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## Road and Rail Infrastructure III

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## FACTORS INFLUENCING DRIVER'S BEHAVIOUR AT INTERSECTIONS CROSSED BY THE TRAM

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### Abstract

Drivers' behaviour in intersections crossed by the tram is not only influenced by the rules of the tramway priority in the intersection but also by the road features that influence right or wrong behaviour of the driver. The driver follows the road with expectation and orientation logic formed by his experience and recent perceptions. This means that the road has to be constructed accordingly, so as to be understood, perceptible and recognizable.

Our research was aimed at finding out, how, in the dynamics of driving in intersection crossed by the tram, do drivers perceive and identify road situations, change in them, and the regulating actions they imply. We consider the causes of driver's operational error as the first step in a chain of actions, which may proceed to unwanted events. This paper describe our methodology for the analysis of driver behavior in real driving conditions, involving two techniques: the observation and measurement of two intersections crossed by tram at Rabat city, which were selected according to the number of collision and related incidents that occurred there combined with an assessment of the driver's behaviour during a journey made from within the vehicle itself. The merits of such an approach are highlighted and the main results are discussed and interpreted

*Keywords: human factor, cognition, intersection, tramway, road environment, representation and perception logic*

### 1 Introduction

The modern tramway has resurfaced as the cure to today's urban transport problems such as pollution, road congestion and uneven access to transit. However trams at intersections often experience frequent and extended delays due to vehicles crossing the tram tracks. There is an increased potential for conflict between trams and vehicles at these locations and crashes are common. Indeed from 2011 to 2013, it was reported a total of 222 tram-involved crashes in Rabat city, 4 fatal, and 81 with serious injury consequences. Of these, 125 (56%) involved tram-to-vehicle collisions at intersection.

Statistical data prove that there is a need to conduct research about the influence of tramway and surrounding environment, (specifically at crossroads) on car drivers' behaviour; the focus remains on creating an environment that minimises likelihood of serious injury.

With this focus in mind, our study aim to allow a systematic sorting out of the different malfunctions which intervene in the genesis of unwanted event at intersections crossed by tram. It is particularly important to recognize that the drivers' behaviour in intersections crossed by the tram is not only influenced by the rules of the tramway priority in the intersection but also by the road features that influence right or wrong behaviour of the driver.

Our analysis is based on the human factors concept taking into consideration the triggers of the driver's reactions and patterns of behaviour, which may result in an accident or even near miss. The systematic study of driver behaviour in real driving conditions makes in our view a useful contribution for such analyses.

The following article first situate the human aspect involved in driving activity, then for the purposes of illustrating our approach, we will briefly discuss some research method and their interest for understanding the way drivers behave in the situations concerned, we present in the last part our experimental study to collect data on driver performance at intersections crossed by tram and the primary finding of our research

## **2 The driver's ability to understand the road intersections crossed by tram**

In order to better understand how we function as drivers at intersections crossed by tram we first turn to Endsley's thoughts on how human operators have evolved during the evolution in interaction with the world. According to this author, situational awareness is the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and projection of their status in the near future,[1]. Applying Endsley's model to the driving environment, the driver firstly perceives road situations. The driver then has to comprehend what they have perceived, by forming "a holistic picture of the environment, comprehending the significance of those objects and events". Finally, the driver takes this understanding, and projects into the near future, in order to take the most appropriate action [2]. Situation awareness plays a vital role in driving as in every dynamic decision making. So driver performance can be evaluated through three parameters: the information received, the interpretation of this information made and the decision taken. An explanation of inappropriate driver behaviour should be sought at each of the different levels of situation awareness.

### **2.1 Driver's perception of the road**

The perception of the road environment, especially its hazards, would be expected to influence driving performance, [3, 4, 5]. There are various level of perception that depends on the stimulus and the task confronting a person. The most basic form of perception is simple detection; that is, determining whether a signal or target is present, [6]. According to the literature [3][7], perception is more than just sensations; it uses memory, classifications, comparisons, and decisions to transform sensory data to a conscious awareness of the environment. This means that through our senses we get an immediate perception of the road environment and what is about to happen around us and we are unconsciously adapting our actions to the road. The physical design of the road and its various parts is the most important source of information to the driver. Drivers perceive the road and the traffic conditions as a whole. In this way, the drivers are the most perceptive of the information they need the most. Indeed drivers seem to be equipped with a well-developed "skip function", they try to acquire messages on aspects of their surroundings that they believe are relevant while ignoring those without useful information. It is an active process that requires significant discipline, as well as knowing what to look for, when to look for it and why.

### **2.2 Expectation and representation**

In the field of cognitive psychology, the notion of representation refers to the idea of internal model developed by the subject for dealing with complex situation. Our understanding is built by combining observations from the real world with knowledge and experience recalled from memory, [8, 9]

The driver follows the road with expectation and orientation logic, which was formed by his experience and recent perceptions [10]. Lunenfeld and Alexander [11] define expectancy as “a driver’s readiness to respond to situations, events, and information in predictable and successful ways”. The expectations are functional for the driver in the sense that they are an important prerequisite for well-adapted driver behaviour [7].

The driver’s expectations, however, will be dysfunctional in case he encounters an unexpected traffic situation. When the driver has false expectations of the road and traffic conditions, this means that he will have an image or idea of what it is to happen which is not in conformity with reality. Indeed the drivers get “confused” and surprised when the road and traffic conditions are not in line with their expectations. In a situation where prompt action is required, problems often occur because there is not enough time to take proper actions, which implies a high risk of missing important information and making wrong decisions, [12].

In order to meet the driver’s expectations, roundabouts crossed by tram have to be recognizable, distinguishable, interpretable and safe. This means that they must be designed in a consistent and standardized manner.

### 2.3 Driver’s ability to read the road and self-explaining road

In the road safety context, Salmon and al [13] argue that incompatibilities in situation awareness across road users lie at the root of conflicts between them. A malfunctioning road and traffic environment is identified by the fact that drivers do not behave as intended. A large occurrence of deviant behaviour then indirectly shows that the drivers misunderstood and were surprised by the road and the traffic environment. Because the driver’s reaction characteristics cannot be changed, the attention should be focused on a self-explanatory road design.

Concepts such as “positive guidance” [11], “road readability” and “self-explaining road” [14] all these terms have been applied to those road designs that communicate to the driver what type of roads they are, or that can be easily categorized by drivers as requiring specific kinds of driving behaviour. They seek to identify the relevant infrastructure features likely to provide a clear picture of the functionality of the road space: how to cross an intersection crossed by tram, who has priority, what kind of information can be expected and so on. Designing road environments that facilitate the ‘connection’ of different road users’ situation awareness therefore seems to provide an appropriate way to reduce collisions between them.

These questions raised from this perspective have led us to formulate our general hypothesis of research, which can be defined as follows: Driver behaviour at tram crossroads will depend very much on what is seen or “not seen” by the driver, in the road scene and how he “reads” the situation. Our research aims to evaluate which expectations the drivers have to tram crossroads and how they drive on it.

## 3 Overview of research method

In order to do analysis on road traffic dealing with human behaviour, it is required a great amount of data. The range of methods typically used includes observations, questionnaire, verbal protocol analysis and experts (police, road engineers, etc). In depth analysis normally requires experimental observations or field observations with specific supporting equipments. The general rules regarding data collection are (a) not to rely on one source of information and (b) to beware of potentially misleading information.

For the purposes of illustrating our approach, we will briefly discuss some research method and their interest for understanding the way drivers behave in the situations concerned.

### 3.1 Observation

Observation consists of recording behaviour during task performed. The three main ways that observational data are collected are direct observation, indirect observation, and participant observation. These methods can be used in combination with each other in order to obtain a broader understanding of the task. According to Stanton [15], one of the main concerns with observation is the intrusiveness of the observational method. Observing people affects what they do; people observed can bias the results as they might perform an unrepresentative range of tasks; and the way in which the data are recorded could compromise the reliability and validity of the observations. Overcoming these potential problems requires careful preparation and piloting of the observational study. In planning observational studies, a researcher identifies the variables to be measured, the methods to be employed, and the observational time frame. [16] For our study, the observation was based on an analysis grid that we have developed to carry out the assessment, and to examine whether it would be possible to identify characteristics of intersection crossed by tram that coincide with a higher likelihood of unwanted events. To guide our choice of elements to be included in this grid, we were inspired by the work of Millot [17] taking care to adapt the reading points to our own field of study and to our specific questions, [18].

### 3.2 Verbal protocol analysis

Verbal protocol analysis (VPA) is a method which involves participants ‘thinking aloud’ as they perform a task. Verbal protocol analysis uses data from verbal transcripts to analyze the content there in. These transcripts could come from protocols gathered from recordings of live performance of the task. The transcript can be coded and analyzed at various levels of detail, from individual words, to phrases, to sentences, to themes [19]. Verbal protocol analysis has found use within human factors research as a means of gaining insight into the cognitive underpinnings of complex behaviors. Walker [20] has pointed out the importance of Verbal protocol analysis; he stated that” Within the context of exploring hypotheses and conducting studies in naturalistic settings, verbal protocol analysis can be extremely useful and has much to offer”.

To take into account all of these characteristics and the construction of driving in connection with a given situation, we felt that it was essential for our study, to put drivers in real driving situations. The methodology used entailed making observation from within the car during driving on two intersections crossed by tram. At these intersections we consider the point of view of drivers on how they carried out the activity, in order to collect explanatory data on it. This technique enables driver to make comments about his behavior, especially as regards to the environmental conditions which influenced him and came into play in the various situations he encountered.

### 3.3 Interviews

The interview is one of the original methods for gathering general information, and it has been popularly applied across a range of fields. Interviews can be classified into 4 types of informal conversation, semi-structured, standard structured and focus group interviews, [21]. Greenberg [22] proffers the idea that the task analyst can discover what tasks people perform and develop task descriptions through observation and then validate the descriptions through interviews with the same people. Annett [23] argues that data collection should comprise observation and interviewing at the very least.

Based on the literature review above, a specially designed questionnaire was carried out for the purposes of our study. The questionnaire was composed of three parts. The first part of questionnaire concerns the driver characteristics (gender, age, level of education), the second part concerns information about the driving characteristics of the interviewee (driving

experience, yearly kilometers driven, etc) and the third part of questionnaire contains a basic questions on the road design, the meaning of road signs related to tram, behaviour of other road users, and general questions about the problems that drivers could be experiencing with the tramway crossroad.

## 4 Study methodology and preliminary findings

### 4.1 Validation

As a first step, a validation exercise was carried out to assess the feasibility of the methodology. Two crossroads (see figure 1 and figure 2) at Rabat city were selected according to the number of collision and related incidents that occurred there in the last three years from 2011 to 2013.

During the validation exercise, observations were carried out. This involved spending periods of time at each crossroads and observing the behaviour of users. A review of the physical aspects of each crossroad and its surrounding were made. An assessment of the driver's behaviour during a journey within the vehicle itself was also used. A detailed explanation of the driving process was provided by the drivers as they progressed through the sequence of each roundabout, after the journey, the participants were asked to answer a questionnaire with relevant questions about the scene in order to better determine their knowledge and their representations of the driving situations studied.

### 4.2 Preliminary findings

The following list highlights a number of human factors and design features at each crossroads that can have an influential role in unwanted events and contribute to unsafe conditions. The list can be supplemented by further observations and interviews:

(i) At crossroad AL MANSOUR place at Rabat



Figure 1 Tramway crossroad AL MANSOUR PLACE

- A high traffic volumes and pedestrians movement due to shops, this requires car drivers to be alert for pedestrians and tram approaching;
- A stop line is not demarcated, either with a white line or appropriate pavement marking, to attract the driver's attention and help drivers identify safe stopping location;
- Tramway signs are not always conspicuous due to their position relative to other signs;

- Many drivers indicated that unfamiliarity with the tramway crossroad or driving at night would make the maneuver more challenging;
- Parked cars before and after the tramway line may result in vehicle drivers slowing and being caught on the tracks while a tram approaches
- Non compliance with traffic signal encouraged sometimes by police due to problems of traffic congestion;
- The sequence of lights is believed to be confusing in whether the lights are functional or not; the waiting time is perceived to be too long for all car drivers interviewed, which can be considered as an agent for psychological stress.
- The crossing being completed without the necessary caution increases during rush hours and on working days;
- Text in association with trams signs can be hard to read due to car driver's speed;
- For many drivers there is no difference between all the roads signs related to tram and they just ignore these roads signs so they cannot understand what is expected for them to do.

(ii) At crossroad street IBN ROCHD



**Figure 2** Tramway Crossroad Street Ibn Rochd.

- At some locations there is considerable visual clutter from surrounding infrastructure, which can detract from the primary safety messages “give way to tramway” and “beware of tram”;
- Text in association with trams signs can be hard to read due to car driver's speed;
- Some users failed to fully understand the meaning for various trams signs and aren't aware of the rules and procedures for correctly using trams crossroads;
- Drivers can be distracted from scanning for trams while they seek an appropriate gap in traffic on main road;
- A stop line is not demarcated, either with a white line or appropriate pavement marking to help drivers identify safe stopping location;
- Vehicles waiting or queuing across the tram tracks due to traffic congestion;
- The curvature of the intersection creates a difficult angle from which to observe on-coming trams;
- The desire to pick gaps generated by traffic platoons can result in crossing being completed without the necessary caution, indeed the amount of time the users expect to wait at trams crossroads may influence their risk taking behaviour;

## 5 Conclusion

The conclusions of the preliminary findings of our study has identified a number of problems associated with tramway crossroad and has explored some of the road design and human factors that contribute to the difficulties experienced by drivers at these intersections. Evidence has been found that at the intersections visited , road scene elements and traffic condition play a role in the difficulties that drivers encounter when crossig these intersections. It is clear that much further investigation is required on the causal factors of errors and on the implications that these driver errors have on tram crossroad safety.

The second stage of the study is now to address the relationship between the elements of the tram environment and types of driver errors; this work is on progress, with the aim to provide suggestions for minimizing potential conflict between cars and trams and for enhancing error tolerance at tramway crossroads.

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