Training in Budapest, Hungary
Safety culture
Level crossing: Risk evaluation and human factors

26-30 June 2017

J-M Dechamps, Safety Unit

EUROPEAN
UNION
AGENCY
FOR RAILWAYS

Key topics

Purpose of the presentation

- Illustrate, by an example, how an Infrastructure Manager may proceed to take into account human factors in risk evaluation related to level crossing

Key points of the presentation

- Introduction on risk evaluation
- Risk evaluation performed by the **National Investigation Body of Portugal** (by courtesy)
- Conclusion

Introduction: Accident at level crossing

Infrastructure managers, railway undertakings, road authorities:

"We are not responsible of accidents at level crossing".

" it is always the fault of road user who does not respect rules"

"A road user should only enter into a level crossing after assuring himself that nothing opposes it and that it is perfectly safe to do so."

"Road drivers are responsible for their own safety at level crossings and act on their own risk and responsibility."

"People die at level crossings only because they want to."

" That is the fault of road administration"

So why losing our time with this?

Questions: If it is not a railway responsibility, why spending so much money to adapt infrastructure or making prevention campaigns?
Useful but is it enough? Do we understand the root causes of LX accidents?

Introduction: Shared risks

- Who creates the danger? RAILWAY. No railway → no level crossing.
- But who is guilty(criminal and civil liabilities) in case of accident? It depends who causes the fault. Statistically road users.
- Who suffer after an accident? Whole society.
- Who must control risks according to legislation? Road administration, road users, … and railway actors mainly IMs and RUs.

→ SHARED RISK

- Who can put measures in place to prevent accidents? Road administration and … infrastructure manager.

Introduction: What says the EU legislation?

- Infrastructure Managers and Railway Undertakings must collaborate with each involved relevant party to control the risks associated to their activities.

- New Safety Directive 2016/798
  - article 4 § 3 (a) and (b)
  - Article 4 § 4 (a)
  - Article 9 §3 (e),
  - Article 9 §4 (shared risks)

EU legislation details (for information)

- Article 4 §3 *"Railway undertakings and infrastructure managers shall:*
  (a) implement the necessary risk control measures referred to in point (a) of Article 6(1), where appropriate in cooperation with each other ***and with other actors****;*
  (b) take account in their safety management systems of the risks ***associated with the activities of other actors*** *and third parties; …"*

- *Article 4 §4 "…and all other actors having a potential impact on the safe operation of the Union rail system,…shall:*
  (a) *implement the necessary risk control measures, where appropriate in* ***cooperation with other actors****".*

EU legislation details (for information)

- Article 9 §3. "*The safety management system shall contain the following basic elements: …*
  (i) procedures to ensure that accidents, incidents, near misses and other dangerous occurrences are reported, investigated and analysed and that necessary ***preventive measures are taken****;*"

- Article 9 §4 " The safety management system shall also take into account, where appropriate and reasonable, the **risks arising as a result of activities by other actors** referred to in Article 4."

Introduction: Risk assessment: Basic principles (1)

- Hazard: Anything that has the **potential** to cause **harm**
- Risk evaluation = Evaluate the risk associated to an hazard.

Risk = Likelihood of occurrence X Severity of hazard

- Likelihood of occurrence: Examples:
  - Improbable – so unlikely that probability is close to zero
  - Remote – unlikely, although conceivable
  - Possible – could occur sometimes
  - Probable – not surprised, will occur several times
  - Likely – occur repeatedly/event only to be expected
- Likelihood may be also be expressed by figures.
- Likelihood may be defined upon **expert's judgement.** The expert's judgement can be supported/explained by mathematical probabilities or **statistics of occurrences**.

Introduction: Risk assessment: Basic principles (2)

- Severity of hazard: Example
- 1 = No injury, material damages
- 2 = Minor injury – may need some first aid assistance, not life threatening
- 3 = Major injury – admission to hospital
- 4 = 1 Fatality
- 5 = Catastrophic: Many fatalities

In the following example, we will show how **human factors** in specific environment may strongly influence the **likelihood of occurrences** of accident at level crossings.

This example describes a study performed by the National investigation of Portugal

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33rd NIB Plenary meeting – Lille, 23rd March 2017

Investigating the influence of the sun on a level crossing accident

Fatal accident of a moped driver at a level crossing, in 28-01-2015

[Investigation ID Inv_20150128]

THE SETTING

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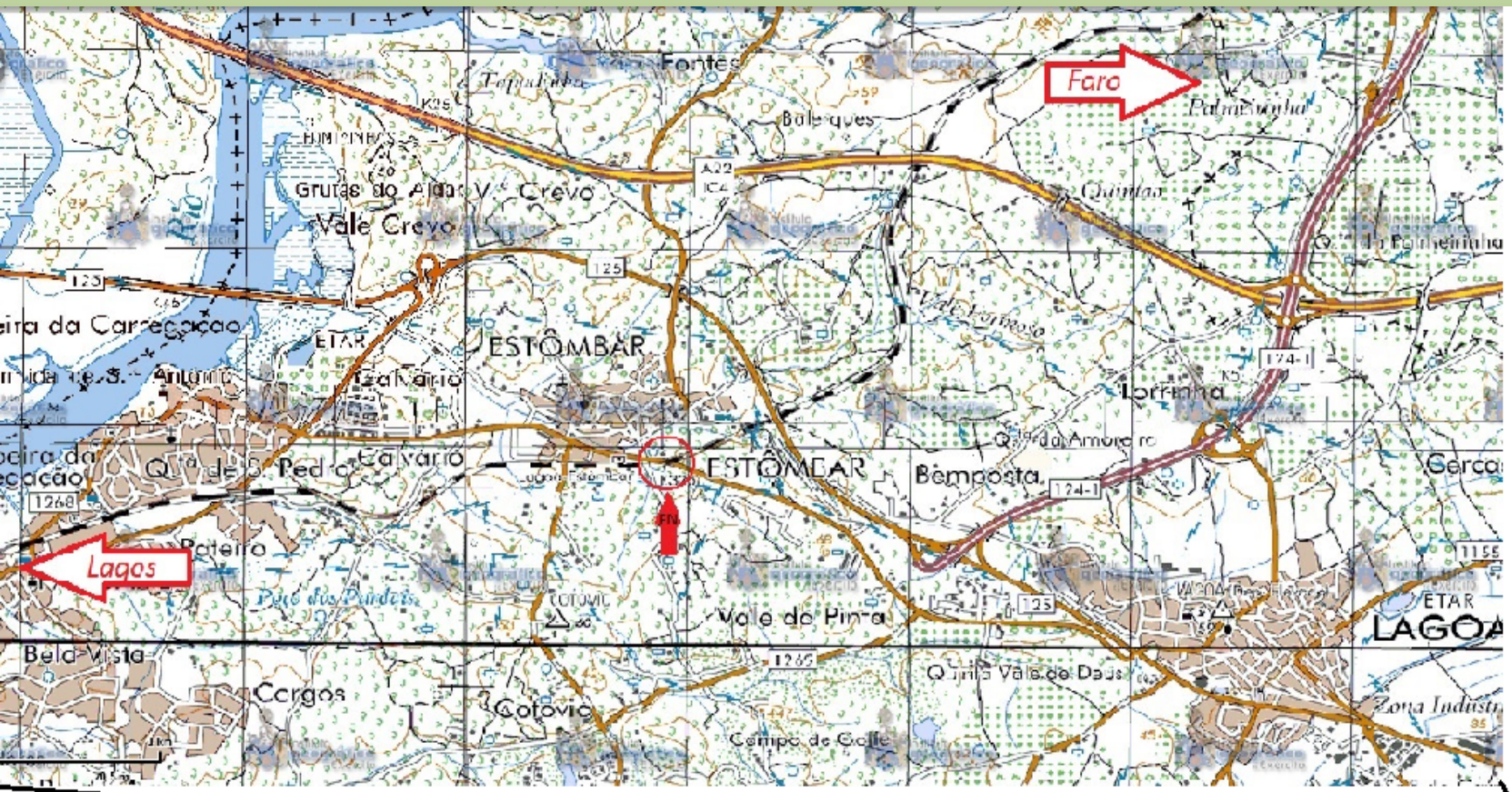
Location



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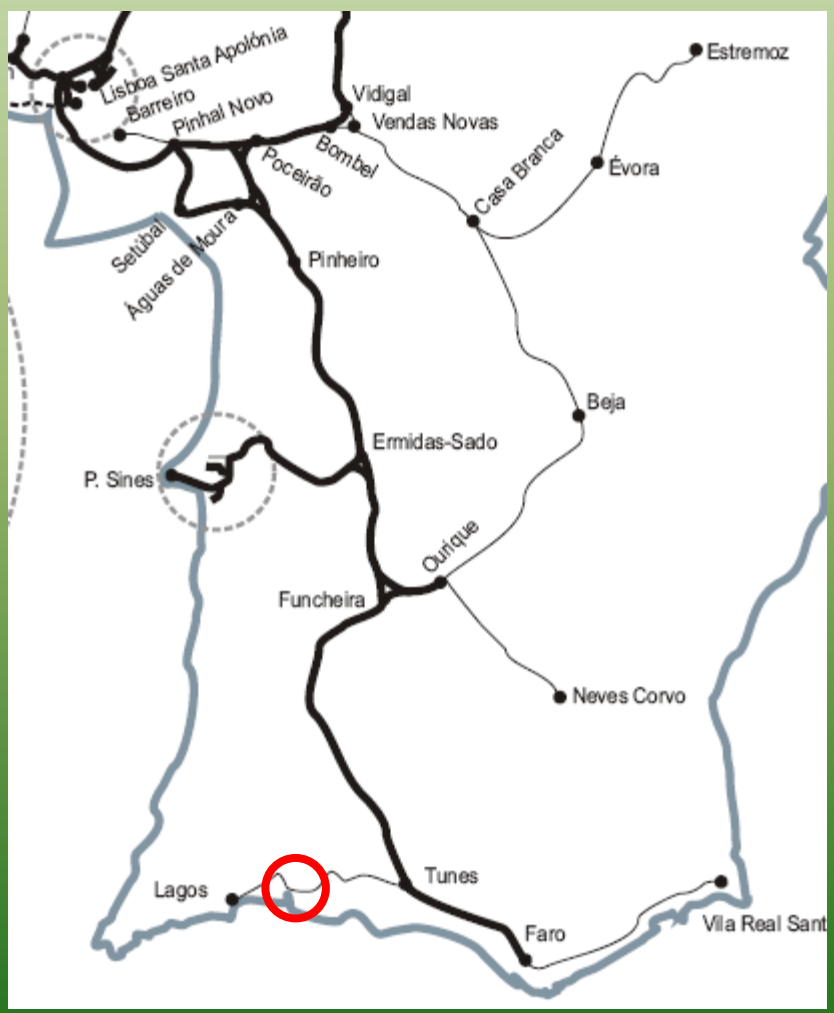


- Single line
- Not electrified
- Electronic block system
- ATP
- No train-ground radio system
- Automatic Half-Barrier Level Crossing

Location


R. 20 de Junho
Portimão
EM-25
PN 324,964
Linha do Algarve
Silves
Estômbar-Lagoa
Lagoa

Location

THE FACTS

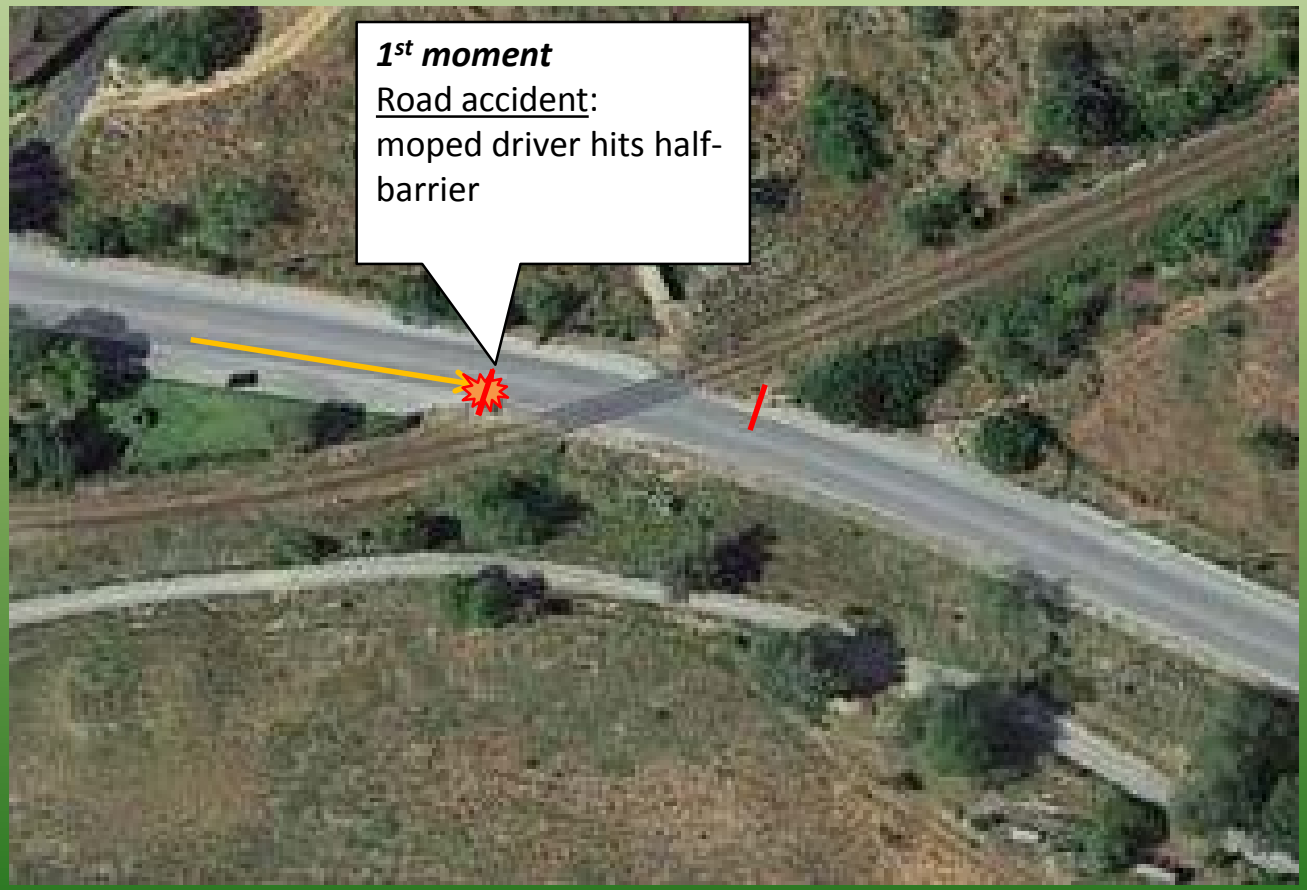
28/01/2015 - **08:27:06**

00m00s

28/01/2015 - **08:27:20***

00m14s

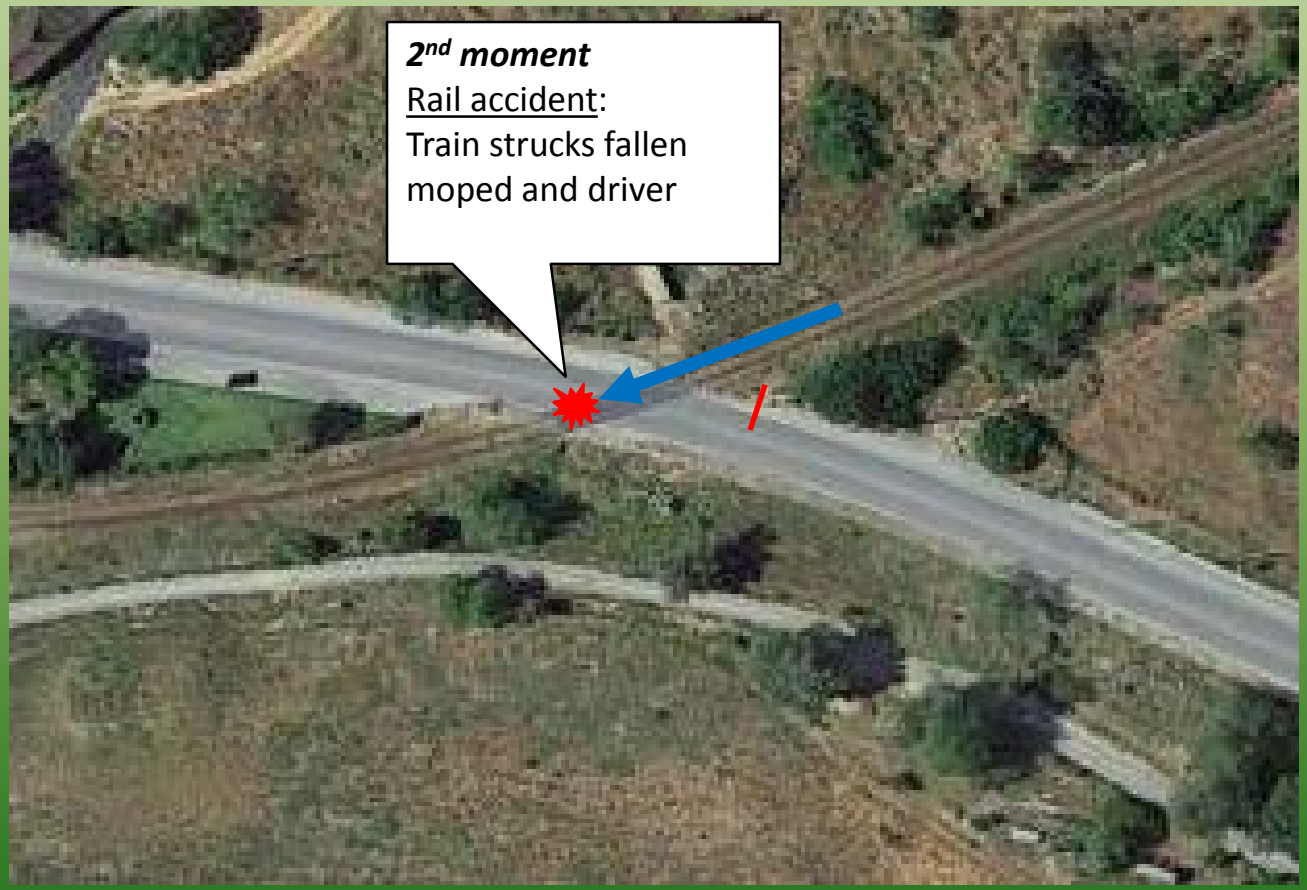
28/01/2015 - **08:27:29***



28/01/2015 - **08:27:30**

00m24s

28/01/2015 - **08:27:36**

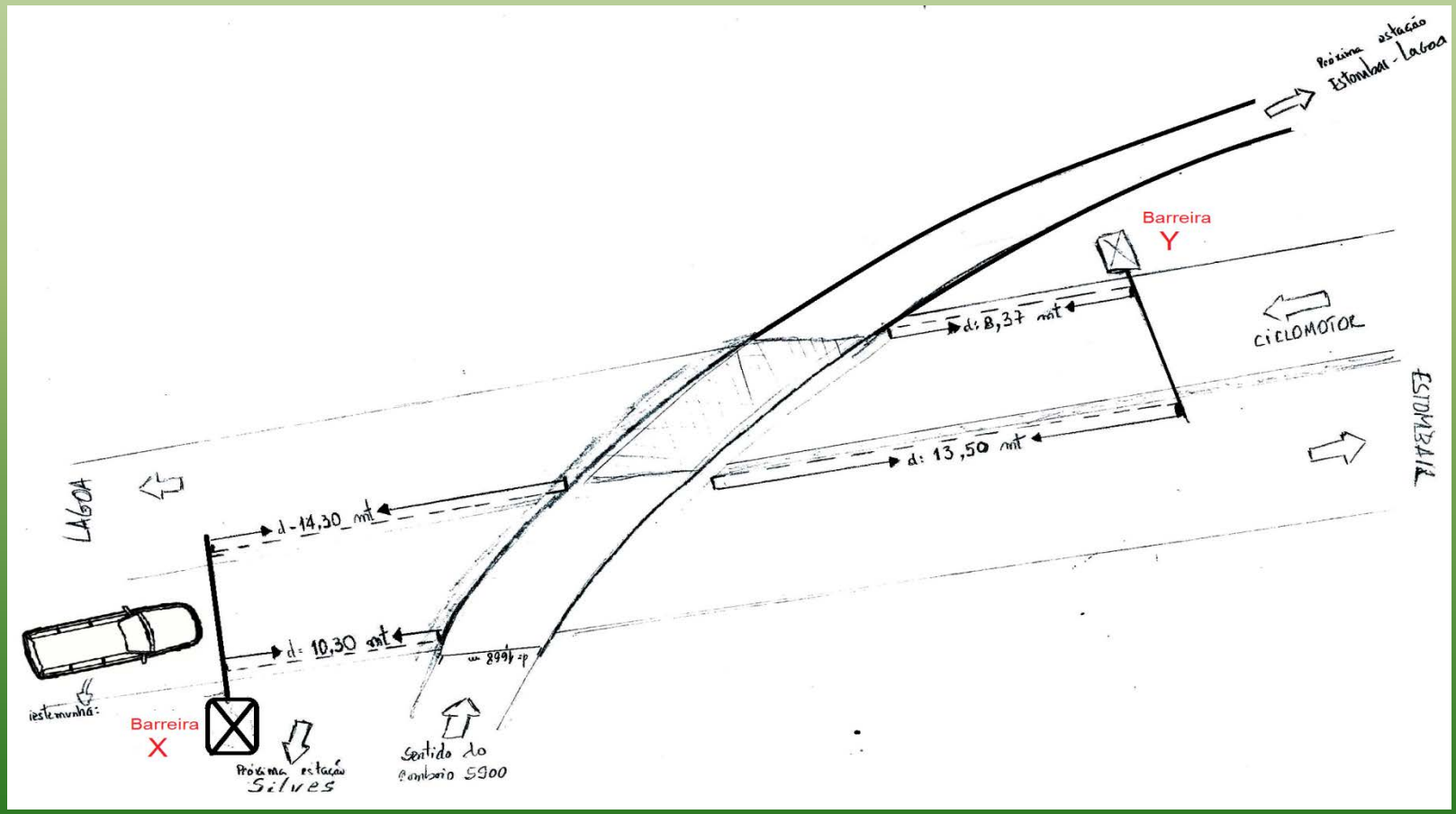


The weather conditions

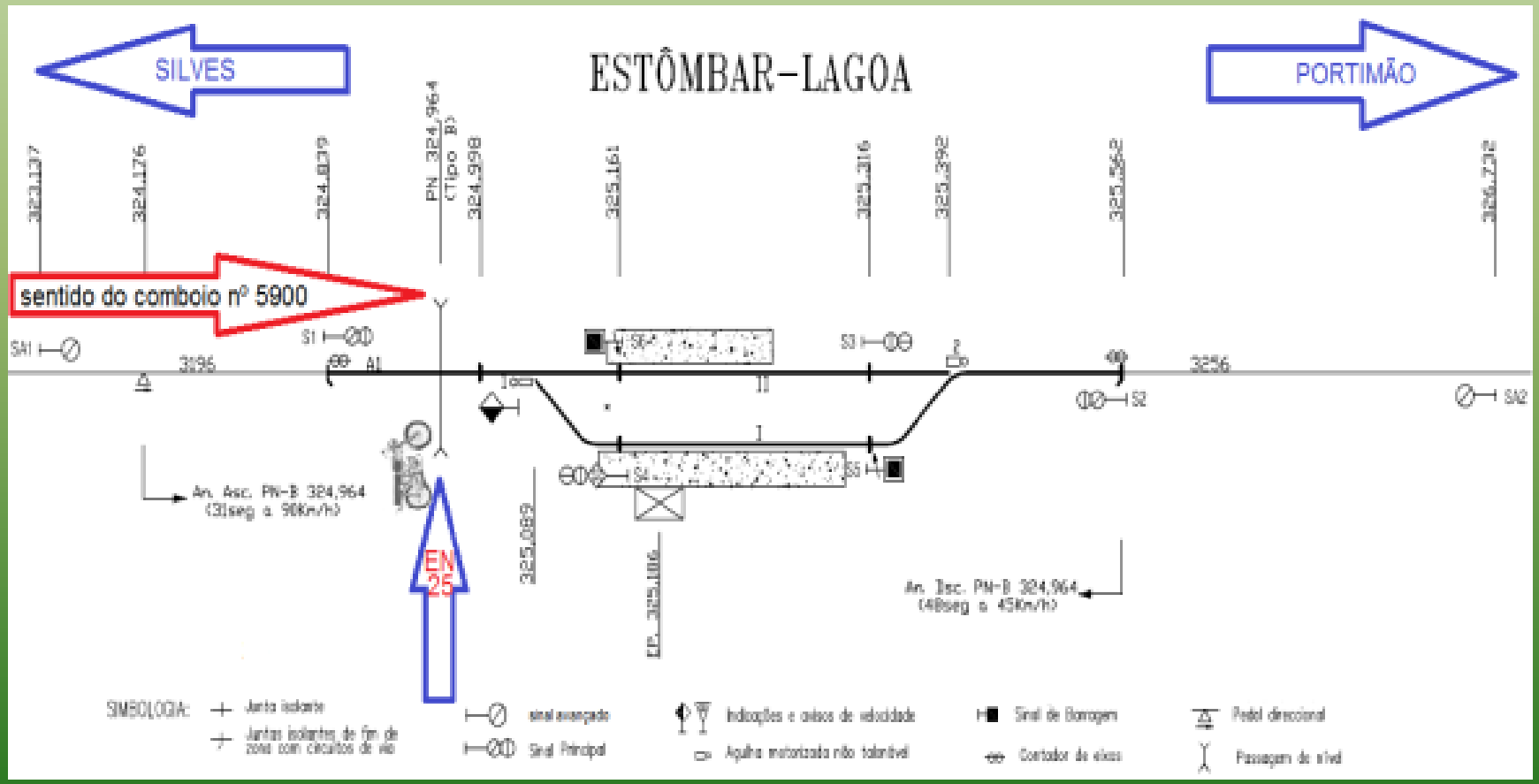
- Clear weather.
- Humidity: 76%;
- Temperature: 9º C;
- Sun rise at 07:39, coming into the visual horizon at 08:05;

The Level Crossing

The Level Crossing



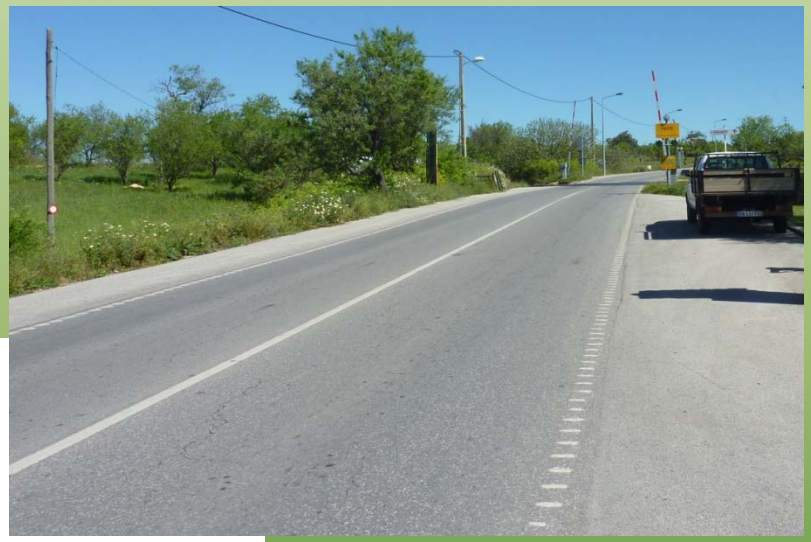
The Level Crossing

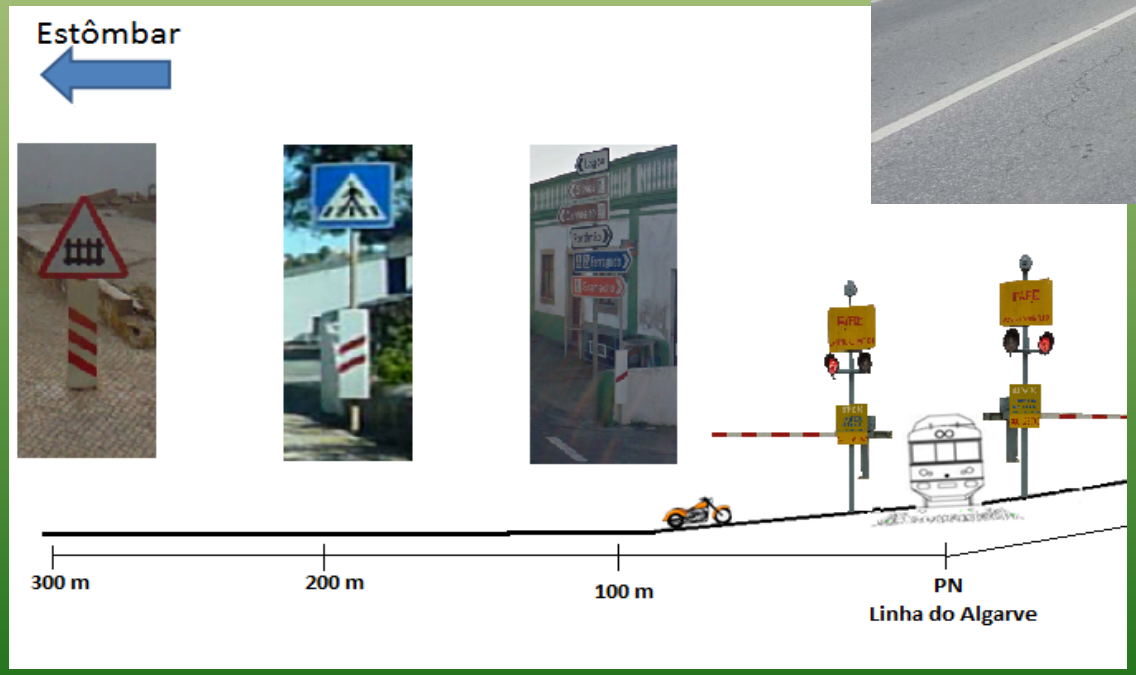


The Level Crossing

- **All technical systems worked as designed and expected**

The road approach to the Level Crossing





The road approach to the Level Crossing

- **Signals generally according to the Road Code and no apparent deficiencies in the road**

The train

- Sees the fallen moped driver 73 metres before the Level Crossing, while travelling at 63 km/h;
- Full emergency braking effective 3 seconds later;
- Collision at 45 km/h;
- Stops 105 m after the LX.

The train

- **Technical systems and train driver behaved as expected**

The road vehicle

- Destroyed;
- Wasn't possible to observe any fault or to test it;
- Travelling at an estimated 40 to 50 km/h (from testimonial evidence).

The moped driver

- Age: 82;
- No abnormal cognitive or visual impairments (for his age);
- Valid moped driving licence;
- Daily user of the LX;
- *Post-mortem* tests showed no evidence of intoxication.

The moped driver

- **Testimonial evidence indicates that on the approach to the LX and until hitting the half-barrier, the moped driver didn't reduce the speed nor did he show any change in his behaviour.**

1.st moment: Road accident

Moped travelling on public road, from West to East

Moped driver disregards LX activated signals and lowered half-barrier

Half-barrier struck, moped and driver fall

Moped and driver on the LX

- **Evidence suggests that road vehicle was functioning properly.**

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1.st moment: Road accident

Moped travelling on public road, from West to East → Moped driver disregards LX activated signals and lowered half-barrier → Half-barrier struck, moped and driver fall → Moped and driver on the LX

- **Evidence suggests that road vehicle was functioning properly.**

2. nd moment: Rail accident

Regional train 5900 travelling below maximum speed → LX pedal pressed by train + LX activated + Clear signals for train → Closed LX → Moped and driver appear within braking distance and are struck

- **Evidence shows that rail systems functioned as designed and expected.**

So…

Was this just one more Level Crossing accident due to the usual suspects of road driver misbehaviour, inattention or disregard for his own safety?

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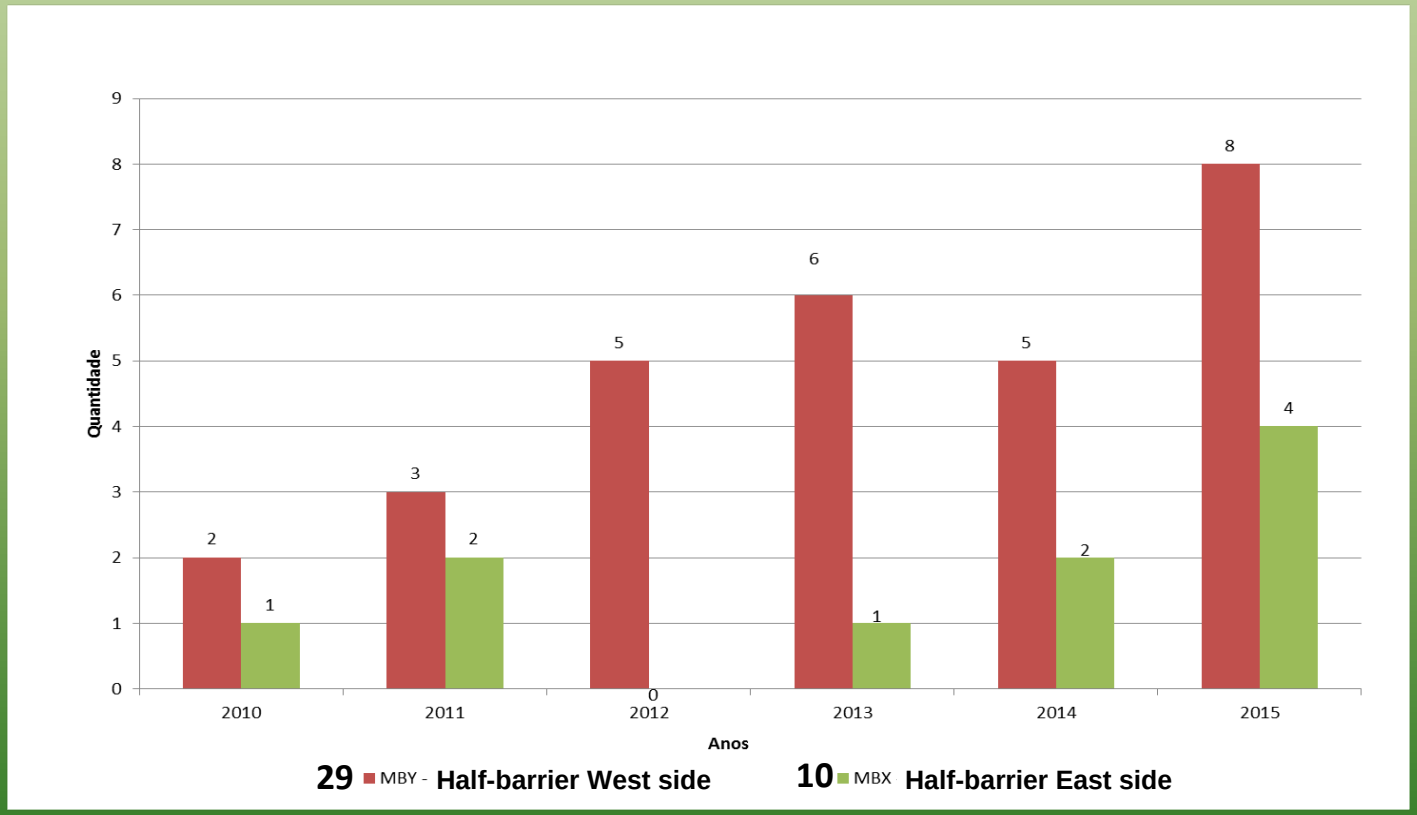
PRELIMINARY INVESTIGATION

Level crossing occurrences history



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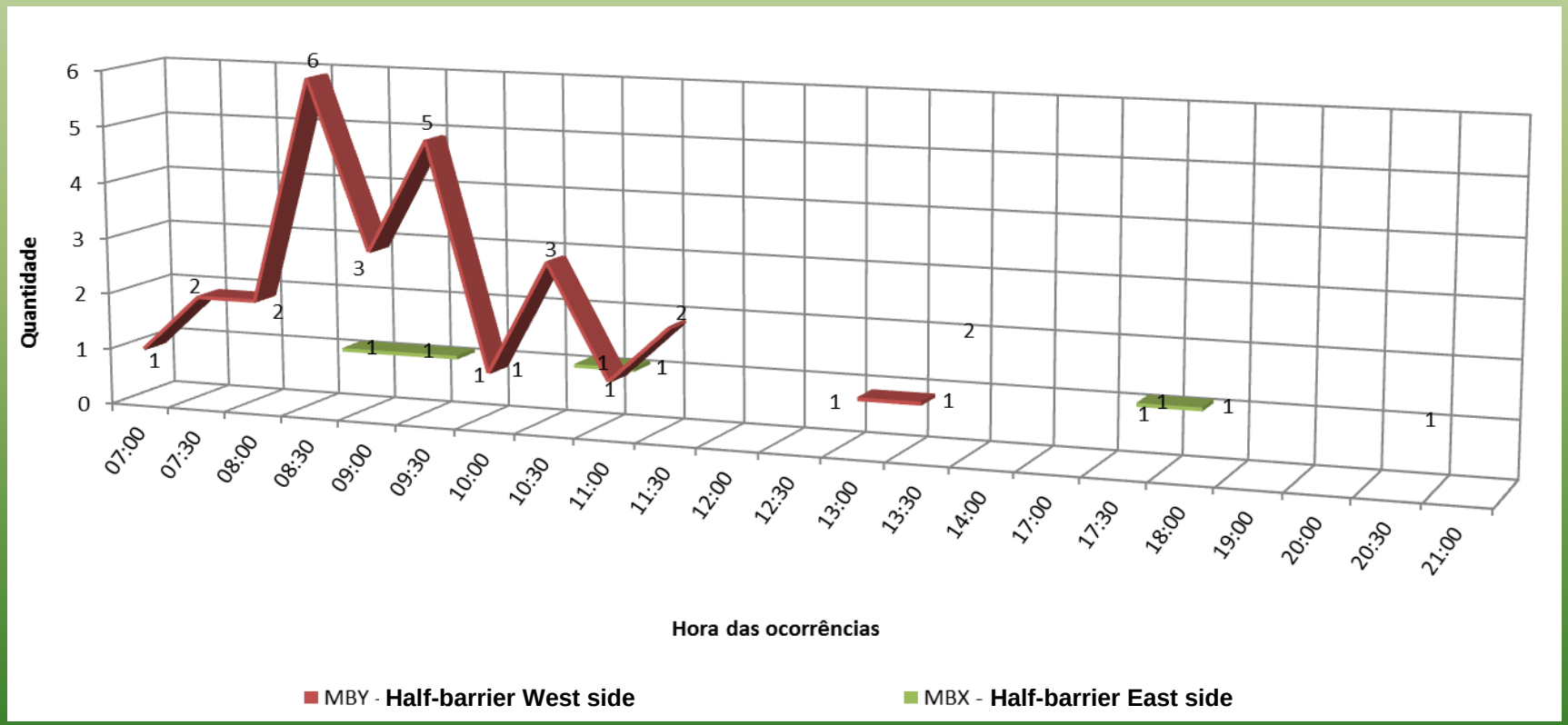
Level crossing occurrences history



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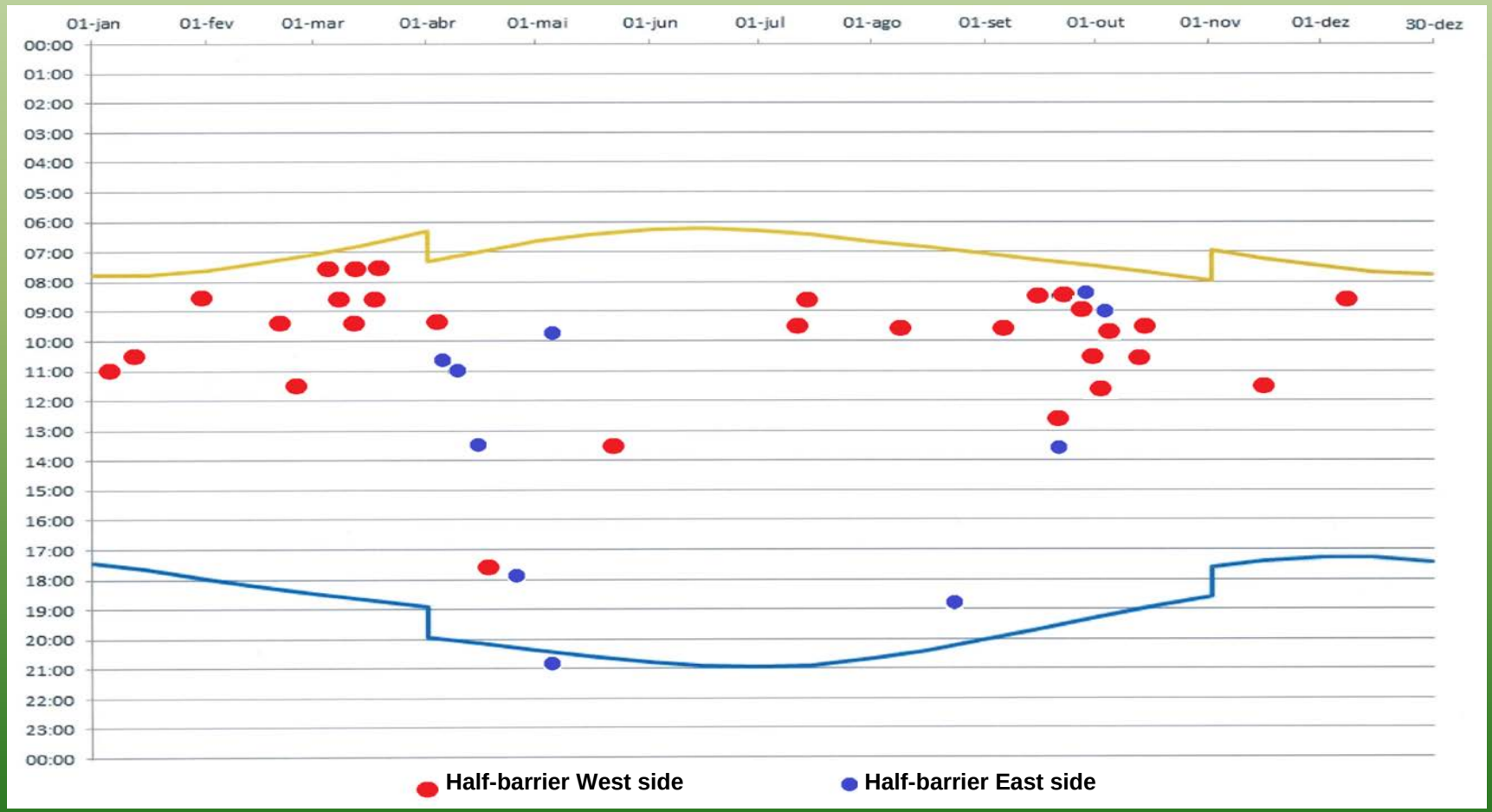
Level crossing occurrences history



Other information

- Testimonial evidence, both from road users and from IM local workers, identify that, on that LX, the low-sun in the morning is very disturbing for road drivers approaching from the West;

- The risk assessment of the LX by the IM identifies the possibility of disturbance to road users due to low-sun.

Site visit

Site visit

Site visit

Conclusion from the preliminary investigation

The analysis of the LX occurrences history, the testimonies from road users and IM workers, and the observation of the site during morning hours, **clearly showed** that the low-sun **may** result in the road drivers not seeing the lowered half-barriers nor the flashing lights, because:

1. It causes a severe disturbance to the road drivers' vision and concentration,
2. It diminishes the conspicuity of the LX crossing half-barriers and lights,
3. There are no mitigation measures implemented at the LX (including it's approaches) to counter the effects of the low-sun (despite the IM risk assessment having determined the existence of the risk).

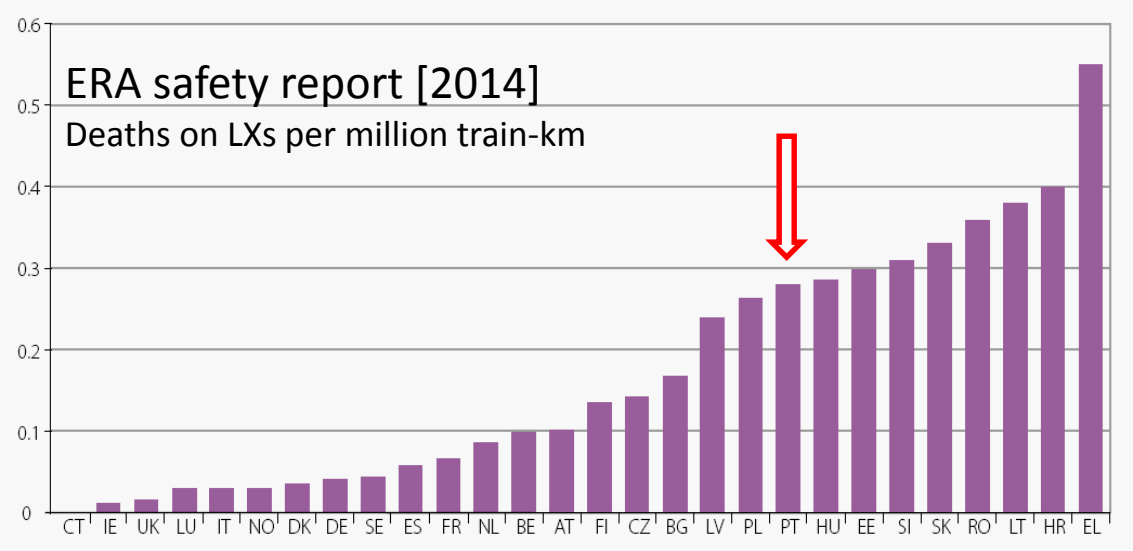
However...

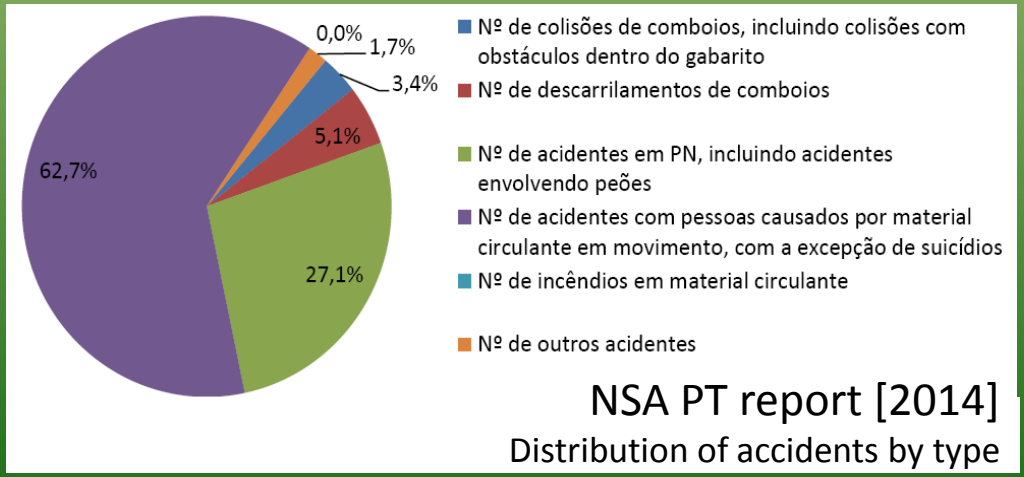
"A road user should only enter into a level crossing after assuring himself that nothing opposes it and that it is perfectly safe to do so."

"Road drivers are responsible for their own safety at level crossings and act on their own risk and responsibility."

"People die at level crossings only because they want to."

And also


ERA safety report [2014]
Deaths on LXs per million train-km
0.6
0.5
0.4
0.3
0.2
0.1
0
CT IE UK LU IT NO DK DE SE ES FR NL BE AT FI CZ BG LV PL PT HU EE SI SK RO LT HR EL


0,0%
1,7%
3,4%
5,1%
62,7%
27,1%
Nº de colisões de comboios, incluindo colisões com obstáculos dentro do gabarito
Nº de descarrilamentos de comboios
Nº de acidentes em PN, incluindo acidentes envolvendo peões
Nº de acidentes com pessoas causados por material circulante em movimento, com a excepção de suicídios
Nº de incêndios em material circulante
Nº de outros acidentes
NSA PT report [2014]
Distribution of accidents by type

➢ Decision to investigate

Scope:

- *Road drivers' human factors*
- *Level crossing design procedures*
- *Legislation on LXs*
- *IM's SMS – control of risks by IM; data collection and analysis; incident reporting and investigation; internal auditing*
- *Supervision by NSA of SMS application by the IM*

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➢ *Road drivers' human factors*

Investigation on the effects of the sun on road drivers, applied to LX accidents

The effects of the sun on road drivers at the LX

- Scientific studies have determined the physiological effects of the sun glare in reducing human visibility as well as the intervening factors: incidence angle and physiological related factors (age and visual impairment).
  - Vos, J.J., 2003, *On the cause of disability glare and its dependence on glare angle, age and ocular pigmentation*, Clinical and Experimental Optometry, vol. 86(6), pp. 363-370.
  - Zwahlen, H.T., *(Conspicuity of suprathreshold reflective targets in a driver's peripheral visual field at night)*, Transportation Research Record 1327, pp. 35-46: 1989.

The effects of the sun on road drivers at the LX

- Several scientific studies have identified a significant statistical correlation between road accidents and sunlight conditions

  - Churchill, Andrew M. & Lovell, David J. *(A procedure for auditing highway alignments for the effects of sun glare),* Maryland: 2009.
  - Hagita, K., Mori, K. (2011), *(Analysis of the Influence of Sun Glare on Traffic Accidents in Japan)*. Journal of the Eastern Asia Society for Transportation Studies, Vol.9, p1775-1785, 2011.
  - Hagita, K., Mori, K. (2013a), *(Analysis of the influence of sun glare on bicycle or pedestrian accidents with turning vehicle)*. Proceedings, 13th World Conference on Transport Research, Rio de Janeiro: 2013.
  - Hagita, K., Mori, K. (2013b): *(The Effect of Sun Glare on Traffic Accidents in Chiba Prefecture, Japan)*. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9, 2013.
  - Mitra, S., *Investigating Impact of Sun Glare on Transportation Safety*. Transportation Research Board. EUA: 2008.

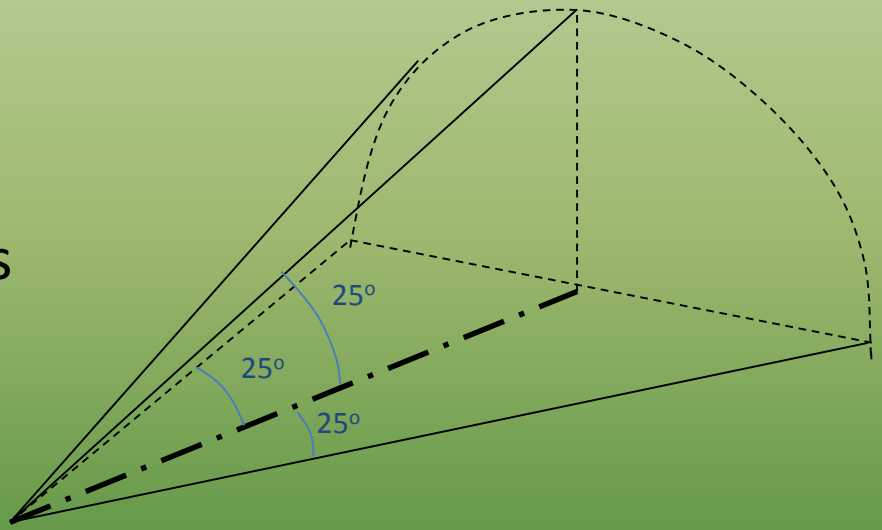
The effects of the sun on road drivers at the LX

- Several relatively simple methods for predicting the generic risk of sun glare were developed, either for the design of new roads or for the assessment of existing ones.

  - Churchill, Andrew M. & Lovell, David J. *(A procedure for auditing highway alignments for the effects of sun glare),* Maryland: 2009.
  - Jurado-Piña, R. & Pardillo-Mayora, J.M. *(A methodology to predict driver vision impairment situations caused by sun glare). Transportation Research Record 2120*, pp. 12–17. Transportation Research Board, Washington, D.C.: 2009.
  - Jurado-Pina, R., Pardillo-Mayora, J. M. and Jimenez, R., *(Methodology to Analyze Sun Glare Related Safety Problems at Highway Tunnel Exits)*. Journal of Transportation Engineering, No.6, 545-553. 2010
  - Jurado-Piña et al, *(Software tool for the analysis of highway alignments to detect and prevent sun glare vision impairment hazards).* Madrid: 2010.
  - Pardillo-Mayora, J. M. & Jurado-Piña, R., *Application of human factor centered checks in Road Safety Audits of highway design projects in Spain*, 4th International Symposium on Highway Geometric Design. Espanha: 2010.

The effects of the sun on road drivers at the LX

- The investigation considered the criteria used by the Spanish Ministry of Development [Piña, Mayora & Huarte (2010)] : 25º from the line of view for drivers aged over 60.



Note: Although sunlight up to a 25º angle is proven to physiologically cause glare on a person, some studies suggest that even greater sunlight angles can have a disturbing effect on drivers' vision and concentration.

The effects of the sun on road drivers at the LX

The effects of the sun on road drivers at the LX

www.sunearthtools.com

www.sunearthtools.com/dp/tools/pos_sun.php?lang=en

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User page

16:56 | Wednesday 08 March 2017

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select your points
search
select your shadow profile
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50° 38' 25.084" N 3° 4' 31.743" E
SunRise: 05:43:37 * 87.23° | SunSet: 18:05:50 * 273.09° |
299 Boulevard de Leeds, 59777 Lille, França
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year month day hour minute
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Time zone GMT 0 DST Default

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Mode: caminho de dom

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Gare Lille Flandres
Gare de Lille Flandres
Euralille
Le Nouveau Siècle
Cimetière de l'Est
St. Maurice Pellevoisin
Parc des Dondaines
Caulier
Centre commercial Les Tanneurs
Rue Royale
Rue du Ballon
Rue Saint-Gabriel
Rue Vantroyen
Rue Eugène-Jacquet
Rue de Flers
Rue Gutenberg
Rue Nationale
Pont de Flandres
Boulevard Carnot
Rue de la Barre
Avenue du Peuple Belge

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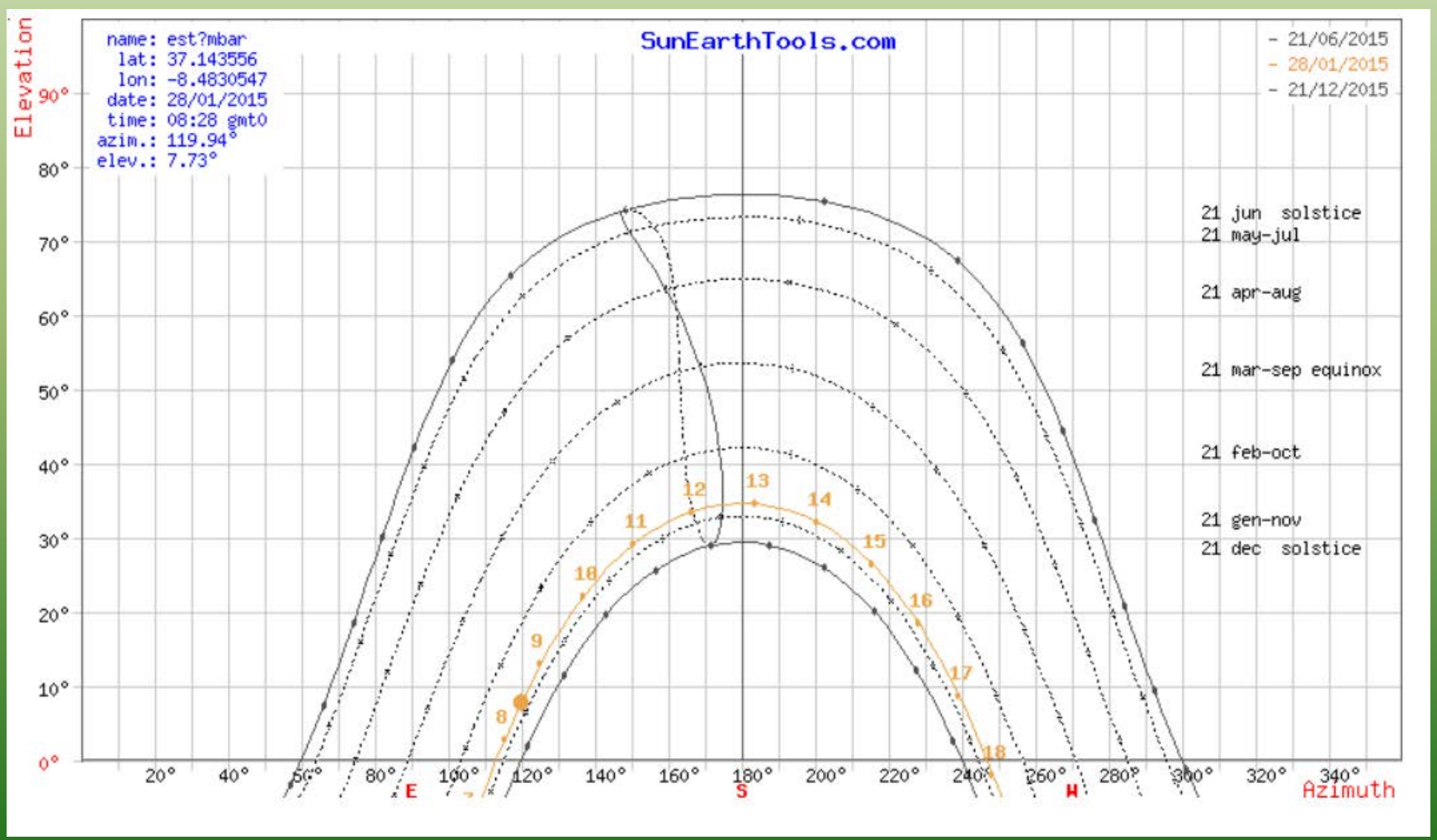
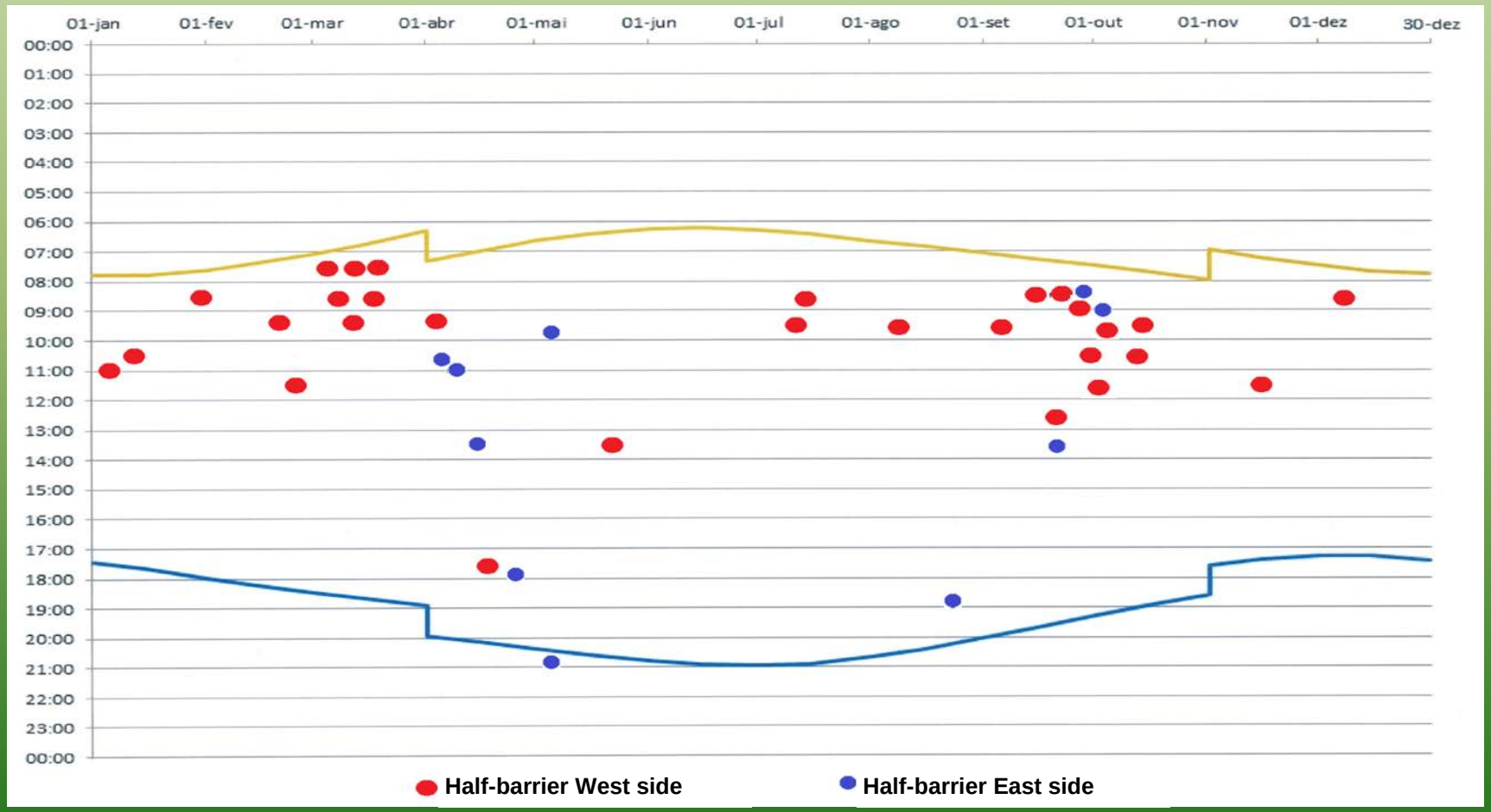
The effects of the sun on road drivers at the LX



The effects of the sun on road drivers at the LX



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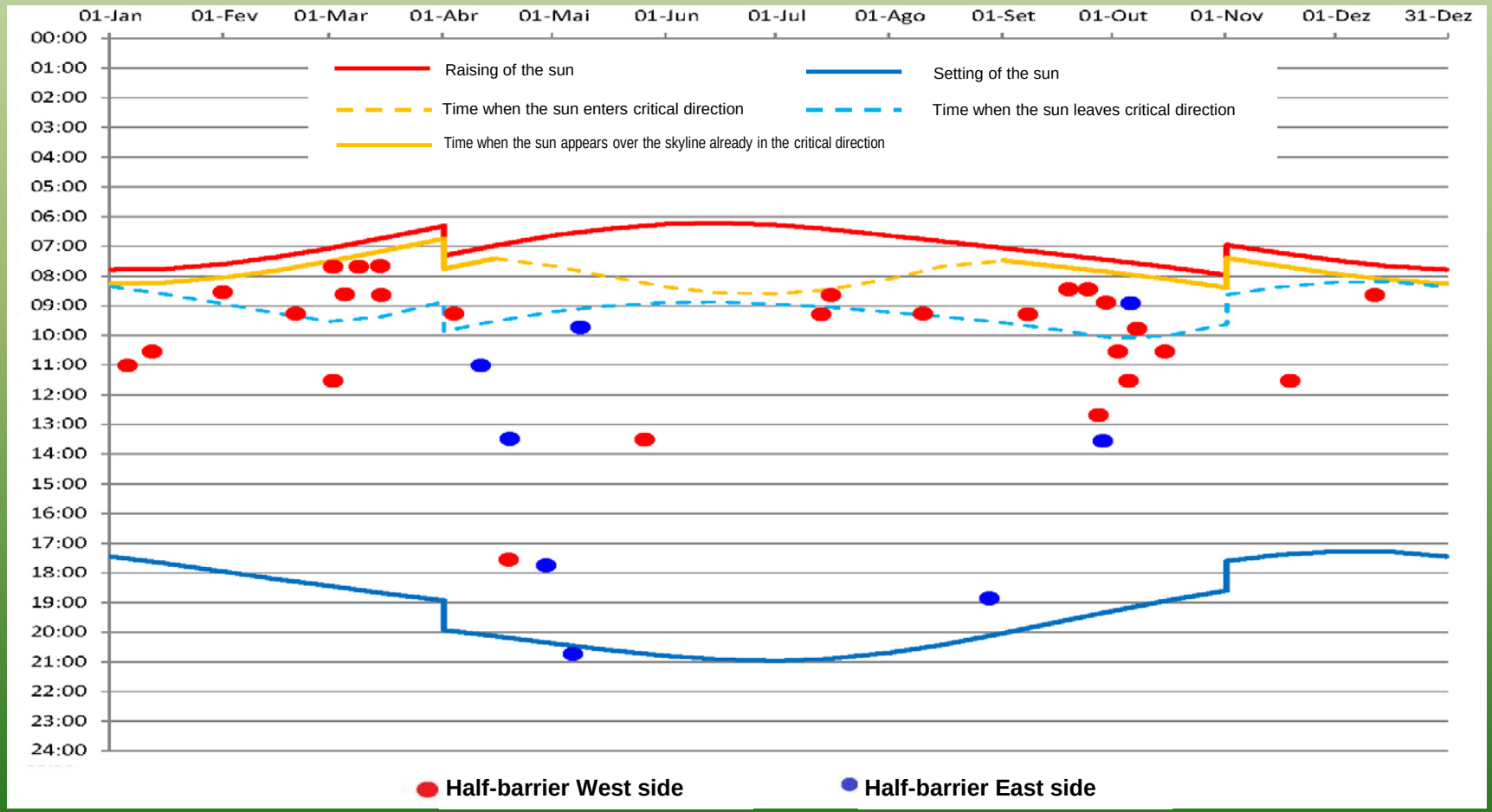

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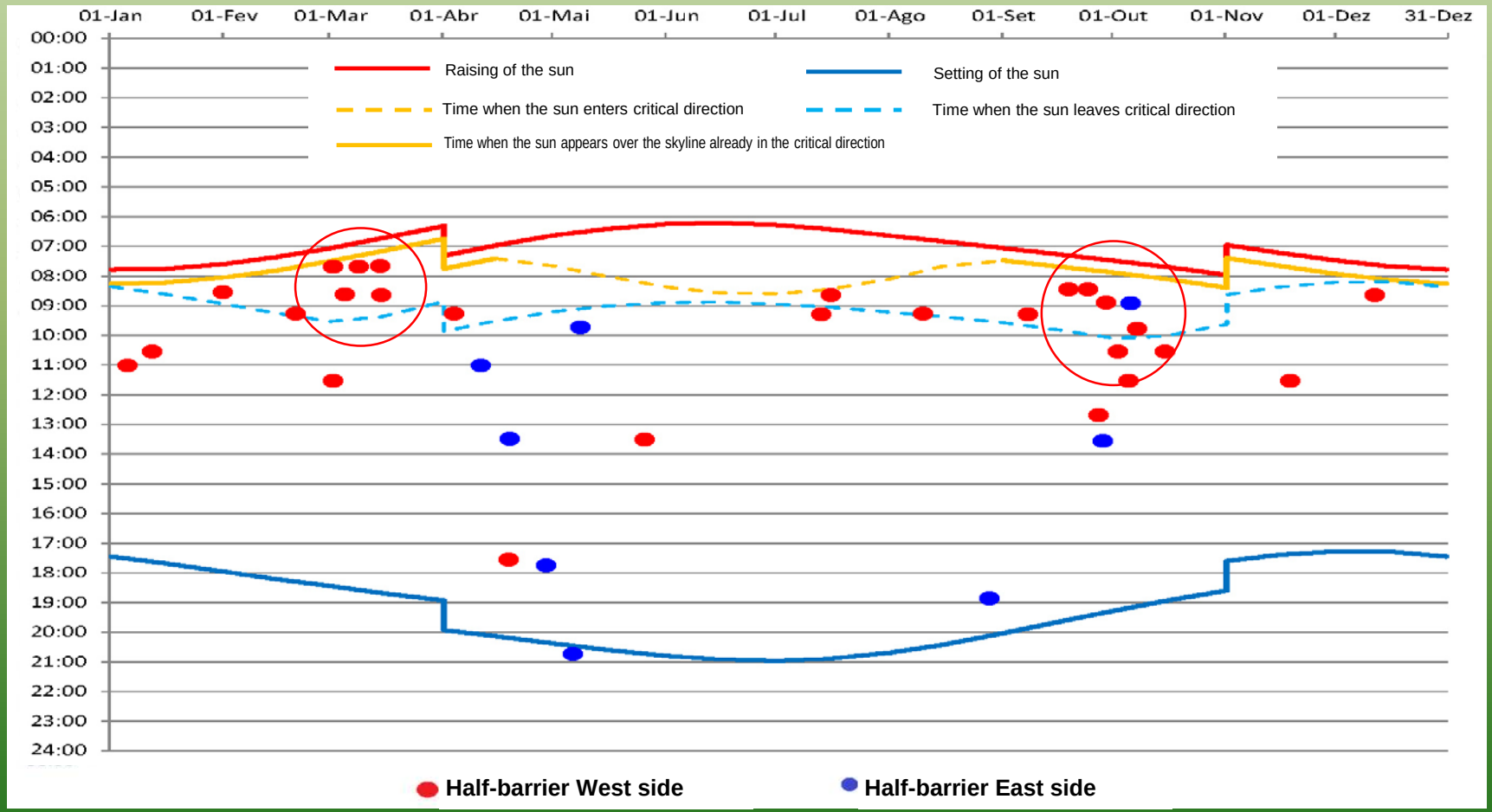

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The effects of the sun on road drivers at the LX

Conclusions

- **56% of collisions** with the west half-barrier happen during the critical time-slot where it was determined that the sun causes significant glare, which is **only 11 % of the total** sunlit period (rail and road traffic being fairly constant along the day).

Frequency of collisions with the west half-barrier in that short period is **ten times higher** than a collision in the much larger remaining period.

- There is a **clear** concentration of occurrences in the two yearly periods when the sun is for a longer period of time in the position that was determined to cause glare (February, March, September and October). Consistently, in the months when the sun is for a very short period in the position where it causes glare (April to August and November to January) there are very few occurrences.

The effects of the sun on road drivers at the LX

Conclusions

- This analysis allowed NIB PT to state that there is **strong evidence** to conclude that the position of the sun at certain periods of the day, variable along the year, can
  (i) disturb the concentration and vision of road drivers, as well as
  (ii) cause the level crossing, its half-barrier and its signalling to be less conspicuous to road users,
  factors that combined have the effect of making it difficult for road drivers to see that the level crossing is activated.

- In the report, NIB PT considers that there is a **very high degree of probability** that these effects are a relevant causal factor in the numerous collisions with barriers registered at this level crossing and of the fatal accident subject to the investigation

The effects of the sun on road drivers at the LX

What was the benefit of this analysis to the investigation?

The effects of the sun on road drivers at the LX

What was the benefit of this analysis to the investigation?

- It gave an enhanced relevance to the existing data.
- It allowed to transform a potentially inconclusive debate on driver behaviour and carelessness into objective findings on human factors.
- It evidenced that some LX accidents don't just happen because "*drivers are careless*".
- It gave scientific support to the investigation findings, making them difficult to contradict by the IM with the usual argument of careless drivers.
- It gave an example for an analytical approach that can improve the risk assessment of LXs by the IM in Portugal.

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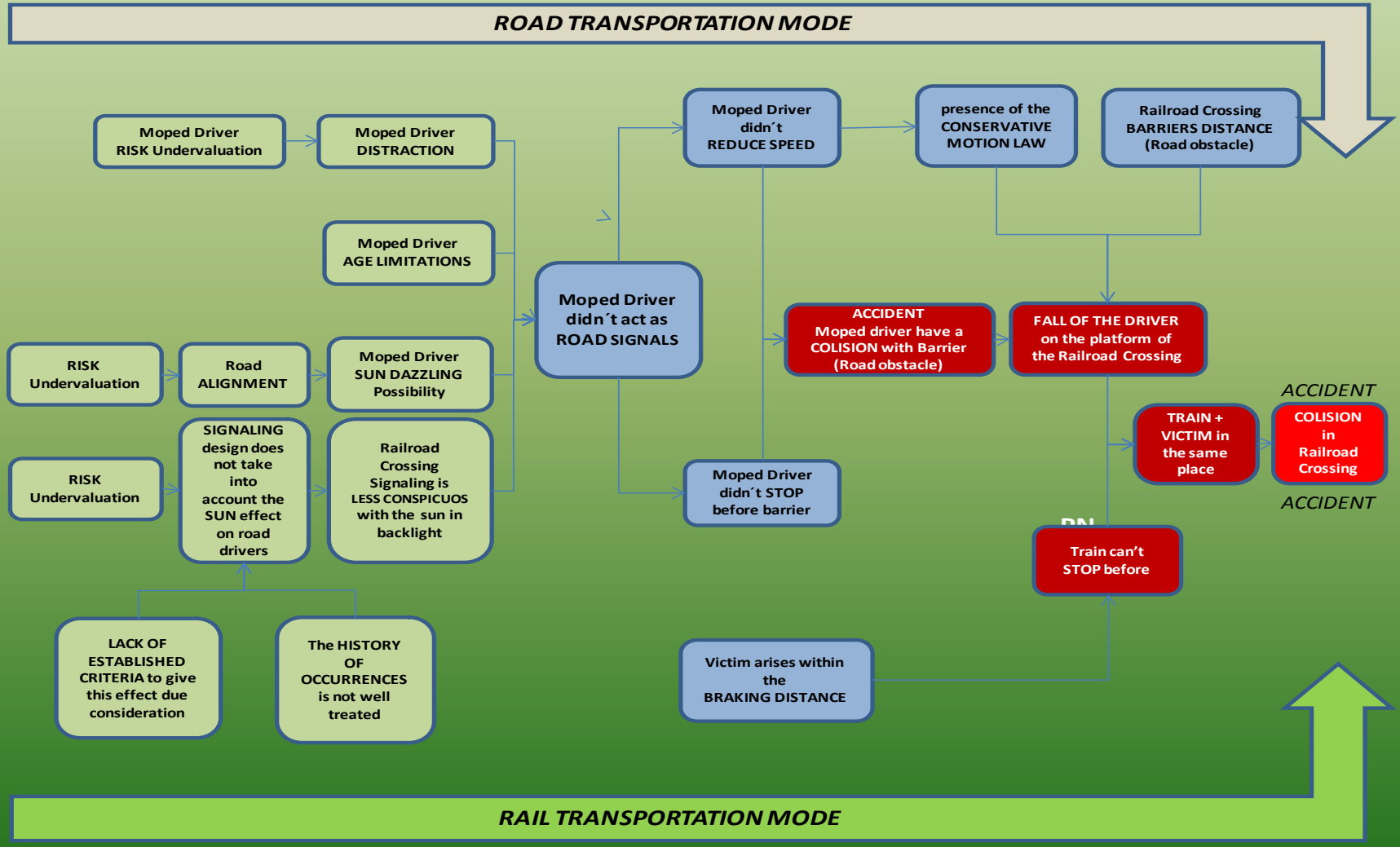
Just an overview of the conclusions for the entire investigation

Causal tree


ROAD TRANSPORTATION MODE
Moped Driver RISK Undervaluation
Moped Driver DISTRACTION
Moped Driver AGE LIMITATIONS
RISK Undervaluation
Road ALIGNMENT
Moped Driver SUN DAZZLING Possibility
RISK Undervaluation
SIGNALING design does not take into account the SUN effect on road drivers
Railroad Crossing Signaling is LESS CONSPICUOS with the sun in backlight
LACK OF ESTABLISHED CRITERIA to give this effect due consideration
The HISTORY OF OCCURRENCES is not well treated
Moped Driver didn´t act as ROAD SIGNALS
Moped Driver didn´t REDUCE SPEED
presence of the CONSERVATIVE MOTION LAW
Railroad Crossing BARRIERS DISTANCE (Road obstacle)
Moped Driver didn´t STOP before barrier
ACCIDENT Moped driver have a COLISION with Barrier (Road obstacle)
FALL OF THE DRIVER on the platform of the Railroad Crossing
ACCIDENT
TRAIN + VICTIM in the same place
COLISION in Railroad Crossing
ACCIDENT
Train can't STOP before
Victim arises within the BRAKING DISTANCE
RAIL TRANSPORTATION MODE

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❖ 12 new safety recommendations on the causal factors of the accident

- 2 addressed to the NSA, relating to:
  - The definition of national design standards regarding to LXs,
  - The supervision on the application of the IM's SMS;

- 6 addressed to the NSA and having the IM as end implementer, relating to:
  - The design of the LX where the accident happened,
  - Criteria for the design procedure of LXs,
  - Risk analysis of LXs and control of risks,
  - Register and analysis of safety relevant information,
  - Internal auditing of the SMS;

- 2 addressed to the NSA and having the RU as end implementer, relating to:
  - Training and maintenance of competences by staff;

❖ 12 new safety recommendations on the causal factors of the accident

- 1 addressed to the Municipality (road manager), relating to:
  - The design of the road approach to the LX where the accident happened;

- 1 addressed to the National Guard, relating to:
  - Procedures in rail emergencies.

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❖ 4 new safety recommendations relating to additional observations

- 1 addressed to the NSA, concerning:
  - The legal framework applicable to LXs;
- 1 addressed to the NSA and having the RU as end implementer, relating to:
  - Procedures applicable to assess the immediate fitness of staff involved in "person under train" accidents;
- 1 addressed to the NSA and having the IM as end implementer, relating to:
  - The updating of operational documents,
- 1 addressed to the National Road Safety Authority, relating to:
  - The criteria for the collection of statistical information on road accidents.

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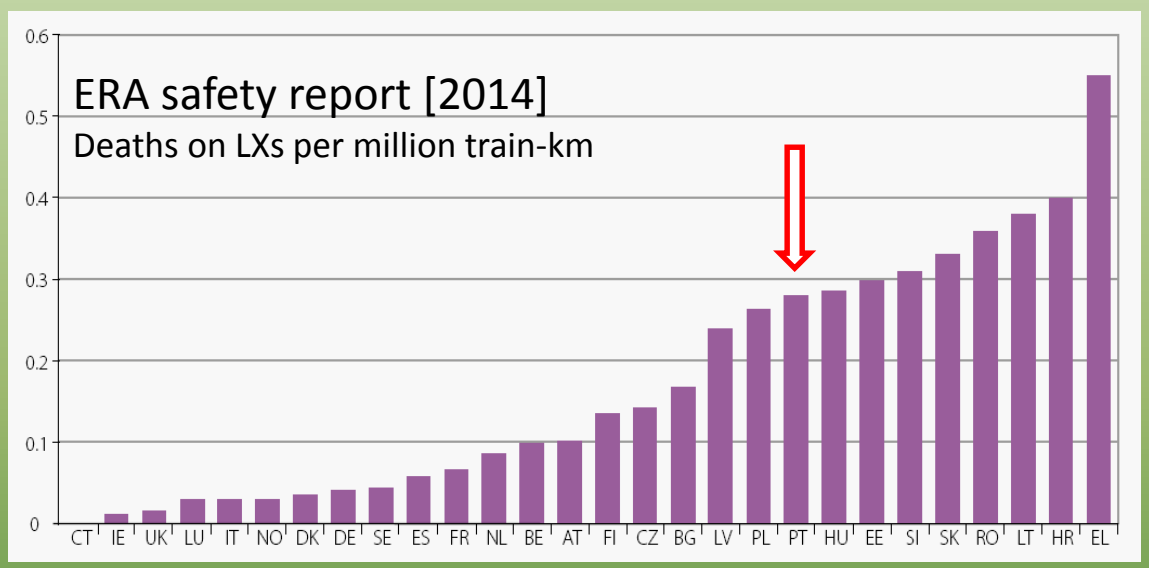

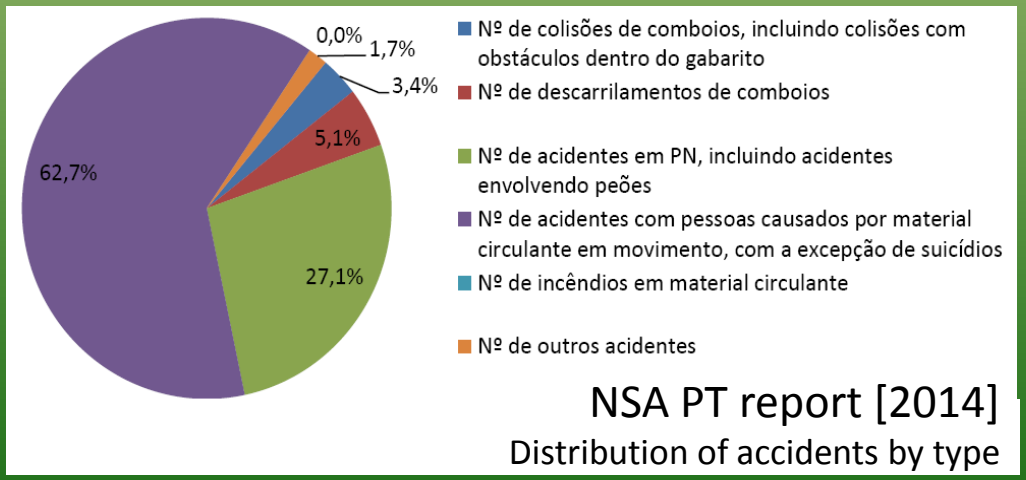

NSA PT report [2014]
Distribution of accidents by type

Thank you for your attention!

Any comments or questions?

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Conclusion

- This example shows that a risk evaluation can be made on the base of :
  - Statistics of incidents/accidents to persons,
  - Existing scientific studies on physiology of human beings. Those studies publicly available.
- This scientific support/justification to the risk evaluation makes difficult to contradict.
- It shows also that the infrastructure manager and the road administration should and can collaborate to address shared risks. “Knowing = acting”.

Human factors consideration is not only based on subjective perception but also on ‘hard’ scientific studies

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