SAFER-LC

SAFER LEVEL CROSSING BY INTEGRATING AND OPTIMIZING ROAD-RAIL INFRASTRUCTURE MANAGEMENT AND DESIGN

WP5 - Cost- benefit analysis

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Agenda

1. Introduction of WP5 & CBA-CEA (10 mn), IFSTTAR
2. Lessons learnt from past projects (20 mn)
   - RESTRAIL (2010-2014)- REduction of Suicides and Trespasses on RAILway property. FP7
   - SELCAT (2006-2008) "Safer European Level Crossing Appraisal and Technology". FP6
3. Presentation of SAFER-LC selected scenarios (UIC) (10 mn)

4. Discussion on
   - Various aspects to be considered in CBA
   - Identification of measurable/qualitative indicators

Conclusion of the session

WP5 – Cost- benefit analysis -Overview

- **Duration**: M6 → M36
- **Leader**: IFSTTAR
- **Contributors**: All
- **Total effort**: 50 M.M

UIC	NTNU	**IFSTTAR**	CERTH-HIT	Trainose	GLS	COMM	IRU	SNCF
7	4	**17**	3	5	1	2	10	1

Objectives

- Perform a comprehensive C/B analysis of the developed solutions, taking into account various aspects:
  - Economical
  - Social
  - Environmental
- Issue a concise set of recommendations pertaining to:
  - Technical specifications
  - Human processes
  - Organizational and legal frameworks
- ==> Implementation of the solutions + Feed into future international standard in rail and road → Safer LX

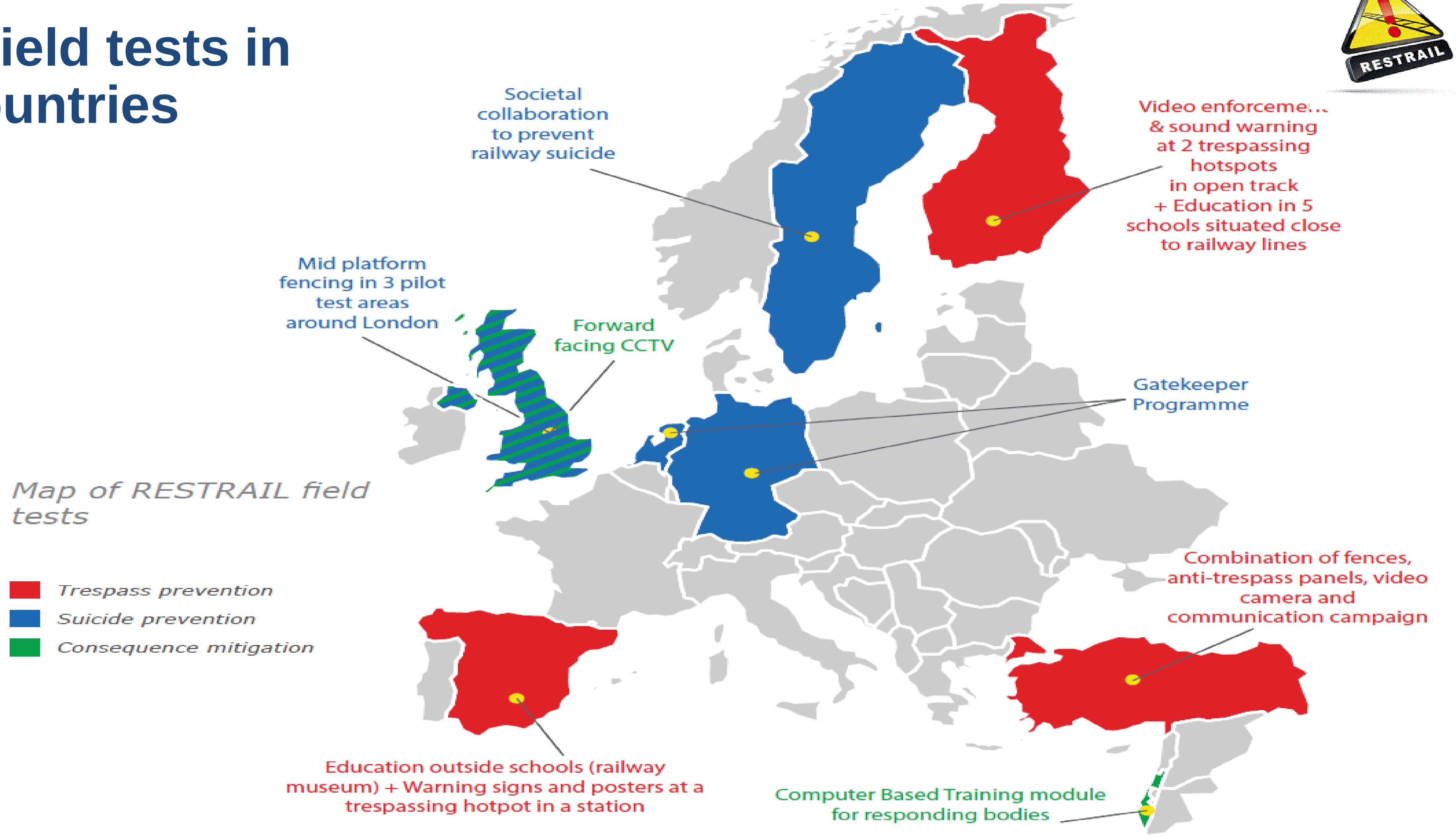
Lessons learnt from past projects (20 mn)

- RESTRAIL (2010-2014)- REduction of Suicides and Trespasses on RAILway property. FP7

- SELCAT (2006-2008) “Safer European Level Crossing Appraisal and Technology”. FP6

RESTRAIL project

11 Field tests in 8 countries



Development of a method for the evaluation of measures

An initial set of 83 preventive measures to reduce the occurrence of suicide or trespassing has been grouped into 38 families of measures in which the modes of action for incidents and accidents are similar.

Several criteria were chosen for the evaluation procedure:

(1)durability of effects,
(2) costs and benefits (based on expert judgment and not on calculation of the C/B ratio),
(3) integration with other policy measures,
(4) impact on railway operations,
(5) impact on people and jobs,
(6) technological issues,
(7) environment,
(8) acceptance,
(9) transferability issues.

Lessons leant from the CEA / CBA

Mostly CEA (and mini CBA in two cases) were performed with the cost and effectiveness data collected within the pilot studies. Unfortunately, it was not possible to perform any preliminary economic analyses in the case of four pilot tests (Dutch gatekeeper programme, German gatekeeper programme, training based on CBT and Forward Facing CCTV).

The RESTRAIL frame was very efficient to develop field tests of measures but cannot gather the whole set of data required for conducting CEA or CBA to actually compare between the various options in the same
(or very similar) locations.

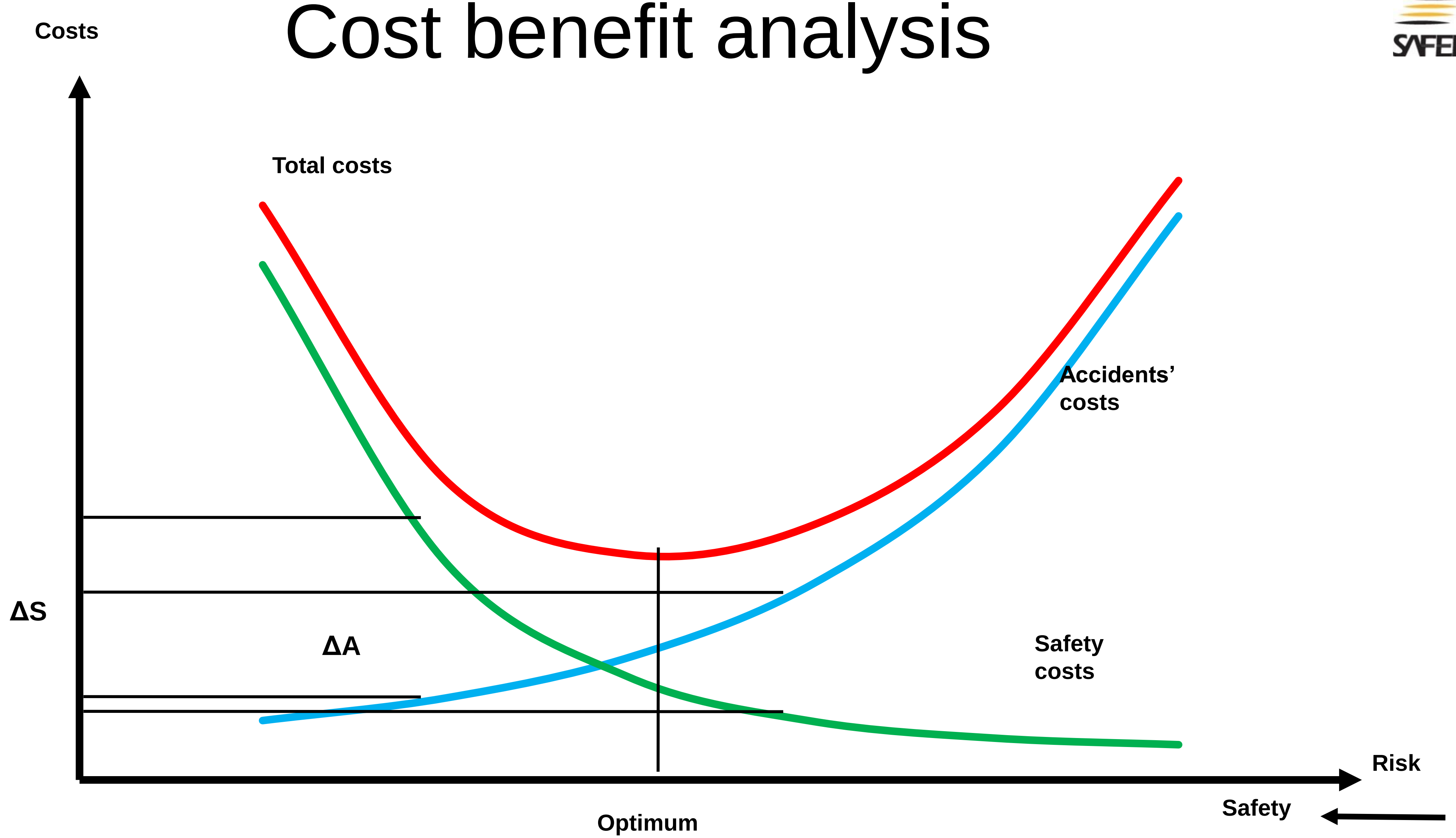
The greatest problems in CBA is to obtain valid and reliable monetary valuations of all relevant impacts.

LC Case study for cost benefit analysis

SELCAT

Safer European Level Crossing Appraisal and Technology

Cost benefit analysis

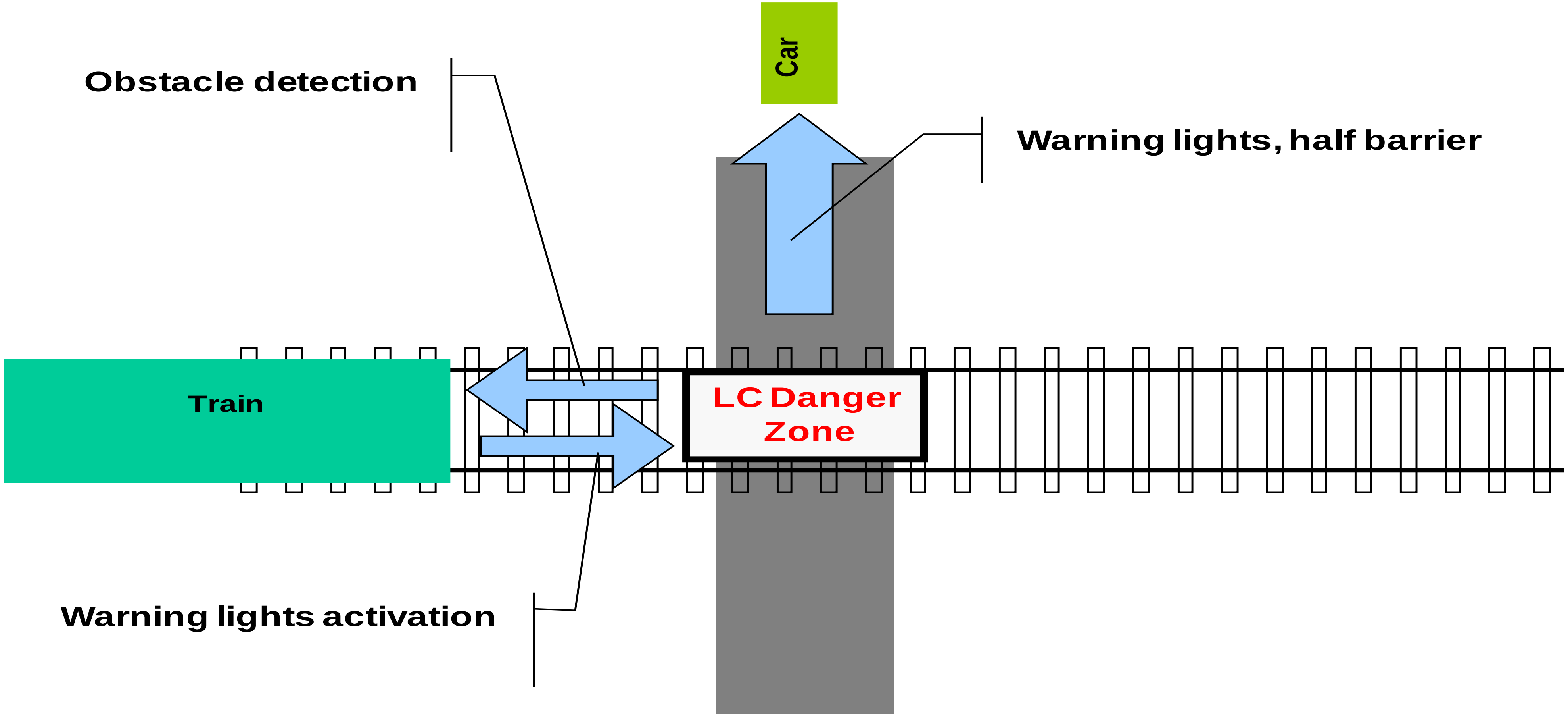


Cost Benefit analysis Major tasks

There are three essential principles of the approach to cost benefit analysis:

- Analysis of the quantitative risk, in order to estimate the safety gains inherent in a given investment or way of working;
- Economic analysis, in order to calculate the net cost of a given safety-related investment or way of working;
- Ethical and social analysis, in order to determine at least the relative value of different safety gains, and if possible their absolute value.

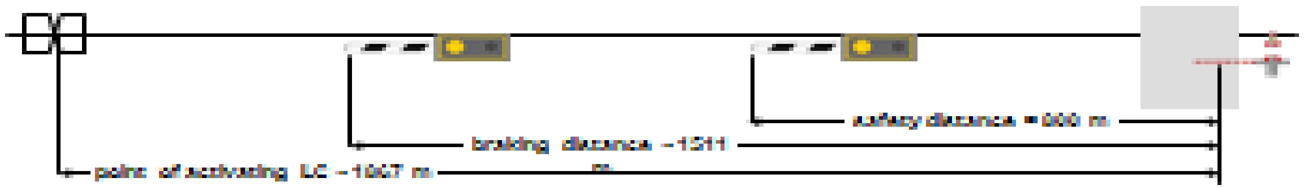
Analysed case study AHB with obstacle detection



1) Radio Communication to Train

2) Obstacle announcement by one signal

3) Obstacle announcement by two signals



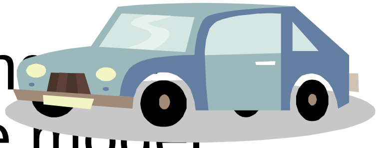
Technical implementations of the obstacle detection

Analysis of the quantitative risk: Road traffic consideration

Type 1 represents the road vehicles whose drivers are violating the level crossing warning system deliberately or non-deliberately. It is considered that road vehicle of the type 1 doesn’t stay in danger zone longer than 3 seconds.

Type 2 represents road vehicles which enter the danger zone at the time when there are no warning lights activated but is forced to stop without having the possibility to clear completely before 2 minutes elapse.

Type 3 represents the road vehicles whose drivers are enterin danger zone deliberately despite activated warning lights. The model assumes that the presence of the vehicle of the type 3 in the danger zone can take up to 5 minutes.



Analysis of the quantitative risk
AHB crossing accident causes

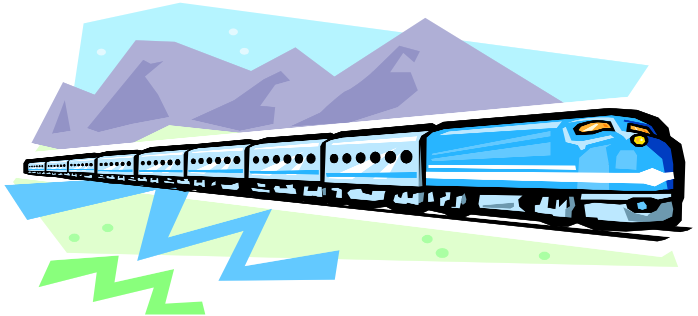
Road vehicle Type	Cause	Cause Risk Contribution	Cause Type Risk Contribution
Type 1	Zigzaging	33.5%	
	Visibility	17%	
	Second Train Arrives	16%	
	Sun dazzle	0.5%	67%
Type 2			
	Grounding	13.5%	
	Adhesion	8.5%	
	Blocking Back	8%	30%
Type3	Suicide or Vandalism	3.5%	3.5%

Analysis of the quantitative risk
Railway traffic consideration

Nominal Speed 160 km/h

Emergency Braking coefficient = 0.7 m/s²

At nominal speed, it needs 44 sec or 1400 m to stop



Quantitative risk analysis - summary

Obstacle detection

Accidents caused type 1 events e.g zigzagging are not prevented

eliminates accidents type 2 events (e.i. vehicles in the danger zone before the lights activated) (30%). Therefore the expected safety benefit is limited

Reliability of 99% of the obstacle detection should be sufficient

Economical analysis

ΔR = efficacy of a measure (assessment of risk-reduction potential and monitoring of the risk),

ΔC = the costs of a measure,

ΔC / ΔR = cost-benefit ratio,

ΔC / ΔR	Ratio
< 0.1	Extremely favourable
0.1 ... 0.5	Favourable
0.5 ... 2	Well-balanced
2 ... 5	Unfavourable
> 5	Extremely unfavourable

Starting risk

Accidents in Germany on 4000 LC-s in 2005 (Type LzH)	Absolute numbers	Ratio per 1 accident (%)
No. of accidents	48	
No. of fatalities	7	**14.58**
No. of serious injuries	15	**31.25**
No. of light injuries	25	**52.08**

Unit costs

Costs	**Cost per unit in Germany (€)**	**Cost per unit in the UK (€)**
1 conventional obstacle detection device used on LC-s (single track)	56,000	250,000
2 LC warning signals installed 1500m before the LC from both sides (track sides)	180,000	880,000
2 supervision cameras for road traffic rules enforcement including evaluation equipment	40,000	190,000

Economical analysis
Starting risk and assumed unit costs of equipment

Costs

Cost of the 1 Signal equipment implementation	€
1 obstacle detection device	56,000
2 LC warning signals	180,000
Total per 1 LC	**236,000**
Total per 4000 LC-s (ΔC)	**944,000,000**

Benefits

	Ratio per 1 accident (%)	Absolute numbers	Fin. Cost per unit (€)	Total cost (€)
Accidents saved		13	250,000	3,250,000
Fatalities saved	14.58	1.90	2,100,000	3,981,250
Serious injuries saved	31.25	4.06	210,000	853,125
Light injuries saved	52.08	6.77	21,000	142,188
Total saved per year				**8,226,563**
Total saved in life cycle (ΔR)				**205,664,063**

Cost-benefit ratio ΔC / ΔR = 944,000,000 € / 205,664,063 € = 4.59

2 < 4.59 < 5 - *unfavourable*

Economical analysis

Cost Benefit ratio evaluation (equipment of 4000 LC)

Costs

Cost of the 1 Signal equipment implementation	€
1 obstacle detection device	56,000
2 LC warning signals	180,000
Total per 1 LC	**236,000**
Total per 500 LC-s (ΔC)	**118,000,000**

Benefits

	Ratio per 1 accident (%)	Absolute numbers	Fin. Cost per unit (€)	Total cost (€)
Accidents saved (80%)		10	250,000	2,500,000
Fatalities saved (80%)	14.58	1.46	2,100,000	3,062,500
Serious injuries saved (80%)	31.25	3.13	210,000	656,250
Light injuries saved (80%)	52.08	5.21	21,000	109,375
Total saved per year				**6,328,125**
Total saved in life cycle (ΔR)				**158,203,125**

Cost-benefit ratio ΔC / ΔR = 118,000,000 € / 158,203,125 € = 0.75

0.5 < 0.75 < 2 - *well-balanced*

Economical analysis

Cost Benefit ratio evaluation (equipment of 500 LC)

Social analysis and ethical issues

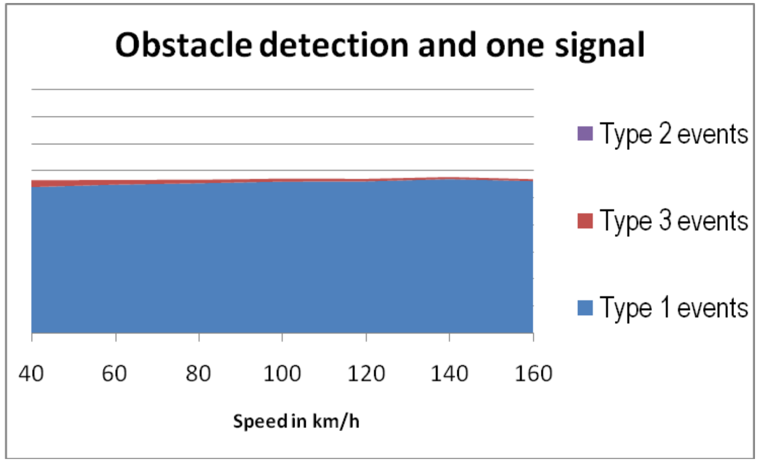
Benefits:

Road users would feel more secure crossing the LC
Road users see good use of tax money

Disbenefits :

LC actors including drivers, train driver are over relying on obstacle detection devices
Possible increase to road users' level of risk tolerance which makes more prepared to engage in risky situations (risk compensation)
Road users pay less attention to other warning signs around the LC
Road users' mental model of the function of the LC may be altered

Residual risk:
Residual risk reduction



How to reduce the accidents caused by event of the Type 1?

Traffic Rules Enforcement

- Application on 500 most critical level crossings assuming 80% of all accident risk
- Assumption of 50% reduction of the influencible risk

Economical analysis (traffic rules enforcement)
Cost Benefit ratio evaluation (equipment of 500 LC)

SAFER-LC

Costs

Cost of the Supervision cameras equipment implementation	**€**
2 supervision cameras + evaluation equipment	40,000
Total per 1 LC	**40,000**
Total per 500 LC-s (ΔC)	**20,000,000**

Benefits

	Ratio per 1 accident (%)	Absolute numbers	Fin. Cost per unit (€)	Total cost (€)
Accidents saved (80%)		23	250,000	5,750,000
Fatalities saved (80%)	14.58	3.35	2,100,000	7,043,750
Serious injuries saved (80%)	31.25	7.19	210,000	1,509,375
Light injuries saved (80%)	52.08	11.98	21,000	251,563
Total potentially saved per year				**14,554,688**
Success rate (drivers obeying)				**50%**
Total saved per year				**7,277,344**
Total saved in life cycle (ΔR)				**181,933,594**

Cost-benefit ratio ΔC / ΔR = 20,000,000 € / 181,933,594 € = 0.11

0.1 < 0.11 < 0.5 – *favourable*

Social analysis (traffic rules enforcement)

Benefits:

Increase in danger perception → Higher compliance of road users to LC rules because they know that there is a real personal benefit

Road users would feel more secure crossing the LC

Road users are less subject to peer influence→ Seeing other people ignore warnings will not reduce perception of danger

Disbenefits :

Aversion of road drivers→ privacy issues

Road users may be distracted with technologies used to enforce traffic rules

Road users with a high tolerance for risk may want to beat the supervision camera and engage in risky actions

Discussion on

Various aspects to be considered in CBA

Identification of measurable/qualitative indicators

Open discussion & questions

1) *CEA/CBA*
2) *Values of life*
3) *Accident cost (Property damage)*
4) *Values of delays (passenger, freight)*
5) *LC data*
6) *Factors to determine risky LC (FB, HB Road signal and unprotected)*
7) *Cost of measures*
8) *Effects which usually are not monetarized Accident*
9) *Social analysis and ethical issues*
10) *Other projects*

CBA/CEA

Cost benefit analysis (CBA) is an important part of the cycle of understanding and quantifying risk, modelling and monetarising its effects and the cost of reducing it, and then applying expert judgement to decide which option to adopt

Cost-Effectiveness Analysis (CEA) - this technique compares the projected costs for a range of proposed risk control alternatives, all intended to meet the same objective. CEA is useful most often when the benefits of a risk reduction scenario are difficult to quantify in monetary terms but the government wishes to know which option will achieve social benefits or government objectives most cost effectively.

CBA/CEA

$$\text{Cost Effectiveness Analysis (CEA)} = \frac{\text{Number of accidents / incidents prevented}}{\text{Cost of implementation}}$$

$$\text{Cost Benefits Analysis (CBA)} = \frac{\text{Present value of all benefits}}{\text{Present value of the implementation costs}}$$

CEA can be complemented with a CBA , if the effect the measures can be translated into money.

	CEA	CBA
Advantages	- is easier to calculate benefits in physical terms - less information is required and more accessible; - compares the projected costs for a range of proposed risk control alternatives, all intended to meet the same objective. - is useful in areas such as health, accident safety and education	- is useful when there are multiple objectives (e.g., both safety, environment and mobility), because it considers all relevant impacts; - Several objectives are partly conflicting
Disadvantages	- can only be used for ranking measures with a common (single) target, - Does not take into account of social and political (government) factors unless they can be somehow converted in monetary value.	- Complexity of data collection (costs , benefits) - not all effects can be translated into money - Very difficult to estimate and reach agreement on the economic impacts of benefits and disbenefits - Peoples willing to pay to save a human life

Q1: About CEA/CBA
Which method is appropriate for SAFER-LC?
Why?

Values of life

Country specific values or EU-averaged values?

The values applied in the national frameworks vary considerably across countries. For example, the values used for a fatality lie between approx. €200.000 and approx. €1.650.000 and great differences between regions can be observed.

Values of life

Country specific values:

More acceptable when the values used derive directly from the national context;

Specific unit values may not exist or be of poor quality for individual countries (e.g. differences in the values of human lives between countries may not be acceptable to decision-makers);

Lack of good quality data covering all member states;

EU-averaged values:

Simplify the appraisal process and increase transparency;

May be acceptable on the basis of perceived equity;

not fully reflect differing preferences and resource costs;

Dependent values, from local authorities

Q2: Values of life
Country specific values or EU-averaged values?   *Give 2 arguments for your proposal:*

Accident cost (Property damage)

Q3: Accident cost (Property damage)
Which are the five main elements to be considered in the accident cost?

Values of delays (passenger, freight)

Values of Time (VT) refer to the monetary value of delays incurred by users of rail transport (passengers and freight customers) as a consequence of accidents or incidents. It is proposed to be calculated using the following formula (from ERA 2013, p.):

- Value of time for a passenger of a train (VTP) = [VT of work passengers]*[Average percentage of work passengers per year] + [VT of non-work passengers]*[Average percentage of non-work passengers per year]

VTP is measured in € per passenger per hour.

- Value of time for a freight train (VTF) = [VT of freight trains]*[(Tonne-Km)/(Freight Train-Km)]

VTF is measured in € per freight tonne per hour

Values of delays (passenger, freight)
Do we need to integrate de delay of neighbors’ lines?

LC data

Collisions
Number of collisions
Full Barrier
Half Barriers
Road side Signal
Unprotected
Number of fatalities
Full Barrier
Half Barriers
Road side Signal
Unprotected
Number of heavy injured persons
Full Barrier
Half Barriers
Road side Signal
Unprotected

Q6: LC data
Do we need to integrate the slight injuries?

Factors to determine risky LC (FB, HB Road signal and unprotected)

Classifying the more critical level crossings is done by calculating a factor, called the “factor K”. The formula is given by the following:

$$\text{Factor K} = \text{ɱ} \times n_{acc} / 10^3$$

ɱ is the “moment of circulation” calculated as follows:

ɱ = number of trains x number of road vehicles (over one year)

n_{acc} is the number of incidents (knocked barriers) and of accidents over 10 years .

The factor K is calculated for each level crossing and gives a list of level crossings to be improved.

Nota: Expert’s judgment is required.

Q6: Factors to determine risky LC (FB, HB Road signal and unprotected)

(1) Expert's judgment
Please indicate 2 more factors to be analysed?

Cost of measures

Installation cost
Training and education cost (staff)
Operational cost
Maintenance cost
False Alarm (if any)- delay time
Renewal cost saving (if any)
…

Q7: Cost of Safer-lc measures

Are there any more main costs to be considered for a given measure?

Equipment
Installation cost
Training and education cost (staff)
Operational cost
Maintenance cost
False Alarm (if any)- delay time
Renewal cost saving (if any)
…

Which duration (10, 15 or 20 years) is more appropriate for economic evaluation of suggested measures?

Q8: Effects which usually are not monetarized Accident

Are there any more effects to be considered for a given measure?

Easy issues of implementation;
Easy issues of use;
Competitiveness of the European Railway industry;
Effects on the environment;
Customer satisfaction with the safety system;
Capacity performance;
The possibilities of by-passing the system;
Maturity of the technology

Q9: Social analysis and ethical issues of Safer-lc solution
Identify the benefits and disbenefits for given solution?

Past projects to be analysed

NETIRAIL (2015-2018) « Needs Tailored Interoperable Railway” H2020
RESTRAIL (2010-2014)- REduction of Suicides and Trespasses on RAILway property. 7ème PCRD
ROSA (2006-2009), “Rail Optimisation Safety Analysis”. DEUFRAKO
SELCAT (2006-2008) “Safer European Level Crossing Appraisal and Technology”. 6ème PCRD
….

Q10 : Other projects

Is there any project that could be useful for Safer-lc CBA?

- Thank you!