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Designing Human-Machine Interface for Autonomous Vehicles

S. Debernard*, C. Chauvin,**
R.Pokam*, S. Langlois******

** LAMIH UMR CNRS 8201, Université de Valenciennes et du Hainaut Cambrésis, Campus du Mont Houy, F59313 Valenciennes, France, (e-mail: Serge.Debernard@univ-valenciennes.fr)*
*** Lab-STICC, IHSEV team, UMR CNRS 6285, Université Bretagne Sud, F56100 Lorient, France (e-mail: christine.chauvin@univ-ubs.fr)*
**** LAMIH UMR CNRS 8201, Renault, France (e-mail : raissa.pokam@ renault.com)*
*****Research Dept, Renault, 1 avenue du golf, F78084 Guyancourt, France (e-mail:sabine.langlois@renault.com)*

Abstract: This paper deals with Human-Machine Interface (HMI) design for autonomous vehicles. This automation level involves automated driving phases as well as transition phases where the driver has to reengage in the driving task. Each phase requires an appropriate interface to allow the driver to establish accurate situation awareness. The paper presents a methodology aiming to answer the following questions: what should be displayed, how and when? This methodology relies on the Cognitive Work Analysis framework as well as on the notions of Human-Machine Cooperation and Transparency. Taking the example of the "lane change" function, it leads to identify and to categorize the information to be displayed in order to make "transparent" the autonomous system.

Keywords: driverless vehicles, Human-Machine Interface, Cognitive Work Analysis, Human Machine Cooperation, Transparency

1. INTRODUCTION

Over the years, many automobile functions have become automated. Recent advances have led to automation of the main driving task. The vehicles of the future will allow the drivers to delegate control to an automated system (technical agent) when they wish to and when it is technically possible. Different taxonomies define different levels of autonomy: the National Highway Traffic and Safety Administration (NHTSA) taxonomy, the Society of Automotive Engineers (SAE) taxonomy, and more academic taxonomies such as those of Sheridan and Verplank (1978), or Endsley and Kaber (1999). At the highest level of automation, the technical agent will be responsible for the entire driving task; we then talk about self-driving, fully autonomous, or driverless vehicles.

This paper deals with Human-Machine Interface (HMI) design in autonomous mode. The issue of HMI design in autonomous mode is to provide the drivers with the right amount of information about vehicle operations, so that they can keep control. In this particular case, the notion of "control" does not mean that human beings drive the vehicle, but that they are aware of what is going on.

In the first part, we present the research context and the methodology used. In the second part, we use Cognitive Work Analysis (CWA) to determine which information is used during a specific phase of driving, namely lane change. Then, we present two approaches used in order to determine which information must be displayed to the human driver in autonomous mode.

2. CONTEXT AND METHODOLOGY

In the perspective of autonomous vehicles, many projects have been conducted. The present work is part of the LRA project (French acronym for Localization and Augmented Reality), a French collaborative project that aims to design an Augmented Reality Interface for autonomous driving at the Level 3 of automation in the NHTSA taxonomy. The NHTSA specifies that *vehicles at this level of automation enable the driver to cede full control of all safety-critical functions under certain traffic or environmental conditions and in those conditions to rely heavily on the vehicle to monitor for changes in those conditions requiring transition back to driver control* (Marinik, Bishop, Fitchett, Morgan, Trimble, & Blanco, 2014). This automation level involves two particular phases:

- The automated driving phase where the technical agent controls the vehicle. Consequently, the driver can carry out some secondary activities. It is said that the driver is out-of-the-loop.
- The transition from automated to manual driving where the human agent should reengage cognitively and physically in the driving task. This phase, if not completed properly, can lead to accidents.

These particular phases constitute the main focus of our work regarding the HMI design issue. Each phase requires an appropriate interface to allow the driver to be aware of what is going on outside the car, i.e. to establish accurate *situation awareness* (Endsley, 1995). The driver must also be aware of what is going on inside the car in order to understand what the technical agent can do, what it will do, and what it has done. To this end, it is necessary to determine and display the right information, in a suitable form, and at the right time.

Three fundamental research questions were identified to orientate the interface design:

1. In autonomous mode and in handover processing, which sufficient representation should the driver maintain or

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establish? According to the Situation Awareness model defined by Endsley, this question may be subdivided into three sub-questions: (i) What should the driver perceive? (ii) What should he/she understand? (iii) Which projection of the external environment and the system should he/she perform?

2. How should we design the displays? (i) What should be displayed? (ii) How should that information be displayed? (iii) When should it be displayed? With which prioritization?
3. What is the added-value of Augmented Reality in the displays? In others words, can driver maneuvers be impacted by Augmented Reality?

The different steps of our methodology are shown in Figure 1:

- The first step involved the extraction of information required by drivers. For this purpose, we applied the CWA methodology.
- In the second step, the information requirements were determined, based on human-machine cooperation and the principles of transparency defined by Lyons (2013). This led to the definition of an algorithm. In this step, we also defined the format and the display modality of the information by taking into account Driver-Vehicle-Environment (DVE) conditions.
- Next, there was the step of interface specification where interaction between the technical agent and the human agent was designed according to the relevant use cases chosen.
- The last step consisted in setting up users' tests to assess the interface and improve it. In a simulated environment, some tests will be conducted in order to refine our previous rules.

In this paper, we focus on the first two steps.

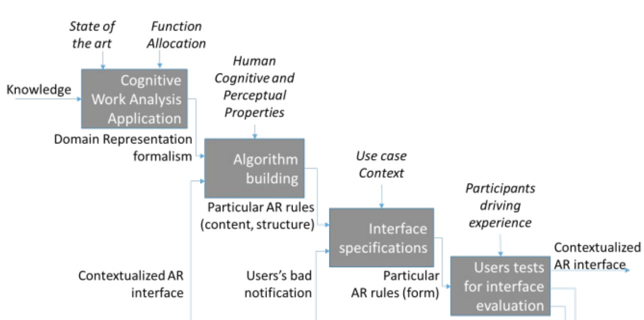

Fig. 1. Design Methodology

3. A COGNITIVE WORK ANALYSIS

The CWA methodology was proposed by Rasmussen (1986), Rasmussen et al. (1994), and further developed and codified by Vicente (1999). This framework is used to produce "ecological interfaces" designed to help knowledge workers adapt to change and novelty (Vicente, 2002). It has already been used in a large number of systems (cf. Naikar, 2013), including the driving domain (Stoner, Wiese, & Lee, 2003; Jenkins, Stanton, Walker, & Young, 2007; Birrell, Young, Jenkins, & Stanton, 2012). It is a formative constraint-based approach, consisting of five successive stages: Work Domain Analysis, Control Task Analysis, Strategies Analysis, Social Organization and Cooperation Analysis, and Worker Competencies Analysis. Two of these stages are presented and used in this paper: Work Domain Analysis (WDA) and Control Task Analysis (ConTA).

3.1 Work Domain Analysis

The WDA is the most important stage of the CWA methodology. WDA deals with the constraints that are placed on actors by the functional structure of the field or the environment in which the work occurs. This phase is associated with a modelling tool, the Abstraction Hierarchy, which can be used to break down any work domain in terms of:

- ends (purposes, goals) and means (to reach the goals) according to an implementation hierarchy;
- whole and parts according to a decomposition hierarchy.

The implementation hierarchy enables the description of a work domain in terms of five levels of abstraction: functional purpose (the purpose of the work domain, its "raison d'être"), priority measures/abstract functions, general functions, physical processes and activities, and physical resources and their configurations. Each level is connected by a structural means-end framework to the next upper or lower level.

The decomposition hierarchy is destined to break a domain down into sub-systems, then each sub-system into functional units, each unit into sub-sets, and finally each sub-set into components. A Level 3 autonomous vehicle may be seen as a "joint driver-car" system (Hollnagel, 2006), where the driver and the vehicle "per se" constitute two sub-systems in interaction. The vehicle itself may be decomposed into several functional units.

Functional purposes:
The main purposes of a Level 3 autonomous vehicle are to ensure safe and efficient road transport.

Values and priority measures:
This level of abstraction represents the criteria that must be respected for a system to meet its functional purposes. In the case of an autonomous vehicle, these criteria are the following ones (Anderson & Kaira, 2014): a reduction of crashes, injuries, and fatalities as well as a reduction of the "cost of time" in a car, since the driver will be able to engage in other activities.

Purpose-related functions:
This level represents the functions that a system must be capable of supporting, so that it can fulfil its functional purposes. A Level 3 autonomous vehicle has to perform the same functions as those that are described at three different levels in Michon's model (Michon, 1985): define the goals of the trip, select the route, assess the associated costs and risks (at the strategic level), avoid obstacles, carry out overtaking, carry out lane changing (at the tactical level), ensure the lateral and longitudinal control of the vehicle (at the operational level). Some of these functions may be realized either by the driver or by the technical agent, depending upon the traffic and environmental conditions; they are "lane changing", "overtaking", and "ensuring the lateral and longitudinal control of the vehicle". An additional function consists in managing the transition from manual to automated driving (and vice versa).

Object-related processes:
This level represents the functional processes or the functional capabilities or limitations of the physical objects in a system. In the case of an automated vehicle, this level reveals the capacity and the limitations of the sensors ensuring information acquisition, information analysis, decision making and action implementation (Parasuraman, Sheridan & Wickens, 2000).

Physical objects:
This level may represent physical or artificial objects (such as artefacts and infrastructure). In the case of the "lane changing" function, the physical objects are all the sensors used by this purpose-related function, namely cameras, RADAR, and LIDAR. They are also the road traffic signs and signals (such as speed limitation traffic signs, direction traffic signs, traffic markings, and stationary cameras/police cars). The Abstraction Hierarchy provides an informational basis, since the model may be converted into a list of variables. One of the main challenges of interface design is to make the constraints at all levels of the abstraction hierarchy visible.

3.2. Control Task Analysis

The ConTA is related to the activity required for meeting the purpose of a system. Naikar et al. (2006) proposed to characterize this activity as a set of recurring work situations, work functions, or control tasks. Work functions are related to functions to be performed in a work system. They are defined at the purpose-related function level or at the object-related process level in the abstraction hierarchy (Jenkins et al., 2008). They may be performed in different work situations.
The decision ladder is used to decompose activity into a set of control tasks for each work situation and/or work functions. It uses the formalism of the decision ladder defined by Rasmussen to model a diagnosis and decision task (Rasmussen, 1986). In this formalism, rectangular boxes represent information-processing activities, and circles represent states of knowledge resulting from these activities. In the LRA project, the “lane change” function was selected for analysis because it can cause misunderstandings between the driver and the autonomous vehicle. Figure 1 shows the different stages of the "lane change" performed by the technical agent and identifies the products of each of them in terms of information requirement.

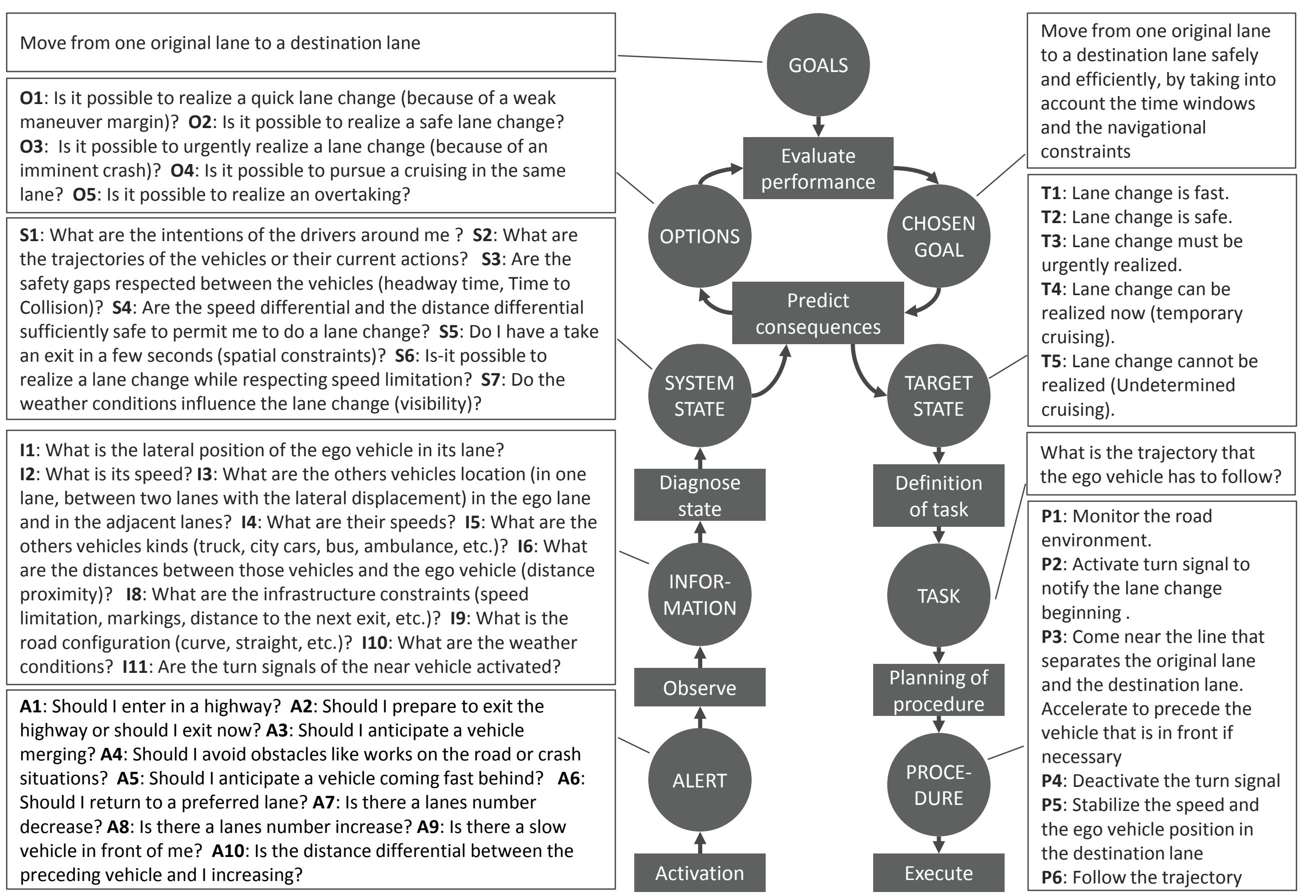

Fig. 2. Lane change Decision Ladder (Pokam, Chauvin, Debernard, & Langlois, 2015)

Table 1 shows that information is generated by the four processes that have been identified previously. Information analysis consists either in the comprehension of their meaning (e.g., trajectories of the other vehicles) or in the projection of their status in the near future (e.g., intentions of the other drivers). Bennett and Flach (2011) summarized the goal of an ecological interface when viewed through the lens of WDA on the one hand and of the decision ladder on the other. At the WDA level, it is to make the constraints at all levels of the abstraction hierarchy visible; ideally, "the operator should be able to see the state of the work domain in relation to the goals, the costs, and the fields of possibilities associated with physical and regulatory laws and organizational layout" (Bennett & Flach, 2011, p.103). When considering the decision ladder, they recommended that the representation provide signals and signs that map directly onto states/ constraints of the work processes to support productive thinking (e.g., chunking, automatic processing, and recognition-primed decisions).

Table 1: Classification of information according to the processes involved in its production

Information acquisition	Information analysis	Decision making	Implementation
I1-I11	S1-S7	O1-O5	P1-P6/ T1-T5

These recommendations concern a system piloted by a human agent. In the CWA, nothing is said about the design of interfaces showing a human agent what is done or foreseen by a technical agent piloting the system.

Two additional frameworks are relevant to consider this point of view. First, the Human-Machine Cooperation framework proposes the design of a Common Work Space (CWS). Second, the concept of transparency and, more precisely, Lyons' model for human-robot interaction (Lyons, 2013), allow designers to choose the information that must be displayed in the CWS.

4. HUMAN MACHINE COOPERATION

Human Machine Cooperation (HMC) is a research domain in which several disciplines are involved; some are involved in describing and understanding the psychological mechanisms underlying cooperative activities; others are involved in determining the tools and human-computer interfaces necessary for supporting these cooperative activities. Cooperation refers to a situation where human operators and machines work on the same overall task and perform operations (action) together (cooperation), which requires some information exchange between the individual activities.

In the LRA project, the technical agent ensures the autonomous control of the vehicle. In this phase, the human driver may perform other activities and can be out-of-the-loop progressively. However, he/she must be able to trust the technical agent. Hence, it is necessary that he/she could build a model of the system's behavior. Moreover, when the system asks the driver to do so, he/she must be able to resume driving in manual mode; to this end, the driver must be able to return in the loop of control, hence quickly understanding the context of the driving situation. It is therefore necessary to provide the human driver with all the information related to both the situation and the behavior of the technical agent to enable him/her to perform this particular task.

Various human-machine cooperation studies have shown how information can be shared so that each agent understands what the other is doing. Royer (1994) argued that a system is more cooperative when cooperation integrates several levels, namely perception, analysis, decision, and action. Hence, cooperation does not involve solely the coordination of actions between several agents; it also depends upon the merging of perceptions, the confrontation of situation analyses, and the convergence of decisions. That is why we used the concepts of HMC in order to determine the information to display to the driver. Decortis and Pavard (1994) have defined the shared cognitive environment as a set of facts and hypotheses that are a subset of each agent's cognitive universe. In order to manage situations, human agents build a frame of reference which contains different attributes (Pacaux, Debernard, 2001). To cooperate, human agents pass on information, problems, strategies, solutions and commands to share their own frame of reference. Thus, they build a virtual common frame of reference (Hoc, 2001). In a project called AMANDA, the principle of task delegation between air traffic controllers and a technical agent was evaluated (Debernard & al., 2002). To allow agents to cooperate, a CWS was implemented in order to support cooperative activities (Figure 3). A first experiment resulted in determining the effective contents of the CWS in the case of air traffic control. A second one showed that this CWS could support and improve cooperative activities (Debernard et al., 2009) because the space problem is better defined, there is less conflict between the agents because they understand the others' decisions better, and interactions thrive on problem solving strategies.

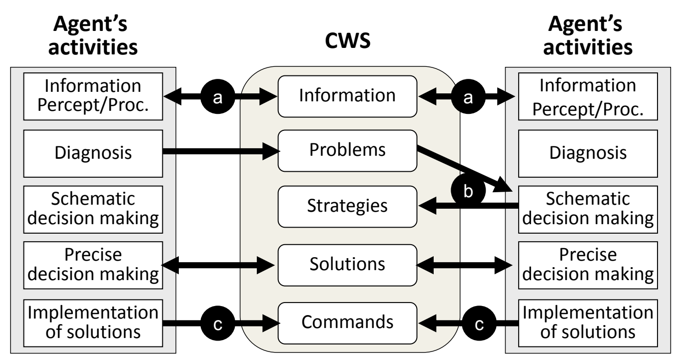

Fig. 3. Cooperative interaction between agents through the CWS (a- debative form; b- integrative form; c- augmentative form), (Debernard et al., 2002)

We believe that in the LRA project, if there is no cooperation, the sole observation by the driver of the technical agent's behaviors is not sufficient to lead to proper understanding of what the vehicle is actually doing. Hence, the HMI must also provide a transparent representation of the different stages of the decision-making process of the machine. This must be done in accordance with the information commonly used by drivers, information which has been identified during the Control Task Analysis. In order to complete the principles of CWS, the Lyons' model was investigated.

5. TRANSPARENCY

Lyons (2013) explained that transparency between an autonomous system and a human being is one mechanism to facilitate effective interactions between humans and their robotic teammates in a dynamic environment under some conditions of uncertainty. According to this author, transparency factors involve several different models. From each model, several principles were extracted that seem to be relevant to autonomous driving. In the <u>intentional model</u>, Lyons argued that it is important for the user to identify the major functionalities of an autonomous system in order to fully understand its purpose. Two principles were extracted:

Principle 1: *The driver should know the maximum autonomy level of the vehicle as well as the external and internal conditions that allow it to enter the autonomous mode*.

Principle 2: *The driver must know which tasks the autonomous system is capable of performing, under which conditions it can perform them, and how it will perform them. The driver should know what general functions are allocated to the autonomous system.*

Principle 3: *The driver must know how the system prioritizes its behavior when multiple options are possible.*

The task model includes an understanding of a particular task, information relating to the system's goals at a given time, information relating to the system's progress in relation to those goals, information signifying an awareness of the system's capabilities, and awareness of errors.

Principle 4: *In the autonomous mode, the driver must be informed that the system will control the vehicle by following accepted driving practices and traffic laws (predictability of the behavior of the vehicle). Furthermore, the driver must be able to detect the actions (e.g., lane change) being performed by the vehicle and understand them*.

Principle 5: *In the autonomous mode, the driver must be able to perceive the intention of the system (the maneuver it intends carrying out), why, how, and when this maneuver will be carried out.*

In the case of a lane change, the decision should be displayed, as well as its cause (in pointing out for example a slow vehicle in front of the ego vehicle).

Principle 6: *In the autonomous mode, the driver should know each maneuver that could possibly interrupt the current one. This information will help him/her avoid being surprised or frightened by what is happening.*

The analytical model communicates the underlying analytical principles used by the system to make decisions.

Principle 7: *In the autonomous mode, the driver should know how a given maneuver is being carried out or why a particular behavior of the vehicle is observed*.

In the environment model, the autonomous system should be capable of communicating to humans an understanding of its environment and of the temporal constraints.

Principle 8: *In the autonomous mode, the driver should have a sufficient understanding of what the autonomous vehicle perceives to realize its analyses and to make its decisions. The driver must be confident that the autonomous vehicle has the right information to make the right decisions and if not, he/she must be able to take control.*

To understand a lane change, the driver has to know that the system perceives other vehicles back and in front of his/her vehicle.

Principle 9: *It is important that the driver knows the boundaries of vehicle sensors, given that he/she can see information that the sensors may not receive.*

A teamwork model is essential to understand the division of labor for a given task or set of tasks.

Principle 10: *The driver should know what the current mode is, in order to avoid any mode confusion.*

Principle 11: *The driver should clearly know how to migrate from one mode to another.*

Principle 12: *The driver should know when and where the autonomous mode will be available to drive the vehicle.*

These 12 principles enabled us first to select the information that had been determined during the CWA, and second to add information in order to make the system transparent. For example, the maneuvering intentions identified in the CTA (chosen goal) are related to the task model of Lyon and then to principles 5 and 6. The display of information considered and identified in the CTA (information) will address the principle 8 (environment model). The boundaries of vehicle sensors that have been identified in the WDA (object-related processes) are linked to the principle 9.

In augmented reality, there can be a rather large amount of information to be displayed, which will not necessarily be easily perceived by the driver. Two approaches are used to solve this problem. First, as for the CWS presented in Section 3, the information to be displayed is classified according to the type of activities, but also by level of activity specific to the driving task (Michon, 1985). An example is given in Table 2 related to information concerned by principle 5.

Table 2. Classification of information according to type of activities, and to level of activities.

	Information acquisition	Information analysis	Decision making	Implemen-tation
Strategic				
Tactical				
Operational				

Then, this classification is used to structure the information display in several areas according to the level of activities and to define the format and the modality of this information. Second, filtering the information is carried out in order to minimize the number of displayed symbols. The filter depends on the traffic environment, and some operational level information can disappear in favor of more important information.

6. CONCLUSION

This paper presented the first two phases of a project called LRA. It deals with Human-Machine Interface (HMI) design for autonomous vehicles. The paper presented a methodology aiming to identify and to categorize the information used by the driver in order to make "transparent" a Level 3 autonomous system. Nevertheless, the questions concern also other levels of automation and particularly level 2 where the human driver has to monitor the automation performance. We used the first two stages of Cognitive Work Analysis (CWA) in order to determine which information is used during a specific phase of driving, namely lane change. Previous work in human-machine cooperation was then applied in order to classify information according to the type of activities, but also by level of activity specific to the driving task. Finally some principles of transparency are defined from the Lyons' model and will allow to define the information display.

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REFERENCES

Anderson, J.M., and Kaira, N. (2014). Autonomous Vehicle Technology: A guide for Policymakers. Rand Offices, Santa Monica.

Bennett, K.B., & Flach, J.M. (2011). Display and interface design: Subtle science, exact art. Boca Raton: CRC Press.

Birrell, S.A., Young, M.S., Jenkins, D.P. and Stanton, N.A. (2012) Cognitive work analysis for safe and efficient driving. *Theoretical Issues in Ergonomics Science*, Vol.13 (No.4). pp. 430-449.

Debernard S., Cathelain S., Crévits I., Poulain T. (2002). AMANDA Project: Delegation of tasks in the air-traffic control domain. M. Blay-fornarino, A-m. Pinna-dery, K. Schmidt, P. Zaraté (Ed.), *Cooperative Systems design*, IOS PRES, pp. 173-190, janvier.

Debernard S., Guiost B., Poulain T., Crévits I., Annebicque D., Millot P. (2009). Integrating Human Factors in the Design of Intelligent Systems: an example in Air Traffic Control. *International Journal of Intelligent Systems Technologies and Applications*, 7, 2, pp. 205-226.

Decortis, F., Pavard, B. (1994) Communication et coopération : de la théorie des actes de langage à l'approche ethnométhodologique. In Pavard B. (Ed.), *Systèmes Coopératifs de la modélisation à la conception. Toulouse*, France, Octarès

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 37(1), 32-64

Endsley, M., R. & Kaber, D.B. (1999). Level of automation effects on performance, situation awareness and workload in a dynamic control task. Ergonomics, 1999, vol. 42, n°3, pp. 462-492.

Hoc J-M. (2001). "Towards a cognitive approach to human-machine cooperation in dynamic situations". *Int. J. Human-Computer Studies* 54.

Hollnagel, E. (2006). A function-centred approach to joint driver-vehicle system design. *Cognition, Technology & Work*, *8*(3), 169-173.

Jenkins, D. P., Stanton, N. A., Walker, G. H., & Young, M. S. (2007). A new approach to designing lateral collision warning systems. *International Journal of Vehicle Design*, *45*(3), 379-396.

Jenkins, D.P., Stanton, N.A., Salmon, P.M., Walker, G.H., & Young, M.S. (2008). Using cognitive work analysis to explore activity allocation within military domains. *Ergonomics*, 51, 798-815.

Lyons, J. B. (2013). Being transparent about transparency: A model for human-robot interaction. AAAI Spring Symposium Series: Trust and Autonomous Systems.

Marinik, A., Bishop, R., Fitchett, V., Morgan, J. F., Trimble, T. E., & Blanco, M. (2014, July). *Human factors evaluation of level 2 and level 3 automated driving concepts: Concepts of operation*. (Report No. DOT HS 812 044). Washington, DC: National Highway Traffic Safety Administration.

Michon, J. A. (1985). A critical view of driver behavior models: what do we know, what should we do?. In *Human behavior and traffic safety* (pp. 485-524). Springer US.

Naikar, N., Moylan, A., & Pearce, B. (2006). Analysing activity in complex systems with cognitive work analysis: concepts, guidelines and case study for control task analysis. *Theoretical Issues in Ergonomics Science*, 7, 371-394.

Naikar, N. (2013). *Work domain analysis: Concepts, guidelines, and cases*. CRC Press.

Pacaux-Lemoine, M.-P., Debernard, S., (2002). "Common work space for human-machine cooperation in air traffic control". *Control Engineering Practice, A Journal of IFAC, 10 (5),* pp. 571-576.

Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model of types and levels of human interaction with automation, *IEEE Transactions on Systems*, *Man and Cybernetics, 30*, 286–297.

Pokam Meguia R., Chauvin C., Debernard S., Langlois S. (2015). Towards autonomous driving: an Augmented Reality Interface for lane change. 3rd International Symposium on Future Active Safety Technology Toward zero traffic accidents - FAST-zero'2015, Gothenburg, Sweden.

Rasmussen, J. (1983). Skill, rules, and knowledge; signals, signs and symbols, and other distinctions in human performance models. *IEEE Transaction on Systems, Man, and Cybernetics* (pp.257-266), SMC-15, N°3.

Rasmussen, J. (1986). *Information processing and human–machine interaction*. Amsterdam: North Holland.

Rasmussen, J., Pejtersen, A.M., & Goodstein, L.P. (1994). *Cognitive systems engineering*. New York: Wiley.

Royer, V. (1994). « Partage de croyances : condition nécessaire pour un système coopératif ? ». In Pavard B. (Ed.), *Systèmes Coopératifs de la modélisation à la conception*. Toulouse, France, Octarès. pp. 253-270

Sheridan, T. B., & Verplank, W. L. (1978). *Human and computer control of undersea teleoperators*. Massachusetts Institute of Technology Cambridge Man-Machine Systems Lab.

Stoner, H. A., Wiese, E. E., and Lee, J. D. (2003, October). Applying ecological interface design to the driving domain: the results of an abstraction hierarchy analysis. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 47, No. 3, pp. 444-448). SAGE Publications.

Vicente, K.J. (1999). *Cognitive work analysis: toward safe, productive, and healthy computer-based work*. Mahwah, NJ: Erlbaum.

Vicente, K.J. (2002). Ecological interface design: progress and challenges. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *44*, 62-78.