Derivation of common safety targets for the European railways

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Abstract

Revitalising the railways is a top priority of the European Union’s common transport policy. A declared objective is to aim towards the creation of an homogeneous European Railway that should help increase the share of railway traffic throughout Europe. At the moment the technical and operational fragmentation between the different Member States are seen as main obstacles for the competitiveness of railway transport, not only for cross-border operations, but also within Member states as it may hinder competition for the provision of railway services. Such considerations have led recently to the development of common solutions (i.e. ERTMS/ETCS for signalling) as well as to common technical specifications to allow interoperability (i.e. TSIs for high-speed and conventional railways). It is recognised that this drive towards interoperability also needs to be accompanied by some convergence in safety practices across Member States. This is meant on the one hand to maintain a high level of safety on the whole European railway network, and on the other hand to facilitate access to new entrants wishing to offer services in any country. The so-called Safety Directive has recently been adopted by the European Parliament and is intended to provide a common framework for achieving such a convergence. Among other provisions, the Safety Directive requires the gradual introduction of Common Safety Targets. These will have to eventually be proposed for adoption by the new European Railway Agency. Common Safety Targets is a sensitive issue, hence the need for a large consensus building currently ongoing. This paper shall present some aspects of the discussion that took place on this subject in the European Research project SAMRAIL. Emphasis is placed upon the various ways the Common Safety Targets could be defined and set.

Keywords: European Transport policy, railway safety, safety targets, risk.
1 Introduction

Several European Directives have been passed to help establish a harmonized European Railway System. Some were related to the adoption of common solutions, like ERTMS, and common technical specifications for interoperability (TSI) in order to help interoperability and overcome the technical differences (signalling, train control, power supply...) still prevailing between member states [1][2]. Others were aimed at opening or easing access of the rail networks within Member States to new entrant railway undertakings [3][4][5]. On top of it, the so-called Safety Directive [6] came into force last year and was meant to “establish a common regulatory framework for railway safety” (Safety Directive, preamble 1). The general idea behind this Directive is that the usually high level of safety in the railways should be at least maintained in this process of harmonization and opening up of the rail networks, while safety practices ought to be converging in order to reduce national or specific barriers to network access that may exist on safety grounds. The objective is thus to make railway safety more transparent across the European Union and hence make it easier for railway companies to provide services anywhere in Europe, without compromising safety.

The Safety Directive demands among other things the development of Common Safety Targets (CSTs) which shall define “the safety levels that must at least be reached by different parts of the rail system [...] and by the system as a whole, expressed in risk acceptance criteria” (Safety Directive, Article 3). These Common Safety Targets should help to assess the safety performance of different railways and to provide a minimum level of safety which has to be fulfilled by them in each Member States. Common Safety Indicators (CSIs) – also demanded in the Safety Directive – shall show the fulfilment of these targets.

As a means to investigate the requirements of the Safety Directive and to make recommendations for the implementation of these requirements, the European Commission launched in 2003 the research project SAMRAIL (“SAfety Management in RAILways”) along with the thematic network SAMNET (“SAfety Management and interoperability thematic NETwork in railway systems”) [7]. The members of these projects are research institutes and universities (as INRETS, TU Dresden, TU Braunschweig, TU Delft etc.), railway industry (Alstom, Siemens, Bombardier etc.), assessors and Notified Bodies (Atkins Rail, TÜV, EBC etc.) railway-associations (UIC, UNIFE) and operators and infrastructure managers (DB AG, RFF, PRORAIL, RFI etc.).

These projects were to provide guidelines and proposals on the following topics:

- a common framework for railway safety management systems (SMS),
- risk analysis and Common Safety Methods (CSM)
- acceptable risk levels and Common Safety Targets (CST)
- Safety approval and cross-acceptance
- European incident- and accident-reporting system and Common Safety Indicators (CSI)
harmonisation of different safety requirements (e.g. standards) and
rules.

The output of these projects should help the new established European
Railway Agency (ERA) to start their work in 2005 and to implement the
requirements of the Safety Directive.

This paper shall focus on the discussion and results of the SAMRAIL project
concerning the Common Safety Targets, which was covered by SAMRAIL
Work Package 2.4 [8].

2 SAMRAIL analysis on CST

2.1 Definition of risk

Risk in general can be defined as “a combination of the probability of occurrence
of harm and the severity of that harm”. As there is no definition of risk given in
the Railway Safety Directive itself, this definition has been taken e.g. from
IEC 61508.

The directive demands risk acceptance criteria for “individual risks relating to
passengers, staff including the staff of contractors, level crossing users and
others, and […] individual risks relating to unauthorised persons on railway
premises” and „societal risks”.

The meaning of individual and societal risk is not quite clear. These
expressions are used in the Railway Safety Directive but are not further
explained. Therefore for the purpose of this paper individual risk should be
understood as “a risk which is related to a single individual only”. Following
these definitions it was felt appropriate to consider the following risk of an
individual for the scope of CSTs:

\[
Risk = \frac{\text{personal damages}}{\text{reference unit}}
\]

Frequently “personal damages” can be understood as fatality for which more
easily an agreement for definition can be found between member states. But this
will narrow the scope for statistical evaluation and analysis. Therefore for
„personal damages” instead of pure fatalities also serious and minor injuries
should be taken into account. This leads to the definition of “equivalent
fatalities” which means that one fatality equals for example 10 serious injuries
and one serious injury equals 10 minor injuries. For the reference unit different
values could be used. For the definition of individual risk of a passenger, train
kilometre appeared to be the most appropriate unit as this data will be the
simplest available. This results into the following individual risk of fatality
(IRF):

\[
IRF_{tkm} = \frac{\text{equivalent fatalities}}{\text{train kilometre}}
\]

If the average speed and the average number of passengers per train are also
available the reference unit could be transformed to passenger hours which
would have the advantage that the time is considered during which a person is exposed to potential hazards. In conclusion SAMRAIL proposed rather a spectrum of applicable definitions with respect to different reference units, and points to the need of reaching agreement rapidly on this issue, before CST can be determined and set [9].

2.2 Determination of Common Safety Targets

2.2.1 Global Safety Targets
Considering the demands of the European Safety Directive, CSTs have to be defined for each of the following groups:

- passengers,
- staff including the staff of contractors,
- level crossing users,
- unauthorised persons on railway premises,
- others.

The reference in the Safety Directive to Common Safety Targets that must be reached by the system as a whole in each Member suggests that there should be at least a global target for each of the above groups.

As the Railway Safety Directive demands that “the first set of draft CSTs shall be based on an examination of existing targets and safety performance in the Member States and shall ensure that the current safety performance of the rail system is not reduced in any Member State” it was deemed appropriate to take, as suggested by the UIC Safety Platform [10], an average of the current safety performance in the Member States as global CSTs with the condition that countries which are better should not reduce their current safety performance. The related Common Safety Indicators shall be derived from statistics.

2.2.2 Specific Common Safety Targets
The reference in the Safety Directive to safety levels for different parts of the railway system implies that in addition to global CST there should also be specific CST defined for parts of the system. This touches on the issue of risk apportionment and was therefore also investigated and discussed in SAMRAIL WP 2.4 [11].

In contrast to the global CSTs, this topic was much more difficult and contentious. Problems arise by the diversity of the EU railway systems as well as by the integrated nature of the railway systems. As a result, it is often very difficult to allocate acceptable risk levels unambiguously to separate parts and add them up to reach an acceptable global safety target, even more so at a European level.

A first question for setting up specific CSTs concerns the level at which these CSTs should be defined. Different possibilities were considered and were initially discussed during the work on WP 2.4:

- CSTs for types of organisation (e.g. railway undertaking, infrastructure manager)?
- CSTs for types of railway services (e.g. high speed traffic, conventional traffic, dedicated freight traffic) as suggested in the Railway Safety Directive definition for CSTs?
- CSTs on the level of railway functions and processes or/and railway constituents?
- CSTs for types of accidents or/and types of accident causes?

SAMRAIL came early to the conclusion that the first two suggestions (organisation and type of service split) would not be very practicable due to the difficulty of clear separation of risks at these levels. Therefore the discussion focused more on the apportionment possibilities contained in the remaining 2 points.

The starting point of this study was to consider the different levels from a safety analysis point of view. This is illustrated in figure 1. The figure is centred on hazards, which under certain circumstances could evolve into accidents (top triangle). These hazards in turn occur or are not protected against due to some failures of some protection functions. The functions are implemented by constituents of the system (technical sub-systems and components, human operators, rules) whose failures, in various combinations, then constitute the underlying causes of an accident (bottom triangle). Using this general view, various strategies for risk apportionment can be envisaged that correspond to the different levels as shown on the right side of figure 1.

Figure 1: Safety analysis overview.
Table 1: Overview of different risk apportionment strategies.

<table>
<thead>
<tr>
<th>Breakdown Approach</th>
<th>Description of Breakdown Approach</th>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>System breakdown approach</td>
<td>• Decomposing the whole railway system in its major organisational and/or physical constituents parts (e.g. track, rail, switch, rules, drivers, etc.)&lt;br&gt;• Assigning a risk portion to each part, depending on the estimated or required contribution of each part to global risk</td>
<td>• Common safety requirements at constituent level&lt;br&gt;• Provide direct references for cross-acceptance of products and definition of TSI quantitative requirements</td>
<td>• Does not respect heterogeneity of EU railways&lt;br&gt;• Unambiguous apportionment difficult (interfaces/transverse safety functions)&lt;br&gt;• Depends heavily on current state of technology, needs frequent update</td>
</tr>
<tr>
<td>Breakdown by categories of hazard causes</td>
<td>• Proposed by UIC Safety Platform&lt;br&gt;• CSTs related to causes of hazardous situations, based on the following classification:&lt;br&gt;  – technical faults&lt;br&gt;  – human errors&lt;br&gt;  – organisational failures&lt;br&gt;  – external causes&lt;br&gt;• Allocation of responsibility of each (infrastructure manager or railway undertaking)</td>
<td>• Only 4 specific CST, good for comparison purposes&lt;br&gt;• Correspondence with broad indicators of SMS performance/failing</td>
<td>• Does not respect heterogeneity of EU railways especially in regard of operational and technical aspects&lt;br&gt;• Some overlaps between categories; multiplicity of causes in accidents&lt;br&gt;• Depends heavily on current state of technology, needs frequent update</td>
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<td>Functional breakdown approach</td>
<td>• Determination of all phases, functions and processes taking place in the operation of a railway system&lt;br&gt;• Identify related hazards&lt;br&gt;• Evaluating potential resulting risks associated with each function, process and subsequently the phase of operation (bottom-up)&lt;br&gt;• Alternatively apportioning the global risk to each phase, function and process (top-down)</td>
<td>• CST independent of technical realisations and implementation at high level&lt;br&gt;• Provide reference values for deriving safety requirements at constituent level</td>
<td>• Interfaces between functions makes unambiguous apportionment difficult, especially at low level&lt;br&gt;• Functional decomposition at low level depends on safety rules, still varying across Member States</td>
</tr>
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Table 1: Continued.

| Breakdown by hazard types | Apportionment between generic system level hazards which can lead to accidents |
|---------------------------|--|---|
|                           | Derivation of specific CSTs by a top-down apportionment of the global residual risk or directly by a determination of the acceptable risk level per hazard |
|                           | CST independent of technical realisations and implementation |
|                           | Provide reference values for deriving safety requirements at constituent level |
|                           | Unambiguous apportionment (no overlap / interface) |
|                           | Definition and consensus on generic hazards is difficult |
|                           | Many hazards, means potentially many CST |
|                           | Requires additional structure for hazard analysis to assure completeness |
| Breakdown by accident types | Basis is a list of typical railway accidents |
|                           | Global residual risk (per group category) is apportioned to the different accident types, using statistics |
|                           | Unambiguous apportionment |
|                           | Classification of accident easy and uncontroversial |
|                           | Few CSTs, easy comparisons |
|                           | No focus on underlying causes of accidents |
|                           | Not very helpful for deriving safety requirements |

For completeness, the table 1 summarizes the analysis of the various schemes that had been looked at by the project team.

3 Recommendations from SAMRAIL on CST

In conclusion, it was agreed by the consortium team that any determination of future Common Safety Targets, especially specific CST, should require careful analysis if it is to achieve a large consensus base among the various stakeholders. CST are a sensitive issue, and there exist some fears, especially among operators, of being imposed targets that would be inappropriate and could have adverse effects on their railways. Although it appeared that global CST might in the end not be too controversial and could be determined and adopted well within the time-table set by the ERA (first targets by 2009), the debate has shown widely differing views and understandings regarding the definition of specific Common Safety Targets. As a result, the final recommendations of SAMRAIL on this issue is to proceed cautiously and take a step by step approach to investigate down to which level in the hierarchy presented above it would be feasible/sensible to define specific CST. It is therefore suggested to start first with a decomposition of the global risks into categories of (registered) unsafe events, using statistics, and refine the apportionment further with a functional breakdown approach at a high level, as this would offer a generic method which is in principle applicable to different kinds of railway systems.

For this functional approach, the document “Railway Architecture” [11] which was elaborated by the European Association for Interoperability of Railways (AEIF) to define the TSIs was chosen as a basis. For that document, a functional system analysis of a conventional railway system covering the full
chain of railway transport was developed. This analysis represents a systematic and coherent decomposition of functions up to four levels of decomposition for some functions. One of the advantages of this document is that functions had been related also to TSIs. The consistency of this analysis has been checked. To avoid overlap or misinterpretation of defined functions, further work will be required to define the functions and their interference clearly.

*Figure 2* shows as an example the functional breakdown from the global CSTs for passengers over to the first-level function “F8 – Operate a Train” and the second-level function “F806 – Run a Train” down to the third-level sub-functions.

To get an overview of all related hazards of the railway transport process and its related functions, a preliminary hazard analysis (PHA) should also be carried out. Result of this PHA should be a list of hazards and their possible consequences (accidents - CSI) that are related directly to functions, e.g. considering functions F8060 to F8062 in *figure 2* there are different kinds of accidents (ac8060-1...). which could occur. When these accidents/hazards could unambiguously be assigned to these sub-functions it will be possible to define a CST for this sub-function.

Based on statistical evaluation of frequency and consequences of these accidents quantitative safety targets can thus be set up, which helps to identify functions that are more safety relevant than others and shows the contribution of functions to overall safety performance of railway transport. However a PHA and some associated risk analysis should also help determine whether a function, with for instance no accident statistics to be assigned to, is safety relevant or not.
4 Conclusion

The SAMRAIL and SAMNET projects are two European projects to further illuminate and detail the requirements of the Railway Safety Directive in particular with respect to practicable definitions of Common Safety Targets and Common Safety Indicators. Participants from many European Countries and different fields of railway transportation got an opportunity to discuss and exchange their views and convince themselves of the overwhelming complexity of the subject.

The work of SAMRAIL WP 2.4 resulted in an evaluation of various possible approaches with a final recommendation for a functional breakdown approach for setting up specific Common Safety Targets, based on a hazard and a functional analysis. However it should be stressed that the diversity in technologies and operational rules in Europe requires high caution in use and application of any method chosen eventually for allocating CST.

References


