

Lessons learned from the collaborative European project RESTRAIL: REduction of suicides and trespasses on RAILway property

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Abstract

Background RESTRAIL was a three year EU FP7 research project which aimed to help reduce the occurrence of suicides and trespasses on railway property and the costly service disruption caused by these events. The project was coordinated by the International Union of Railways (UIC) and provided the rail industry and researchers worldwide with an analysis of the most cost-effective prevention and mitigation measures. The goal of this paper is to inform the railway and scientific community about the successful completion of the project and to present an overview of the main results and key innovations. **Method** The project covered five relevant issues which significantly contributed to improve the prevention of railway suicide and trespass, and to mitigate their consequences: (1) collection and analysis of data related to railway suicides and trespassing accidents and information about preventative strategies; (2) assessment of preventive measures to reduce railway suicide and trespass; (3) assessment of measures to mitigate the consequences; (4) pilot tests to evaluate some promising measures on the field; and (5) practical recommendations and guidelines. **Results** The main project outcomes included: an integrated data analysis on railway suicide and trespass, a list of 25 recommended measures, 11 field tests which provided new pieces of evidence for the effectiveness of different measures, and a free online toolbox for decision-makers. **Discussion** These achievements are discussed in relation to the ongoing need of

practical and exploitable results from EU-funded research projects, since the scientific and applied outcomes of RESTRAIL are an example of good practice for the benefit of the entire railway community and society.

Keywords Safety · Security · Rail suicide · Trespass · Incident prevention · Consequence mitigation

1 Introduction

Suicides represent more than two thirds of all railway fatalities and together with the deaths of unauthorised persons they account for 88 % of all fatalities occurring within the railway system [1]. Railway suicides and trespassing accidents have human and economic consequences with high impact on the whole society. Beyond the human loss, these incidents cause important delays [1] as well as post-traumatic stress to the railway staff [2, 3] and discomfort to passengers and bystanders [4–6]. These issues are alarming for both governmental authorities and railway companies, which are more and more interested to find cost-effective solutions against railway suicides and trespassing accidents.

RESTRAIL (REduction of Suicides and Trespasses on RAILway property; www.restrail.eu) was a EU FP7 collaborative project implemented from October 2011 until September 2014 and coordinated by the International Union of Railways (UIC). The project benefited from multi-disciplinary expertise provided by a consortium of 17 partners from 12 countries (i.e. railway undertakings (RUs), infrastructure managers (IMs), research centres, universities, and manufacturers from Belgium, Finland, France, Germany, Italy, Israel, the Netherlands, Poland, Spain, Sweden, Turkey and the United Kingdom).

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The project provided the rail industry and researchers worldwide with an analysis of the cost-effective measures to reduce the frequency and impact of suicide- and trespass-related incidents. The project had the following workflow: first, we collected and analysed data related to railway suicides and trespassing accidents and information on possible countermeasures. Second, we assessed the measures to reduce railway suicides and trespassing accidents in order to identify 25 most recommended ones. Third, we investigated how the railway system can enhance its efficiency by better responding to fatalities and trespassing accidents which jeopardise its reliability, punctuality and attractiveness to potential users. Fourth, we evaluated some of the most promising measures through 11 pilot field tests implemented in various countries. Finally, we developed a toolbox for decision-makers which integrated all the practical information collected and produced during the project and all the evidence-based recommendations.

This paper aims to inform the railway and the scientific community about the main results of the project, as well as about those outcomes which will continue to be exploitable on the long term. The current synthesis is based upon previous RESTRAIL publications: project deliverables, peer-reviewed scientific articles, conference proceedings, and ongoing follow-up activities. The method and main results of the project are briefly presented in the following chapters with links towards the original sources. The RESTRAIL workflow is discussed in relation to the relevant literature which has been published since the end of project.

2 State-of-the-art on railway suicides and trespassing accidents

RESTRAIL research started through an extensive collection and analysis of data about railway suicides and trespassing accidents. The work resulted in a description of the state-of-the-art based on a literature review, up-to-date statistics on railway suicides and trespassing accidents compiled from different sources, information on possible countermeasures to prevent railway suicides and trespassing accidents, and analysis of the consequences of railway suicides and trespassing accidents (see [7] for detailed review).

2.1 Data on railway suicides and trespass

Two major international databases concerning railway suicides and trespassing accidents were identified, namely ERADIS (European Railway Agency Database of Interoperability and Safety) and the UIC safety database. Based on the analysis of these two databases a stable trend was identified in Europe over the last ten years: there are around 3.000 railway suicides and roughly 800 trespassing accidents per year in Europe. The latest available data can be

consulted in the most recent reports published by ERA [1] and UIC [8]. Additional data were collected using forms or questionnaires that were completed by RESTRAIL partners, who typically acquired the requested data from documents or by interviewing national experts, and in some cases by organising workshops (see for e.g. [9]). In total, 14 countries provided data which became valuable input for the railway community since this was the first attempt to collect information on railway suicides and trespassers together, from a broad range of countries and data sources.

Most of the received information concerned the age, gender, timing of events and locations whereas the least information was received concerning the access point, mental health and distance from incident location to home or to closest mental hospital. The analysis of detailed incident data (provided by 12 countries) showed for example that (a) victims were predominantly males, both for suicides and trespassing accidents, (b) victims were typically between 20 and 59 years of age, (c) railway suicides and trespassing accidents seem to be fairly evenly distributed throughout the year, (d) all weekdays are represented quite evenly, and (e) suicides were almost always committed by persons alone, and even in trespassing accidents there was seldom more than one victim. These data are comparable with the ones published in recent works by Mishara and Bardon in Canada [10], Savage in USA [11], Too et al. in Australia [12], and Uittenbogaard and Ceccato in Europe [13]. However, as pointed out by Mishara and Bardon [10], it is unfortunate that data from Europe are not available from lower income countries and the few reports that exist describe only a few incidents in a specific area, making generalisation difficult.

2.2 Information on countermeasures

The RESTRAIL literature review highlighted the main differences and similarities between railway suicides and trespassing events and discussed the preventive measures [14]. These measures can be applied to both events or be specifically targeted to prevent either railway suicides or trespassing accidents [14]. According to a survey among RESTRAIL partners more than 40 different (partly overlapping) measures for the prevention of railway suicides and trespassing accidents have been implemented in EU Member States. Furthermore, several ideas on possible new measures were collected. The reported implemented measures concerned especially social measures targeting suicides (e.g. national and local prevention programmes, media guidelines on suicide reporting), but also different kinds of behavioural measures (e.g. posters, information campaigns and education at schools), physical measures (e.g. fencing and landscaping) and technological measures (e.g. video surveillance). In parallel with this RESTRAIL work, the US Federal Railroad Administration (FRA) published a report on counter measures to mitigate railway suicide [15] and Mineta Transportation

Institute (MTI) a report on actions to prevent suicide on commuter and rail systems [16]. These reports are complementary with the RESTRAIL review [14] discussing the same categories of interventions. They show that parallel work conducted on another continent lead to convergent results. In addition, they point to the same overall conclusion highlighted by RESTRAIL: the data on the effectiveness of measures are almost non-existent and the need of evaluation work is imminent. In this context, the added value of the RESTRAIL project is that it also provided: (a) an international expert assessment of the measures in order to filter the most promising ones (discussed in chapter 3) and (b) the specific evaluation of some measures on the field (discussed in chapter 5).

2.3 Consequences of railway suicide and trespass and incident investigation

In line with the international literature [2–6], RESTRAIL research has shown that railway suicide and trespassing accidents have far reaching consequences for a wide range of actors and agencies within society (see [17], for more details): amongst them the victims and their families and close associates, train drivers and other witnesses, railway companies, emergency services and passengers. All countries have guidelines and procedures for managing the immediate consequences of railway suicide and trespassing accidents, and in some cases measures to mitigate the onset and development of post traumatic stress disorder amongst affected drivers. The most commonly collected data regarding impacts concerns damage to humans (number and type of victim and severity of injury) and delays (duration, frequency, number of trains). There are differences in how the financial costs of deaths and serious injuries are calculated in different countries, which makes data comparison very difficult. Average delays range from 45 min to 3 h in different countries and cause considerable inconvenience to passengers as well as significant operational and financial impact for railways. This is consistent with the disruption time reported by ERA [1].

Accident investigation practices and processes also vary between countries. In Europe, the Railway Safety Directive [18] set the minimum requirements for data collection, but did not regulate the investigation process otherwise. The classification on whether the case was a suicide or accident is most often made by the police or a coroner. The organisations involved in the investigation and their roles vary between countries. In most countries the police are responsible for at least a part of the investigation. Infrastructure managers (IMs) and railway undertakings (RUs) or specific investigation bodies can do their own investigations. Consequently, RESTRAIL found that the major need for railway stakeholders is to reduce the traffic disruption time, and recommended that this should be the main focus of the mitigation measures. In this sense, the the industry may need to consider how it can engage more effectively with

external organisations and the public who are using the railway, in further efforts to understand and respond with empathy to these complex issues of railway suicides and trespass.

2.4 Lessons learned from the state-of-the-art

To our knowledge, the state-of-the-art conducted in RESTRAIL was the first of this kind (at least in Europe if not worldwide). It identified opportunities for learning from different data sources (e.g. about problems which have been identified through these data, practices for investigation and analysis, and options for prevention) and based on the detailed review of the gaps in the current knowledge base (e.g. about victims, locations of incidents, contributory factors, behaviours, consequences of incidents, uniformity in investigation processes). It also allowed new recommendations for the railway and scientific community. Detailed descriptions of actions related to each recommendation are listed in Table 1. Some of these actions were achieved during the project's lifetime; others are still ongoing based on RESTRAIL recommendations.

3 Assessment of measures to reduce railway suicides and trespasses

Next, RESTRAIL project focused on the assessment of the existent countermeasures, taking into account the research findings from the state-of-the-art and the good practices (e.g. technical and non-technical) collected from IMs and RUs. Special attention was given to the development of new approaches to non-technical measures (i.e. “soft” measures) to prevent suicides (e.g. gatekeeper training) and trespassing accidents (e.g. collaboration, education). The process has been successful in discriminating differences between different types of measures, hence a shorter list of more promising preventative measures has been identified to prevent suicide and trespass either jointly or separately. These measures were considered suitable for more in-depth testing in RESTRAIL and were selected for potential field test implementation. Furthermore, the results of the assessment process provided useful recommendations about the most cost-effective measures and were therefore included into a practical toolbox for decision-makers.

3.1 Development of a method for the evaluation of measures

An initial set of 83 preventive measures to reduce the occurrence of suicide or trespass was grouped into 38 families of measures in which the modes of action for incidents and accidents were similar, using a safety barrier model. Since overlapping existed between preventive measures against suicide and trespass, a model has been proposed [19] to take into

Table 1 Recommendations of the state-of-the-art review

Recommendation	Detailed description of actions	Achieved during RESTRAIL	Ongoing as follow-up action	Out of RESTRAIL scope
Additional data collection	<ul style="list-style-type: none"> Establishment of European database for detailed incident data from national sources Development of European wide guidelines for collection of detailed incident data Systematic collection of data on frequency of trespassing Raising awareness in the railway companies on the importance of collecting data on railway suicides and trespassing accidents to be used as a basis for their decision making 	X	X	X
Additional analysis	<ul style="list-style-type: none"> Making the assessment of effectiveness a regular element in all plans concerning the implementation of preventative measures Developing common methods for the determination of factors contributing to individual trespassing accidents Considering in-depth case studies of limited number of suicides and/or trespassing accidents, to gain knowledge of specific features of incidents that are not included in the routine collection of detailed incident data Analysing behaviour in accidental and suicide events from larger samples of pre-existing documents or other sources of data to have better understanding of behaviours that indicate risk of subsequent incidents 	X	X	
Better access to information	<ul style="list-style-type: none"> Enabling and facilitating access to relevant databases, for researchers but also for the general public Making the results of studies on railway suicides and trespassing accidents available to the interested parties more widely, especially to those working in the railway sector Promotion of publication of results from studies and experiments in scientific publications, even if the results are not as positive as expected 	X		
Encouraged cooperation between organisations	<ul style="list-style-type: none"> Cooperation between organisations involved in investigations of railway suicides and trespassing accidents to enable exchange of documented information on the incident 	X		

account shared and specific suicide and trespassing characteristics as well as important psychological aspects such as the individual motivation to trespass or the suddenness of the suicide decision. The originality of this model is also that it specifies different effect mechanisms needed to be achieved in prevention interventions at each stage of the sequential process. These range from primary interventions aimed to influence people's perceptions and decisions, to secondary interventions aimed to restrict the means or to influence risky behaviour, until tertiary interventions aimed to reduce the consequences of a possible collision. The model is useful because it helps visualise how each stage of the suicide or trespassing processes can be linked to suitable families of measures.

3.2 Assessment of suitable measures (technical and soft)

The objective of the work conducted was to assess the 38 families of preventive measures previously identified using expert knowledge and experience. All measures were reviewed and assessed using the same evaluation process, experts and criteria [20, 21]. The assessment process took into account factors and information that could impact the success

of measures if they were applied in different European environments, and drew conclusions on a list of measures defined as recommended and promising.

The 38 families of measures were assessed by a group of 21 experts from the railway safety and security sector, railway infrastructure, railway operations, research and academia. Each family of measures was assessed separately for suicide and for trespass. A set of available data was used for the preliminary classification that allowed sector experts in a second phase to assess the principles for classifying measures as "Recommended" or "Promising", i.e. effective, cost-effective, and free of shortcomings. Three main sources of information were used: the preferences of IMs and RUs; estimates of impact at European level; weighted and individual scores according to several criteria (developed from earlier work in the field of road safety [22]) which represented implementation practicalities for each family of measures: (1) durability of effects, (2) costs and benefits (based on expert judgment and not on calculation of the cost/benefit ratio), (3) integration with other policy measures, (4) impact on railway operations, (5) impact on people and jobs, (6) technological issues, (7) environmental issues, (8) acceptance, and (9) transferability issues.

The assessment procedure resulted in a set of “recommended” and “promising” measures as well as an outline of the factors affecting successful implementation of the measures [23]. The method has demonstrated the capacity to support the analysis and selection of the most cost-effective measures: 8 families for suicide and trespass, 10 families for the prevention of suicide and 4 families of measures against trespass (see Table 2). This rigorous assessment method explains why the final set of RESTRAIL measures is shorter than the exhaustive set of known measures identified from reviews of the scientific and grey literature [14–16]. However, the assessment method allowed the inclusion of some new promising approaches which are barely described in the literature and which have been identified from complementary workshops and focus groups with railway experts.

3.3 New approaches to soft measures for the prevention of suicides and trespassing accidents

Among the whole set of preventative measures, special attention was given to the “soft” measures against suicide and trespass. “Soft” measures are influential, social, or psychological

interventions dedicated to influence the actors’ knowledge and attitudes and to deter risky behaviours by calling for more socially-responsible actions or for voluntary decisions to comply with the safety rules.

In order to assess information on existing and emerging soft measures against railway suicide and their degree of implementation, a survey was designed and conducted among RESTRAIL partners, Bahnhofs Mission, German train drivers union, and among Spanish engine drivers [24]. The analyses showed that several soft measures against railway suicides were already implemented in European countries and worldwide. Soft measures are often a part of a more general suicide prevention programme. Soft measures against railway suicide included the design and placement of signage and posters in a railway environment, advertising crisis hotlines, mass media campaigns and media guidelines or local prevention campaigns, intervention at schools and provision of educational materials, briefing of station staff or security personnel, announcement in trains and at stations, gatekeeper programmes and hotspot analysis and education. In particular, the analysis showed that: (1) *awareness raising programmes* were implemented in five European countries media approaches in six;

Table 2 The list of preventative families of measures against railway suicide and/or trespass following the RESTRAIL assessment procedure

Family of measures	Classification for suicide	Classification for trespass
1. Targeted campaigns (including shock campaigns)	Recommended	Promising
2. Fences and barriers at specific parts of stations	Recommended	Recommended
3. Fences and barriers at locations outside stations where people take shortcuts	Recommended	Recommended
4. Surveillance to deter based on patrols	Promising	Promising
5. Mass media campaigns	Promising	Promising
6. Risk assessment (e.g. of stations, special circumstances, risk groups etc.)	Promising	Promising
7. Monitoring and learning from research and best practice	Promising	Promising
8. Collaboration between organisations and agencies	Promising	Promising
9. Surveillance and light to influence behaviour	Recommended	-
10. Detection system combined with sound warnings	Recommended	-
11. Increased visibility by lighting at railway crossings, tunnels and hotspots	Promising	-
12. Increasing visibility through removal of vegetation	Promising	-
13. Surveillance based on local intelligence (e.g. from police, health authorities)	Promising	-
14. Media Guidelines	Promising	-
15. Emergency information at stations (signs, posters, information on screens etc.)	Promising	-
16. Societal collaboration to prevent railway suicide and trespassing accidents	Promising	-
17. Emergency button at unstaffed stations	Promising	-
18. Training of staff - Gatekeeper training	Promising	-
19. Education and prevention in and outside of schools	-	Recommended
20. Warning signs and posters to address trespassing	-	Recommended
21. Prohibited access signs	-	Promising
22. Training of staff - General Awareness Raising	-	Promising

(2) *help lines* were offered and operated in many countries, but only in five countries the information about the hotline was displayed in a railway environment; (3) *poster campaigns* were also launched in five countries; (4) *suicide hotspots* were officially identified in nine of the countries but only five reported that actions have been taken at the identified sites; (5) ten countries had *special announcement* to passengers waiting on stations and in trains and even though all countries avoided using the word “suicide”; (6) the *gatekeeper programme* was only implemented in Great Britain but several different European countries were planning to set up gatekeeper programmes for frontline staff.

In order to analyse the development of new approaches to soft measures against trespassing, two complementary approaches were used: (a) quantitative criteria to distinguish the new measures from mainstream approaches in the current literature and (b) qualitative criteria to define innovative approaches from the viewpoint of railway safety experts who participated in several focus groups in Spain, France, and Turkey. The main results suggested that new effective interventions were based on integrative approaches to soft measures [25].

Soft measures against railway trespass included new approaches to education, innovative collaboration between institutions and agencies, soft approaches to physical barriers, and training railway staff to dissuade certain groups of trespassers. First, the results pointed towards the need to raise risk awareness in less conventional locations situated close to the tracks, to educate urban planners and community representatives, and to combine education campaigns with punitive measures. Second, there was a need for a better joint work within communities, between IMs and RUs on one hand, and urban planners, local authorities, municipalities, etc. on the other, and the main recommendation was that railway companies should seek collaboration partners. Third, it was suggested that one of the most popular physical measures (i.e. fencing) may in fact be used as a symbolic barrier, indicating the boundary of an area with restricted admission, or that smearing the bars of fences with heavy grease could potentially reinforce the deterrent effect on behaviour. Last but not least, it was shown that in some countries like Spain or Turkey there was a need to train the railway staff to detect and warn trespassers, and to communicate with third parties in difficult situations.

4 Mitigation of consequences by improving procedures and decision making

Beyond prevention itself, another objective of RESTRAIL was to improve the post-incident intervention phase. To our knowledge this was the first time when a joint research effort

resulted in methods and technological tools that can be integrated with existing procedures and technologies in order to achieve the most effective and cost-efficient means of mitigating the impact of suicides and trespasses on railway infrastructures. As clearly indicated in the state-of-the-art review, in order to mitigate the consequences of such incidents, system shut down time must be minimised. The project allowed a systematic identification of several important interfaces between IMs, RUs and first responders involved in managing suicide or fatal trespassing incidents [26], and modelled three key-elements with direct impact on the post-incident disruption time. The operational arrangements, represented by the *information reference source*, support the stakeholders as they assimilate the identified methods, tools, procedures and man agerial models in order to reduce the shut down time associated to suicides and trespassing incidents. The collection of best practice concerning information, *situation management and decision support platform* [27], as well as the *line restoration model (LRM)* [28] were meant to improve the situational picture of the incident, the information collection and dissemination tools, the management of the business processes related to the incident response and decision making processes of the involved IM and RU; between them and the first responders, primarily the police; contractors and other RUs. Therefore, the added value of RESTRAIL comprised new products which help improve the full range of operational and technical arrangements between key responders, whilst enabling the responding organisations to meet their legal responsibilities.

4.1 Consequences mitigation information reference source

First, the project addressed the “procedural” aspects associated with mitigating the consequences of attempted suicides, completed suicides and trespassing incidents with casualties [26]. It enabled the development of a functional information reference source for IMs, RUs, police (state, municipal and railway), fire services and other first responders, regulatory and investigation bodies, which supports response management and consequences mitigation actions, particularly with respect to the shut-down time of railway operation. The reference source covered the following topics as displayed in Fig. 1: (1) incident response arrangements of IM, RU, the police, the fire brigade, emergency medical services (EMS) and others; (2) information management and lines of communication among responding bodies and with decision makers, with emphasis on information sharing and coordination; (3) decision making processes for traffic restoration, including aspects relating to prior agreements among the responders, awareness of rail arrangements, managers’ competence and training in handling incidents and decision making on- and

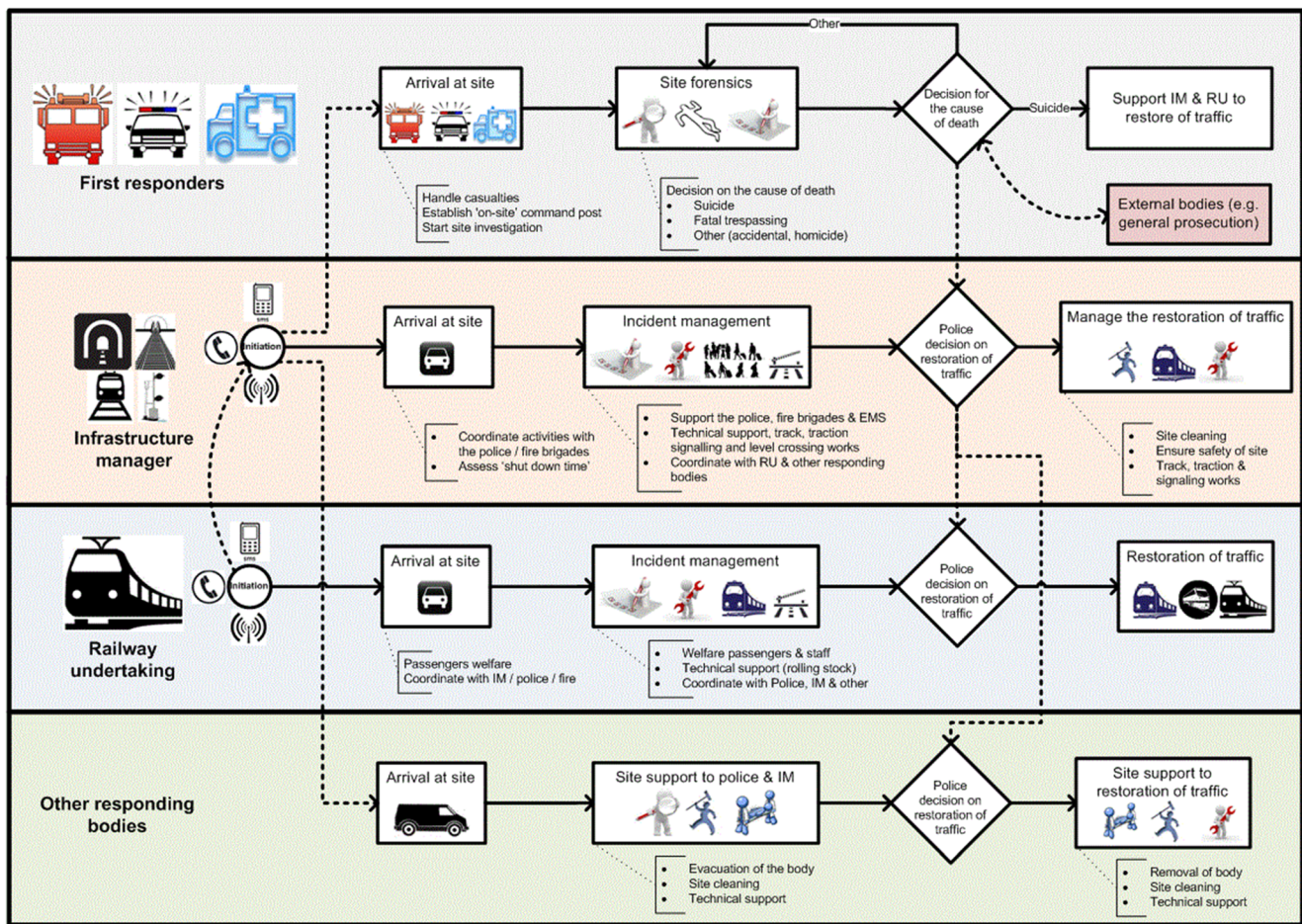


Fig. 1 Generic flow of incident response responsibilities and arrangements

off-site; and (4) a summary of the practices associated with the procedural aspects of handling suicide and trespassing incidents with casualties and their impact, and how these might be improved to minimise their impact on rail operations.

4.2 Information, situation management and decision support platform

Second, the project focused on information sharing platforms and effective lines of communication between responding bodies, which are essential for effective and coordinated incident management [27]. Data shared in real time included geo-data on the incident location and track access points; information on the site of the incident and on possible involvement of third parties, on train data recording and essential actions as part of the response – safety, assistance to passengers, evacuation.

For the very first time, RESTRAIL proposed technical specification and prototype of the situation management system, intended to assist IMs and RUs to achieve the above goals, improve coordination among first responders and help

reduce system shut-down time due to incidents with casualties. Specific results of RESTRAIL indicated that the system should include:

- **Full customisation:** easy-to-use and customise-planning tools and menu-driven operations, and a Business Process Manager (BPM) workflow/rule correlation engine. The business rules, as a set of workflows, will automate the appropriate incident management response.
- **Hierarchical solution** multiple layers, which may consist of multiple sites. Each site will be capable of monitoring and managing its own local facility and incidents, systems and client views. Access to higher layers will require authorisation.
- **Effective and coordinated incident handling via incident execution:** pre-planned incident response workflows will be activated automatically by a time schedule or a sensor alert, or manually by control room operators or field personnel. Incidents can be manually categorised, to present operators with an incident task checklist enabling adaptation to evolving situations.

- **Intuitive multi-layered Geographical Information System (GIS)-based display with dynamic updating** to support effective monitoring, decision making and interaction using an IM / RU's existing GIS infrastructure and supporting GIS standards, such as Open Geospatial Consortium (OGC) and proprietary formats (e.g. ESRI, Google, and etc.).
- **Unified management of all IM and RU video systems:** public video IP feeds, station, way-side and on train Forward Facing CCTV (FFCCTV). The single video matrix relevant to the incident will be automatically displayed, and may be shared among RU and IM. Operators will be able to manipulate cameras as required, to optimise incident handling.
- **Incident assessment:** time-coded playback of incident handling for debriefing to support improving incident response and for evidential purposes.
- **Reporting/custom reporting:** automated and fully customisable.

4.3 Improving situational picture and communication between control centres – the line restoration model

Last but not least, a model was developed to reduce the line operation restoration time following suicide and trespassing incidents [28]. The model receives information concerning the incident and its handling from the Situation Management System, and uses it to forecast the restoration time. By providing IMs and RUs with accurate as possible information, it allows them to prepare and take necessary action to resume operation without unnecessary delay, as soon as the incident is resolved. The limited size of this paper does not allow us to present this model in detail. However, the model's forecasts are of great value to the IMs and RUs, as they allow them to optimise the rescheduling of regional and long distance rail traffic, and also improve passenger service by providing passengers with information that allows them to decide whether to use alternative routes and/or modes of transport. Details can be consulted in the original source [28].

5 Testing the effectiveness of a sample of recommended measures

As shown in the state-of-the-art work, there is little published evidence on the effectiveness of preventative measures to reduce railway suicides and trespasses and their consequences. Moreover, the effectiveness of some measures has never been assessed. RESTRAIL research aimed to tackle this issue and assess a selection of the most promising measures. The RESTRAIL consortium members selected several measures for in-depth field assessment using the lessons learned during

the project, as well as the needs of the corresponding national stakeholders. They developed a series of 11 field pilot tests in different locations (Spain, Finland, Sweden, Turkey, UK, Germany, the Netherlands, and Israel).

5.1 Planning and monitoring of the pilot tests

Each pilot test was conducted according to a specific implementation plan in order to monitor the evaluation process and to provide additional empirical evidence for the effectiveness of measures (see [29] for more information concerning the selection of the measures and their implementation in pilot test planning and execution). The main purpose of these evaluations was to estimate quantitatively the effect of single measures or combination of measures on a specific problem. Some field trials focused on measures to prevent suicides only, others on means to prevent trespass, while others addressed the consequences of incidents. Table 3 displays the final list of tested measures, their target problem and the location of the field test.

5.2 Method for implementation of the field trials and evaluation of the tested measures

The methodologies used in the evaluation of these measures depended on the nature of the measures. In most cases, results have compared the data obtained from the baseline evaluation with the data collected after the application of the measure (i.e. before-and-after measurements). However, for mid-platform fencing a different method was used. A logic map was created to clarify the overall objectives of the intervention and the context in which the intervention was implemented. As result of this, important steps were described as a series of inputs, outputs, outcomes, and impacts (as defined by Hills and Junge [30]). Other specific methodologies were used in the evaluations targeted at mitigation of consequences of suicide and trespassing accidents. The evaluation of the CBT module was qualitative – assessing the CBT's capacity to achieve its objectives. In the case of FFCCTV, it was not possible to organise a field trial. Instead, a study was carried out focusing on the numbers and costs to the rail industry of rail fatalities; the application, costs and the effectiveness of FFCCTV; and how, by whom and for what purpose the available information is used. Furthermore, where possible the pilot tests included a socio-economic evaluation of the implemented measure(s) in the form of CEA (Cost-Effectiveness Analysis) and CBA (Cost-Benefit Analysis) (see [31] for more details). For each possible pilot test, cost data included those related to design, implementation, maintenance, whereas effectiveness data included one or several variables assessed before and after the test period. However, CEA and CBA ratios were not comparable between measures for many structural reasons, thus the main results enabled only to make clear the amount of

Table 3 Overview of the 11 RESTRAIL pilot tests which were designed and implemented between May 2013 and July 2014

Measure	Problem addressed	Country (Partner*)	Specific implementation
1 Warning signs and posters	Trespass prevention	Spain (CIDAUT)	Valladolid Universidad station
2 Railway safety education programme		Spain (FFE)	Madrid and Catalonia Railway Museums; and three primary schools in Alicante
3 Education in schools for 8–11 year old children		Finland (VTT)	Four schools located near the railway lines in the city of Tampere
4 Video enforcement and sound warning		Finland (VTT)	Two trespassing hotspots on open track in southern Finland
5 A combination of measures: fences, anti-trespass panels, video camera and communication campaign		Turkey (TCDD)	Aydin station situated near several schools, a stadium, a hospital and a shopping centre
6 Mid-platform fencing	Suicide prevention	UK (UNOTT)	Three pilot areas in Great Britain around London, including 51 stations, among which 22 had some form of mid-platform fencing
7 Societal collaboration to prevent railway suicides		Sweden (TrV&KAU)	Skåne county in southern Sweden
8 Gatekeeper programme “Train the trainers”		Germany (HMGU)	University Hospital Klinikum rechts der Isar, Department of Psychosomatic Medicine and Psychotherapy, TUM
9 Gatekeeper programme: “Contact with a (possibly) suicidal person”		Netherlands (ProRail & NS)	ProRail and NS premises
10 Computer Based Training (CBT) module for responding bodies	Consequence mitigation	Israel (MTRS 3)	Using a learning management system that police and law enforcement agencies could run on a standard browser
11 Forward Facing CCTV in trains		UK (MTRS 3)	In Great Britain on existing installations at Virgin Trains, Greater Anglia, South West Trains and South Eastern Railway

*CIDAUT – Fundación para la investigación y Desarrollo en Transporte y Energía; FFE – Fundación de los Ferrocarriles Españoles; VTT – Teknologian Tutkimuskeskus; TCDD – Turkish State Railway Administration; UNOTT – University of Nottingham; TrV – Trafikverket; KAU – Karlstad University; HMGU – Helmholtz Zentrum München Deutsches Forschungszentrum für Gesundheit und Umwelt (GmbH); ProRail B.V.; NS – Dutch Railways; MTRS3 Solutions and Services LTD

investment required to achieve the given goal in the circumstances where the measure was implemented.

5.3 Results and main conclusions of the field studies

The results of the pilot tests provided altogether new recommendations to improve reduce the number of railway suicide, (fatal) trespassing accidents and post-incident consequences (see [31] for more details about the results of the pilot tests and lessons learned during the trials). Those results which did not bring new recommendations were in line with the evidence from the literature, and provided new empirical support for the effectiveness of particular measures.

Concerning the reduction of the number of suicides, the results of the both *gatekeeper training courses* were comparable to those reported in the literature [32, 33]. Gatekeepers are people who have frequent contact with possibly suicidal members of the community on account of their professional status (e.g. railway personnel, security staff, fire-fighters, local charity workers). The gatekeeper training teaches them to identify people at risk by recognising suicidal risk factors, to

assess the levels of risk, and to manage the situation appropriately by employing adequate approaching tactics. Both RESTRAIL evaluations (one in Germany and one in the Netherlands) have shown that the training provided a significant improvement in (a) skills such as knowledge about railway suicide, (b) attitude toward railway suicides, and (c) the feeling of competence of staff. These increases occurred for both men and women, for all ages, and particularly for those employees with less than 20 years of job experience. These types of courses are highly recommended since they are cheap and adjusted easily to different circumstances and settings, and prior knowledge on the part of participants is not required. The contents of the course depend on the local culture and in countries where suicide is not accepted this course probably will not work. Finally this type of course can be combined with other measures without any problem.

Another measure aimed at railway suicides was *societal collaboration*. This measure had not been evaluated before; therefore this field test had a major added value. This measure is a joint venture between the RU, IM, police, fire brigade/rescue services and health authorities from a local area. The

responder that first becomes aware of any person in the track area requests and receives a temporary traffic shut-down on the concerned railway line. According to the results, 40 of the 64 persons threatening to commit suicide were found and taken to psychiatric care by the Police. In addition, train services were less disturbed by short traffic stops on more occasions than an actual fatal accident. For example, short traffic stops (involving 25 h for 64 threats of suicide) where people have been saved could be compared to 4 cases where this was not the case involving trains stopped for 30 h. This study identified the great importance of the need for very clear communication among the participants and actions to ensure that effective collaboration is achieved.

The evaluation of *mid-platform fencing* as anti-suicide measure had been one of the more expected, since there have been no previous studies of the effectiveness of this type of fencing at stations. This has been an extensive trial in RESTRAIL and the findings were encouraging. This measure consists of a fence along the central line of an island platform aiming to block pedestrian access from one edge of the platform to the other edge. It is usually used to separate people from the trains passing at high speeds or to isolate fast lines where trains might not stop from the regular lines which should be easily accessible. This field study compared the number of suicides at 51 stations around London between 1994 and 2014 (22 of these stations equipped with mid-platform fencing as part of recent programmes of suicide prevention). There has been only one fatality at fast lines at a station, after mid-platform fencing has been fitted. This result needs, however, to be interpreted with caution. The monitoring period (post-intervention) has been short in relation to many of the stations, therefore there is need for collection and analysis of statistics over a longer period of time to determine if the fencing of fast lines is potentially contributing to a displacement of incidents to other lines or stations. The evaluation has also shown a positive public perception: people liked the fencing and thought that they worked in preventing incidents. There may also be other benefits, such as increasing perceptions of safety while on platforms and the prevention of unsociable behaviour and access to places where people should not be. This type of fencing can be used in combination with other interventions (e.g. training of staff, improved surveillance) and should not present problems in transferring to other countries. It can be costly and is not a solution that can be applied and every station. However, this can be a realistic option to consider where there is an appropriate station configuration and a high proportion of non-stopping trains at a platform at the station.

Regarding the prevention of trespassing incidents, two measures focused on the *educational aspects*. The education programme in schools for 8–11 year old children implemented in Finland had a positive effect on (a) the level of knowledge related to railway trespassing, (b) reported crossing behaviour,

and (c) pupils' assessment of safety related to crossing railway lines. The detailed results of this RESTRAIL field study have recently been published (see [34]), suggesting that a 45-min lesson on safe behaviour could even have a positive effect on the future frequency of trespassing. Similarly, the Railway Safety Education Programme implemented in Spain achieved (a) an increase in teacher awareness about the need to cover railway safety at school and (b) greater confidence, skills and commitment to do so in the future. Moreover, students were able to apply this knowledge to explain the repercussions for someone acting dangerously on or near the railway tracks and in a station. The findings from both evaluations are in line with the published evidence [35, 36] but also suggested the children's knowledge of railway safety and their subsequent behaviour was heavily influenced by the actions observed in the adults around them. For this reason, education outside of schools also plays an important role in communications the safely message. In this sense the railway museums have a crucial role in bringing the society closer to the world trains. These programmes can be applicable in different social contexts, although it is obviously necessary to adapt the contents to the reality of where the measure is being applied and contents should take into account the demographic profile of the target population and the features of the local implementation site.

The use of *warning signs and posters* proved to be effective in discouraging pedestrians from using illegal crossing places when the displayed messages provided information concerning the possibility of being fined in combination with information about rail safety. The results were consistent with the few published studies, namely that the effect is likely to be significant but not necessarily large [35, 37]; however, the recommendations from this study were threefold: (a) the design and content of the signs/posters should be carefully planned to fit the local context and culture as well as the preferences of the national train operators that might disagree with the displayed message; (b) the amount of signs and posters should be carefully considered, to avoid unnecessary signage; and (c) the period of time the signs and posters are exposed in a specific area should be considered, since the effect of is likely to be reduced over time. The optimal measure would be to combine signage with wider targeted campaigns against trespass.

After the implementation of the *video enforcement and sound warning system* at two sites in southern Finland, the number of trespassing incidents dropped significantly [38]. The system included a video camera linked to a motion sensor and a loudspeaker. Trespassers were observed by automatic camera that took a series of pictures whenever movement was detected on the illegal crossing route. Upon detection the trespasser was given a warning message by the loudspeaker. The effect on the frequency of trespassing was calculated by comparing trespasser counts before and after the implementation.

In the two pilot test sites the reduction in the frequency of trespassing was 18 % and 44 %, supporting the only existing study [39]. However, because of the lack of control sites the effect may have become somewhat overestimated. Those who are planning to implement a similar measure are advised to use an expected effect of the reduction of trespassing between 10 % and 30 %, depending on local circumstances, especially the distance to alternative legal crossing facilities. In general, there were no difficulties regarding the system's maintenance. It seems likely that adding media campaigns and a true threat of punishment to video enforcement and sound warning, its effect on trespassing could be enhanced, at least on the short term. In order to maintain the effect high, media coverage should be maintained and include also information on issued penalties.

Lastly, *the field trial which evaluated a combination of different measures* in Turkey included: (a) anti-trespass panels in conjunction with fencing at platform ends and intermediate fencing between the tracks to physically block the access; (b) video surveillance camera; and (c) warning and prohibitive signs informing the public of the dangers and illegality of trespassing. This trial had high added value since it was not known whether similar combinations of measures against trespassing in railway area had been implemented before, nor which was their combined effect on the frequency of trespassing. The results indicated an immediate reduction of almost 95 % on trespass behaviour. Therefore, this combination of measures could be a good option in order to reduce the number of trespassers in specific railway areas. This is also supported by a recent field trial conducted in Belgium [40], which indicated that a somewhat similar combination of measures applied to a relatively similar context reduced the number of trespassers by 78 %.

Concerning the mitigation of consequences, two studies were conducted and the results of the both measures were innovative. The *computer based training (CBT) module* was effective in making a positive contribution to the understanding by decision makers handling suicides and fatal trespassing incidents of the manner in which such incidents are handled. Collaboration between decision makers, RUs and IMs for effective incident management and the manner in which it can support them in managing these incidents was emphasised. Altogether this training was considered highly relevant with extremely high effectiveness for RUs and the police. Above all, the means described in the lesson was perceived as valuable to reducing shut-down time as a result of suicides and fatal trespassing incidents.

In addition, the analysis concerning *Forward Facing CCTV*, has shown that FFCCTV with a wireless link provided real time remote access to images by key decision makers, particularly the police, facilitating the earliest possible decision making on the circumstances involved with rail fatalities. Determining whether a suicide, trespassing accident or

homicide is involved has a considerable impact on system shut down time, thus close liaison by RUs and IMs with the police is essential to maximise FFCCTV benefits.

6 Providing guidance material and recommendations through the RESTRAIL toolbox

In line with its specific objectives, RESTRAIL covered the results dissemination at both scientific and practical levels. One core aspect of the practical dissemination involved the development of a toolbox for decision-makers. This toolbox summarises the most relevant practical and scientific information collected and produced during the project [41] and was designed as an online guide to best practice which is easy to disseminate, find, access and update even after the end of the project. Besides the online version, which is openly available at www.restrail.eu/toolbox, a synthesis of the toolbox was published in the final RESTRAIL official document [42] publicly available for download on the project's webpage.

6.1 Goal and development method

The aims of the RESTRAIL toolbox are threefold: (1) to lead decision-makers through the process of selecting from the range of preventative and mitigation measures; (2) to provide more detailed guidance on the implementation of those measures; and (3) to provide a framework for collecting and structuring information in order to feed an accessible and documented database on measures implementation and efficiency across the rail community and beyond.

These three objectives meet the needs and requirements identified in the state-of-the-art phase and are an attempt to fill in the gaps (both theoretical and empirical). Thus, the toolbox was developed through a systematic process which began with inputs from the state-of-the-art reviews and the collection of international data and best practices, results of the assessment process and results from the field trials. The toolbox was drafted in several stages, with systematic evaluations after each draft. Each working version has been reviewed by the RESTRAIL consortium and additional evaluations were conducted through two joint workshops during the RESTRAIL mid-term conference held in Paris on 12 June 2013. These workshops provided external evaluations from actual expert and non-expert end-users and enabled further adjustments according to their feedback.

6.2 Organisation and content

The toolbox includes two parts. The former provides general guidance through a multistep approach which structures the analysis of a problematic situation. The question answered by the general guidance is *how to analyse a problem and choose*

the optimal preventative or mitigation measure(s)? Consequently, this part of the toolbox provides a general methodology for the inexperienced end-users who deal with a suicide or trespassing problem, as well as with post incident consequence mitigation difficulties. For the experienced end-users, it can be a useful checklist in the problem-solving process. This first part of the RESTRAIL toolbox is a much needed top-down approach for systematic interventions [43] (i.e. driven from theories and examples of good practice in related areas, in absence of consistent empirical data about the effectiveness of measures).

The latter part of the toolbox includes specific guidance, providing details about the implementation of different measures. The question answered by the specific guidance is *how to implement the selected measure(s) in order to minimise the shortcomings and enhance the expected effect?* This part of the toolbox provides the end-user with a wide list of preventative and mitigation measures (70 specific measures grouped into 25 families and classified in 3 broader categories according to their type and general mode of intervention). The measures are also classified according to the theoretically driven model which explains the sequential process of railway suicide and trespass [19]: measures to (1) influence decision, (2) deter access, (3) influence behaviour in track area, (4) reduce consequences, and (5) improve practice and processes. Moreover, this second part of the toolbox includes implementation tips and other useful details which may be important during the implementation phase. The presentation of each specific measure follows a standard structure: description, recommendations, warning points, observations, study results, and a gallery with examples and/or attached documents.

To our knowledge the RESTRAIL toolbox is the first attempt to provide (a) an evidence-based practical tool for decision-makers and (b) a structured research framework for behavioural scientists concerned with railway suicide and trespassing issues. The RESTRAIL toolbox provides a systematic but flexible approach, allowing the end-users to adapt it to their specific needs and according to particular national / cultural problems. Furthermore, the toolbox is continuously maintained and updated by UIC, therefore its contents are ever expanding and improving as new studies are published (see for e.g. [10–13]).

7 Discussion and conclusions

In summary, the RESTRAIL project has covered at least five relevant issues which significantly contribute to the prevention of railway suicide and trespass, and mitigation practice: (1) collating details across a wide range of countries of what is happening in terms of prevention, data on incidents and processes for investigation and the management of suicide and trespassing incidents, etc.; (2) developing and using

methodology for the evaluation of extensive sets of measures; (3) providing recommendations for further examination of selected preventative measures; (4) looking for additional empirical support for a sample of selected measures; and (5) providing a toolbox with guidance materials and best practice examples to help IMs and RUs implement measures more effectively tailored to their specific needs.

7.1 The added value of the project

Before RESTRAIL there was no integrated research about railway suicide and trespass prevention and no global classification of recommended or promising measures. The available resources included only limited evaluations of some measures (single studies specific to one railway network) and just a few country-specific guidance materials [14]. With RESTRAIL everything is integrated and available for the concerned stakeholders and researchers. Furthermore, the advanced knowledge achieved in the project has clear practical implications for society which enabled the European Commission to classify this completed project as a “Success story” [44].

The project produced innovative proposals, which can help save lives, money and time for both railway companies and passengers. In this respect, the project achieved three major impacts, considering its initial objectives. The first one is on safety, by helping reduce the number of deaths and injuries. The project provided an integrated list of recommended measures, a classification system to organise them, and new evidence on their effectiveness. In other words, these research outputs directly contribute to the reduction of life loss and human suffering, thus improving community well-being. The second implication is for the citizens who use the trains on a regular basis, for example for commuting. RESTRAIL helps reducing the traffic shut-down time after an incident improving the service punctuality. The project modelled the most important interfaces between the post-incident responding bodies, identified four cost-effective mitigation strategies and tested two of them, providing totally new recommendations to reduce the traffic disruption time. In this way, pedestrians and passengers will be less affected by traumatic events, will feel safer and more secure in the railway environment and will have a better perception of the train operating company. The third implication concerns the railway industry, which is seriously affected by suicides and trespassing accidents, in terms of economic costs, stress among train drivers and other railway staff, and negative public image conveyed by these incidents. RESTRAIL helps the industry significantly reduce the direct and indirect costs arising from these events with a practical tool which provides guidance and evidence-based recommendations for rail decision-makers.

7.2 Strengths and limitations

The RESTRAIL frame was very efficient to collect and integrate international knowledge and examples of good practice, to develop an evaluation methodology and to assess the existing body of prevention and mitigation measures, to develop field tests, and to initiate a practical toolbox. However, there were some limitations mostly because of the inherent gaps which were impossible to overcome within the project's timeframe. For example, it was not possible to perform any preliminary economic analyses in the case of four pilot tests (the two gatekeeper programmes, CBT module, and Forward Facing CCTV), due to the: (1) lack of time to collect long-term and robust data; (2) missing data or unavailability of actual measures of effectiveness and/or of other effects and impacts on the network at the time of the trials. As revealed in the RESTRAIL workflow, a high amount of data and evidence are still unavailable or difficult to obtain, thus requiring further relevant indicators from the field, improved collection procedures, and tools at a wider scale than it was expected to do in the RESTRAIL context. Furthermore, the study periods for pilot tests in RESTRAIL project were limited and did not allow collection of data on long term effects [34]. However, the RESTRAIL field tests provided considerable added value to the overall knowledge on the effectiveness of measures against railway suicide and trespass.

7.3 The way forward

Possible follow-up research activities include developing more sound socio-economic evaluations of measures for preventing suicide and trespassing accidents. This will require a whole dedicated project focused on a smaller set of measures or combination of measures and on their evaluation in longer trials so as to collect more reliable data, leaving more time and more possibilities to implement several experimental and control situations in parallel. More thorough evaluations could employ controlled characteristics to select the different experimental sites and measurement tools that enable the collection of all relevant data, during longer periods, and testing several comparable preventative measures and objectives.

Several field trials are now ongoing in various European countries and some of them are trying to overcome the time limit encountered in the RESTRAIL field studies and to include the lessons learned during the RESTRAIL project: (1) anti-trespass panels are evaluated by French Railways in several stations close the level crossings and in Belgium by INFRABEL in several locations; (2) anti-suicide blue lights are evaluated in Belgium by INFARBEL and in Great Britain by Network Rail; (3) intelligent detection systems consisting of automated video cameras and sound warning speakers are evaluated in the Netherlands by ProRail; (4) thermal cameras are evaluated in Belgium by INFRABEL; and (5) several types of platform screen doors (PSDs) are tested in the

Stockholm metro system. The results will be included in the toolbox once they become publicly available.

Furthermore, the elaboration of a theory-based framework [45] is required to accurately support these evaluations and economics estimates. In other words, one can elaborate an explicit conceptualization of the chosen prevention measures in terms of a theory that attempts to explain how it produces the desired effects (e.g. significantly decreasing the number of rail suicides, significantly reducing trespassing behaviours, etc.) as well as the various relevant impacts (e.g. in terms of time loss and delays). A further step could thus be verifying and sometimes modifying the assumptions of this theory-based framework. This would involve new studies and investigation whenever needed. The recently proposed model of suicide and trespass process [19] and the updated knowledge and practice available in the RESTRAIL toolbox could provide the basis for initiating such a theory-based approach as a follow-up of the project.

Research on railway suicide and trespass prevention continues to be formally endorsed in Europe by ERA which has been developing a research programme on the use of behavioural techniques to reduce fatality rates in suicide/unauthorised person categories since April 2015. Additionally, periodic workshops on reporting and preventing suicides on railway premises are systematically organised by ERA at European level as part of their project 1.5 – Improving safety performance. In the meantime, UIC continues to look for new collaboration opportunities on this topic and to promote the existing best practices at a global level.

The continuation of RESTRAIL and its subsequent toolbox has been supported by systematic dissemination actions targeted at complementary audiences (i.e. railway safety and security experts, Human Factor specialists, traffic and transportation psychologists, researchers, academics, students). This paper is meant to be another contribution to this long-term dissemination strategy among relevant readers.

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