

## 13 Moving Block Risk Evaluation

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### 13.1 Introduction

This contribution provides an overview of the past and current works of the safety works in the X2Rail Projects Moving Block Work Packages, focusing on the identification and evaluation of risks inherent to systems following the ETCS Level 3 specifications.

### 13.2 Structure and contents of the X2Rail Moving Block Works

One goal of Shift2Rail is to provide demonstrators that implement European Train Control System (ETCS) Level 3 Moving Block systems. These systems shall conform to the existing ETCS specifications. However as the specifications apply to all levels of ETCS, some of these requirements have to be stated more precisely for Level 3 to reach the level of detail needed to develop individual, interoperable ETCS systems. To aim for the different needs of the market, several prototypes are to be developed up until X2Rail-5 for different railway operation systems (High speed, urban, freight and overlay systems) as well as the four railway types:

- Full Moving Block with and without Trackside Train Detection (TTD) and
- Fixed Virtual Blocks with and without TTD

To be operated in the European railway market, a new system has to be certified by the European Railway Agency. One crucial part of this certification is the proof of safety. Therefore, a process of risk management has been implemented on European level that follows the risk oriented approach of safety evaluation, using so-called Common Safety Methods (CSM). To make sure to begin the risk management as early in the system development process as possible, it is flanking the other works of the Moving Block Work Package along the whole project runtime.

The first results of the Moving Block works, and the basis for the further works in X2Rail-3 including the risk evaluation presented in this contribution, were the following Deliverables of X2Rail-1:

- D5.1 Moving Block System Specification
- D5.2 Moving Block Operational and Engineering Rules
- D5.3 Moving Block Preliminary Safety Analysis
- D5.4 Moving Block Application Analysis

## 13.3 Risk evaluation

### 13.3.1 Approach and Methodology

Starting with a Preliminary Hazard Analysis (PHA) in X2Rail-1 [1], the works in the Moving Block Work Packages in X2Rail-3 follow the standardized risk-oriented approach of safety evaluation, using the Common Safety Methods, as mandated by the European Legislation [2].

After defining and confining the examined system, in a PHA systematically possible hazards are identified (for the methodical approach see [1]). In the next step these hazards are then assessed in respect of their expected frequency and severity estimated according to tables that are shown in the Figures 13-1 and 13-2.

Frequency level	Description
Frequent	Likely to occur frequently. The event will be frequently experienced.
Probable	Will occur several times. The event can be expected to occur often.
Occasional	Likely to occur several times. The event can be expected to occur several times.
Rare	Likely to occur sometime in the system life cycle. The event can reasonably be expected to occur.
Improbable	Unlikely to occur but possible. It can be assumed that the event may exceptionally occur.
Highly improbable	Extremely unlikely to occur. It can be assumed that the event will not occur.

Figure 13-1: Categories of hazard frequency levels

Severity category	Consequences to persons or environment	Consequences on service/property
Catastrophic	<ul style="list-style-type: none"> <li>Affecting a large number of people and resulting in multiple fatalities, and/or</li> <li>extreme damage to the environment</li> </ul>	Any of the below consequences in presence of consequences to persons or environment
Critical	<ul style="list-style-type: none"> <li>Affecting a very small number of people and resulting in at least one fatality, and/or</li> <li>large damage to the environment</li> </ul>	Loss of a major system
Marginal	<ul style="list-style-type: none"> <li>No possibility of fatality, severe or minor injuries only, and/or</li> <li>minor damage to the environment</li> </ul>	Severe system(s) damage
Insignificant	<ul style="list-style-type: none"> <li>Possible minor injury</li> </ul>	Minor system damage

Figure 13-2: Severity categories

The resulting risk is estimated and evaluated according to a risk matrix that is also part of the CSM and shown in Figure 13-3.

Frequency of occurrence of an accident (caused by a hazard)	Risk Acceptance Categories			
	Frequent	Undesirable	Intolerable	Intolerable
Probable	Tolerable	Undesirable	Intolerable	Intolerable
Occasional	Tolerable	Undesirable	Undesirable	Intolerable
Rare	Negligible	Tolerable	Undesirable	Undesirable
Improbable	Negligible	Negligible	Tolerable	Undesirable
Highly improbable	Negligible	Negligible	Negligible	Tolerable
	Insignificant	Marginal	Critical	Catastrophic
	Severity of an accident (caused by a hazard)			

Figure 13-3: Risk matrix used for risk evaluation

If a risk is found to be undesirable or even intolerable, risk mitigation measures for future Moving Block implementations have to be proposed to lower the risk to an acceptable level. That can be additional system requirements or the implementation of operational procedures.

### 13.3.2 Assumptions and constraints

The works in the Moving Block safety evaluation task in the X2Rail projects is carried out to assess ETCS Level 3 risks. Therefore, risks that occur in other ETCS Levels are not considered, only such inherent to solely Moving Block systems.

The Moving Block system, as it is defined in the X2Rail projects, comprises the ETCS Level 3 Trackside, including interlocking and Radio Block Center, and the ETCS On-board system. A detailed system description containing boundaries of the evaluated system as well as interfaces to other ETCS system components, as for example the Train Integrity Management System (TIMS), the driver and Traffic Management, is conducted in [1]. The assumed functions and characteristics of the Moving Block systems are in line with the system definitions and requirements carried out in the works of the X2Rail Moving Block Work Packages

Further assumptions of the functionality of ETCS Level 3 systems that were made within the scope of the risk evaluation are

- No signals – unless required at boundaries
- No TTD – unless required e.g. at boundaries, points, or because System Type with TTD has been selected
- Level 3 Trackside uses Train Position Reports as primary source of information on train location, used to determine Track Status
- Level 3 Trackside controls points, locks routes, and issues Movement Authorities up to next obstruction
- All trains fitted, including with TIMS, unless 100% TTD.

### 13.3.3 Previous and actual results

An overview of ETCS Level 3 Moving Block hazards that were identified in the PHA carried out in X2Rail-1 is shown in Table 13-1. They are described in detail in [1].

Table 13-1: Identified Moving Block Hazards and their causes for, from PHA [1]

Identified Hazards	Possible Causes
<b>1. Track status erroneously cleared</b>	1.1 Dispatcher interaction in L3 Trackside initialization 1.2 Using invalid/outdated information for L3 Trackside initialization 1.3 Deactivating shunting area 1.4 Driver confirms train integrity 1.5 Recovery of a failed train
<b>2. Error in train location</b>	2.1 Confidence interval reduced at End of Mission 2.2 Lack of linking information
<b>3. Error in train length</b>	3.1 Reported train length shorter than actual 3.2 Reported train length longer than actual
<b>4. Cold Movement Detection erroneously validates position</b>	4.1 Wrong side failure in CMD
<b>5. Undetected movements</b>	5.1 Rollback after standstill 5.2 Movement in NP ("no Power") mode 5.3 At entrance to Level 3 area 5.4 After End of Mission 5.5 Loss of train integrity 5.6 Propelling train 5.7 Shunting train
<b>6. TTD erroneously indicates track clear</b>	6.1 Wrong side failure of TTD
<b>7. Points moved under train</b>	7.1 Points moved after communication failure

Currently in X2Rail-3 Workshops with European railway experts are conducted to carry out the CSM risk evaluation process explained above. At this moment definitive conclusions are still to be assembled, but for example following first tendencies could be observed:

For most hazards the assumed severity category is catastrophic, including pure freight lines, as accidents could result in extreme damage to the environment (compare Figure 13-2).

The different railway operation systems (high speed, freight, etc.) have no impact on the assumed severity category, but can have an impact on the assumed frequency level, influencing the resulting risk assessment in this way.

For systems with TTD many hazards can be evaluated the same way as in ETCS Level 2 systems, therefore excluded from further X2Rail evaluations.

## 13.4 Outlook

The next step in the risk evaluation process carried out in X2Rail-3 is to look at the resulting categories in the risk matrix and for every hazard and either

- define additional system requirements and operational measures for Moving Block systems to lower the risks to an acceptable level or
- show that the risks are not higher than in ETCS systems today and can therefore be deemed acceptable following the CSM “comparison to similar Reference Systems” approach.

## 13.5 References

- [1] X2Rail-1 Deliverable 5.3: Moving Block Preliminary Safety Analysis; X2Rail-1 Deliverables will be available in the near future under [https://projects.shift2rail.org/s2r\\_ip2\\_n.aspx?p=X2RAIL-1](https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1)
- [2] Commission Implementing Regulation (EU) No 402/2013 of 30 April 2013 on the common safety method for risk evaluation and assessment and repealing Regulation (EC) No 352/2009

## 13.6 Authors



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