69	38	694.94	30	75	-5	-7.1
01/18/07 23:39:17.0 01/18/07 23:40:45.0	Train from SJ (Dep @ 22:00)	on off	88	55	1,005.84	30	98	-10	-10.2
01/19/07 16:05:38.5 01/19/07 16:06:56.5	Train from McAdam (Dep @ 15:05) Dropped signal for 0.5 seconds	on off	78	52	950.98	30	94	-16	-16.9
01/19/07 22:15:20.0 01/19/07 22:17:17.0	Train from SJ (Dep @ 20:50)	on off	117	56	1,024.13	30	99	18	17.7
01/20/07 20:07:44.5 01/20/07 20:09:17.5	Train from McAdam (Dep @ 17:10)	on off	93	57	1,042.42	30	101	-8	-7.7
01/21/07 21:46:03.0 01/21/07 21:47:29.0	Train from SJ (Dep @ 20:20)	on off	86	55	1,005.84	30	98	-12	-12.3
01/22/07 18:00:09.5 01/22/07 18:01:23.5	Train from McAdam (Dep @ 15:10)	on off	74	40	731.52	30	78	-4	-4.6
01/22/07 23:14:47.0 01/22/07 23:15:50.5	Train from SJ (Dep @ 21:45)	on off	64	30	548.64	30	64	0	-0.6

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
01/23/07 16:43:46.0 01/23/07 16:45:36.0	Train from McAdam (Dep @ 13:45)	on off	110	63	1,152.14	30	109	1	1.0
01/23/07 22:00:04.0 01/23/07 22:01:54.0	Train from SJ (Dep @ 20:35)	on off	110	59	1,078.99	30	103	7	6.3
01/24/07 18:30:10.5 01/24/07 18:31:08.0	Train from McAdam (Dep @ 15:10)	on off	57	24	438.91	30	56	2	3.2
01/24/07 21:45:08.0 01/24/07 21:46:33.0	Train from SJ (Dep @ 20:25)	on off	85	50	914.40	30	91	-6	-6.8
01/25/07 17:02:53.0 01/25/07 17:04:17.0	Train from McAdam (Dep @ 14:05)	on off	84	45	822.96	30	84	0	-0.4
01/25/07 22:09:23.0 01/25/07 22:11:07.5	Train from SJ (Dep @ 20:45)	on off	105	31	566.93	30	65	39	60.1
01/26/2007 16:41:14 01/26/2007 16:42:00	Train from McAdam (Dep @ 13:50)	on off	46	16	292.61	30	45	1	2.6
01/26/2007 21:50:03 01/26/2007 21:51:45	Train from SJ (Dep @ 20:30)	on off	102	55	1,005.84	30	98	4	4.1
01/27/2007 17:24:49 01/27/2007 17:27:00	Train from McAdam (Dep @ 14:25)	on off	131	68	1,243.58	30	116	15	13.2
01/28/2007 22:42:28 01/28/2007 22:44:07	Train from SJ (Dep @ 21:20)	on off	99	57	1,042.42	30	101	-2	-1.7
01/29/2007 17:39:46 01/29/2007 17:41:16	Train from McAdam (Dep @ 14:45)	on off	89	52	950.98	30	94	-4	-4.7
01/29/2007 21:23:03 01/29/2007 21:24:26	Train from SJ (Dep @ 20:05)	on off	83	34	621.79	30	69	13	18.9
01/30/2007 16:53:01 01/30/2007 16:54:19	Train from McAdam (Dep @ 14:45)	on off	78	52	950.98	30	94	-16	-16.9
01/30/2007 21:43:52 01/30/2007 21:45:05	Train from SJ (Dep @ 20:05)	on off	73	34	621.79	30	69	4	6.0
01/31/2007 20:02:59 01/31/2007 20:04:04	Train from McAdam (Dep @ 17:05)	on off	65	35	640.08	30	71	-6	-8.1
02/01/2007 0:17:37 02/01/2007 0:19:07	Train from SJ (Dep @ 22:59)	on off	91	50	914.40	30	91	-1	-0.8
02/01/2007 18:44:53 02/01/2007 18:46:37	Train from McAdam (Dep @ 15:50)	on off	103	62	1,133.86	30	108	-4	-3.8
02/02/2007 0:03:25 02/02/2007 0:04:56	Train from SJ (Dep @ 21:55)	on off	91	61	1,115.57	30	106	-16	-14.8
02/02/2007 17:56:13 02/02/2007 17:57:11	Train from McAdam (Dep @ 15:00)	on off	58	35	640.08	30	71	-13	-18.0
02/03/2007 0:41:45 02/03/2007 0:43:24	Train from SJ (Dep @ 23:20)	on off	99	61	1,115.57	30	106	-7	-6.8
02/03/2007 17:21:08 02/03/2007 17:22:27	Train from McAdam (Dep @ 14:20)	on off	79	43	786.38	30	82	-3	-3.8
02/05/2007 1:12:37 02/05/2007 1:13:58	Train from SJ (Dep @ 23:20)	on off	81	50	914.40	30	91	-10	-10.6
02/05/2007 19:51:02 02/05/2007 19:52:39	Train from McAdam (Dep @ 16:50)	on off	97	58	1,060.70	30	102	-5	-4.5
02/06/2007 0:01:42 02/06/2007 0:03:14	Train from SJ (Dep @ 22:40)	on off	91	47	859.54	30	87	4	4.5
02/06/2007 18:13:54 02/06/2007 18:15:19	Train from McAdam (Dep @ 15:15)	on off	85	46	841.25	30	86	0	-0.3
02/06/2007 21:32:14 02/06/2007 21:33:10	Train from SJ (Dep @ 20:10)	on off	56	23	420.62	30	54	1	2.1
02/07/2007 18:05:40 02/07/2007 18:06:42	Train from McAdam (Dep @ 15:10)	on off	62	35	640.08	30	71	-9	-12.3

Date Time	Notes	State	Recorded Activation Time (sec)	# of Cars	Length of Train (m)	Speed (mph)	Expected Activation Time (sec)	Difference	% Diff
02/07/2007 22:21:10 02/07/2007 22:22:39	Train from SJ (Dep @ 21:00)	on off	89	53	969.26	30	95	-7	-7.1
02/08/2007 18:24:10 02/08/2007 18:25:06	Train from McAdam (Dep @ 15:15)	on off	56	22	402.34	30	53	3	5.7
02/08/2007 22:33:39 02/08/2007 22:35:00	Train from SJ (Dep @ 21:12)	on off	80	53	969.26	30	95	-15	-15.5
02/09/2007 20:03:37 02/09/2007 20:05:15	Train from McAdam (Dep @ 17:00)	on off	98	65	1,188.72	30	112	-14	-12.2
02/10/2007 0:50:47 02/10/2007 0:52:14	Train from SJ (Dep @ 23:30)	on off	87	47	859.54	30	87	0	-0.1
02/10/2007 17:06:24 02/10/2007 17:07:55	Train from McAdam (Dep @ 14:15)	on off	92	45	822.96	30	84	8	9.0
02/11/2007 21:54:42 02/11/2007 21:55:54	Train from SJ (Dep @ 20:35)	on off	72	36	658.37	30	72	0	-0.1
02/12/2007 18:54:40 02/12/2007 18:56:10	Train from McAdam (Dep @ 16:00)	on off	90	51	932.69	30	93	-3	-3.3
02/12/2007 23:48:41 02/12/2007 23:50:04	Train from SJ (Dep @ 22:30)	on off	83	47	859.54	30	87	-4	-4.7
03/22/2007 17:32:57 03/22/2007 17:34:38	Train from McAdam (Dep @ 14:40)	on off	100	73	1,335.02	30	123	-23	-18.4
03/23/2007 17:48:13 03/23/2007 17:49:16	Train from McAdam (Dep @ 14:50)	on off	63	36	658.37	30	72	-9	-11.9
03/24/2007 17:42:02 03/24/2007 17:43:42	Train from McAdam (Dep @ 13:55)	on off	101	64	1,170.43	30	110	-9	-8.4
03/26/2007 18:33:15 03/26/2007 18:35:11	Train from McAdam (Dep @ 15:35)	on off	116	64	1,170.43	30	110	6	5.2

* Activation Time Includes Interruption