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Group of Experts on Improving Safety at Level Crossings

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Identification of the key causes and possible solutions related to human factors contributing to unsafe conditions at level crossing

Submitted by Austria, the German Aerospace Center (DLR) and Cognito Ltd, Israel

1. This informal document submitted by Austria, German Aerospace Center and Cognito Ltd summarizes the following actions requested by the Group of Experts at its fourth session of the human factors subgroup:

2. To provide a summary of its findings to date, including a list of the gaps in the research on human factors, and to the extent possible, to document the draft toolbox that has been developed to date.

I. Background

3. Following the fourth session, the sub-group updated the findings with (1) the work done to date; (2) an identification of gaps in the human factors at level crossings (HF@LC) – research; (3) a conclusion of the Identification of the key causes and possible solutions related to human factors contributing to unsafe conditions at level crossing; (4) recommendations and next steps; and finally (5) a documentation of the draft toolbox that has been developed to date.

II. Work done to date

4. Paragraph 22 of the report of the fourth session of the Group of Experts states, “For the next session, GE.1 requested the subgroup to … In the event that a partner willing to

fund the research is identified, to present the outcomes of the subgroup's further research between the fourth and fifth sessions.”

5. Up to now the subgroup received positive feedback from several countries about the importance of human factors at level crossings. However, the databases or accident investigation reports provided to the subgroup members addresses technical and legal issues but no human factors issues were investigated in the past. It is important to emphasize, that that the reason for most if not all level crossing (LC) accidents are in the sphere of human factors but that none of the investigation techniques known to us take a serious look at human factor issues. Unfortunately no offer of funding to refine and finalize the proposed toolbox has been given.

A. Description of the structure of toolbox

6. Since the fourth session of the Group of Experts the members of the subgroup worked on to become a usable toolbox for the identification of the key causes of level crossing accidents. The members of the subgroup decided to broaden the scope of the toolbox by a separation into two questionnaire-tables: the first one (HFA – Human Factors Analysis) is dedicated solely to the human factors aspects while the second one (LCA – Level Crossing Analysis) is a summary of the structure of conventional level crossing accident investigation reports. In other words, the first table shall be used when analysing human factors at level crossing accidents, while the second table may be used, e.g. when there are no sufficient national level crossing accident investigation reports available.

7. The questionnaire-table LCA which is very similar to existing tools is structured by the areas:

- Accident;
- LC condition;
- local conditions at time of accident;
- drivers;

8. The area ‘accident’ collects information of the position of the LC, the people involved in the accident on road and rail and their state of health, the types of vehicles (both road and rail).

9. The area ‘LC condition’ gives information on the setting of the LC, like type, road and rail parameters like gradient and/or curves, speed limits at the LC and before the LC. The area ‘local conditions at time of accident’ is dedicated to conditions such as weather, visibility, temperature which were given at the time of the accident. The area ‘drivers’ collects information on the drivers such as age and gender of driver, nationality of road driver licence, licence expiry date.

10. The questionnaire-table HFA is dedicated to collect information on real existing accident situations. The information can be (1) questions to the participant(s) with – in most cases - yes/no-statements; (2) observations, of the reporter; (3) objective information which can be measured such as use of alcohol or drugs, average closing time of technical LC-safety device; (4) Testing, e.g. of driver or of traffic behaviour at specific LC. It includes also information out of LCA-table.

11. The table is structured by five areas which are based on a scientific theory developed by the expert group:

- concentration
- perception and perceivability
- cognition
- motivation

• performance

12. The area ‘concentration’ contains a listing of information on potential concentration problems inside and/or outside the vehicle, and also on attention problems based in the road driver. “Did the accident occur because one of the road users was not attentive enough?”

13. The area ‘perception and perceivability’ contains a listing of information on the environment and the surrounding of the LC in terms of general perception conditions. “Did the accident occur because the LX or elements of it were not or could not be perceived in real time?”

14. The area ‘cognition’ contains a listing of information on the environment and the surrounding of the LC in terms of general cognition conditions, including indirect observations like average behaviour at the specific LC, and also cognition aspects of the accident (road) driver. Did the accident driver have problems interpreting or comprehending the situation or did he fail to choose an adequate reaction in real time ?”

15. The area ‘motivation’ contains a listing of information on the (road) driver, like e.g. his/her experience, reason for the ride, behaviour, stress or depression situations. “Were psychological or social factors active which led road user(s) to choose dangerous or unsuitable interpretations or reactions?”

16. The area ‘performance’ contains a listing of information on roadside issues like average and permitted speed before and at LC, up to information on the (road) vehicle. ”Was the motivated, knowledgeable and attentive driver actually unable to do whatever was required to prevent the accident?”

B. Results of discussion with AT accident investigation body and ÖBB-internal departments

17. The two questionnaire-tables of the toolbox were discussed with the head of the Austrian Accident Investigation Body (VERSA - Bundesanstalt für Verkehr - Sicherheitsuntersuchungsstelle des Bundes). The Austrian Accident Investigation Body makes level crossing accident reports of approx. 15% of all level crossing accidents in Austria; these are often the accidents with the highest effects. VERSA is also working on a questionnaire on human factors which is in preparation at the moment and will include the draft findings of the human-factors subgroup of UN-ECE Group of Experts on Improving Safety at Level Crossings.

18. Therefore the responses to the tables by VERSA are highly influenced by the huge experience of daily work in level crossing accident reporting and reflect the feasibility and usability of the toolbox.

III. Gaps in the human factors at level crossings research

C. Previous research on human factors at level crossings – an excerpt

19. Despite signs and signals announcing level crossings, road users often do not recognize or respect the train’s right of way. Accidents at level crossings remain an ongoing international problem. Most level crossing accidents involve a road user who collides with a train. In most countries, more than 90% of all collisions at level crossings originate from the misconduct of a road user. Accidents are most often blamed on human errors like “inattentive driving” on the part of the road user or a “lack of knowledge” about level crossing regulations. Since this description of the human error is rather unspecific and often

not verified, some research has been done in the past to analyse human information processing at level crossings more detailed.

20. Research on this subject has for example been conducted by Rudin-Brown, French-St. George and Stuart (2014), who describe human factors that can lead to unsafe situations at rural level crossings (detection of a train / understanding the need to stop / sightlines / train conspicuity / speed illusion due to the unchanged retinal image of an approaching train / train horn audibility / "looked-but-failed-to-see error" / learned misbehavior / wrong expectations / distraction / driver impairment information processing). In several studies, aspects of driving behavior and attention during the approach towards level crossings have been investigated in different settings and countries (Åberg, 1988, Rudin-Brown, Lenné, Edquist, & Navarro 2012, Wigglesworth, 1978). Wigglesworth (1978) observed driver's behavior at level crossings. He focused on head movements that served as an indicator of the searching behavior of the drivers during the approach. His results reveal that a majority of drivers did not search and look for a train. In the case of level crossings with flashing lights, 72% of the drivers paid attention to neither the tracks to the left nor the tracks to the right. At passive level crossings, 40% of the drivers did not show any head movements at all.

21. In a comparable study, Åberg (1988) observed drivers at 16 different level crossings in Sweden. Of the drivers, 24.8% checked both sides of the level crossing for a train, whereas 59.8% displayed no head movements to either side. 15.4% looked either at the rails to the left or right at the level crossing, but did not search for a train on the other side.

22. Rudin-Brown, Lenné, Edquist, & Navarro (2012) analyzed the driving behavior of 25 participants during their approach towards three different level crossings within a simulator setup. The driving performance and attention of the drivers was analyzed by comparing the number of violations, reviewing speed profiles and evaluating visual scanning patterns. 14 out of 25 participants committed a violation in the case of the passive protection with stop sign. Five violations were recorded in the case of the level crossing with light signals. Seven were recorded for the level crossing with half-barriers. Speed profiles of the approach towards each of the crossings were compared for the share of participants in the study that did not commit a violation. Speed profile results reveal that in the case of a level crossing with stop signs, drivers slowed down earlier on approach compared to the two other level crossings.

23. Concerning the visual scanning patterns of the participants no significant difference could be found with regard to the time spent looking at the peripheral regions of the visual scene at the three level crossings. These results are in conflict with the data presented by Wigglesworth (1978), who found a significant difference in the number of drivers that direct their attention to peripheral locations at active level crossings (with flashing red lights) compared to passive level crossings. A possible explanation is the small sample size and the different setup (simulation) in the study of Rudin-Brown, Lenné, Edquist, & Navarro (2012).

24. More research has been conducted on human factors at level crossings, the overview in the previous just represents a selection in order to form an impression of research in the field of information processing.

25. In addition to the research concerning attentional processes of drivers at level crossings, a lot of possible countermeasures are discussed in the literature, as well as expert groups. Some examples are rumble strips, various lighting systems that highlight sign, colored streets around level crossings, different marking patterns on the ground that lead to speed illusions or an increased enforcement by speed cameras.

IV. Conclusion

D. Gaps in human factors research at level crossings

26. While a lot of research has been conducted on road users perception and countermeasures have been developed, a relatively black spot in research in the field of level crossing safety is the development and especially the evaluation of a systematic template for human factors issues in level crossings accident investigation. Most accident reports focus on rather technical details, e.g. if the train driver tried to brake, or to give the location plan of the area around the level crossing. Items in investigation templates concerning underlying causes on the side of the road user are scarce, therefore oversimplifications of causalities / human error are found often.

27. A systematic accident investigation toolbox like the one named "ASAP", proposed by the subgroup is needed in order to get a deeper understanding of the real accident causes. Only if a greater degree of detail concerning human factors that lead to accidents can be reached, can tailored countermeasures for different kinds of level crossings be developed. Each new system or idea concerning designs to increase safety should be evaluated in a prototypical version, before a larger scale role out can take place.

28. In-field validation of the effectiveness of countermeasures is a second gap in human factors research around level crossings. Accident numbers are often used to judge the effectiveness of a certain measure. Nevertheless, since accident numbers are usually not high for a single level crossing, they are not an appropriate metric to judge the effectiveness of a given concept. A long-term surveillance (e.g. video) of the natural driving behavior of road users (e.g. speeding behavior; amount of violations that do not lead to an accident) at a level crossing before and after the implementation of a countermeasure would be a more suitable approach. The mobile multisensory "research level crossing" by the German Aerospace Center (DLR) was designed for this purpose. It is a long-term surveillance tool that is capable of automatically categorizing human behavior and atypical trajectories at all kinds of level crossings, in order to evaluate the effect of changes in the infrastructure of the level crossing.

29. Besides the validation of technical countermeasures, the validation of the effectiveness of awareness campaigns is often not existent or unspecific. Often the reduction in deaths or accidents is ascribed to certain campaigns, but this practice is questionable, since it is often biased by the effect of the continuous reduction of the overall number of level crossings. Better methods to evaluate the effectiveness of awareness campaigns should be developed.

E. Next steps to be done

30. Before the toolbox can be used as standardized level crossing accident analysis of human-factors the following steps have to be done:

(a) first testing: Real-time testing and analysis of toolbox; outcome: experience and usability of toolbox, including recommendations for detail improvement;

(b) loop back: to improve toolbox in detail by collecting all results of first testing; outcome: (a) final toolbox (structure), and (b) first set of analysis (for multi-analysis);

(c) application: recommendation for (European-wide) use when making accident analysis on HF@LC, by ?? - UIC and ERA?

(d) setup: single data/information collecting point and setup of (virtual) center of excellence for multi-analysis on HF@LC;

(e) Results of discussion with AT accident investigation body and ÖBB-internal departments.

F. Subgroup request GE1 for

(a) Elaborate a process model to become a useable toolbox for human factors accident analysis

(b) Elaborate a recommendation on 'how to use' the proposed toolbox

(c) Elaborate recommendations for "The identification of the key causes and possible solutions related to human factors contributing to unsafe conditions at level crossings"

V. Documentation of the draft toolbox developed to date

31. The toolbox contains two questionnaire-tables

(a) How to use the toolbox: on one hand as questionnaire-tables for a standardized level crossing accident analysis of human-factors; on the other hand – when numerous human-factors level crossing accident analysis is available – to investigate characteristic accident-structures depending on level crossing type.

(b) Who shall use the toolbox: every institution which undertakes level crossing accident analysis.

32. The subgroup will provide a copy of the draft toolbox by the next session.