Abstract

Development of advanced driver security and assistance systems requires careful and thorough evaluation of not only in getting the technology to work, but also user acceptance and adaptation. This work focuses on the usability and security of security and driver assistance system interfaces and, the study of their influence in driving behaviour and performance in interacting with the system’s interfaces while driving. For this purpose, security and assistance systems where developed and integrated in the driving simulator [Por06], that simulates the technology provided by actual available systems in the automobile market by BMW, Volkswagen and Mercedes. The simulated systems are Night Vision, Head-Up Display, Park Assist, Park Assistance and Approximation Detection. The study performed was based on the conduction of usability tests for the integrated systems in the driving simulator, where the driving behaviour and performance of the driver were analyzed given certain tasks for interaction with the system’s interface while driving. The study also analyzed the effectiveness of the system’s assistance functionalities and the benefit of their use for the driver.

Keywords: security and driver assistance systems, driving simulator, road safety, human-centered interfaces.

1. INTRODUCTION

Road safety is a major issue these days, as more and more vehicles enter the streets worldwide increasing the need of safe interaction of these with the global road environment.

Human errors contribute significantly to most transportation crashes across all modes of transportation. Reducing these errors by increasing attention to human performance and behavior issues will reduce crashes, loss of life, injuries, property damage and resultant personal and financial costs.

Nowadays, achieving improvements in road safety is the major priority in the automobile industry. Advancements of vehicle electronic technology have led to development of various systems for assisting drivers and managing driving to improve vehicle safety and driver comfort. Driver assistance systems in general monitor driving situations continuously and take necessary actions to avoid possible accidents even without drivers’ intervention. Development of those driver security and assistance systems requires careful and thorough evaluation of not only the technology, but also user acceptance and adaption [LSLKC].

Awareness of the role of human performance and behavior issues in transportation is increasing at a time when new technologies are being introduced to improve transportation system safety, reliability and productivity. However, the capabilities of these technologies are often compromised because the full range of human performance and behavior issues associated with transportation system design, use, operation, and maintenance were not considered. The use of a “human-centered systems” approach to the design, development, and implementation of technologies is necessary to ensure that the full potential of these technologies can be realized. This potential includes achieving the desired gains in safety, reliability, and productivity, as well as a high degree of public support for, and acceptance of, these technologies [USTRans].

The automobile market offers nowadays a large range of advanced systems, whether referring comfort systems, for the drivers’ entertainment, whether referring security and assistance systems, to avoid dangerous driving situations or to facilitate the driving task. However, these devices have the potential to contribute for the driver distraction, as they require a certain level of the drivers’ attention for him to benefit of the systems functionalities, requiring cognitive, visual, audible and physic skills from the primary driving task.

Therefore, it is necessary to integrate a great effort in the development process of in-vehicle information and
control systems in focusing beyond the technology the interaction with the systems users and their real needs.

For the driver security and assistance systems to be really effective in their functionalities, they need to present a high level of usability. The Interface design is an emerging key area, having a significant impact in the global usability and security of the systems.

1.1 Goals
This work focuses on the usability and security of security and driver assistance system interfaces and, the study of their influence in driving behavior and performance in interacting with the system’s interfaces while driving and in identifying possible usability problems. For this purpose, security and assistance systems where developed and integrated in the driving simulator [Por06], that simulate the technology provided by actual available systems in the automobile market by BMW, Volkswagen and Mercedes. The study also pretends to analyze the effectiveness of the integrated systems in the driving simulator and the benefits of their use for the driver.

2. SOME SYSTEMS IN AUTOMOBILE PRODUCTION
The actual automobile market offers a large diversity of security and assistance systems in his vehicle equipment. Here are presented some of the researched systems in the market by BMW, Volkswagen, Mercedes and Volvo.

Volvo presents the Blind Spot Information System (BLIS) that detects the presence of other vehicles in the blind spots of the driven car. Other active security system by this automobile manufacturer is the Adaptive Cruise Control (ACC). This system allows the improvement of road security, helping the driver to keep a security distance from the front vehicle by setting automatically a right velocity of the vehicle. Additionally, Volvo adds in his new Volvo XC60 the “City Safety” system. This system aims to end with car crashes at low velocities, witch are frequent in the city environment.

The systems researched for BMW where the Head-Up Display and Night Vision.

The Head-Up Display system projects relevant information, such as direction indications, failure warnings, speed or radio settings directly in the driver’s field of view, in the windscreen, not having the driver to take off his easy of the road. This system aims to evaluate the driving security by reducing the time of distraction needed for the reading of the desired information.

The Night Vision system by BMW is capable of reducing the risk of accidents involving humans and animal on the road at night where the visibility and capacities of the driver for their recognition is largely reduced. This system uses a technology of thermal camera based on FIR that covers an area to 300 meters in front of the vehicle creating a image out of the range of the head lights and displaying it in a monitor over dashboard.

The last systems to present are the Park Assist by Volkswagen and the park assistance system by Mercedes.

The Park Assist is a system for automatic parallel backward parking, while the park assistance system presented by Mercedes is a manual park system, which gives the driver the correct steering instruction for a parallel backward parking.

3. INTERFACE USABILITY
In the design of any system it is necessary to have considerations of certain usability principles.

There has been much investigation related with the usability in interface design so that the interaction of the user with the system has the minor possible effect in the primary task of driving safety. Much of these investigations aim the development and production of new technological systems in the market that are useful, easy to use and moreover effective in their functionalities expectation for the end user.

3.1 Driver distraction
Before referring considerations about security and usability it is necessary information about human factors and usability. For the design of a system based on human capabilities and recourses there is a need of acknowledgment about the cognitive psychology and its implication in driver distraction.

An activity that distracts or competes for the driver’s attention while driving has the potential to degrade the performance of driving and, consequently the road safety. The driving task needs the coordination of cognitive, physical, sensor and psychomotor skills of the driver.

American Automobile Association Foundation for Traffic Safety defines driver distraction as occurring “when a driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object or person within or outside the vehicle compelled or tended to induce the driver’s shifting attention away from the driving task”[YMM03].

Nowadays, there can be found a large number of different in-vehicle information systems (GPS, entertainment systems). The driver by interacting with these systems while driving must give attention to many tasks. However, during this interaction there can be cognitive load, where the attention of the driver flaws from the primary task of driving safety, affecting his perception of the road environment and enlarging his reaction time. [YMM03] [Tre80].

Visual distraction occurs when the driver’s visual field is blocked by objects, such as stickers on the car’s windscreen, that prevent them from detecting or recognizing objects or hazards in the road environment [IUA01] or when the driver neglects to look at the road...
and instead focuses on another visual target, such as an in-car route navigation system, for an extended period of time. [YMM03].

Beyond the visual distraction there are other types of distractions to consider when interacting with system’s interfaces while driving.

There can occur fiscal distraction, when drivers remove one or both hands from the steering wheel to physically manipulate an object or auditory distraction when the driver momentarily or continually focuses his attention on sounds or auditory signals rather than on the road environment. Additional considerations and strategies for reducing driver distraction with the interaction of in-vehicle devices are presented in [Por06][Trans03].

3.2 Intelligent transportation systems and interface usability

The integration of innovative systems based on new technological advances provides vehicles with different types and levels of intelligence to complete the driver. Information systems expand the driver’s knowledge and location. Warning systems, such as collision-avoidance technologies, enhance the driver’s ability to sense and perceive the surrounding environment.

Driver assistance and automation technologies simulate the driver’s sensor motor system to operate a vehicle either temporarily during emergencies or for prolonged periods. Such new information and control technologies that make vehicles smarter are arriving on the market as optional equipment or specialty after-market components. These technologies are being developed and marketed to increase driver safety, performance, and convenience. However, these disparate components require further significant integration efforts to create a coherent intelligent vehicle that complements the human driver, fully considering his or her requirements, capabilities, and limitations. A fully intelligent vehicle must work cooperatively with the driver. New, uncoordinated technologies could deliver excessive, competing, or contradictory messages and demands that might distract, confuse, and overwhelm the driver. This could cause an overload of the driver’s limited cognitive resources, thereby decreasing the driver’s performance and safety. An intelligent system senses its environment and acts to reach its objectives. So, its interaction and communication channels—that is, its interface—greatly influence the type of intelligence it can display.

The integration of individual in-vehicle technologies will be reflected in coordinated and streamlined displays and controls. Over time, the vehicle will become increasingly sophisticated in how it communicates information to and accepts commands from the driver. This increasing complexity has underscored the importance of providing system developers with human factors guidance early during design. Driver-centered design, however, means more than the ergonomics of “knobs and dials.” It also requires that designers adopt what the Japanese call kansei, the infusion of human sensibility.

A key criterion for the development and introduction of an innovative technology is that it provides the intended benefits without unintended adverse consequences. Driving is potentially dangerous. Although in-vehicle technologies can enhance the driver’s capabilities and comfort, the distinctive and complex nature of these systems suggests that they could further strain driver capacities and, if not carefully implemented, actually exacerbates existing traffic problems. The design of the driver–vehicle interface, where the driver interacts physically and cognitively with the vehicle, is therefore critical [Cell01].

The Interface design is an emerging key area, having a significant impact in the global usability and security of the systems [JW05].

4. SIMULATORS FOR USABILITY TESTING

The goal of this work is to study ways to enhance the security and assistance provided in the driving task using human-centered design principles for the interfaces together with the computational sciences for the investigation of systems that enhance the driver safety and performance.

The work analysis influences, positive or negative, in the driver’s interaction with security and assistance systems while driving. It also analysis the level of safety and assistance provided through the systems to the driver.

This subject has been studied largely, and the diversity of emerging electronic devices, such as GPSs and handys, induce the automobile industry to explore new ways of controlling these devices more easily, safety and simple.

In this type of investigation the use of driving simulators as study tool are very common, varying from low-cost simulators that look like computer games, to advanced-high-fidelity driving simulators associated with an height cost and integration effort of a realistic driving environment.

This work is also an investigation based on the use of a driving simulator as tool for the study of the influences and measurements of the distraction effects on the driving while interacting with the system’s interfaces.

4.1 Application of driving simulators for analysis of road safety issues

Research examining driver distraction and performance often make use of driving simulators, as they allow for a number of driving performance measures to be examined in a relatively realistic and safe driving environment. Driving simulators, however, vary substantially in their characteristics and this can affect their realism and the validity of the results obtained. High-fidelity simulators offer a realistic driving environment, complete with
realistic components and layout, a colored, textured, visual scene with roadside objects such as trees and signposts, and often have a motion base. Low fidelity simulators offer less realistic driving environments, usually with only major markings (e.g., road line markings) reproduced in the visual scene and they are often fixed-based. Driving simulators have a number of advantages over on-road and test-track studies. First, simulators provide a safe environment to conduct research that is too dangerous to be conducted on the road. Measuring the distracting effects of certain devices on driving is one example of potentially dangerous research that is often conducted in driving simulators. Although test-tracks may be used to examine the distracting effects of devices on driving using single vehicle scenarios, using multiple vehicle scenarios in such situations can be hazardous. Driving simulators, on the other hand, provide a safe environment for the examination of these issues using multiple vehicle scenarios, where the driver can negotiate or interact with other vehicles or road users while using certain devices.

Second, greater experimental control can also be applied in driving simulators compared to on road studies, as they allow the type and difficulty of driving tasks to be precisely specified and potentially confounding variables such as weather can be eliminated. Third, the cost of modifying the cockpit of a simulator to address different research questions may be significantly less than modifying an actual vehicle and ensuring that the modifications are roadworthy or meet the design rules. Fourth, a large number of driving performance measures can be examined in driving simulators, such as speed control and maintenance and lateral position on the road. Additional measures such as eye-movements and glance behavior can also be collected when using simulation. Finally, a large number of different test conditions (e.g., day and night, different weather conditions or road environments) can also be administered with relative ease, and these conditions can include hazardous or risky driving situations that would be difficult or dangerous to generate under real driving conditions.

The use of driving simulators as research tools does, however, have a number of disadvantages. First, data collected from a driving simulator includes the effects of learning to use the simulator and any in-vehicle devices and may also include the effects of being monitored by the experimenter. Driving simulators, particularly high-fidelity simulators, can also be very expensive to install and operate and are often much more expensive than other equipment used to measure driver distraction.

However, one of the most problematic aspects of driving simulator research that has major implications for driver distraction research is the effect of the simulator on driver’s priorities in relation to the driving task and the concurrent tasks of interacting with in-vehicle devices. Driver’s behavior and the amount of cognitive re-sources they devote to performing concurrent tasks while in the simulator may differ significantly from their behavior in real cars on actual roads because there are no serious consequences that result from driving errors in the simulator.

To improve the validity of the results using a drive simulator there must be two concerns. There must be a correspondence between the simulator’s components, control layout, and its response characteristics, with its real-world counterpart. This has referred to as the simulator’s fidelity. The closer a simulator approximates the real-world driving environment, in terms of the design and layout of its controls, the realism of the visual scene and its physical response characteristics, the greater fidelity it is reported to have. The second aspect of simulator validity is behavioral validity and concerns the correspondence between the way in which the driver or operator behaves in the simulator and in actual vehicles. [YMM03]

4.2 The simulator used in this work

The simulator used in this work is based on the simulator developed in [Por06], and was conveniently adapted and modified for the integration of the developed security and assistance systems.

The Simulator used in [Por06] is a low-budget simulator. This simulator offers some possibilities making it useful for usability studies relating to the use of in-car telematic interfaces.

The modifications applied to the previous simulator, offer some possibilities for the realization of studies relating to in-vehicle security and assistance system interfaces. The goal of this work is to use the new simulator for the realization of usability tests regarding the interfaces of the developed and integrated systems. Figure 1 shows and example view of the modified Simulator created in this work.

![Figure 1: Example view of the modified Simulator used in this work](image)
5. DRIVER SECURITY AND ASSISTANCE SYSTEMS DEVELOPED
This section presents the developed and integrated security and assistance system’s interfaces in the driving simulator for usability testing in this work. The systems interfaces and functionalities simulate approximately the actual systems in production by BMW, Volkswagen and Mercedes. The systems developed and integrated are the Night Vision, Head-Up Display, Park Assist, Park Assistance and Approximation detection systems.

5.1 Night Vision
The Night Vision system is based on a thermal camera with FIR technology, enabling the driver the anticipate detection of road obstacles while driving at night, especially humans and animal with the highest temperature. The system displays a black and with image of the environment and obstacles, being the humans and animals the brightest elements. Figure 2 shows an example view of the simulated Night Vision system in the driving simulator.

5.2 Head-Up Display
The Head-Up Display developed and integrated in the driving simulator is based on the technologies of the Head-Up Display from BMW.

The Head-Up Display from BMW projects relevant information such as, speed, direction indication, failure warnings and radio setting directly in the field of view of the driver in the windscreen.

The simulated Head-Up Display in this work when activated projects the speed, rpm and direction information. Figure 3 shows an example view of the simulated Head-Up display.

5.3 Automatic park system and park assistance system
The automatic park system developed in this work is based on the interface design and functionalities of the Volkswagen Park Assist. This system by detecting an appropriate park place takes control over the steering wheel, and the driver only needs to accelerate and brake.

Contrary to the above park system, the park assistance system do not has an autonomous steering control. His park assistance function is to indicate the driver the actual ideal steering angle for a correct parallel parking maneuver. Figure 4 and 5 show example views of these two simulated park systems in the driving simulator.
6. SETUP AND PROCEDURE

The experiment took place at the Laboratório de Visualização Gráfica Avançada at IST, using the simulator developed originally in [Por06], and improved for the aim of this work with the integration of the driver assistance systems.

6.1 Participants

The experiment was conducted on 17 subjects, aged between 20 and 58 years old, with driver’s license time between 1 and 35 years. Two age groups were considered: the young age group (7 male and 4 female, aged 20 thru 34 and having had a driver’s license since 1 to 13 years) and the old age group (4 males and 2 females, aged 40 thru 58 and having had a driver’s license since 17 to 33 years).

Users in this test were considered trained and experienced concerning the driving interface: they all bear a driver’s license and the driving task is simpler than that in real life, at least in Portugal, where cars are equipped with manual gears and the simulator uses automatic transmission. Users are also trained but inexperienced concerning the driver assistance systems interfaces used.

6.2 Equipment

The simulator used in this work is shown on Figure 6. It consists of a computer with a Pentium 4 3.4Ghz with 2Gb of RAM memory and nVidia FX Quadra 4000 graphics adapter, using WACOM Cintiq 21 UX touch screen, and a Logitech G25 for direction and velocity control.

![Figure 6: Driving Simulator used in this work](image)

This simulator was improved and adapted from [Por06] to serve the purpose of this work. Adaption includes introduction of new scenario elements like, park spaces, parked cars, traffic lights, pedestrians and a night scenario. Beyond that, there were created specific driving situations normally found in the real driving ambient like pedestrians circulating on the street or side walk for a more realistic driving environment.

6.3 Procedure

The test consisted of three phases: an introductory phase where the examiner instructed the users how to operate the driving simulator and the various driver assistance systems through a short driving demonstration with the interaction of the systems. After that it was given a certain time to the users for them to learn how to use the assistance systems and to get used to the vehicle’s fiscal behaviour; a formal test phase where users drove along the course performing specific tasks with and without interaction of the systems; and finally users were required to fill in a survey about their opinion of the systems and the experiment.

6.4 Performance metrics

While the user drives in the formal test phase the examiner registers data on a form including attention flaws during the course and errors in performing the tasks using the driver assistance systems.

6.5 Usability criteria

The ISO Standard 9241-11 defines usability as follows: “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (Figure 4). Thus, according to ISO usability criteria are the effectiveness, efficiency and satisfaction, which in an evaluation situation are operationalised into concrete quantitative measures. In this sense the effectiveness is measured as the accuracy with which the users are able to achieve specified goals. Efficiency on the other hand means the resources with which the goals were achieved. Satisfaction refers to freedom from discomfort and the positive attitudes to the use of the product.

Jakob Nielsen wrote his famous book “Usability Engineering” in 1993 many years before the ISO 9241 (1998) standard. Nielsen saw usability as an narrower product characteristic that did the experts who wrote the standard. Nielsen (1993) makes a distinction between utility and usability. In his usability definition utility denotes the correct functionality, whereas the ISO 9241 (1998) views the correct functionality as one of the usability measures in the form of effectiveness.

Nielsen (1993) defines usability as a five dimensional quality attribute of the system. These dimensions are: learnability, efficiency, memorability, error prevention, and satisfaction [NS04].

One ergonomic requirement for control concepts is that they must meet usability criteria, i.e. the criteria guaranteeing the highest possible level of usability (Jordan 1998). One of the main benefits expected from an intelligent driver assistance system is that it will relieve the driver of routine tasks. It must meet the criteria of compatibility, conformity to user expectations, and consistency. It must be compatible with the driver’s resources and must not cause information overload. It must, above
all, provide the driver with clear feedback, be sophisti-
cated enough to perform the required tasks and give
help where needed, always expressing itself clearly and
remaining controllable by the driver. It must be easy to
learn and not error-prone. These usability criteria ob-
viously have areas of intersection [KL02].

Based on the two definitions of usability and the usabil-
ity criteria for driver assistance systems presented in
[KL02], the usability criteria for the security and assist-
ance systems developed in this works were selected.
According to the established criteria we proceed to the
usability analysis of the systems, for eventual identifi-
ation of usability problems, and the influences of their use
in terms of security, performance and driving comfort.
The chosen usability criteria include: effectiveness, effi-
ciency, satisfaction, learnability, compatibility, consis-
tency, given feedback, task adaptation, user controlla-
ble, error proneness, memorability and routine task re-
duction

7. RESULTS AND ANALYSIS

7.1 Errors and task completion performance

This section presents the differences observed in the
tests regarding the driver’s behaviour in the execution of
identical tasks with and without interaction with the
driver assistance systems. The analysis of the driver be-
behaviour is made in terms of errors registered and the performance observed in the task completion.

First are analysed the total amount and type of errors
committed by the users during the usability tests. Figure
7 and 8 present the graphics of the number and types of
errors, A and B, observed in the two situations: simple
driving and driving with interacting with the systems
interfaces given the specified tasks for each system in
identical course and driving conditions.

![Figure 7: Number of errors committed by the users in the tasks without interaction of the systems](image)

![Figure 8: Number of errors committed by the users in the tasks with interaction of the systems](image)

Comparing Figure 7 and Figure 8 there can be observed
that in general there were more errors committed by the
users during the execution of the driving tasks with- 
out interacting with the systems. However, comparing the results referring to the night driving with and with-
out interaction with the system of Night Vision, we con-
clude that the difference of driving performance regard-
ing attention flaws is reduced. That can be explained by
the fact that the driver while driving at night is forced to
give more attention to the driving environment, so an
additional interaction with the Night Visions interface
that induces a visual cognitive load do not influences
implicitly the reduction of attention flaws. Although the
system has the potential of increasing the road safety by
the detection of non visible pedestrians on the road, in
the usability tests there wasn’t verified a significant in-
crease in the driving performance and consequently an
increase in security.

In opposite to the previous driving task analysis, compar-
ing the graphics referring to the task with and without
the Head-Up Display, it can be observed that there was a
significant reduction of the attention flaws committed
by the users by interacting with the system. Therefore,
there was a significant increase in the driving perform-
ance and security.

Comparing the graphics referring to the parking tasks
without systems and with the automatic park system
and the park assistance system, it can be observed that
there were fewer errors, i.e. a better conclusion of the
samples of attention flaws include not repairing a traffic
sign or light. In the parking tasks errors of type A com-
prise small collisions with the front or rear vehicles. Er-
ors of type B occur only in the driving tasks and com-
prise collision situations with buildings, pedestrians and
other objects at considerable risk velocities. However,
the result of having mostly errors of type A, attention
flaws that can cause a situation of accident, but that actu-
ally didn’t occurred, is due to the fact of the inexist-
tence of other vehicles circulating on the streets. This is,
many of the errors of type A in the driving tasks could
actually be serious errors of type B.
parking task with the systems assistance. However, it can be seen that there was a better improvement in the task conclusion performance with the automatic park system than with the park assistance system. The parking task with the automatic park system reduced the number of small collisions and eliminated the repetition of the parking attempt.

7.2 Users subjective opinion
This section describes the results obtained through the surveys made to the users after the task conclusion. The analyses made reflects the users opinion of the various assistance systems tested in the experiment, regarding their perception of aspects like, contribution for security, level of distraction, level of concentration and easiness of learning during the driving task with simultaneous interaction of the systems.

Regarding the Night Vision system, the majority of the users (72%) evaluate the system for pedestrian detection at night driving, as being a significant contribution for the road security improvement. The system is rated by the most users as having a satisfactory easiness of learnability (76%) and by the rest of the users as having an easy (18%) to very easy (6%) learnability. The system has a less satisfactory result in terms of its efficiency, regarding the users recourses consumed for the task conclusion. 65% of the questioned users rated the system as having a satisfactory level of concentration needed for the interaction whereby the other 35% rated this aspect as being less satisfactory. 59% of the users classified the system as having a less satisfactory result in terms of distraction level whereby the remaining users (41%) rate the distraction level of the system as being reasonable.

The Head-Up Display was equally evaluated by the users regarding the previous features. The majority of the users rated the system as contributing significantly for the improvement of road security (59%). The system is rated in general as being easy to use (24% easy and 35% very easy) and having a good efficiency regarding the user’s resources for the task completion. The results indicate that the Head-Up Display needed low levels of concentration for the interaction (low 24% and very low 35%) and had low levels of distraction (low 23% and very low 41%)

The automatic park system, park assistance system and the collision warning system where evaluated by the users regarding their perceived easiness of learnability, level of concentration and distraction and the level of assistance in the parking maneuver.

The majority of the users rated both park systems as having a good learnability and requiring low levels of concentration and distraction during the interaction. The usability criteria of the assistance level given by the automatic park system for the parking task is rated as being of low assistance. In contrast, for the park assistance system the same assistance criteria was rated as giving a high level of assistance during the parking maneuver.

Although the automatic park system showed better improvements in the park maneuver performance during the usability tests than the park assistance system, the users shown a greater satisfaction, acceptance for the manual park system.

The users rated the collision warning system regarding its easiness of learnability, i.e. the easiness of learning how to interpret the acoustic warnings, as being good (41% easy and 18% very easy). The levels of concentration and distraction required for the interaction with this system where also rated as being of low level. Finally, the usability criteria of the assistance level given by the collision warning system for the parking task is rated as being of height assistance (79%).

8. CONCLUSIONS
The results obtained through the experiment point to several conclusions against the goals established for this work.

First the development and simulation of the driver assistance systems and respective interfaces initially proposed for integration in the driving simulator, with a sufficient level of realism for the completion of the usability and security study was achieved. The integration of specific driving situations normally found in a real driving environment allowed an improvement of validity of the results obtained through the usability tests.

The aim of this integrated systems is to assist the driver during the driving task and do facilitate it, searching at the same time reducing to the maximum driver distraction during the interaction. However, so that the systems can be actually efficient in their functionalities, they must present a high level of usability; witch was tested in this work.

Against the targets pretended by the utilization of these systems, the results obtained through the usability tests and the surveys to the users regarding the developed systems allowed various conclusions. The usability criteria evaluated for the usability study of the systems allowed identifying positive usability aspects and also some usability problems.

In general it was verified an increase of driving security, assistance and performance with the use of the driver assistance systems comparing with the driving task without the systems. The subjective opinion of the users confirms this result. In majority the users recognize that the driver assistance systems allow an increase in performance of the tasks, assisting and facilitating the driving.
The existence of the Head-Up Display where the driver can consult relevant information directly in his field of view, on the windscreen, demonstrated a significant increase in the driving performance and security, compared with the consulting of the same information in traditional displays. The distraction caused by this system demonstrated to be reduced compared with the distraction caused with the inexistence of this system.

Regarding the park assistance system it can be concluded that it increases the performance and security of the park task, compared with the manual park maneuver of the driver. This system, although requires some distraction for the information consulting in the display, allows a clearer feedback of the park situation. The user demonstrates a clear preference towards the use of this system for the parking maneuver than for the automatic park system.

However, there were identified some usability problems. The Night Vision system did not presented the expected results of effectiveness, efficiency and security. Although the system has the potential of assisting the driver in a positive way trough the pedestrian’s detection at night driving, the results demonstrated that the system do not influences significantly the driving performance and security. Since the system forces the driver to be more aware at the driving environment, the interaction with the system represents an additional load in terms of visual recourses, inducing distraction in driving. However, the users considerate that the Night Vision system allows a improvement in the pedestrian detection and that the distraction provoked by the information consulting justifies his use because the level of security that can be propositioned is substantially greater.

Other problem of usability identified was the low acceptance for the automatic park systems by the users. Although this system demonstrated better results in terms of effectiveness for the park task compared with the manual parking or the parking with the assistance system, the users showed a certain resistance in accepting a system that controls the steering wheel of the vehicle autonomously.

8.1 Future work
There are numerous opportunities for developing future work in driver assistance systems usability in this simulator. This work focused driver assistance systems that interact with the user’s trough their interfaces, being the driver who has the final decision. A suggestion for a future work is the usability study of security and assistance systems that act autonomously in the driving task.

For the integration of this kind of driving assistance systems, modifications to the simulators scenario are needed, like the integration of other vehicles circulating on the roads.

Other interesting feature that can be developed in future work is an algorithm capable of registering computationally driving faults and errors made by the users in the usability tests.

9. BIBLIOGRAPHY