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PREVENT
EDUCATION TO IMPROVE ROAD SAFETY AROUND WORK ZONES

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Abstract - The relatively high traffic accident rate around work zones is partly caused by driver error. To reduce driver error and to improve driver behaviour around workzones, a training programme was developed within the framework of the European Union "Leonardo Da Vinci" "PREVENT" project. *Literature reviews* and *accident statistics analyses* were carried out to define the objectives of the training programme with respect to crash circumstances, driver errors and violations. This paper presents the outcome of these analyses. The paper demonstrates how these findings were used to define the content of the educational tools necessary for improving *driver behaviour* around work zones. Based on human factors literature, the paper also discusses the possibilities and limitations of education in improving work zone safety and driver performance. It shows that adequate accident and driver data are essential for developing education programmes.

1. INTRODUCTION

This paper describes the development of an educational programme aimed at improving road user behaviour particular at work zones. The programme was developed as part of the European Union (EU) PREVENT project. The paper discusses the necessary steps to achieve a potentially strong educational project.

First the magnitude of the problem is described, as are the causes of road zone related crashes. Combined with a behaviour analysis of the driving task in relation to road zone hazards, the collated results form the basis for developing the framework of an educational programme for road safety. Furthermore the paper describes the areas for improvements

2. CRASHES AND THEIR CAUSES AT ROAD WORK ZONES

Work zones present dangerous situations for both drivers and road construction workers. In California the introduction of work zones increased the accident risk by 17% when compared to the period prior to the start of the works. (Khattak, Khattak & Council, 2002). In the Netherlands, road traffic crashes related to work zones represent about 2% of the annual serious injury crashes (SWOV factsheet), resulting in an average of 25 road fatalities and 245 serious injuries per year (period 1990-2003). Compared to fatalities among road users , road worker fatalities as a result of a road accidents are relatively rare, resulting in an average of one fatality per year. Although this is low when compared to road users it is at the top of most dangerous occupations when compared to other occupational hazards.(Swuste, 1999). This paper deals solely with the crash circumstances of road users in and around work zones.

On crash circumstances, accident data show that most work zone crashes involving road users happen in daylight hours, with more rear-end crashes compared to "normal" crashes. In comparison to works of *long* duration, *short term* works are generally more dangerous. (ARROWS, 1999). Crash numbers peak in summer and autumn, which is probably the result of the high incidence of road works during those months. Driver behaviour resulting in work zone crashes includes:

- Excessive speed before or in the work zone,
- Changing lanes too late,
- Inappropriate following distances ,
- Losing control over the vehicle.

This indicates that dangerous acts as a result of driver errors and violations are important contributors to these crashes. We speak of violations if people intentionally break the rules and driver error if people unintentionally transgress the traffic rules or commit an unsafe act.

3. WHY DO DRIVERS MAKE ERRORS AND VIOLATE AROUND WORK ZONES?

The increased crash risk around work zones is directly related to the nature of work zones. Work zones entail a sudden change in road layout and include changes in speed limits, extra traffic management devices, new signs and markings; lanes are narrower or reduced number of lanes. Together, these factors form a discontinuity in the traffic situation, causing disrupted traffic flows and creating an unpredictable situation in which a driver's expectations are no longer valid. To be safe, the driver needs to notice and recognize the work zone, needs to predict its nature (length, width, alignment, the presence of other road users etc) and to respond to these changes adequately and in time (PREVENT 2005, a, b, c.). Mistakes in any of these assessments and responses may easily result in crashes. This appears to be confirmed by the high crash rate at work zones.

3.1 Driver errors

The answer to the question, why *disruption* and *unexpected* events easily lead to driver error, requires an understanding of the nature of the driving task. The driving task requires certain, physical and mental activities that are in principle beyond the human capacities, such as:

- Detecting/anticipating obscured dangers that require split second decisions,
- Combining simultaneous actions such as checking mirrors, changing gears, road tracking and speed control,
- Selecting relevant information and ignoring irrelevant attention attracting stimuli. ,
- Selecting the traffic rules applicable to that situation.

The complexity of this task, can be demonstrated by comparing inexperienced drivers (< 1 year driving experience) with experienced drivers (> 6 years driving experience) (OECD, 2006). Inexperienced drivers need to pay attention to every aspect of the task, their performance deteriorates when combining tasks, they have poor visual scanning, slow responses in critical situations and they make many errors. In contrast, experienced drivers easily combine various tasks, select relevant information and ignore irrelevant information, choose correct responses without paying attention to every detail, and make only few errors.

The differences between the experienced and the inexperienced driver are related to the hours of experience behind the wheel. With practice, the execution of the driving task becomes more or less automatic, meaning that the driver does not need to pay much attention to details of the task. Instead, he uses his expectations in such a way that a set of conditions leads to a fixed set of actions that are beyond the driver's immediate attentional control. For instance, crossing an intersection with a layout and controls that conform to expectations, automatically leads to the execution of an almost standard set of actions suited to that type of intersection, including visual scanning patterns, speed selection , priority rule application and road positioning. If the routines are correctly trained, and have sufficiently been applied in a wide range of conditions, the combination of expectations and automatic routines leads to high quality performance: error free and fast responses, without exhausting the driver's mental resources.

Drivers can only profit from these previous experiences, if the traffic conditions are in line with a driver's expectations (see also Wegman and Aarts, 2006). Conversely, if the road environment meets driver expectations insufficiently, road users more frequently miss relevant information and delay the action needed to prevent a crash. Work zones typically deviate from the normal situation, in terms of a suddenly lower safe speed, less manoeuvring space and unpredictable road geometry. Therefore the resulting violation of driver expectations may easily lead to the selection of driving routines that are incorrect and even unsafe for that traffic situation. Due to

these deviations from the norm, road works create a potential safety hazard from a road user perspective. To reduce those risky conditions guidelines were developed about the design, the geometry, the marking, warning signs relevant for setting up a safe work zone (ARROWS), aiming to inform drivers on time, and guide their expectation. Such a safe design is a precondition for safe behaviour around work zones.

Since road works tend to complicate the driving task, even adequately designed road works may contribute to a wide range of driver errors, including:

1. A driver fails to notice markings and signs that indicate that road works are ahead.
2. A driver sees the signs and markings but does not recognize that these indicate that road works are ahead
3. Driver's failing to adapt to changes in time. For example, a driver slows down. But his speed is still too high the moment he enters the road works.

3.2 Violations

The nature of work zones may also encourage road users to deliberately violate the traffic rules. The lower speed limits, lane closures and other changes slow the traffic down, which leads to longer travel times. This could create some feel of urgency, particularly when the delay is long and unexpected. In addition, drivers may not be convinced of the necessity to lower speed limits. This is particularly the case when the speed traffic signs are not accompanied by visible road works, or when the road environment does not appear suitably constrained (posted speed limits do not match driver perceptions). .

4. THE DESIGN OF THE EDUCATION PROGRAMME

Unfortunately, analysed road accident data were inadequately detailed to allow for the identification of specific behaviour relating to work zone accidents. In addition to this, no studies were found in which the behaviour of the driver was analysed with the purpose of tracing the nature of the errors and violations. Hence, the questions relating to the type of errors road users make, and to what extent crashes are primarily caused by violations, could not be answered. The distinction between violations and errors however, makes a major difference for the necessary content of an education programme. In the case of *deliberate violations*, the programme should address issues like risk awareness, personal driving styles, potential gains and losses as a result of violations. In the case of *unintended errors* the choice for the content of the education programme is more complicated. One first needs to rule out that this is primarily the result of poor work zone design. The negative effects of poor work zone design as a source of driver error cannot be counteracted by education, and the only effective countermeasure is to improve work zone design.

In case of poor driver performance around adequately designed work zones, education can contribute by improving driving skills by training behaviour such as *were to look* and *how to react*, and *improving knowledge about rules and hazards*. A more detailed analysis of driver performance, errors, violations and the effect of education can be found in Wegman & Aarts (2006)

As the exact nature of driver errors and violations around work zones could not be determined, the proposed education programme could not be targeted at particular features of driver errors and violations. Although such a targeted programme would have been the preferred outcome, there is an alternative approach which also leads to potentially effective programmes. This approach is outlined in this paper. In such an approach (a broad perspective approach) based on a risk analyses all possible reasons to violate and all possible sources of driver error are identified and targeted, irrespective of the fact how frequently these errors and violations lead to dangerous acts and crashes. Based on this, we identified the sub *tasks* drivers had to carry out. Table 1 illustrates this approach specifically for aspects relating to speed. The second column contains *critical competences* a driver needs to acquire in order to complete that task successfully: . The same approach was taken for the problem behaviour of lane change, lane keeping, close following, misunderstanding signs and markings and awareness of risks associated with work zones.

Task	Critical competence	Possible educational approach
Noticing and recognizing speed signs and markings used for work zone situations	Being able to notice and to recognize: For instance: variable message signs, different coloured road marking, rumble strips	Theory exam
Concluding that a work zone is ahead, for which different speed limits are valid	Making the correct conclusions about the valid speed limit in the area of the work zone	Practical assignment, such as showing pictures of different road types and asking what the speed limit would be.
Knowing the consequences and risks related to speeding at work zones	Knowing the consequences and risks related to speeding around work zones: presence of road workers, narrowed lane, etc.	Video of road workers talking about their jobs; reaction time experiment in a driving simulator etc.
Knowing that reducing speed is required and being able to do so	Being able to brake or decelerate in time	Reaction time experiment in a driving simulator
Being willing to reduce speed to the requested level	Being willing to commit to speed levels even if other drivers are speeding	Group discussion or practical assignment: listing factors that would interfere with the requested behaviour

Table 1: Example of elements of an educational programme aimed at addressing speed choice

A handbook was produced on the basis of this broad approach, as well as an e-tool. The e-tool was tested by potential user groups in Slovenia and Greece, and evaluated as a potentially promising approach. In order to make it fully operational each country need to adapt it to its own rules and regulations. As yet the handbook and e-tool are largely dedicated to technical understanding of the lay-out of road works and provides written instruction about safe behaviour around road works. More developments are needed in the field of actual driving skills (e.g. were and how to detect potential dangers in work zones) and safety motivation (e.g. empathy with road workers, self assessment, impulse control, stress reactions).

5. FURTHER DEVELOPMENTS NEEDED

The aim to develop an educational programme on the basis of accidents and problem behaviour as described in literature, was not achieved. An extensive literature review did not deliver studies about the cause of driver errors and violations leading to crashes at work zones. This conclusion led to a shift in focus from a targeted program to a broad programme. In such a broad programme all potential driving errors and reasons for drivers to violate are addressed, by identifying essential tasks and defining critical competences that drivers should possess in order to be able to handle that task. . This more theoretical approach to developing educational objectives showed to be a useful alternative, as it leads to a comprehensive safety related programme,. Aside of a positive evaluation in terms of user acceptance, the programme has some limitations as well. Firstly, the translation from theory into a practical training, the PREVENT project incurred some difficulties. The linking of critical competencies to problem behaviours resulted in proposals for training, which were not fully implemented yet in the actual training programme. Secondly, the programme developed in the PREVENT project for practical reasons primarily focuses on knowledge and insights, and as yet it does not deal with the tendencies of drivers to overestimate their skills, to ignore the extra risks associated with temporary impairment (e.g. the effect of fatigue or alcohol), and to underestimate traffic complexity (e.g. the need for adequate safety margins). These are serious omissions that need to be addressed in later versions of the programme. Recent studies have identified in particular those elements as essential for the process by which a person is stimulated to change and improve his

driver behaviour. And finally, the tools have been applied only in two countries (Slovenia and Greece), while large differences exist between countries in the way they handle safety around road works. For more impact, the material needs to be translated, adjusted to the standards of participating countries and tested.

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