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## Road and Rail Infrastructure II

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University of Zagreb  
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## INTEGRATING HUMAN FACTOR IN THE ANALYSIS OF THE INTERACTION 'TRAM – CAR DRIVERS'

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### Abstract

Trams are effective alternatives to private car as means of travel in Moroccan towns and cities, and on this basis they are being promoted by the government. However, issues relating to their impact on road safety are one of the main societal concerns today. Indeed, trams share the same road network with all road users. Ensuring that the network works efficiently for all modes and users – cyclists and pedestrians as well as car drivers – presents a significant, but essential, challenge for those who plan, design and fund the transport system. In the light of this, many research studies have shown that poor road design may enhance the driver's tendency to error and misjudgement and lead to unwanted situations (accident, pre-accident, congestion, etc.).

Moving the focus of research away from the driver in isolation and focusing more on the interaction of the drivers and the changing environment, through which they move in time and space, can be regarded as hard core among road safety problems to investigate. This supposes assessing human abilities and limitations and ensuring that the resulting systems that involve human interaction are designed to be consistent with these human limitations and will be a full proof system.

The general aim of this article is to further knowledge about the influence of tramway and the surrounding environment on car's driver behaviour. Understanding these influences, involves conducting a systematic review of the cognitive tasks related to driving and identifying the hazards that can arise at each task, and what factors can make these more or less likely to arise, considering the environmental design and behavioural factors. To achieve that, the Hazop approach is conducted for this study. Concerning data collection, our methodology includes site visits to record user behaviour and questionnaires to determine the opinion, concerns and knowledge of car drivers in interaction with the tram environment.

*Keywords: tram, urban development, human factors, road safety, cognition*

### 1 Introduction

In response to growing problems of road safety related to travel, the road transport network in Morocco has been modernized with the implementation of Rabat–Sale tramway since April 2011. After Rabat, the city of Casablanca also launched the realization of this tram project, whose railway length is almost 30 km. Even though the achievements are few, the projects with significant investments are there and therefore it is logical that Morocco is particularly concerned with the road security strengthening.

At the moment, road users in Morocco are also not qualified enough to adapt to the current situation of modern and advanced developments in the road traffic system. In fact, a study

[1] conducted in urban areas of Morocco has shown that, in comparison with the multitude of dysfunctions observed the accidents are few. It has been noticed in this report, that 'The road traffic is distinguished by the local customs of behaviour acquired over time with the evolution of the complexity of traffic'. This finding justifies that research should be conducted to further knowledge about the influence of tramway and surrounding environment, (specifically at crossroads) on car' drivers behaviour, and it is the general aim of this article. Understanding these influences, involves conducting a systematic review of the cognitive tasks related to driving and identifying the hazards that can arise at each task, considering the environmental design and behavioural factors.

The first part of the article seeks to investigate the interaction between trams and cars within the road network; we also discuss problems that drivers have to face with at crossroads. Then from a literature review of driver behaviour psychological models, we propose our framework to study the interaction of Tram-car driver. In the third part we will present our hypothesis and research approach. The conclusion insists on the interest of our approach to understand the drivers' behaviour and the interface between tram environment and car driver. [Second Level Heading] Second level heading

## **2 Car-Tram interactions within the road network**

### **2.1 Some broad issues**

Cars and trams are at opposite in terms of size, mass and manoeuvrability but they share the same road network. Both Trams and cars may have parts of a roadway set aside for their specific use. However, neither of these is necessarily exclusive (especially at crossroad) and conflict can result. The interaction between cars and trams on the road system will have three major types of consequence on:

- Infrastructure capacity requirements: in terms of damages to the infrastructure and rolling stock that can occur during an accident and which may be heavy in terms of economic damages and number of victims. Indeed as a mode of public transport, the accidents involving tram with other road users may involve a large number of victims. However, as of now there is comparatively little information about the background of the involvement of trams in crashes in Moroccan urban areas, but the media side on accidents involving public transport (in this case a tram) should be noted. Even though they are few, they are totally unacceptable to the public opinion;
- Operational performance, in terms of safety and travel time: conflicts between cars and tramway can have negative impacts on both trams and cars in different ways, causing tram delays and inconvenience;
- Perceptions, particularly by the car driver, which lead to changes in travel behaviour.

### **2.2 The urban effects of the tramway: principles of urban development**

In all countries, the fight against pollution and congestion has been tackled in urban areas through the promotion of tramway as they have been considered the optimal option for fostering public transport patronage and also for getting a sustainable mobility for the growing urban population [2]. Tramways provide fast, regular, safe and comfortable services. At the same time, they provide a modern image to the city.

In spite of the growth in the interest of this urban rail system, it is well known that the tramway line implementation leads to changes, both in terms of the urban shape as on the overall functioning of the city. Indeed the place occupied by the tram on the roadway is directly taken from the car. More specifically, most tram-car interaction within the road network takes place in the context of the existing road infrastructure, which has physical limitations and implicit, sometimes explicit, limitations on additional capacity provision. But beyond the

physical dimension of this competition for space, there is also a misunderstanding of the rules relating to this mode as of its constraints of traffic. The rule 'tram has priority over all users' is explained by the fact that the tram is a vehicle on rails, it cannot avoid an obstacle but it is also explained by the big braking distance necessary to a tram to stop. More generally, tram priority is assuring the tram movement through an area without the potential detriment of others users of this area. These will often be where traffic volumes are high, traffic speeds are low and vehicles movements are complex (e.g. crossroads).

### **2.3 Crossroads Problem: understanding human behaviour**

Crossroads navigation is a particularly hazardous component of driving. Even though crossroads comprise just a small amount of the roadway surface area, they are generally more complex and difficult to navigate than most other road segments. More specifically, crossroads can be visually complex, requiring that drivers scan several different areas and keep track of tram and several different elements to get the information they need to safely pass [3]. Specific issues of visibility and manoeuvrability are likely to occur at crossroads. So great attention is paid nowadays to the meaning of the space the driver is moving in. This area of research and action is known as the 'Road readability'.

'Road legibility', 'Road Readability' and 'Self-Explaining Roads' all raise the question of how the road infrastructure could support drivers' activity. The concept of the 'Self-Explaining Road' is defined in terms of the processes by which drivers' expectations are structured. 'SER are roads with a design that evokes correct expectations from road users (...). This means that drivers are given direct information about the type of road they are driving along and the type of behaviour required' [4]. Therefore, for a safe situation it is important that every road user can see all the other road users and that everyone knows what is expected of him.

Road design and traffic management primarily deal with the realities of the road system and of road use. In practice, however, the actual safety and convenience of road use depend heavily on drivers perceptions of both the road and traffic conditions and of other users.

In Morocco, traditional methodologies mostly focus on single effects of causing parameters to traffic unsafe situations. For example, in most of the statistical reports on traffic safety in Morocco [1], it is written 'speeding behaviour has the highest percentage in all causes of traffic conflicts and /or accidents'. However to explain the accident, one should not seek to attach blame to a single and last element, but to see how the interaction system broke down. Many researches have considered that the problem is not unsafe drivers or unsafe road users, but the unsafe complex system. Drivers, pedestrians, and other road users will continue to make errors as long as the road system exists. It was concluded [5] that rather than focusing entirely upon removing road user error, effective error management in road transport should focus on increasing the capacity of the road transport system to tolerate error. This fact has guided our research in this area to an approach that takes into account the Moroccan road context and behaviour of the driver in this context.

## **3 State of knowledge on human behaviour in driving**

### **3.1 Human functional failure**

The specific role of human factors inside the traffic system has to be stressed in order to go further than the usual view on accident factors. It is important to be aware of the very specific role of the human element: it is both a component and the principal actor [6].

When a driver fails to avoid an accident because the situation exceeds their limitations, it is often called 'human error.' Safe and efficient driving requires the adequate functioning of a range of abilities including vision, perception, cognitive functioning and physical abilities,

and loss of efficiency in any of these functions can reduce performance and increase risk on the road [7].

It is consequently the same process which allows the drivers to adapt to the difficulties of the environment and which sometimes may fail and lead them to error. As the cost of human error can be very high, it is important to find out why human error happened and how it can be prevented in the future [8]. For this purpose, the cognitive approach is especially suitable for analysing higher order functions such as problem solving, and decision making.

### 3.2 Human behaviour models

There is a great amount of literature dealing with analysis models, giving preference in one way or another to the description of functional sequences such as: information acquisition, processing, decision, action. This type of model is aimed at understanding the malfunctions. Other model types are built up using the description of driving task [9].

Two theoretical models that originate from cognitive psychology and are frequently mentioned in the literature on road user behaviour are Endsley's model of information processing, and the hierarchical structure of the driving task as described by Michon. The reason for mentioning these models and not others, is that the models listed are all considered to be relevant for describing traffic behaviour [10],[11],[12],[13], and, more importantly, because they are complementary.

Endsley's model of information processing [14], serves as a starting point. Endsley proposes a model of human decision-making related to situation awareness (S.A). The concept of situation awareness focuses on the mental picture of the situation that people find themselves in and how this picture can be distorted or improved by internal and external factors. Endsley's model illustrates three stages or steps of SA: (i) perception, (ii) comprehension, and (iii) projection. The first level of SA, involves the processes of perception, cue detection, and simple recognition, which lead to an awareness of multiple situational elements (objects, events, people, systems, environmental factors) and their current states (locations, conditions, modes, actions). At the second level of SA people combine, interpret, store and retain the collected information. The third and the highest level of SA (called projection) involves the ability to project the future actions of the elements in the environment. These characteristics make it a suitable model for studying the formal stages involved in unsafe or undesirable situations. We also borrowed from Michon [15] the distinction he makes in the driving task between the strategic, tactical and operational level. On the strategic level, driver makes decisions related to planning and executing a trip from origin to destination. The task on the tactical level requires taking decisions about driving speed and how to handle specific traffic situations such as crossing a crossroad. In this situational context he plans maneuvers that suit the navigational objectives. Finally, at the operational level, the driver takes decisions that relate to vehicle control [16].

It's obvious that other aspects of driver behaviour, such as experience, intentions, attitudes, emotions and spatial properties including location, size, separation, connection, shape, landmarks, and movement also play an important role in modeling driver behaviour. Consequently, it is vital to be aware of how spatial knowledge and beliefs are acquired and developed over time; and how aspects of spatial knowledge and reasoning are similar or different among individuals or groups. This approach gained insight from the work of Kevin Lynch (1960), a planner who argued that 'images' of cities guide people's behaviour and experiences of those cities [17], [18], [19]. In fact, there is a growing need to include spatial cognition explicitly in models [20].

With this in mind, the articulation of models presented before seemed to us particularly interesting to fully understand human behaviour in typical driving situations. We also combine notions of cognitive mapping to our own analysis to suggest how cognitive mapping might be employed to help us better understand and predict driver behaviour. We therefore set out



to develop a driver behaviour framework to generate and test hypotheses about the specific causes of (un)safe driving behaviour in crossing crossroads that pass through a tramway line. Figure 1 below, shows the diagram for assessment of the tram – car driver interaction; it indicates variables moderating the hypothesized relationship to be tested in our field study.

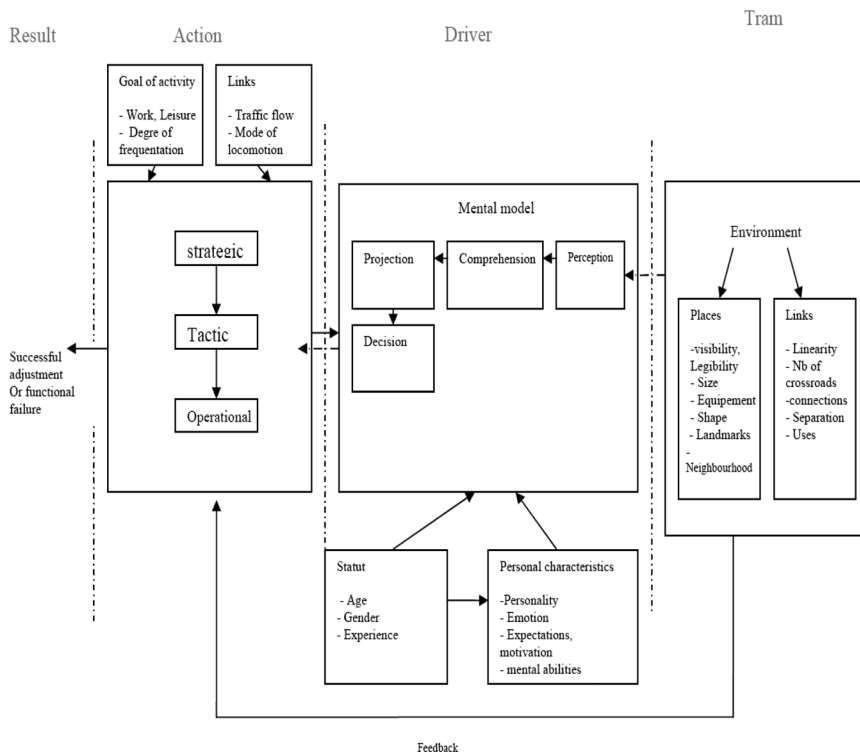


Figure 1 Diagram for the tram-car driver interaction assessment

## 4 Hypothesis and research method

### 4.1 Research hypothesis

Several research works [21], [22], [23] have helped to affirm that road design elements play a role in the difficulties that drivers encounter in traffic. These different studies 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. Briefly speaking, our analysis aims to answer three questions: (i) how (how often) do people behave at specific crossroads crossed by a tramway line? (ii) why do they behave that way? (iii) what are the results of such different behaviours?

## 4.2 Research methodology

To meet our research hypotheses, our methodological proposal is largely based on the functional and dysfunctional approaches which are consistent with our goals. Among them are such techniques as Hazard and Operability Study (HAZOP). In our study, failure constitutes the limits of cognitive functions engaged by the driver in a context of driving activity at crossroad. For each failure that refers to a function of the driver's mental model in degraded mode, a quantitative and qualitative assessment will be conducted to identify potential accidents that can result from the deviations, to determine the cause of the deviation and to find the safeguard which helps to reduce frequency of problems encountered by drivers in crossing tram crossroad.

HAZOP is a classic tool of the industrial world, our work was to adapt it to the context of the study by simplifying it to facilitate its ownership by stakeholders. At this level, our work joins several HAZOP studies in the road sector including one conducted by a research program initiated by 'Rail safety standards and Board' and whose results were published in the report 'Understanding Human Factors and Developing risk reduction solutions for pedestrian crossing at railway stations' [24].

To validate our hypotheses and our methodological proposal, a particular attention is paid to data collection. Observational surveys will be used to record user behaviour and a questionnaire to determine the opinions, concerns and knowledge of users. The observation is based on an analysis grid to carry out the assessment, and to examine whether it would be possible to identify characteristics of crossroads 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 [21], taking care to adapt the reading points to our own field of study and to our specific questions. To complement those observations, a face to face interview using the existing situational questions, will be conducted to encourage drivers to express their opinion and share their potential accident experience information which will contribute significantly to gathering information for hazard identification and prevention of traffic accidents and congestion.

## 5 Conclusion

There is very little literature concerning the interaction between the tram environment and the drivers' behaviour. To address this issue we are therefore oriented towards the methods used in urban development, and human cognition.

While moving, the driver evolves – particularly in crossroads – in a complex and extremely dynamic environment, hence the need to set up developments which allow the driver to discern, to identify and to choose easily in this environment, the indices for the effective regulation of its activity.

The methodology we have presented here represent an analytical approach. The interest of this approach is that it attempts to obtain an overview of drivers' behaviours in specific driving situation (e.g. crossroad crossed by tramway line) and the variables likely to explain them using complementary indicators: site visits to record user behaviour and questionnaires to make drivers precisely explain their perceptions of the facts, their decisions, actions and the difficulties they encountered. The findings from this study will provide suggestions for minimising potential conflict between cars and trams and for enhancing error tolerance at crossroads that pass through tramway lines and within the Moroccan road transport system in general.

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