Israel Railways No Fault Liability Renewal – The Implementation of New Technological Safety Devices at Level Crossings

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Abstract

Two major train accidents, which occurred during 2005 and 2006 with many casualties, initiated major safety changes and improvements, supported by the Israeli Ministry of Transportation and the Israeli Ministry of Finance. Level Crossing Safety Survey was conducted in order to match the optimal technological solution to each LC. Processing survey results enabled mapping of problematic level crossings and fitting of the appropriate solution to each of them. On the basis of the Level Crossing Safety Survey and according to the recommendations of Special Technological Committee it was decided to implement 2 general kinds of devices: prevention devices and treatment devices. In this framework the new technology based on loop detection accompanied with special algorithm was developed. According to the successful pilot, massive implementation of the loop detection system was recently started, followed by deep analyses of its influence, advantages and disadvantages. The philosophy behind this process was to implement a reliable and effective device based on simple, industrial, well known and approved equipment, cheap and easy to install and to maintain, as a part of "basic protection" on each Level Crossing. This concept has replaced the existing policy of expensive and complex devises selective implementation based on risk analysis.

Introduction

The Level Crossing Safety Management can be described as a pyramid in which the basis consists of a set of prevention methods, divided into two main layers: the bottom layer that includes not-technological measures (such as education, propaganda, enforcement) and the higher layer that focuses on technological measures (such as preliminary signs, preliminary lights, pigmentation of LC...
surface). On the top of the pyramid is the accident treatment, including not-technological measures (for instance, observers or operators) and technological devices (like scan radar or VMD camera). The common strategy focuses on the basis of this pyramid by means of huge long-term investments in order to reduce (but not to eliminate) the probability of next accident.

On the other hand, the head of the pyramid requires expensive sophisticated solutions in order to deal with the accident when it happens. Because of the relatively small number of accidents it is very hard to predict precisely where will be the next one, meaning that there is always a chance to accident on the supposedly "not dangerous" Level Crossing not equipped with the appropriate devices.

Deep analysis of the described problem pointed the necessity of new strategy that will focus on the top of the pyramid meaning effective accident treatment on each Level Crossing.

**Level Crossings Safety Activity in Israel**

Two major train accidents, which occurred during 2005 and 2006 with many casualties, initiated major safety changes and improvements, supported by the Israeli Ministry of Transportation and the Israeli Ministry of Finance. First of all, these lethal level crossings were blocked immediately after the accidents by order of the Minister of Transportation. Step by step, the Safety Division on the Israel Railways was established, and State-of-the-Art knowledge and technology were accumulated from British, French, German and others regulations and rules. Two committees, investigation Committee (Pelled) and a Technological Committee (Ben-Israel), were established. The nomination of these committees established a broad framework to promote and improve railways safety.
11th World Level Crossing Symposium
Toward further improvement of level crossing safety -
Coordinated Approach and Individual Efforts

In 2006 the new level crossings safety regulations were published and massive
time and financial investment was granted. The “Level Crossings Engineering
Team” was established, including representatives of Israeli railways, the
ministry of transportation, police, local authorities, etc. This team has conducted
an engineering survey at all level crossings in order to indicate the scope of the
infrastructure improvements, which is possible to fulfill on the basis of new
regulations. The Level Crossings Inter-ministerial Administration Committee,
headed by the general manager of the Ministry of Transportation, was
established. This committee is in charge of making the final approval for the list
of priorities of different safety improvements suggested by the Israeli railways,
and for the elimination of level crossing (after preliminary hearing process).

Step by step, all Level Crossings on passenger lines were protected with barriers,
flashing lights and bells. Level Crossing Safety Survey was conducted in order
to identify possible risk factors which can cause an accident on LC. Analysis of
all the scenarios pointed that collision of train and a car is the most dangerous
and catastrophic in potential. That’s why it was decided to focus on factors
which can possibly lead to train-car accident. Three main scenarios were
recognized: vehicle "stuck" on LC because of downstream queue spill, car driver
failed to stop before activated LC because of visibility problem, and the last
scenario: car broke a barrier and stuck on the track. First two scenarios include
"normative" users, while the third one focuses on "not-normative" behavior.

In order to match the optimal technological solution to each LC according to
described above scenarios, all Level Crossings were surveyed with respect to
following issues:

Queue spill on crossing, including:
- Direction of spill
- Duration of spill
- Existence of nearby junction and distance from crossing

Visibility problems of vehicle drivers approaching crossing:
- Curve on approach to crossing
- Vegetation blocking view
- Other disturbances

Barrier damages statistics:
- Frequency of barriers breaking
- Reason of barriers breaking.

Processing survey results enabled mapping of problematic level crossings and
fitting of the appropriate solution to each of them.
New Technologies for the Level Crossings Safety Improvement

On the basis of the Level Crossing Safety Survey, as described above, and according to the recommendations of Technological Committee (Ben-Israel), it was decided to implement 2 general kinds of devices:

- **Prevention** by means of preliminary warning devices (preliminary traffic lights, active warning signs).
- **Treatment** by means of obstacle detection devices (scan radar, video motion detection camera, loop detection system).

A majority of these devices has no proven experience, except the scan radar which was used in Germany and Italy. So, a special pilot was conducted for each kind of devices (each kind of device was installed on two different LC). The pilot results were positive in the matter of reliability and vehicle driver's behavior, and massive implementation was recently started. Step by step the deep analysis of these new technologies influence, advantages and disadvantages is performed.

The new technologies, as described above, have a potential to wide implementation on different kinds of level crossings according to their geometry, location, distance to downstream intersection, visibility and other characteristics. Also, the wide range of techniques enables to choose the appropriate optimal solution to each kind of level crossing.

**Vehicle queue prevention using preliminary traffic lights**

The profound examination of different kinds of accidents on level crossings identifies a lot of vehicle queue events, because of the traffic jam downstream. In order to prevent cars gathering on the level crossing it was suggested to install the preliminary traffic signal about 24 meters before the barrier. The system consists of traffic lights, controller, and queue detector downstream. The controller receives continuous pulse from train signaling system when barrier is activated. The light switches to red when:

- Train approaches
- X seconds of continuous occupation of queue detector.

The number of parameters needs to be defined according to the geometry of level crossing:

- Distance of downstream junction from LC
- Length of LC
- Distance between queue detectors and the track
- Distance between barrier stopping line and signal stopping line
- Time duration for queue detection.
The design parameters cannot be established categorically for all crossings, thus traffic simulation model was used to determine optimal parameters to each level crossing.

Preliminary warning active signs for vehicle driver

In cases when there are visibility problems of vehicle drivers approaching crossing, such as a curve or vegetation blocking view, there is a need to preliminary alert of vehicle driver, especially when the barrier is already activated. In order to solve this problem the preliminary warning active signs were installed. This system consists of permanent traffic sign integrated with small flashing lights. When the train is approaching a pulse from the train signaling system activates the flashing lights. The goal of this system is alerting approaching vehicle about 100 meters before the level crossing when barrier is activated.

New concept of Level Crossing protection

The report of the Technological Committee (Ben-Israel) as described above included a wide international bibliography summary and the list of technologies recommended for implementation on level crossings in Israel. One of the most important recommendations was to consider implementation of reliable and effective device based on simple, industrial, well known and approved equipment, cheap and easy to install and to maintain. The philosophy behind this decision was to implement such kind of devices as an integral part of "basic protection" on each Level Crossing. This concept has replaced the existing policy of expensive and complex devices selective implementation based on risk analysis. The two main problems of the existing policy are the difficulty of accident probability prediction and the extremely high price of technological safety devices. Instead of pointed investment according to risk level modeling (process that eliminates a small part of risk by means of huge investment) it was decided to cover all existing Level Crossings with a system that become a basic safety tool-kit (process that eliminates about 99% of risk by means of relatively small investment).

The new detection system was design according to the described concept. The system is comprised of autonomous detection and alert components at the Level Crossing, a priority driven central monitoring and control center, and a unique data collection and analysis center which gathers statistics, runs remote diagnostics, and allows precise event debriefing. The goals of this system are detecting vehicles that are stuck at the level crossing area, alerting approaching train and stopping if necessary, according to preset policy. Special algorithm was developed, based on the following principles:

- Vehicle passing detection
- Stuck vehicle detection
Irregular movements detection
Alert removal according to preset policy
Malfunction detection.

The system based on inductive loop sensors for vehicle detection. This technology was chosen due to several compelling reasons:

- Proven all weather reliability
- Familiar and Popular device
- Quick and low-cost installation
- Simple and low-cost maintenance
- Not susceptible to vandalism.

Figure 2: The Loop Detectors system architecture
The system consists of detection subsystem, an emergency alert transmission unit and a special control unit. The detection subsystem is comprised of a set of inductive loop sensors and a detection algorithm controller. The sensors are installed in a specific configuration meant to ensure vehicle detection between barriers and to avoid train and rails detection. The algorithm controller evaluates the sensor readings together with the signal from the level crossings barrier and generates the relevant commands to the other components. The detection subsystem is autonomous in its detection and action decisions. This ensures that as long as the core safety components are functional at the LC, an alert will be transmitted to nearby trains upon identification of a high risk situation.

The emergency alert transmission unit is comprised of a VHF transmitter and a controller. The unit includes a number of preset recordings and is tuned to the emergency frequency. The controller receives commands to transmit preset messages either from the detection subsystem or from the central control. The automatic alert transmission can be overridden by an operator at the safety control center.

The special control unit integrates between the different components at the LC and handles the primary bidirectional communication between the remote centers and the level crossings. This special unit includes:

- Integrated Day/Night visual sensors
- IR illumination
- Multiple communication channels
- A versatile data collection module
- Remote command and command relay capabilities.

A central monitoring and control station at the safety control center is constantly connected to all the level crossings. While the number of monitored crossings may be large, the central control station employs an advanced prioritization logic which allows a single operator to view only those LC which are relevant at any given moment. Via the central control station, the operator may request to initiate various actions at the LC (e.g. request live viewing of a specific crossing). Real time data of the various sub-systems at each crossing are displayed. Upon an event, the relevant Level Crossing window is displayed to the operator accompanied with a sound alert. The Level Crossing’s window is prioritized between other active windows and assigned a color according the risk assessment. In the Level Crossing’s window, the cause of the event is displayed together with current status of all the subsystems at the LC. All events and actions are logged. The central monitoring and control station is synchronized with all Level Crossings.

Safety operators at the center can monitor and control a large number of Level Crossings simultaneously. Thanks to an advanced priority driven display, the operator can be focused on the relevant level crossings at any given time, while
he is free to request information and control any specific LC at any time. In addition, the controller continuously collects and sends data from all system’s components at the LC to a technical center where data is collected and analyzed. The data collected at the technical center facilitates advanced capabilities such as:

- Up-to-the-millisecond debriefing of events
- Statistical analysis
- Remote central diagnostics
- Event simulation at any of the Level Crossings.

Affordability was one of the main design objectives of the system in order to make an “all Level Crossings” deployment strategy feasible. Despite the system’s low cost (about 50,000 euro per LC), versatility and modularity were kept in order to allow adaptation of the systems characteristics to the relevant operating environment. Aspects such as power supply restrictions at the LC and availability of different communication platforms for emergency and control can all be tailored for [1].

The advantages of the described system are:

- System components are well-known and approved (especially as a part of intersection traffic lights system)
- Quick and low-cost installation
- Easy and low-cost maintenance

The disadvantages of the system are:

- Not incorporated with train signaling system
- No detection of non-metal objects.

**Potential for implementation and added value to safety**

During the past 9 months 17 Loop Detectors systems were installed in Israel and about 10 additional systems will be implemented during the next three months. The final goal is to install these devices on all Level Crossings in Israel during next year according to the concept of "basic safety tool kit". The massive implementation of the new detection system will provide an effective accident treatment and the new safety standard on each Level Crossing.

**References**