Achieving Interoperability and Security in the Train-platform Interfaces

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ABSTRACT: *A well-designed interface between trains and platform systems ensures the interoperability and security of the systems. In Europe, inconsistencies in security aspects exist, and they need to be identified and controlled. In this work, we addressed the security issues to ensure smooth functioning.*

Keywords: Safety, Interoperability, Platform-train Interface

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1. Introduction

Technical Specifications for Interoperability (TSIs) are standards produced in accordance with the Railway Interoperability Directives. To achieve interoperability of the national railways with the European railway system, compliance with the TSIs is required. [3]

Safety is one of the essential requirements for achieving interoperability of the railway transport. Boarding and alighting passengers on train is a process of increased hazards and potential of incidents at the PTI. The Railway Safety Directive requires monitoring of the Common Safety Indicators (CSIs) at European level and in case of drastic deterioration of an indicator, proper measures are to be introduced to improve it. Some of the CSIs monitored by European Union Agency for Railways (EUAR) and related to the PTI safety are: [2]

•Total number of persons seriously injured in accidents to persons caused by rolling stock in motion;

•Total number of passengers seriously injured in accidents to persons caused by rolling stock in motion;

•Total number of passengers seriously injured in accidents to persons caused by rolling stock in motion relative to train km;

•Total number of passengers seriously injured in accidents to persons caused by rolling stock in motion relative to passenger train km;

•Passengers seriously injured in accidents to persons caused by rolling stock in motion relative to passenger km;
•Total number of persons killed in accidents to persons caused by rolling stock in motion.

Passenger means any person, excluding members of the train crew, who makes a trip by rail. For accident statistics, passengers trying to embark/disembark onto/from a moving train are included [2].

Results of various reports show an increase in incidents with passengers at the PTI, some of them fatal. This type of incidents account for most of the total passenger fatality risk on the railway network and about one-fifth of the overall passenger fatality and weighted injury risk [12]. To manage such risk we must acknowledge the PTI as part of the system that makes up the railway and not an isolated issue. Spatial studies for the needs of the German railways (DB) and the British railways have been devoted to that issue. In [9] the safety integrity level related to the hazards raised at the PTI is calculated for an individual required by the National Safety Authority of Germany. In the study three types of vehicles are taken into account for calculation of the tolerable individual risk by using three different approaches per vehicle. As a result, the authors recommend the installation of monitoring devices to reduce the risk. Statistics of passenger accidents at the PTI, as well as analysis of the factors affecting the risk is presented in [12] for the United Kingdom. A web based Platform Train Interface Risk Assessment Tool is developed by RSSB in order to manage the safety level case by case. Similar risk model [14] for the needs of DB determines the risk and the necessary safety measures on the platform.

One of the main hazards at the PTI comes in the gap between the platform and the footstep of the rolling stock. This paper analyses the status of the technical rules defining the platform offset from the track centre with highlight to the Bulgarian case, where the possible lack of compliance is identified.

2. System Definition

The PTI is identified by the fixed installation system from one side, which is the platform and from the other side the rolling stock. The position of the platform, in particular the platform edge, in reference to the track is defined by a platform height measured from the rolling surface and a platform offset measured from the track centerline. The various rolling stock manufactures lead to great variety of systems serving the passengers by boarding and alighting on train. As a result comes the gap between the platform and the rolling stock. Figure 1 depicts the platform-train interface definition. [6]

• *Platform offset* is the distance between the upper surface of the platform edge and the running edge of the nearest rail on the track adjacent to the platform, measured parallel to the plane of the rails.
• *Step* is the vertical distance between the platform surface and the train stepping surface.
• *Gap* is the horizontal distance between the edge of the platform and the edge of the train stepping surface.

where, *a* the height difference between the rolling surface and the boarding step
b height of the platform *dh* distance from the platform edge to the boarding step
dv+/- the height difference between the platform surface and the boarding step
bq distance from the platform edge to the track centreline (platform offset)
e depth of the step, if applicable

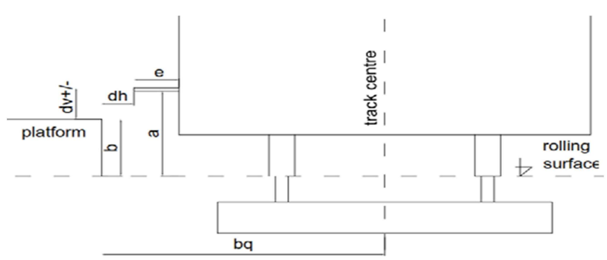


Figure 1. Platform-train interface

3. Rule-based Approach Analysis

At European level, the legislation applicable to determine the position of the platform edge is [4] and [6]. As per p. 4.2.9.2 and p. 4.2.9.3 of the technical specifications for interoperability relating to the 'infrastructure' subsystem (TSI INF) [4] the nominal height *(h_q)* shall be 550 mm or 760 mm for radius of 300 m or more, while the platform offset shall be calculated for the installation limit gauge *(b_{qlim})* on the basis of the reference clearance profile G1 as defined in chapter 13 of [6] (Figure 2).

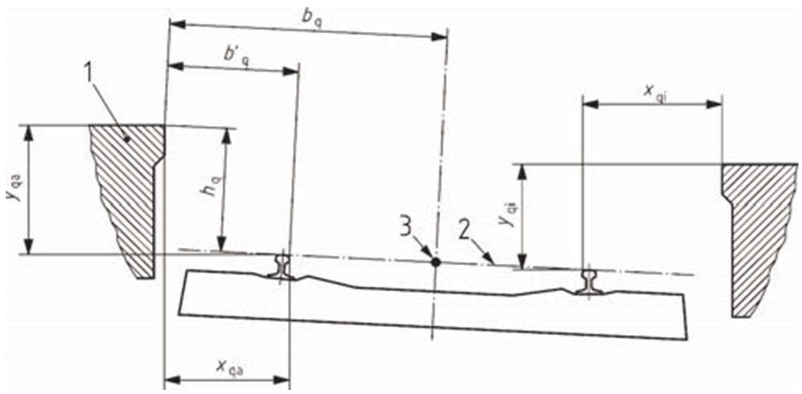


Figure 2. Installation of the platform

Chapter 13 of [6] states that "the platform shall be installed as close as possible to the passenger coaches whilst ensuring the safety of the rail traffic. It is important to limit the gap between the vehicle steps and the platform edges in order to provide acceptable stepping distances for passengers." Following the provision of [6] the simplified formula for calculation of the platform offset in straight level line is

$$b_{qlim} = b_{cr} + \Sigma_{2cin} \qquad (1)$$

where, b_{cr} = 1620 for heights from 550 mm to 760 mm according to the reference clearance profile G1;

Σ_{2cin} is calculated for installation limit gauge and takes into account the following coefficients of the allowances: track position error, cross level error, as well as oscillations; loading dissymmetry and suspension adjustment dissymmetry of the vehicle.

Based on the recommended coefficients of the allowances, the calculated value for b_{qlim} is 1650. For some administration this Value may vary up to 1670, due to different coefficients of the allowances.

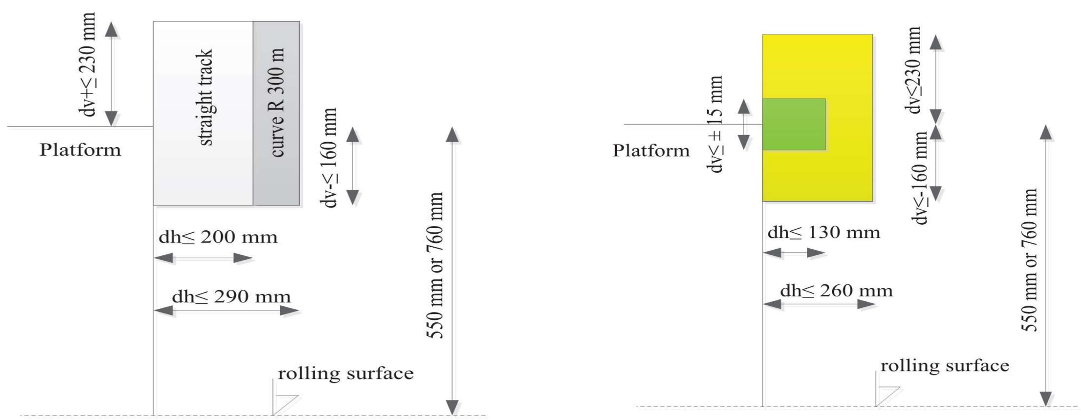
When the track along the platform is situated in curve, the platform height and the platform offset is changing based on the relative values y_{qi} and x_{qi} for the inside of the curve and y_{qa} and x_{qa} for the outside of the curve. The formulas for calculation of these measurements are determined in chapter 13 of [6]. Table 1 presents an example of how the platform edge installation changes as a function of curve and cant.

Curve R=1400 m;	Cant D=100 mm	
	b_{qlim}	y_q*
Platform inside	1690 mm	490 mm
Platform outside	1620 mm	610 mm

Table 1. Platform Edge Installation Changes

*It should be noted that the TSI INF [4] requires calculation according to [6] only for the platform offset. For the platform height [2] defines nominal values of 550 and 760 mm. Application of the requirements of the standard for calculating the platform height, in case the platform is situated in curve, depends on the national rules.

The step position for vehicle access and egress is defined in p. 4.2.2.11. of [5] as "It shall be demonstrated that the point situated in the central position on the nose of the access step of each passenger access door on both sides of a vehicle in working order with new wheels standing centrally on the rails, shall be located inside the surface identified as 'step location". The step location defined in [5] is visualized as shaded area on Figure 3 a)



(a) (b)

Figure 3. Step location

The values of *dh*, *dv+* and *dv-* on Figure 3 a) is considered as reference requirements, which satisfy interoperable operation of the line. More detailed study for the risk analysis of the PTI [9] determines the green area shown on Figure 3 b) as not critical for the access/egress step. Beyond that area some measures must be taken.

At national level, the platform installation is defined by Ordinance No. 55 [7] and Ordinance No. 58 [8]. The platforms shall be installed along the track in straight level line or in curve with radius equal or greater than 600 m, without cant or with cant equal or less than 100 mm. They are classified as law, semi-high and high with a platform height and platform offset as given in Table 2.

	Platform height*	Platform offset*
Law	300 mm	1650 mm
Semi-high	760 mm	1750 mm
High	1100 mm	1750 mm

Table 2. Platform Classification

*Values valid for platforms on a straight level track. For platforms on a track with a curve these values change according to the rules defined in [8].

The position of a low and a high platform is also defined in [4], p. 7.7.3 as a specific case for Bulgaria.

New projects for modernization of the railway lines in Bulgaria have to meet the TSI requirements, as well as the national rules. The practice shows that in the common case the platforms are installed at platform height of 550 mm and platform offset of 1750 mm, as the nominal value for the platform height of 550 mm is not defined in the Bulgarian legislation.

4. Risk-based Approach

The rule-based approach analysis identified cases, where the technical requirements for an interoperable gap are not satisfied. In such cases additional measures are needed to maintain the required safety integrity level.

Deviation from the interoperability requirements affects safety requirements, posing an additional danger to passengers. The risk of these hazards should be further analyzed by establishing a risk model taking into account all risk factors.

Proposing the risk-based approach different factors to the risk have been identified, such as:

- Type of the platform
- Width of the platform
- Visibility indicators
- Weather
- Light conditions
- Profile of the passengers (age, gender)
- Intoxication
- Day of the week/time of the day.

By interaction of the two systems, from the one hand PTI and from the other hand a passenger, the hazards appear on the boarder of the system (Figure 4). In case of external event, e.g. the train starts moving, an accident is possible. Such accident could be fatal or not. The scope of that approach is the hazard of accidents due to the gap.

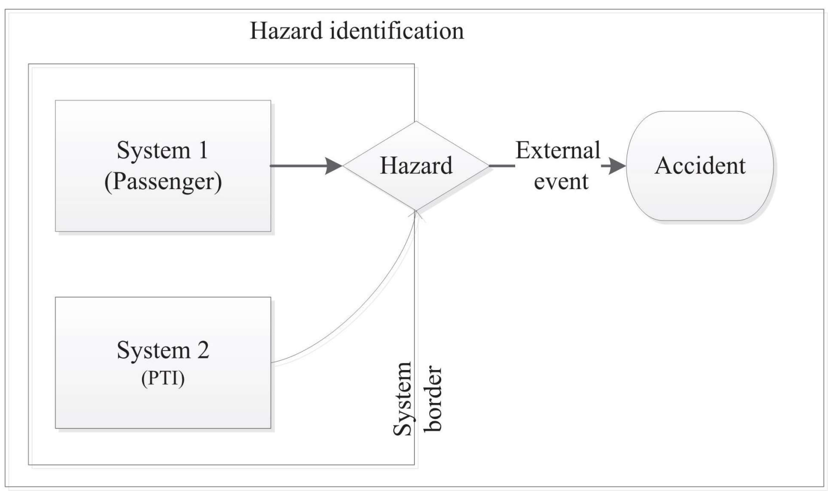


Figure 4. Risk-based model

For the risk assessment the estimated severity (S) and the estimated frequency (K) shall be taken into account. K is function of:

- The frequency and the duration of the exposition of the hazard (F);
- The probability of the hazard to happen (W)
- The possibility to avoid the accident or to reduce the damage (V)

$$Estimated\ risk = (S)\ X\ (K) \begin{cases} F \\ W \\ V \end{cases} \tag{2}$$

$$Estimated\ risk = \frac{SxFxW}{V} \qquad (3)$$

We can consider V as factor of reduction, which is reciprocal to the possibility to avoid the accident. A fault tree diagram is applicable for determination of V (Figure 5).

Applying the equation (3) for a common evaluation of the tolerable individual risk we can go to the equation (4).

$$THR = \frac{TIR}{SxFxWxV} \qquad (4)$$

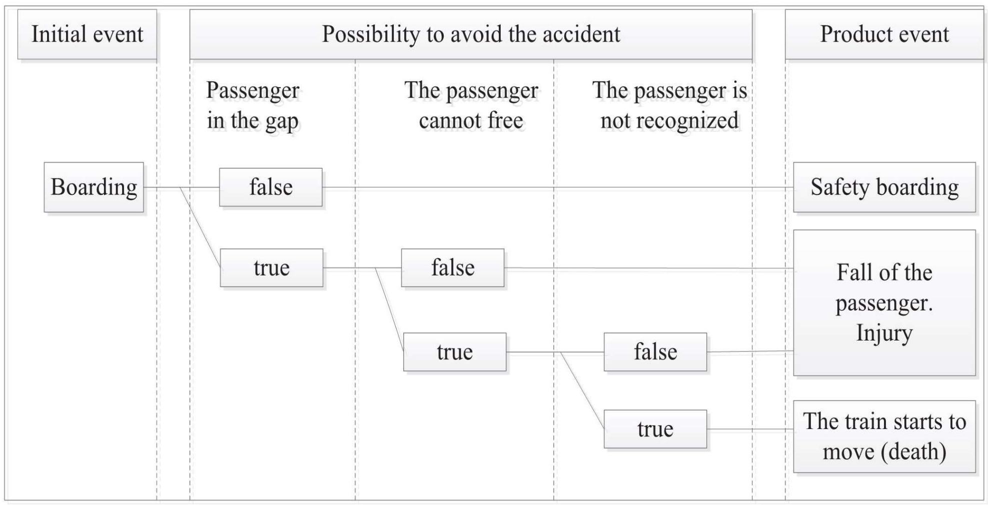


Figure 5. Fault-tree diagram

where,
THR – Tolerable Hazard Rate

TIR - Tolerable Individual Risk of death per an individual Explicit for the Bulgarian railways the following hazards have been identified to be used in the risk assessment process:

- Opening a door earlier
- Opening a door on the wrong side
- A door remains open
- Forcibly opening a door by a passenger
- A boarding step doesn't open or closes earlier

5. Conclusion

The platform-train interface poses risk to passengers (including members of the public) and staff. This risk is comprised of high likelihood but low severity hazardous events (slips, trips and falls) and low likelihood but high severity hazardous events (dragging, falling from the platform and being struck by the train, and being struck by the train when standing on the platform).

The differences between the national technical requirements of Bulgaria and the European rules for PTI parameters are identified. How this nonconformities affects the interoperability of the railway transport and the safety of the passengers are analysed. Assuming the presented analysis of the applicable rules for determination of the platform installation in Bulgaria, the following conclusion could be made:

•The current national rules allow a big variety of platform installation.

•There is a gap between the European and the national legislation concerning the platform offset.

•The missing national rule for platform height of 550 mm is assumption for different approaches for determination of the platform installation in curves.

•The track condition and the maintenance plan are not taken into account.

All these factors are prerequisite for a step position beside the uncritical area, where the safe operation of PTI is assured. (Figure 2 b). The rule based approach does not take into account significant factors for the PTI operation like passenger flow, staffed/ unstaffed stations, safety measures taken in the station. All these factors confirm the need of risk assessment tool for the PTI case by case. Such tool could consist of a control system, which will manage the risk case by case. Input of the tool will be the external conditions, which have an impact to the risk, and the type of the operation train. Based on the risk assessment results, the outputs will lead to explicit established measures in order to reduce the risk to an acceptable level.

Acknowledgement

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