THE "COGNITIVE CAR"
A ROADMAP FOR RESEARCH ISSUES IN THE AUTOMOTIVE SECTOR

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Abstract: The numbers of cars on roads are increasing continuously. Consequently, streets and motorways are becoming more and more crowded and the risk of accidents is rising. In spite of the fact that in recent years cars have been made more efficient and capable, the driver behind the wheel is often overburdened with traffic situations. Therefore, scientists and engineers are challenged to develop a car which is safer and less stress-burdened than today. This paper outlines some future developments of such a more autonomous car within the next 15 years. The approach describes the roadmap for this "Cognitive Car" suggested by RWTH Aachen University.

Keywords: Automobiles, control application, design, safety, traffic

1 INTRODUCTION: CHALLENGES IN AUTOMOTIVE RESEARCH

The numbers of automobiles on the roads are increasing continuously. Consequently, the risk of accidents rises. At the same time, the EU-Commission demands that the number of victims of traffic accidents should be reduced by 50 % during the period from 2003 to 2010.

There are several possibilities to reach this goal, e.g. stricter legislation and control, better training of drivers, limiting engine power and safer road design. These possibilities are quite restrictive and the success is uncertain. A better way to safer traffic is improving the vehicles themselves – giving the car the ability to assist the driver in difficult or dangerous situations or even act partly *autonomously* and in cooperation with other road users.

Therefore, the challenge for scientists and engineers in the automotive sector is to develop a car which is safer and less stress-burdened than the cars of today. It would deploy advanced and highly developed technology taking into account information processes (neuro-science) and cognitive abilities (psychology) of the driver. To reach this goal, multidisciplinary teams are at present working on solutions, utilising recent findings of engineering sciences, mechatronics and cognition science.

To integrate a more human centered point of view it is important to consider cognitive driving assistance systems and their acceptance within society in general. At present, social sciences are beginning to

tackle the subject of individual mobility (e.g. Petry 2006). The effective realisation of the expected benefits, however, depends on conditions of system implementation. In particular, the system has to respond to the driver's needs, it has to be compatible with the driver's functional capacities and has to satisfy the criteria of relevance, usability and acceptability. The level of workload and distraction of the driver has to be minimised. These are the main reasons for a more active participation of the social and human sciences in the various stages of system development and for a concept of technological development clearly centred on humans. They are also the starting point of the European Network of Excellence "Humanist" (Human Centred Design for Information Society Technologies, see Risser, Turetschek 2005).

Demographic changes are also influencing demands on future technology and therefore, on research interests. As the number of older people in society grows, seniors constitute the fastest growing segment of car drivers. Researchers are investigating cognitive factors related to driving problems in particular in elderly adults (De Raedt, Ponjaert-Kristoffersen 2006; MacLeod et al. 2004).

Besides issues of safety, reliability, stress reduction and sociological challenges, economic questions also play a role in future automobile design. The latter are also reflected in the dissemination of new technologies which is often slow compared to the time needed to achieve technological development. Legal implications of technological developments are similarly difficult to investigate especially if *autonomous driving* is concerned. These issues are followed further in several European projects briefly described as follows.

The project "Traffic Impact, Legal Issues, and Acceptance", works in close cooperation with INVENT (Intelligent traffic and user-oriented technology). It will develop methods for the evaluation of driver assistance systems, also taking into account legal implications. It comprises research in the areas: traffic impacts; innovation, acceptance, and the consumer; legal aspects and economic assessment (Benz et al. 2003).

The time needed for dissemination of new technologies is difficult to estimate due to the described economic and sociological factors. In this paper, a particular roadmap will be presented for research issues in the automotive sector. It will concentrate on *technological* progress. Technological progress is always the product of two promoting powers: the impact of market demands or political demands on the one hand, and technological innovation on the other hand. Therefore, in the case of the "cognitive car", the demands of the EU-Commission on decreasing the numbers of traffic victims can be understood as *political pull*. The development of technologies necessary to evolve this cognitive driving assistance system is to be considered as *technological push* (Alkassar et al. 2003).

2 "THE COGNITIVE CAR" – A CONCEPT FOR THE FUTURE

This paper outlines some future developments in automobile engineering within the next 15 years. The approach described is based on the work of a group of researchers from RWTH Aachen University who have drawn up the roadmap for development of the "cognitive car" (RWTH Aachen 2004). In this research cluster, scientists of the following fields of research are involved: automotive engineering, control engineering, psychology, embedded computer systems, wireless networks, traffic research, mobility and information management. They are working together to shape future developments. This work is aimed at developing safer and easier vehicle guidance, and to increase traffic efficiency considerably.

"Cognitive car" in this context means the vehicle as a technological system which can perceive itself and its environment, as well as collect and structure information in an autonomous way. This definition is derived from the definition of "cognitive technological systems" by the German Research Society (DFG 2004)

To meet the demands of future mobility and traffic, the technological system "car" has to be augmented with cognitive abilities: According to the definition it must be able to *process information.* If autonomous driving is considered a goal for future developments, the automobile has to be able to *act autonomously* which includes the ability to reason and to learn.

The underlying concept of these considerations is the general approach to transfer cognitive processes and abilities to *technological application systems* such as vehicles (or similarly, production systems), using new methodologies and computational systems. According to this approach, the research aims at technological systems to perform cognitive processes, hence creating a cognitive interaction between human actions and technological systems.

This approach evokes research questions concerning the car as a cognitive technological system, taking into account the demands and skills of future drivers. Some questions are:

In what way can actions of the human driver and the traffic be classified and forecasted according to the analysis of the competencies of the driver and the