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Projects to Improve Safety at Railway-Pedestrian Level Crossings

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Abstract

A brief description of two traffic signal projects is presented. The projects have been designed to provide more information on the protection and operational status of railway level crossings to achieve a higher probability of successful performance for pedestrians and final rail and road operators.

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Introduction

The railway track has a unique characteristic: it includes a dedicated track exclusively for rail vehicles, which have the right of way in traffic circulation. This means that pedestrians, passersby, and automobiles are not permitted to travel along the track and may only cross it at properly designated and authorized locations, known as railway-pedestrian crossings or level crossings (LCs).

Railway crossings, railway-pedestrian crossings, and pedestrian level crossings are part of what is known as "interaction environments" within the operational railway context defined for our complex socio-technical system. These specific environments constitute a risk interface in operational processes related to rail transport as well as in those related to road transportation, including pedestrian traffic.

The risks of accidents and incidents at railway and pedestrian level crossings will remain at acceptable levels as long as the rules of coexistence between road-pedestrian traffic and rail traffic are properly followed. When this does not occur, the risks provoke a hazardous event, which can lead to undesirable occurrences that generally result in human injuries and/or material damage. The undesirable events are referred to as "level crossing accidents" or "bimodal accidents."

The purpose of this article is to share initiatives and actions aimed at reducing the aforementioned risks with the reader. Without being exhaustive, there are two basic management action groups applied in Safety Management Systems (SMS): the implementation of preventive and predictive strategies, and the implementation of defense barriers for risk management in the transportation system. In this article, two projects are presented that fall into the second group of actions: Train Signal Traffic Light and Other Train Traffic Light, both designed for railway-pedestrian crossings.

According to the aspects that define the operation of defense barriers within the framework of an SMS, the classification includes various conceptual issues. They take into account the different characteristics that devices or instruments may have in relation to the mode of operation and effectiveness compared to the function for which they are designed.

In general, defense barriers are devices or instruments that detect and manage unacceptable deviations occurring in an element, system, subsystem, or process, and counter the effects by minimizing possible consequences. These devices can be material or immaterial and act when active failures occur, not before. Defense barriers, ranging from the most rigid to the most flexible, can be physical, symbolic, functional, or organizational. While the effectiveness of barriers follows the order in which they are listed, an immaterial or organizational defense barrier is not necessarily weak. A strong and positive safety culture within an organization can serve as a very powerful defense barrier.

> ***"The risks of accidents and incidents at railway and pedestrian level crossings will remain at acceptable levels as long as the rules of coexistence between road-pedestrian traffic and rail traffic are properly followed.***

The projects developed in this article refer to the implementation of defense barriers classified as symbolic-functional. By providing more information about the protection status and operational state of railway crossings, the barriers increase the likelihood of successful human performance for final railway operators (Train Signal Traffic Light project) as well as for key road actors and pedestrians (Other Train Traffic Light project).

General Characteristics of Safety Technical Projects Implementation

In general, the Safety Technical Projects have two origins: the dealing with the problem and the proposal of improvement aspects as common safety objectives.

The two projects discussed in this article originate from addressing the problem, as vehicle and pedestrian collisions at level crossings represent a significant issue in the current rail transportation process.

The information collected from risk indicators along with their Probable Cause Systems (which have eventually led to specific Safety Recommendations) served as the starting point for the development of the projects.

It should be noted that the sources of information do not originate solely from accidents and incidents, but also from tele-surveying processes (static and dynamic Closed-Circuit Television [CCTV] and drone surveys) and predictive monitoring processes (online static and dynamic CCTV).

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Static refer to the information coming from fixed CCTV installed at level crossings, stations, and high-risk areas, and dynamic refer to the information coming from mobile CCTV installed on trains or from tele-surveys using cameras like GoPro, placed on the rolling stock occasionally. Regarding the collected information, it is important to note that the Criticality or Risk Index assigned to a crossing is not exclusively related to the number of accidents or the levels of severity reached (number of casualties or damage), but rather considers the potential risk condition based on the specific characteristics of a crossing. In many cases, there may be a higher potential risk for a crossing that reports fewer accidents than another.

Regarding the development of the projects addressed in this article, we consider the support of Design Thinking[1], processes to be fundamental. This spirit is consistently upheld by the safety team at Trenes Argentinos Operaciones when approaching projects or action plans. This methodology aims to achieve innovation within an organization by introducing changes to an element, device, system, subsystem, process, regulatory aspect, or service, based on a specific purpose. Throughout the process, participatory thinking is applied by a multidisciplinary team focused on design innovation, composed of areas with the necessary technical competencies and those that understand the final use conditions of the proposed solution.

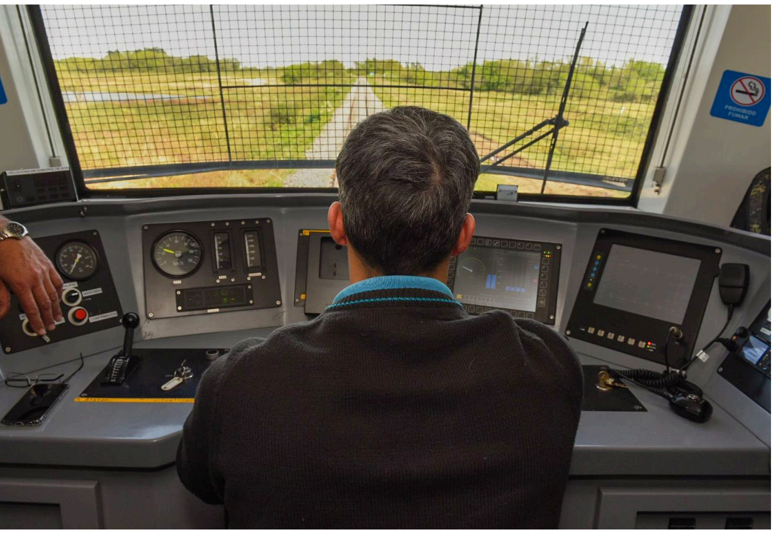

Photo: courtesy of Trenes Argentinos.

In the solution processes proposed for the "Train Signal Traffic Light" and "Other Train Traffic Light" projects, the five stages required by the mentioned methodology were applied, leading to the prototyping and field evaluation phases, where verification and validation processes were applied.

1. Methodology that is conceptually more product-oriented, although it can be used for the design or redesign of processes or aspects necessary for the management of change in an organisation.

Another characteristic aspect of the way we approach Safety Projects is related to the concept of a "pilot plan," meaning the direct implementation on the line or sector where the proposed development takes place. The duration of a pilot plan can depend on multiple factors: prototype development, budgets, actions within the supplier's domain, supplier development, negotiations with municipal bodies, dealings with regulatory authorities, regulations, etc.

The implementation of the projects involves essential aspects that go beyond the boundaries of the railway organization itself and often present greater challenges than a technical solution. Pilot plans are highly useful to stress the implementation and observe all possible circumstances, many of which are often unforeseeable during the design phase.

Train Signal Traffic Light Project for Level Rail-Pedestrian Crossings[2]

The technical condition of the infrastructure in the railway operational area of the Buenos Aires Metropolitan Area (AMBA) coexists with various protection systems at rail crossings and rail-pedestrian crossings.

The barriers that restrict access to the operational area at a crossing can be operated automatically, via a control logic (electromechanical operation through track-circuit detection), or manually by a specialized operator (level crossing guard or gatekeeper). The operator ensures the crossing's protection by manually moving the barrier arms or activating an electromechanical system that performs this action, even remotely (telecommanded barriers). There are also manual operations conducted from a signal cabin.

Within this set of systems, the most favorable current scenario is the use of automatic barriers, which offer an intrinsic safety condition (fail-safe) with an approach circuit complemented by ATS/ATP (Automatic Train Stop).

The operational irregularity of a train passing through with a raised barrier is considered a critical Safety Non-Conformity. This active failure can clearly be part of the Probable Cause System for accidents and incidents, such as a collision with a vehicle at a level crossing.

2. This project was initiated by the Roca line's Operational Safety Department, which reports to the Operational Safety Management of Trenes Argentinos Operaciones, and has the co-participation of the Roca line's Management and other key players, such as the line's Signalling area, the Engineering Department of SOFSE Central, the Technical Development and Standards Department, the Training Department of the La Fraternidad union of the Roca line, together with driving staff, and the Roca line's Development and Technical Standards Department, the Engineering Management of SOFSE Central, the Sub-management of Technical Developments and Standards, the Training area of the La Fraternidad trade union of the Roca line together with the driving staff, and the Railway Technical Inspection Management of the National Commission for Transport Regulation (CNRT).

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Although the Train Signal Traffic Light project currently covers crossings equipped with automatic barriers, a new project is being developed for crossings protected by manual barriers. The new project considers significant operational differences, given that the safety level at manual crossings is closely tied to the operator's human performance and the process in which they represent the final stage.

Although automatic barriers are inherently safe, they can still be vulnerable to unsafe failure conditions, compromising the crossing protection process. In certain cases, the failure of the barrier arm to lower has been detected, not due to technical malfunctions, but because of voluntarily or involuntarily placed objects or devices, such as stakes installed by third parties or irregular overhead cable installations. These elements have severely affected the protection of the level crossing, creating highly unacceptable risks and even leading to accidents.

The Train Signal Traffic Light project originated from a Safety Recommendation (SR) related to a Preliminary Accident and Incident Report prepared by the safety division of Trenes Argentinos Operaciones on the Roca line. The report addressed a vehicular collision at the former rail level crossing on Ramella Street, on the Plaza Constitución–La Plata branch, near Bernal station (Quilmes city), which occurred on April 5, 2017. Among the measures suggested in the SR was the implementation of a train signal traffic light system, which marked the beginning of the design and development of the system.

"The Train Signal Light project foresees a feasibility study for the installation of a switchable beacon to provide information on detected irregularities."

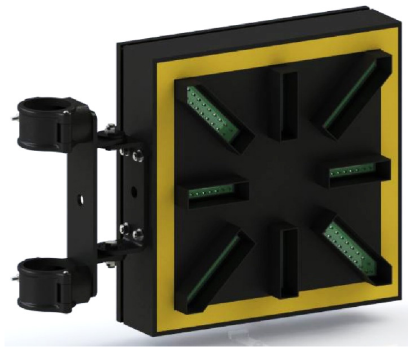
Fundamentally, it is a traffic light positioned ahead of the crossing, consisting of two LED modules. One module forms a hollow white "X" when activated, and the other displays a yellow LED cross at a 45° angle to the first, resembling a Greek cross. The traffic light also features a retroreflective yellow border.

Photo: courtesy of Trenes Argentinos.

The LED modules of the traffic light serve distinct purposes:

1. White X-shaped cross: Provides information to the train crew about the status and progress of the crossing's protection as the train approaches.
2. Yellow cross (+): Alerts the train crew to faults or irregularities detected at the crossing as the train approaches.

Figure 1. Side-supporte train signal traffic light (for lateral mounting on a pedestal or column)



Source: Trenes Argentinos Operaciones, 2019

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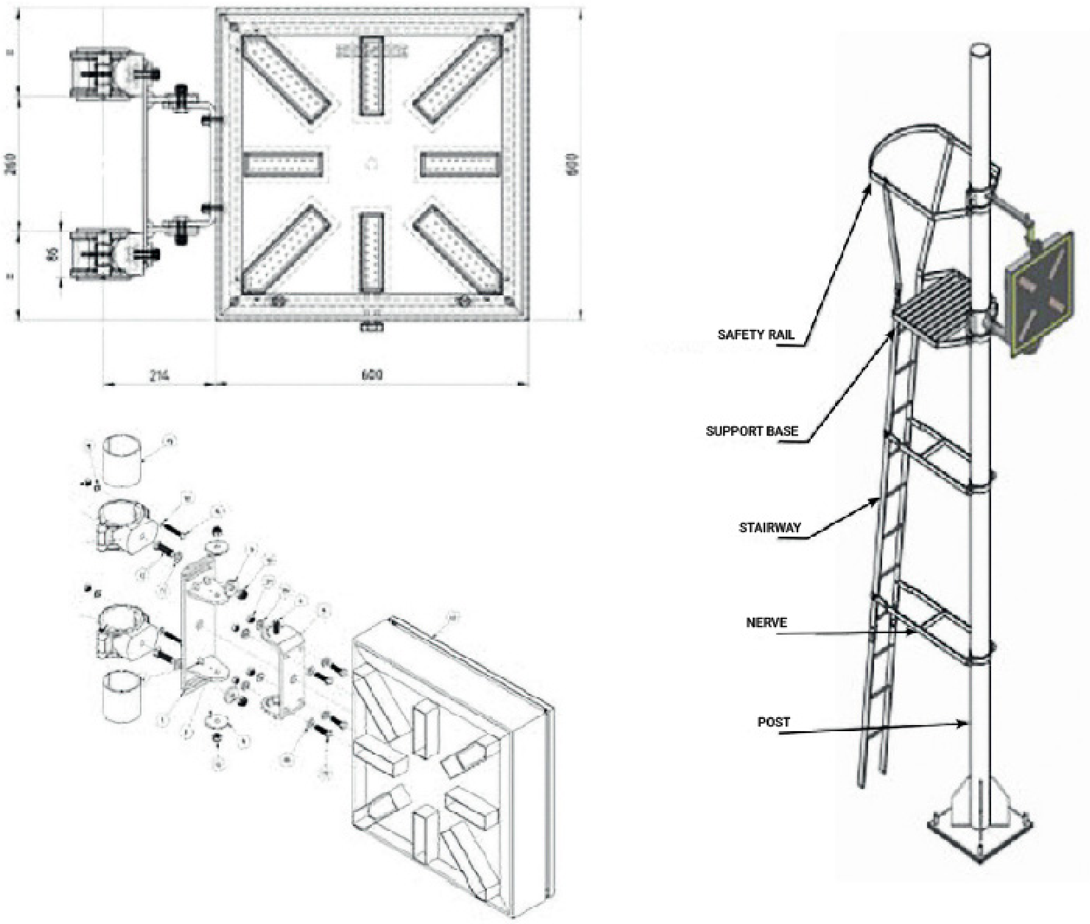
Figure 2. Schematics of the Train Signal Traffic Light



Source: Trenes Argentinos Operaciones, 2019

Operating Mode

Functionality of the White Cross (X)

- Signal off:
  - º Barrier arm positioned between 90° and 85° (vertical position).
    - * Level crossing with high barriers (unprotected).
- Flashing white cross:
  - º Barrier arm positioned between 85° and 5° (intermediate position).
    - * The barrier system is in a protection cycle (arm in the process of descending).
    - * The flashing frequency is synchronized with the frequency of the audio-visual signal.
- Steady white cross:
  - º Barrier arm positioned between 5° and 0° (horizontal position).
    - * Level crossing with low barriers (protected).

Functionality of the Yellow Cross (+)

The yellow cross serves to provide information to train operators about irregularities or failures in the system that can be detected at the level crossing. It is activated under various circumstances that indicate a failure in the protection of the level crossing: track circuit occupied for longer than a specified time with the barrier arm in a position other than horizontal, broken or damaged barrier arm, barrier arm stuck or held by an external object, inoperative audio-visual signal, signaling crew working on the system, additional systems such as trapped vehicle detection, possible remote operation by staff stationed at the level crossing, etc. The detection of failure conditions will depend on the sensors installed to identify the selected irregularities:

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- The yellow aspect, activated when a barrier experiences a failure (or irregular condition), will flash at double the frequency of the audio-visual signal system.

- The yellow aspect may be activated either locally or remotely (if this function is available) by authorized personnel from the relevant authority who deem this activation necessary.

- When the yellow aspect is activated, the operation of the white cross is automatically disabled.

Each railway crossing, whether single or double track, will have two signals: one for each direction of train traffic. There will also be an approach disc located 500 meters from the crossing, informing the train operator that they are approaching a level crossing equipped with this system.

The disc will also indicate when it is located in an area with consecutive level crossings.

Figure 3. Approach disc on the Plaza Constitución-La Plata branch of the Roca Line

Source: Trenes Argentino Operaciones, 2019.

Risk analysis and assessment methodologies allow for at least three alternatives for these processes[3] in some global safety management systems.

1. The application of recognized practical codes, approved and accredited by specialized regulations accepted in railway operations.

3. These criteria are drawn from research on regulations in other countries. Here they are expressed according to concept, adaptation and own development, product of such research.

2. The application of a risk-based approach through the implementation of a Preliminary Risk Analysis, which stems from the explicit assessment of risks and their control measures.

3. The selection of a reference system that is already in use, recognized, and proven in terms of its effectiveness and compliance regarding the subsystems involved in the project, when the similarity or equivalence of the intended implementation is verified.

The "Traffic Light to Train" project is based on the third alternative, as its implementation was investigated in other countries around the world. To adopt this reference system, the Spanish technical specification ET 03.365.522.6 for Special Railway Signals for LED Level Crossings (AIDF Spain, 2018) was analyzed, and illuminance measurements were conducted at the National Institute of Industrial Technology (INTI) on Spanish Electrans traffic lights, which were acquired and imported exclusively for this purpose. Additionally, during the prototyping phase, daytime and nighttime field tests were carried out with the participation of train operators, conducting verification runs focused on detection and glare.

Currently, 114 traffic lights have been installed on the Plaza Constitución-La Plata branch of the Roca Line in compliance with the first stage of implementation. The traffic lights are being logged to start operating.

Figure 4. Installation of the Traffic Light to Train in Plaza Constitución-La Plata Branch of the Roca Line

Source: Trenes Argentino Operaciones, 2019.

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The "Traffic Light to Train" project also includes a feasibility study to install a switchable beacon at the appropriate distance, providing early information about detected irregularities and enabling the train to reach a safe condition under the protection of the ATS system.

The outcome of the implementation has incorporated the contributions and opinions of all involved parties. Currently, a second phase of acquisition and installation of the traffic lights is being carried out on the same line of the State Railway Operating Company (SOFSE).

Other Train Traffic Light Project for Railway-Pedestrian Level Crossings[4]

This project was initiated in 2022 after observing a significant number of occurrences where motorists and pedestrians speed through the operational railway area at level crossings before the area is fully cleared by passing trains. The individuals proceed without realizing that after one train passes, another train may be approaching from the opposite direction or even from the same direction, leading to pedestrian and vehicular collisions, which often occur with the barriers in the horizontal position.

The purpose of the project is to provide information to pedestrians and road vehicles approaching the crossing about the presence of another train that may be approaching the level crossing, also indicating the direction from which it is coming. This could prevent the premature crossing by pedestrians and vehicles, reducing the high probability of accidents that occur in these situations.

As with the previous project, the traffic light that alerts about the approach of another train at level crossings aims to implement a symbolic-functional defense barrier that provides additional information. This will increase the likelihood of successful human performance, in this case, for vehicle users at level crossings.

This active protection system for railway-pedestrian and railway-vehicle-pedestrian crossings, already seen in other countries, such as Japan, consists of the automatic symbolic indication of semi-arrows that intermittently signal the presence of trains approaching the crossing where the traffic light is located.

4. The project was initiated by the Operational Safety Department of the Sarmiento Line, which reports to the Operational Safety Department of Trenes Argentinos Operaciones, and has the co-participation of the Sarmiento Line Management and key players such as the Signalling area of the Sarmiento Line, the Engineering Department of SOFSE Central, the Technical Development and Standards Department and the participation and support of the Railway Technical Inspection Department of the CNRT (National Railway Transport Regulatory Authority).

The project is currently in the verification stage, when field tests will be conducted as a pilot plan on the Once-Moreno electric branch of the Sarmiento Line.

Figure 5. Traffic light prototype developed by SOFSE Sub-management of Development and Technical Standards

Source: Trenes Argentinos Operaciones, 2019.

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"The Other Train Traffic Light project provides information to both pedestrians and vehicles about to cross, about the presence of another train that may be approaching the PAN, also indicating the direction from which it is coming."

Biography

Alejandro Leonetti. Mechanical Engineer, specializing in Rolling Stock and Safety applied to Railway Transportation. He joined Ferrocarriles Argentinos in the Mechanics Department of the General Roca Line in 1981 and has been involved in railway activities to date. He also holds a postgraduate specialization in Human and Organizational Factors in Risk Management from UDESA and a certification as a Facilitator Instructor in CRM and Human Factors focused on railway operations. He is currently in charge of the Safety Management at Trenes Argentinos Operaciones, an area established in 2014. In the academic field, he serves as a lecturer in Mobile and Towed Rolling Stock in the postgraduate Railway Engineering program at UBA, as well as in the Master's program in Transportation Planning and Management—Safety and Rolling Stock Safety at UBA. He also participates in the Master's program in Transportation at UTN and teaches in the Railway Safety courses of the degree in Railway Management and Technology at San Martín University and the degree in Railway Technologies at Lanús University. Additionally, he teaches classes for the degree in Safety Management at JST, DECAHF, and UTN (FRH).

CONCLUSIONS

The technical projects developed in this article, aimed at improving railway operations safety, are part of the Directed and Specific Actions outlined in the Railway Safety Management System in our country.

The main purpose of these actions is to reduce the risk rates occurring at railway-pedestrian level crossings, where there is a significant involvement of third-party active failures. Undoubtedly, any initiative in this regard will generate positive impacts on the overall safety of transportation, which includes pedestrians, motor vehicles, and railway vehicles, and on operational aspects related to costs from damages, cancellations, and delays that affect the railway system and the community as a whole.

Based on applications derived from a systemic approach aimed at improving transportation safety, it is important not to overlook the complete definition of a system. In this regard, we must consider the entirety of the subsystems that make it up, the interfaces between them, their performance characteristics, and the preventive and predictive actions based not only on technical factors but also on human, organizational, and cultural factors within the context of our complex sociotechnical system, namely, railway transportation.