RESTRAIL

REduction of Suicides and Trespasses on RAILway property

Collaborative project

Evaluation of measures, recommendations and guidelines for further implementation

Pilot test #4

Video enforcement and sound warning – VTT

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RESTRAIL Consortium

	List of Beneficiaries		
No	**Beneficiary organisation name**	**Beneficiary short name**	**Country**
1	Union Internationale des chemins de fer	**UIC**	**FR**
2	Teknologian Tutkimuskeskus VTT	VTT	FI
3	Trafikverket - TRV	TrV	SE
4	Institut français des sciences et technologies des transports, de l'aménagement et des réseaux	IFSTTAR	FR
5	MTRS3 Solutions and Services LTD	MTR	IL
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13	ProRail B.V	PR	NL
14	Nice Systems Ltd	NICE	IL
15	Ansaldo STS	ASTS	IT
16	University of Nottingham	UNOTT	UK
17	INFRABEL	INFRABEL	BE

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Acronym	Meaning
ADIF	ADministrador de Infraestructuras Ferroviarias
ERA	European Rail Agency
BTP	British Transport Police
CAEX	CAPital Expenditure
CBT	Computer Based Training
CCTV	Close-Circuit TeleVision
CN	Canadian National
DOW	Description Of Work
FFCCTV	Forward Facing Closed-Circuit TeleVision
GDL	German Drivers Leasing
HMTreasury	Her Majesty's Treasury
IM	Infrastructure Manager
IP	Important Point
IT	Information Technology
NPV	Net Present Value
OPEX	OPeration Expenditures
OTDR	On Train Data Recorder
PIER	Program in Interdisciplinary Education Research
2RProtect	Rail and Road Protect
RAILPOL	European Network of RAILway POLice Forces
RSSB	Rail Safety and Standards Board
RU	Railway Undertaking
SMIS	Safety Management Information System
SPSS	Statistical Package for the Social Sciences
STS	SysTemS
SWOV	Institute for Road Safety Research
TCRP	Transit Cooperative Research Programme
VAS	Visual Analogue Scale
VPC	Values of Preventing a Casualty
VT	Value of Time
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis

1.1 Video enforcement and sound warning – VTT

1.1.1 Overview of the piloted measure

The measure *Video enforcement and sound warning* was piloted at two locations in southern Finland between May and December 2013. At the pilot test locations trespassing occurred along illegal footpaths across railway tracks. Trespassers were detected by video cameras which triggered a sound warning by a loudspeaker when movement was detected in a predefined area in the picture. A detailed description of the measure and pilot test is in RESTRAIL Deliverable 5.1 (2014).

1.1.2 Methodology to evaluate the piloted measure

The evaluation of the effects on the frequency of trespassing and trespassing accidents was based on trespasser counts before and after implementation. It was assumed that changes in the frequency of trespassing reflect the effects on the frequency of trespassing accidents. This is a fair assumption since e.g. in road accident studies exposure (expressed for example in kilometres driven) is by far the most important variable explaining the number of accidents (Elvik et al. 2009). Even though the effect of exposure is not necessarily strictly linear, changes in exposure have a clear effect on the probability of accidents.

The evaluation method was a naive before-after study, meaning that the frequency of trespassing after the implementation of the measure was compared to respective frequency before implementation, without control for other factors which may have - and probably have – affected the frequency of trespassing during the study period. Examples of such factors include e.g. seasonal variation of pedestrian traffic, weather, temperature, and number of daylight hours per day. It would have been desirable to use a control group for the elimination of the effects of such confounding factors. However, it was practically impossible to find valid comparison data because the development of trespassing frequency in time can vary between sites. The routes pedestrians use daily can change for reasons other than safety measures, and the changes can vary between sites. In a small-scale study like ours it was not possible to use control data that would have enabled reliable estimation of what would have been the frequency of trespassing at the test sites if the measure had not been implemented.

The effect of the measure on the frequency of trespassing was calculated by a method designed for naive before-after studies (Hauer 1997). In principle, the method consists of two steps:

- Step1: prediction of frequency of trespassing in the after period, if the measure had not been implemented and;
- Step2: estimation of the frequency of trespassing in the after period, when the measure was at place.

The effect of the measure is achieved by comparing the results of these two steps.

In the first step the predicted frequency of trespassing is calculated by multiplying the trespassing frequency in the before period by the ratio of the durations of after and before periods. The estimate of the trespassing frequency in step two is simply the observed frequency.

It is assumed that the number of trespassers per unit time is Poisson distributed. Then the statistical notations and calculations are as follows:

K is the observed number of trespassers per observation unit in the before period.

L is the observed number of trespassers per observation unit in the after period.

π is the predicted number of trespassers of a specific entity (location) in the after period, if the measure had not been implemented.

λ is the number of trespassers of a specific entity in the after period.

r_d is (duration of after period)/(duration of before period).

VAR means variance

s means standard deviation.

θ is the effect of the measure: estimated frequency of trespassing when the measure was at place compared to respective frequency without the measure.

The 'hat' above the symbols indicates estimate.

$\hat{\lambda} = L$	(1)	$VAR(\hat{\lambda})=L$	(2)
$\hat{\pi} = r_d \cdot K$	(3)	$VAR(\hat{\pi})=r_d \cdot K$	(4)
$\hat{\theta} = \dfrac{\frac{\lambda}{\pi}}{\left[1+\frac{VAR(\hat{\pi})}{\pi^2}\right]}$	(5)	$\dfrac{\left(\frac{VAR\{\hat{\lambda}\}}{\lambda^2}+\frac{VAR\{\hat{\pi}\}}{\pi^2}\right]}{\left[1+\frac{VAR\{\hat{\pi}\}}{\pi^2}\right]^2}$	(6)
$s(\hat{\theta}) = \sqrt{VAR(\hat{\theta})}$	(7)		

Approximate 95% confidence interval of the effect is $\hat{\theta} \pm 1{,}96 \cdot s(\hat{\theta})$.

The effect of the measure on the frequency of trespassing was calculated for all observations as a whole and for each weekday separately.

1.1.3 Reported costs for measure

Reported costs for the measure implemented in the test are given in **Table 1.1-1.**

Table 1.1-1: costs for video enforcement and sound warning

Cost	Nature	value (€)
Planning of study design	50 hours á 100 €	5000
Preliminary search for pilot test sites	35 hours á 100 €	3500
Equipment for monitoring pedestrian movements and providing sound warnings	Two sets á 3000 €	6000
Travel to potential and final pilot test sites	Search for potential sites 700 km á 0,43 € = 301 €. 30 return trips to Kirkkonummi site á 50 km = 1500 km á 0,43 € = 645 €. 20 return trips to Tammisaari á 180 km = 3600 km á 0,43 € 1548 €. Total 2193 €.	2494
Implementation and removal of equipment	14 ours per installation = 28 hours á 100 €	2800
Collection of before-data	Included in travel costs above	

Collection of after-data	Included in travel costs above	
Total		19794
Maintenance, if equipment uses mains power	Periodic maintenance checks, e.g. 4 days per year = 28 h á 100 €	2800
Total		22594

1.1.4 Evaluation results

In Kirkkonummi, 829 trespassers were observed during the before period and 688 in the after period. In Tammisaari the respective numbers were 267 and 782. The lengths of before and after periods in Kirkkonummi were 47 and 67 days, respectively. In Tammisaari the lengths were 15 and 54 days. In the before period, the average number of trespassers per day was almost the same at both test sites. In the after period, however, fewer trespassers were observed at the Kirkkonummi site compared to the Tammisaari site (**Table 1.1-2** and **Table 1.1-3**).

Table 1.1-2: Observed daily numbers of trespassers at the Kirkkonummi site

	Before (28.5.-21.6. & 30.8.-23.9)										After (25.9.-6.12.)											
	28.5.-2.6.	3.-9.6.	10.-16.6.	17.-21.6.	30.8.-1.9.	2.-8.9.	9.-15.9.	16.-22.9.	23.9.		25.-29.9.	30.9.-6.10.	7.-13.10.	14.-20.10.	21.-27.10.	28.10.-3.11.	4.-10.11.	11.-17.11.	18.-24.11.	25.11.-1.12.	2.-6.12.	
	1	2	3	4	5	6	7	8	9	Mean	1	2	3	4	5	6	7	8	9	10	11	Mean
Mon		17	26	7		11	9	18	19	15,3		4	7	7	2	13	3	3	3		10	5,8
Tue	16	21	26	24			19	10		19,3		14	9	13	9	2	5	4		5	11	8,0
Wed	15	11	17	36			20	12		18,5	17	12	2	5	10	7	13	9		8	15	9,8
Thu	20	26	20	27			19	7		19,8	9	23	10	13	1	8	10	10		8	16	10,8
Fri	28	18	16	8	18	21	25	38		21,5	14	23	16	14	16	12	9	12		9	6	13,1
Sat	22	10	13		17	30	9	13		16,3	10	16	12	14	14	8	10	8	18	11		12,1
Sun	11	15	14		6	12	22	10		12,9	16	9	14	11	12	3	2	4		15		9,6
Mean	18,7	16,9	18,9	20,4	13,7	18,5	17,6	15,4	19,0	**17,6**	13	14,4	10,0	11,0	9,1	7,6	7,4	7,1	10,5	9,3	11,6	**10,0**

Table 1.1-3: Observed daily numbers of trespassers at the Tammisaari site

	Before (1.-15.10.)				After (17.10.-16.12.)										
	1.-6.10.	7.-13.10.	14.-15.10.		17.-20.10.	21.-27.10.	28.10.-3.11.	4.-10.11.	11.-17.11.	18.-24.11.	25.11.-1.12.	2.-8.12.	9.-15.12.	16.12.	
	1	2	3	Mean	1	2	3	4	5	6	7	8	9	10	Mean
Mon		15	22	18,5		17	19	8	13		22	21	26	30	19,5
Tue	22	17	20	19,7		32	19	7		3	16	16	20		16,1
Wed	29	9		19,0		20	13	12		16	25	15	11		16,0
Thu	31	23		27,0	16	17	16	16		6	16	13	17		14,6
Fri	12	21		16,5	13	15	7	13		19	20	6	13		13,3
Sat	7	19		13,0	9	4	1	11		17	22	23	13		12,5
Sun	12	8		10,0	12	16	8	1		9	8	18	6		9,8
Mean	18,8	16,0	21,0	**17,8**	12,5	17,3	11,9	9,7	13,0	11,7	18,4	16,0	15,1	30,0	**14,5**

The development of daily trespassing before and after the implementation of the measures is shown in **Figure 1.1-1** and **Figure 1.1-2**. At both locations there seems to be a decrease in trespassing after the implementation of the measure. In Kirkkonummi the drop is greater than in Tammisaari. In Kirkkonummi after implementation there is a decreasing trend that continues until week 46. In Tammisaari the daily number of trespassers seems to increase slightly with time after implementation.

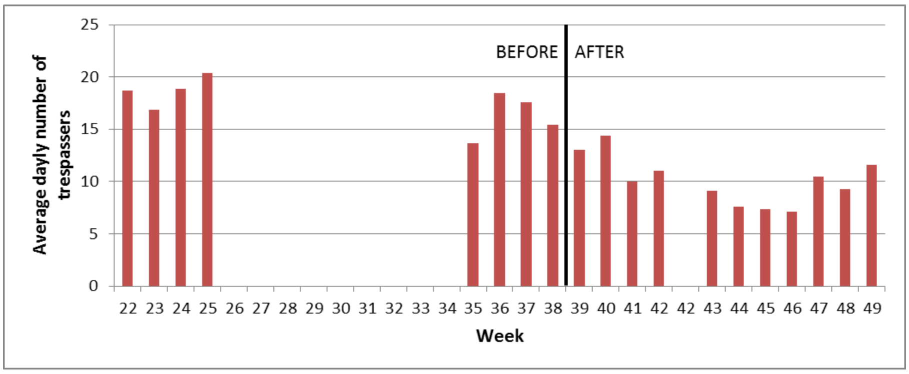

Figure 1.1-1: Average daily numbers of trespassers by week at the Kirkkonummi site

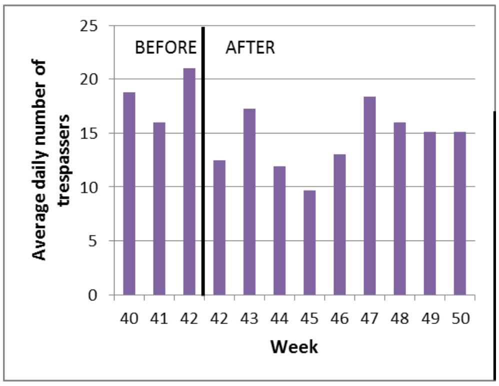

Figure 1.1-2: Average daily numbers of trespassers by week at the Tammisaari site

The results of trespasser counts are summarised in **Table 1.1-4** which includes the values of all variables needed for the calculation of the effect according to equations presented earlier.

Table 1.1-4: Summary of trespasser counts at the two test sites

	Kirkkonummi				Tammisaari			
	Before		After		Before		After	
	Days	Tres-passers	Days	Tres-passers	Days	Tres-passers	Days	Tres-passers
Mon	7	107	9	52	2	37	8	156
Tue	6	116	9	72	3	59	7	113
Wed	6	111	10	98	2	38	7	112
Thu	6	119	10	108	2	54	8	117
Fri	8	172	10	131	2	33	8	106
Sat	7	114	10	121	2	26	8	100
Sun	7	90	9	86	2	20	8	78
Total	47	829	67	668	15	267	54	782

The results of the effect calculations for the two test sites were: in Kirkkonummi, the total effect was a 44% reduction in trespassing and the 95% confidence interval of the reduction was from 38 to 50% and in Tammisaari, the reduction was 18% and the 95% confidence interval was from 6% to 30%.

In Tammisaari the before period was quite short (only about two weeks) for reasons explained in RESTRAIL Deliverable 5.1 (2014). This is shows in the confidence which are much greater than in Kirkkonummi where the lengths of before and after periods were in better balance.

In Kirkkonummi there were significant differences in the effect between weekdays: The reduction was smaller during weekend (26%) than on Monday and Tuesday (63% and 59%). No explanation for this difference could be found. In Tammisaari the confidence intervals of the effect estimates of different days were overlapping, and there were no significant differences between weekdays.

Trespassers were also classified by e.g. age, sex, direction of travel and whether they were alone or part of a larger group. No clear differences in the effect were detected between such categories.

CBA for video enforcement and sound warning

Concerning this measure, costs are essentially study and design costs, location research costs, maintenance and implementation equipment costs. The variables used to assess the measure are the number of prevented trespassers for each site.

When a cost-effectiveness study is performed, it is imperative to express the cost-effectiveness ratio (CER),that is obtained by dividing the efficiency E by the cost generated by the implementation of the measure C:

$$CER=E/C$$

With regards to this measure, efficiency is defined as the number of prevented trespass on the tracks by cost unit of the implemented measure:

CER = (number of trespass prevented by the implementation of the measure) / cost of the measure).

Reported to a one-year period, we can calculate the number of avoided trespass since the implementation of the measure and the real cost of the measure for the same period, which provides a CER = 2078/22594 = 0.091984205. It should be note that the higher is the CER value, more efficient is the measure. Results and assumptions are provided in **Table 1.1-5.**

Table 1.1-5: CEA for video enforcement and sound warning

Cost	**22 594 €**
Effectiveness measures **Number of trespassers prevented per year**	2078 (365* 5,69 prevented / days)
Assumption(s)	The reduction in the number of trespassers is considered as constant and representative of the cumulated effect whatever the period in the year
Cost effectiveness ratio (CEA results (E/C)	0,091984205

The resulting CEA ratio can be interpreted in the following way: an investment of 1 euro enable to reduce by 0.09 the number of trespasser per year at a location. A Cost-Benefit analysis would probably be more meaningful in terms of decision support. For that purpose however, it is necessary to operate the efficiency variables, in particular here the number of trespass prevented by the measure. Financial gain can be calculated depending on the type of avoided trespass-related events; deaths, light and serious injured being fixed in an ERA document (see section 3.1.5) With no information on the distribution of trespass consequences, we can focus on trespass causing no deaths or injuries (majority of cases), that may result delays linked to reduction in speed on the rail network (service or emergency braking, disruption in service, run on sight, restricted speed....). The cost of delay per time unit is considered in subsection 3.1.5.2. Performing a CBA from CEA would be easy to apply provided that all these input variables will be given, estimated or assumed.

1.1.5 **Discussion and conclusions**

The fact that there was a clear reduction in the frequency of trespassing at both test sites indicates that the measure worked as intended. The calculated effect was quite high -44% (-38…-50%) in Kirkkonummi and -18% (-6…-30%) in Tammisaari. However, because no control site was included in the study, the effect was not only the effect of the measure but included also the effects of other factors such as the changes in people’s needs to cross the railway, season of the year and weather, for example. It seems likely that the detected effect represent the upper boundaries of the real effect of the measure rather than the long term effects of possible similar installations. This is the case because in both pilot tests sites the conditions for walking were less favourable (less daylight hours, colder weather) in the after periods than in the before periods.

In principle, the effects could have been affected by the regression-to-the-mean; i.e. a statistical phenomenon meaning that if a variable is extreme on its first measurement, it will tend to be closer to the mean on its next measurement. It is not likely, however that the results were much contaminated by such regression tendency, because the sites were selected because of frequent trespassing during several years rather than only previous year, for example.

The large difference in the effect between test sites also indicates that the effect depends greatly on local circumstances, and perhaps also on safety culture of the society in general. For example, the effect can depend on the motives for illegal crossing and the distance to alternative (safe and legal) crossing facilities. Pedestrians who take the shortcut as part of their daily exercise could change their route easier than people who hurry to work in the morning. It is also easier to take another route if safe and legal crossing place is near compared to a situation where it is far away. It is also possible that the effect was smaller in Tammisaari because the speed of trains was lower there (typically about 50 km/h) than in Kirkkonummi (up to 120 km/h), and sites with slower train speed may be considered less dangerous.

In these pilot tests there was no real threat of punishment for illegal crossing, even though the sound message given to trespassers mentioned that crossing in this particular place was illegal and dangerous. Some people may have thought that there is also a possibility of punishment, but it is also possible that such fears diminished with time as there were no knowledge or rumours that somebody had actually been punished.

These pilot tests were not advertised in the media, and the perceptions of the public about the measure were based on their own experiences (and perhaps also the experiences of other people they know). In a way this may have increased the effect of the measure, because people remained uncertain about the possibility of punishment for trespassing. Media attention could also have increased the perception of dangers related to trespassing, and thus improved the effect.

It seems likely that adding media campaigns and true threat of punishment to video enforcement and sound warning, its effect on trespassing could be enhanced, at least in the short term. In order to maintain the effect high, media coverage should be maintained and include also information on issued penalties.

Overall, video enforcement combined with sound warning can reduce trespassing significantly. In the two pilot test sites the reduction in the frequency of trespassing was 18% and 44%. 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.

The pilot test equipment operated on 12 V batteries, which had to be changed weekly. Otherwise the system seemed to work reliable with the exception of a breakdown of infrared sensor at the Tammisaari site (RESTRAIL Deliverable 5.1). The need for maintenance would be much reduced if mains power was used instead of batteries.

Video enforcement combined with sound warning suits best to locations where trespassing is concentrated in a limited area, such as a footpath across the railway, where detection of trespasser is more reliable and sound warnings are less likely to be disturbing to those living or moving in the neighbourhood, compared to sites where trespassing is spread to a wider area. Furthermore, mains power should be fairly easily available to avoid the need for frequent maintenance of the system. An obvious alternative to video enforcement and sound warning is fencing, which can be more effective, suits for limited locations where trespassing is concentrated on certain routes and does not need electricity.

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