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Towards development of a smart automotive dash instrument as a way to decrease distracted driving

Diseño de un tablero automotriz intelingente como una forma de disminuir la conducción distraída

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Abstract

In spite of all technological advances incorporated in vehicles by the automotive industry in making vehicle production safer and more efficient to mitigate accidents or collisions, for example, Intelligent Transportation Systems (ITS) to provide services relating to different modes of transport and traffic management, which enable users to be better informed and make safer to reduce car accidents, additional to this efforts, the use of Smartphones are already being used on cars to perform a valuable solution for powering ITS and can be integrated on vehicles, despite these technological advances, automobile accidents continue in ascent and continue to be responsible for thousands of casualties each year. To diminish them, several technical solutions have been developed, however, additional research is required in this area. With the purpose of helping to reduce distracted driving caused by visual, auditory, physical, and cognitive distractors, the present research paper was approached, which was divided into two main processes, the first one, a systematic literature review of the main factors that are responsible for vehicle distraction during driving, and a survey process to discover distracted driving causes. As a result of this research, a technological solution was designed to reduce distracted driving situations. From the results obtained, the option of developing a prototype of a smart automotive dash instrument that helps to reduce distracted driving is proposed. This paper presents the first phases of development of the software life cycle addressed for the design of the prototype, as future work on the development and tests of the prototype are considered.
Keywords: Automotive dash instrument, distracted driving.

Resumen

A pesar de todos los avances tecnológicos incorporados en los vehículos por la industria automotriz para la fabricación de vehículos más seguros y eficientes en mitigar los accidentes o colisiones, por ejemplo, Sistemas Inteligentes de Transporte (ITS), donde se proporcionan servicios relacionados con los diferentes modos de transporte y gestión del tráfico, permite a los usuarios estar mejor informados y más seguros para reducir los accidentes automovilísticos; adicional a estos esfuerzos, el uso de Smartphone se utiliza en los coches para llevar a cabo una solución valiosa en la alimentación de ITS y se pueda integrar en los vehículos. A pesar de estos avances tecnológicos, los accidentes automovilísticos siguen en aumento y son responsables de miles de víctimas por año. Para disminuirlos, se han desarrollado varias soluciones técnicas, sin embargo, se requiere investigación adicional en esta área. Con el propósito de ayudar a reducir la conducción distraída causada por distractores visuales, auditivos, físicos y cognitivos, se abordó el presente trabajo de investigación, el cual se dividió en dos procesos principales, el primero, una revisión sistemática de literatura de los principales factores que son responsables de la distracción vehicular durante la conducción, y un proceso de encuesta para descubrir las causas de la conducción distraída. Como resultado de esta investigación, se diseñó una solución tecnológica para reducir las situaciones de conducción distraída. A partir de los resultados obtenidos, se propone la opción de desarrollar un prototipo de instrumento inteligente para el salpicadero del automóvil que ayude a reducir la conducción distraída. En este trabajo se presentan las primeras fases de desarrollo del ciclo de vida del software abordado para el diseño del prototipo y se plantean trabajos de desarrollo a futuro y pruebas del prototipo.
Descriptores: Tablero automotriz inteligente para automóviles, conducción distraída.

Introduction

Nowadays, the technological advances achieved by the automotive industry in production of safer and more efficient vehicles, has driven cars assembly faster, lighter; with substantial improvements in fuel consumption, improvements have also been achieved in their equipment, such as infotainment, comfort driving assistance systems, among others (Fernandes *et al.,* 2015).

Smartphones are already being used on cars to perform a valuable solution for powering ITS and can be integrated on it. For example, Android-based solutions have been developed for car accident detection and notifications in accident cases and it is expected vehicle-to-vehicle communication will be able to provide driving with more information about their environment (Normark, 2009).

The National Highway Traffic Safety Administration considered distracted driving a dangerous epidemic on America's roadways. Fatality and injury crash statistics indicate that the youngest and oldest drivers represent the greatest crash risk relative to their driving exposure. Teenagers (i.e. those 16-20 years of age) represent 6.0 % of drivers but account for 9.6 % of all drivers involved in fatal crashes (Guo *et al.,* 2017).

There were 37,461 motor vehicle traffic fatalities in the United States in 2016 (U.S. Dept. of Transportation 2016).

The 5.6 % increase from 2015 to 2016 is down from the 8.4 % increase from 2014 to 2015. The largest percentage increase prior to the 8.4 % increase was the 9.4 % increase from 1963 to 1964. There were back-to-back total motor vehicle fatality increases from 2014 to 2015 (8.4 %) and from 2015 to 2016 (5.6 %) (U.S. Dept. of Transportation 2016).

This research paper has been sectioned as follows. Section Background includes the validation methodology applied to guarantee the reliability results. Section Theoretical framework presents the reasons to propose this technological solution, the research objectives are indicated, it explains the process of systematic literature review and is explained the initial survey application process. Section Methodology shows the analysis phase in order to obtain the software requirements specification (SRS), ISO 26262 was taken into account since the proposed technological solution is developed in the automotive area. Additionally, design phase was developed, to this stage the SysML language was used to carry out the modeling solution, which was represented through use cases. Additionally, this section the outcomes from the systematic literature review process and the survey results, and the technological software justification regarding intelligent automotive dash instrument is shown. Section Results includes the SRS document contains vital information about functionality and describes the required quality to user satisfaction. After that, this section includes the analysis phase outcomes where some diagrams and use cases are presented. Section Conclusions and section Future work are shown.

Background

According to the World Health Organization (WHO), studies carried out in different countries indicate the driver's percentage of drivers who have distractions while driving has increased over the last 10 years. Traffic Accidents (TA) are a worldwide problem with 1.25 million fatalities each year (Jain & Busso, 2011).

In the distractor's classification, the cognitive, sensory, and motor aspects affected by them are considered:

- Visual distraction occurs when the driver loses sight on the road they are traveling on while performing a secondary activity, even for a few seconds (Gras *et al.,* 2008; Regan, s/f; Labuschagne, 2016).
- Auditory distraction occurs when the driver focuses their attention on sounds or voices rather than the traffic situation (Gras *et al.,* 2008; Regan, s/f).
- Physical distractors refer to removal one or both hands from the steering wheel or gear shift to manipulate another object not related to driving (Gras *et al.,* 2008; Regan, s/f; Labuschagne, 2016).
- Cognitive distractions can be caused by thoughts or other activities which can be absorbed during driving in such a way they interfere with their driving task. For example, arguing, trying to convince a passenger in the vehicle about something, thinking about the tasks to be carried out throughout the day (Gras *et al.,* 2008; Labuschagne, 2016).

This research was focused on seeking information on accident and/or collision situations caused by the four distractors type, mentioned above; it was approached in two directions, the first one through a systematic literature review on factors who are responsible for automobile distraction during driving, and the second research direction was given by a survey process.

Theorethical framework

For the methodology development, the following theoretical framework was investigated and applied.

Research methodology

Based on Sampieri's research methodology a qualitative and quantitative validations were performed.

Qualitative approach

As an analysis stage, phases 1 to 5 indicated in Figure 1, were followed, which were updated as the research progresses (Hernández *et al.*, 2014).

For validation stage, phases 6 to 9 indicated in Figure 1 will be followed which were updated as the research progresses (Hernández *et al.*, 2014).

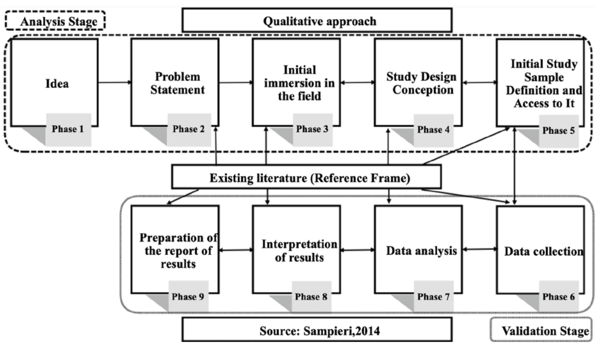

Figure 1. Qualitative approach (Hernández *et al.,* 2014)

Quantitative approach

As an analysis stage, phases 1 to 6 indicated in Figure 2 were followed (Hernández *et al.*, 2014). For validation stage from quantitative stage, phases 7 to 10 indicated in Figure 2 were followed (Hernández *et al.*, 2014).

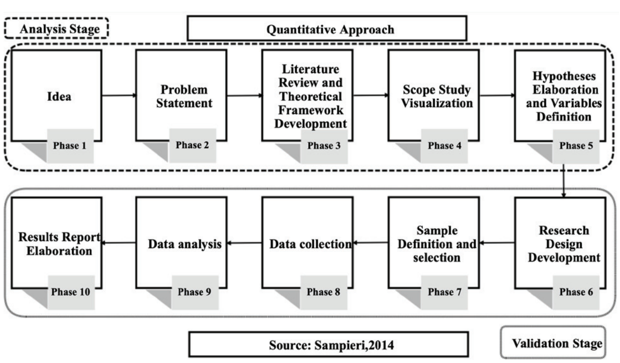

Figure 2. Quantitative approach (Hernández *et al.,* 2014)

Likert scale

Likert scale was used to measure attitudes and determine respondents' conformity degree to a certain affirmative or negative sentence, thus allowing us to determine respondents' level of agreement or disagreement (Claveria, 2018).

Cronbach's alpha

The Alpha coefficient method is a suitable method that can be used for Likert scale items (e.g., 1-3, 1-4, 1-5). Thus, it is not limited to the true-false or correct in correct format.

Cronbach alpha coefficient is weighted standard variations mean, obtained by dividing the total of the k items in the scale, to the general variance (Ercan *et al.*, 2007) (Figure 3).

$$a = \frac{n}{(n-1)}\left(1 - \frac{\sum_{i=1}^{n} \sigma_{Y_i}^{2}}{\sigma_T^{2}}\right)$$

Figure 3. Cronbach (Ercan *et al.,* 2007)

Where:

n: Number of the items
σ_{Yi}: i^{th} item's standard deviation
σ_T: General standard deviation

If the items are standardized, coefficient is calculated by using the items' correlation mean or variance-covariances' mean. The Cronbach's Alpha coefficient was applied to compute the survey reliability (Ercan *et al.*, 2007) (Table 1).

Table 1. Cronbach's Alpha Table (Ercan *et al.,* 2007)

Cronbach's Alpha	Internal Consistency
$0.9 \le \alpha$	Excellent
$0.8 \le \alpha < 0.9$	Good
$0.7 \le \alpha < 0.8$	Acceptable
$0.6 \le \alpha < 0.7$	Questionable
$0.5 \le \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Cronbach scale is deemed reliable if its alpha coefficient is equal or above 0.7 (Ercan *et al.*, 2007).

Analysis phase

Engineers start planning by defining the work that needs to be done in as much detail as possible. If all they have is a one-sentence requirements statement, then that statement shall be the basis for the plan (Brackett, s/f).

Conceptual Design. To make an estimate and a plan, engineers first define how the product is to be designed and built. However, since the planning phase is too early to produce a complete product design, engineers

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produce what is called a conceptual design (Robinson *et al.*, 2015).

Once the idea of a project is formed, the development can start. The set of activities used to build a program is called the software development life cycle (SDLC). Each activity, or phase, is a step in the life cycle. The goal in creating and using an SDLC is to produce the fastest, least expensive, and highest quality product (Dailey, s/f).

The steps can vary, and sometimes overlap, but most program development processes include most or all of the following phases: planning, analysis, design, implementation, and support/security (Dailey, s/f) (Figure 4).

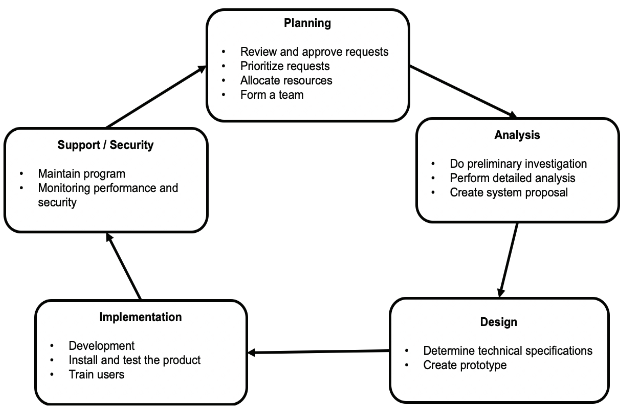

Figure 4. Software development life cycle (Dailey, s/f)

Requirements

There are many definitions of requirements. The IEEE software engineering glossary defines requirement as (Brackett, s/f):

1. A condition of capability needed by a user to solve a problem or achieve an objective.
2. A condition or capability that must be met by a system or system component to satisfy a contract, standard, specification, or other formally imposed document.

The outcome of requirements definition is the formulation of functional requirements, non-functional requirements, and design and implementation constraints.

Although the requirements, fall into four classes (Robinson *et al.*, 2015):

- Functional requirements.
- Non-functional requirements.
- Inverse requirements.
- Design and implementation constraints.

In this research, only functional requirements will be included.

A functional requirement specifies a function that a system or system component (i.e., software) shall be capable of performing.

Non-functional requirements are those relating to performance, reliability, security, maintainability, availability, accuracy, error-handling, capacity, ability to be used by specific users' class, anticipated changes to be accommodated, acceptable training level or support, or the like (Casamayor & Campo, 2010).

Design phase

Requirements analysis in systems engineering and software engineering, encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product, taking account of the possibly conflicting requirements of the various stakeholders, analyzing, documenting, validating, and managing software or system requirements. Analysis involves reaching a richer and more precise understanding of each requirement and representing sets of requirements in multiple, complementary ways. Elicitation is the gathering and discovery of requirements from stakeholders and other sources. Analyze the intended use of the system and focus on gathering sufficient data to specify the functional and data requirements. Connect the functional requirements to the data requirements (Kaur, s/f).

The requirement analysis management is categorized into the following two categories (Kaur, s/f) (Figure 5):

1. *Requirements eliciting practices.* Which is the gathering and discovery of requirements.
2. *Requirement analysis and specification practices.* Serves as the foundation for system design and development; captures user requirements to be implemented in a new or enhanced system.

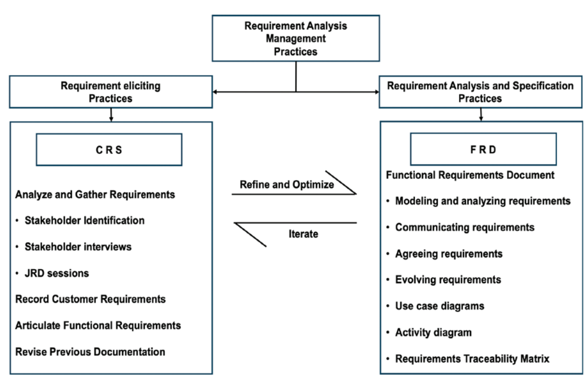

Figure 5. Block diagram showing requirements analysis management process

SysML

Once the requirements are written and verified, they should be graphically represented using the corresponding model described by SysML (Figure 6).

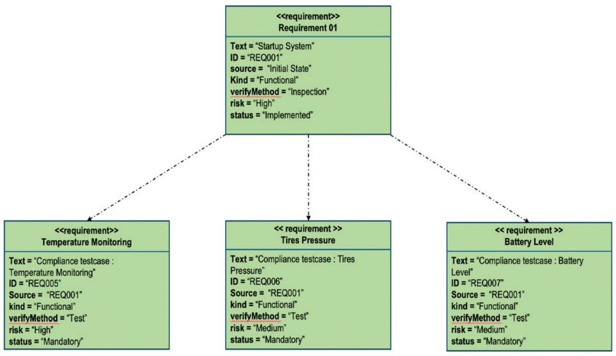

Figure 6. Requirement diagram example

Even though requirements diagrams have great importance in SysML, they are no use without proper supporting diagrams to represent the overall system operation. These supporting diagrams are divided in behavior and structure diagrams (Gulias *et al.*, 2016).

Behavior diagrams are broken down into four types: activity, sequence, state machine and use case diagrams (Gulias *et al.*, 2016).

Use case diagrams describe basic interactions between system actors and the goals expected from them (Gulias *et al.*, 2016).

Methodology

Motivation

Given the large accidents/collisions number that continue to occur today, the present work goal was to develop a technological solution to design a smart automotive dash instrument to reduce distracted driving caused by visual, auditory, physical and cognitive distractors.

Once the problem was identified, the work focused on the research process through a systematic literature review and through the survey application.

After performing the literature review and obtaining the data. The Sampieri's research methodology was taken, so the information was gotten from systematic literature review and survey process and it was validated using Cronbach's alpha method, the results of the survey data were interpreted, with these activities the following results were gotten (Figure 1 and Figure 2).

The following objectives were proposed:

General Objective: Collect and analyze data on automobile accidents/collisions caused by the main visual, auditory, physical, and cognitive distractors during driving.

Specific objectives were derived:

- Specific Objective 1: Identify the causes which generate visual, auditory, physical, cognitive distractions.
- Specific Objective 2: Identify the automobile accidents/collisions consequences caused by distracted driving.
- Specific Objective 3: Conduct a systematic literature review to know the state of the art of research in this area.
- Specific Objective 4: Conduct field research through a survey application, to identify the causes which generate visual, auditory, physical or cognitive distractors and identify alternative solutions.
- Specific Objective 5: Design, develop and test a technological prototype focused on a software perspective to reduce distracted driving caused by visual, auditory, physical and cognitive distractors.

Based on these objectives, the following research questions arise:

a) RQ1: What are the factors that cause distracted driving?
b) RQ2: What are the consequences due to distracted driving?
c) RQ3: What kind of alternatives could decrease distracted driving?

Systematic literature review

The systematic literature review was composed of 8-step. It found the main factors which contribute to distracted driving: visual, auditory, physical, and cognitive (Figure 7).

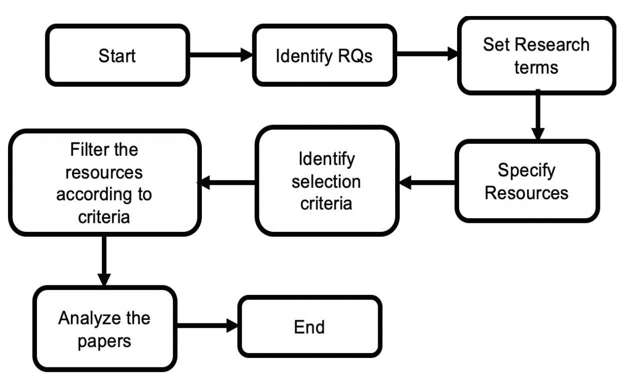

Figure 7. Systematic literature review research methodology

Phase 1:
Start. The main idea was defined: A systematic literature review on factors causing distracted driving.

Phase 2:
Identify RQs. The research questions were defined.

Phase 3 Set Research Terms:
The search terms were defined: ''distracted driving", "Literature review Distracted Driving", "distraction automotive dash Instrument".

Phase 4 Specify Resources:
The libraries considered in this research were: 1. IEEE Explorer, 2. Google Scholar, 3. Science Direct, 4. ACM Digital Library, 5. Due to ease access to articles; were defined.

Phase 5:
Identify selection criteria: The criteria definition to inclusion, exclusion and elimination articles consulted; were defined.

Phase 6 Filter Resources according to criteria:
The articles selection was carried out.

Phase 7: Analyze the papers:
Research, answers were shown.

Phase 8 End:
The results were analyzed.
Generate a technical solution to reduce distracted driving as needed.

Survey

The survey consisted of 23 questions. It was divided into 4 sections:

- *Section 1:* Visual distractors.
- *Section II:* Auditory distractors.
- *Section III:* Physical distractors.
- *Section IV:* Cognitive distractors.

From 23 questions. 20 closed questions were asked and 3 open questions were asked.

For sections 1, 2 and 4, the following Likert scale was applied (Table 2).

Table 2. Likert scale used in survey sections 1, 2 and 4

Very frequently	Frequently	Occasionally	Rarely	Never

For section 3, a dichotomous scale with open questions the following Likert scale was applied (Table 3).

Table 3. Likert scale used in survey section 3

Yes	Not	Comments if answer was YES

Results

The survey's questions arose as a result of the systematic literature review where it was clearly observed that despite the technological advances that have been integrated into the latest generation of automobiles, the number of accidents continues increasing and it was also observed that sometimes technological advances become a distraction factor in themselves.
Among the first results gotten from the application of the survey focused only on Mexico, we identified that 80 % were male drivers and 20 % female drivers. 100 % were more than 40 years old and 100 % with more than 5 years of experience in driving.
The following dependent and independent variables were defined for the survey application process.
The independent variables included the following:

- Visual distraction.
- Auditory distraction.
- Physical distraction.
- Cognitive distraction.

The following dependent variables were identified:

- Visual distractor.
- Auditory distractor.
- Physical distractor.
- Cognitive distractor.

The survey was divided into 4 sections, the target was to identify different kind of factors that generate any of the four distractors:

Section 1 was made up of 15 questions. We had the following organization by distractor type (Table 4 and Figure 8):

- Visual distractor: Q5, Q12, Q13, Q14.
- Auditory distractor: Q1, Q3, Q4.
- Physical distractor: Q2, Q6, Q7, Q8, Q9, Q10, Q11, Q15.
- Cognitive distractor: No questions were identified.

Table 4. Data archived in the study-survey section 1

	Section 1	Very Frequently	Frequently	Occasionally	Rarely	Never
Q1	Do you have a conversation with the passenger in the next seat?	14.29 %	**42.86 %**	**42.86 %**	0.00 %	0.00 %
Q2	Do you adjust the vehicle's climate control?	14.29 %	0.00 %	28.57 %	**42.86 %**	14.29 %
Q3	Do you talk or listen on your cell phone without a hands-free device?	0.00 %	**28.57 %**	14.29 %	**28.57 %**	**28.57 %**
Q4	Turn on the radio / change radio stations / insert or remove a CD or USB drive?	0.00 %	**42.86 %**	14.29 **%**	28.57 %	14.29 %
Q5	Look at objects outside the vehicle?	28.57 %	14.29 %	14.29 %	**42.86 %**	0.00 %
Q6	Locate, reach, answer or dial a number on the cell phone?	0.00 %	**42.86 %**	14.29 %	**42.86 %**	0.00 %
Q7	Check or send text messages?	14.29 %	**28.57 %**	**28.57 %**	0.00 %	28.57 %
Q8	Check or send emails?	14.29 %	0.00 %	0.00 %	**42.86 %**	**42.86 %**
Q9	Check your social networks?	0.00 %	0.00 %	14.29 %	28.57 %	**57.14 %**
Q10	Do you use the electronic agenda to search for a contact without using an electronic assistant?	0.00 %	14.29 %	**28.57 %**	**28.57 %**	**28.57 %**
Q11	Do you program or reprogram your browser?	0.00 %	14.29 %	28.57 %	14.29 %	**42.86 %**
Q12	Do you attend to children or animals in the back seat of the vehicle?	0.00 %	0.00 %	28.57 %	**57.14 %**	14.29 %
Q13	Do you pick up objects from the floor or between the seats?	0.00 %	0.00 %	0.00 %	**57.14 %**	42.86 %
Q14	Observe signs and/or advertisements?	0.00 %	**42.86 %**	**42.86 %**	14.29 %	0.00 %
Q15	Do you eat or drink?	0.00 %	0.00 %	28.57 %	**57.14 %**	14.29 %

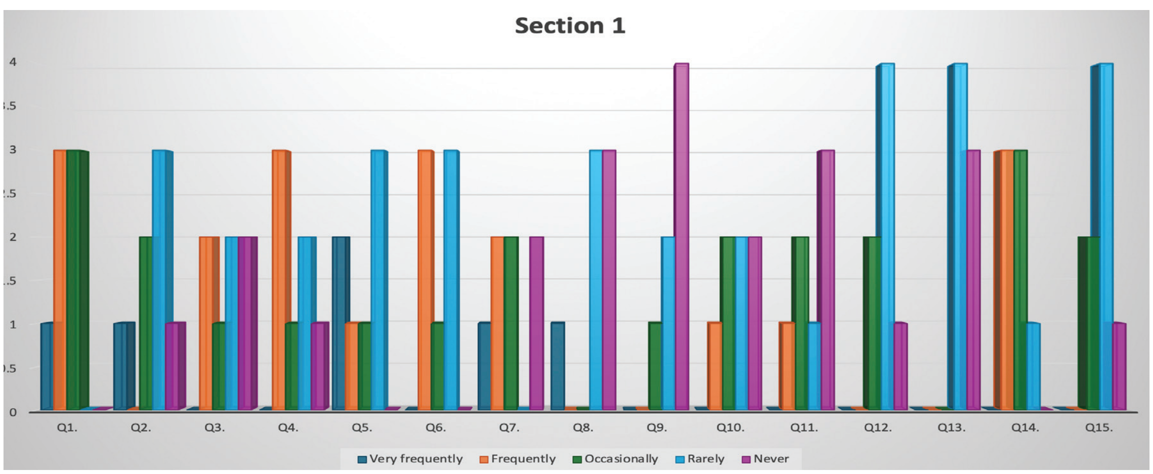

Figure 8. Data achieved in the study-survey section 1

Section 2 was made up of 4 questions. We have the following organization by distractor type (Table 5 and Figure 9):

- Visual distractor: Q16, Q17.

Section 3 was made up of 3 questions. We have the following organization by distractor type (Table 8 and Figure 11.

- Cognitive distractor: Q20, Q21, Q22.

During the survey application, the following results were gotten.

The questions for section 1 can be seen in Table 4 and Figure 8. To find the highest number of distractors we found that for questions Q1, Q4, Q6 and Q14 with a 42.86 % and for questions Q2, Q10, Q11, Q12 and Q15 with a 28.57 %.

This can be translated as follows. While driving, the driver:

- Frequently or occasionally has had a conversation with the passenger in the next seat.
- Frequently turn on the radio/change radio stations/ insert or remove a CD or USB drive.
- Frequently locate, reach, answer or dial a number on the cell phone.
- Frequently or occasionally tends to observe signs and/or advertisements.
- Occasionally adjust the vehicle's climate control.
- Occasionally check or send text messages.
- Occasionally use the electronic agenda to search for a contact without using an electronic assistant.
- Occasionally program or reprogram the car browser.
- Occasionally pick up objects from the floor or between the seats.
- Occasionally eats or drinks.

Section 2 was made up of 4 questions, the results of these questions can be seen in Table 5 and Figure 9. To find the highest number of distractors we found that for questions Q17 with a 50.00 % and for Q19 with a 33.33 %.

This can be translated as follows. While driving, the driver:

- Rarely has had problem with the authorities for not respecting road signs.
- Rarely has been in a situation where the driver has put other cars at risk because of a distraction.

Section 3 was made up of 3 questions, the results of these questions can be seen in Table 8 and Figure 11. To find the highest number of distractors we found that for questions Q20 with a 71.43 % and for Q21 57.14 %.

This can be translated as follows. The driver:

- Has driven after receiving bad news.
- Hasn't driven after a discussion at work.

Section 4 was made up of a question, the results of this question can be seen in Table 6 and Figure 10. To find the highest number of distractors we found that for question Q23 with 57.14 %.

This can be translated as follows. While driving, the driver:

- Never has been in a risky situation derived from a driver's distraction.

Tables 7 and 9 provide a summary of the Cronbach Alpha values about the four survey's sections and of the overall scale. As the alpha values indicate the survey's results have good internal consistency. Table 7 shows the result of Cronbach's alpha coefficient of .086 for survey sections 1, 2 and 4. Table 9 shows the result of the Cronbach's alpha coefficient of .075 for section 3 of the survey.

Both Cronbach's alpha coefficients of .860 and .750, respectively, way above the recommended 0.7 coefficient (Table 1). In view of these results, it can be safely assumed that the survey process-is reliable and internally consistent.

Table 5. Data achieved in the study-survey section 2

	Section 2	Very frequently	Frequently	Occasionally	Rarely	Never
Q16	Have you had any problems with the authorities for not respecting speed limits?	0.00 %	16.67 %	0.00 %	0.00 %	**83.33 %**
Q17	Have you ever had a problem with the authorities for not respecting road signs?	0.00 %	0.00 %	16.67 %	**50.00 %**	33.33 %
Q18	Have you ever been in a situation where you have put bystanders at risk because of a distraction?	0.00 %	0.00 %	0.00 %	0.00 %	**100.00 %**
Q19	Have you ever been in a situation where you have put other cars at risk because of a distraction?	0.00 %	0.00 %	0.00 %	33.33 %	**66.67 %**

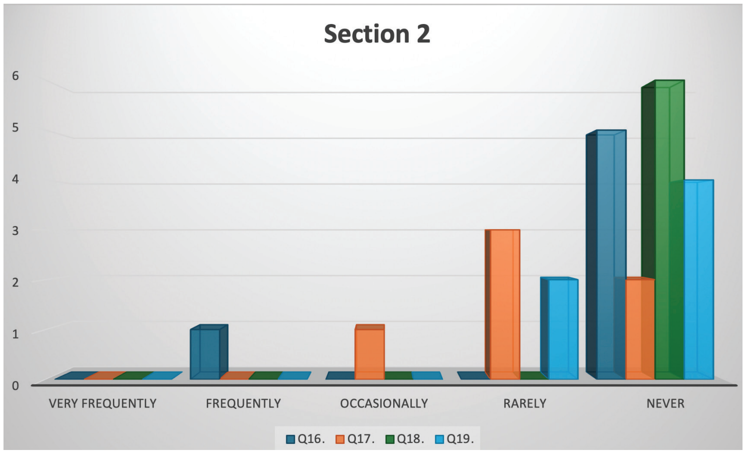

Figure 9. Data achieved in the study-survey section 2

Tabla 6. Data achieved in the study-survey section 4

Section 4	Very frequently	Frequently	Occasionally	Rarely	Never
Q23. Have you ever been in a risky situation derived from a driver's distraction?	0.00 %	0.00 %	0.00 %	42.86 %	**57.14** %

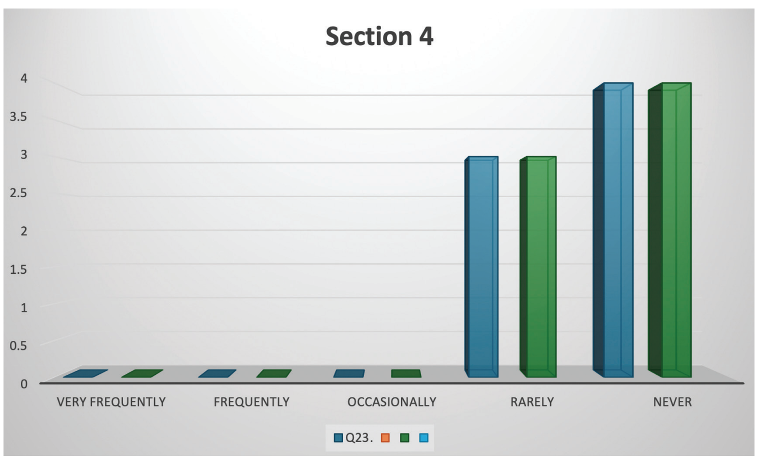

Figure 10. Data achieved in the study-survey section 4

For survey sections 1, 2 and 4. The Cronbach's Alpha was: 0.860800872 "Good".

Table 7. Data achieved in the study. Cronbach's alpha Sections 1,2,4

Two-factor analysis of variance with a single sample per group

Summary	Account	Sum	Average	Variance
Row 1	20	72	3.6	1.094736842
Row 2	20	71	3.55	1.628947368
Row 3	20	47	2.35	2.660526316
Row 4	20	69	3.45	1.628947368
Row 5	20	89	4.45	0.471052632
Row 6	20	83	4.15	0.871052632
Row 7	20	74	3.7	1.905263158
Column 1	7	15	2.142857143	0.476190476
Column 2	7	24	3.428571429	1.619047619
Column 3	7	25	3.571428571	1.619047619
Column 4	7	22	3.142857143	1.476190476
Column 5	7	19	2.714285714	1.904761905
Column 6	7	21	3	1
Column 7	7	21	3	2.333333333
Column 8	7	28	4	2
Column 9	7	31	4.428571429	0.619047619
Column 10	7	26	3.714285714	1.238095238
Column 11	7	27	3.857142857	1.476190476
Column 12	7	27	3.857142857	0.476190476
Column 13	7	31	4.428571429	0.285714286
Column 14	7	19	2.714285714	0.571428571
Column 15	7	27	3.857142857	0.476190476
Column 16	7	27	3.857142857	4.142857143
Column 17	7	25	3.571428571	2.952380952
Column 18	7	30	4.285714286	3.571428571
Column 19	7	28	4	3.333333333
Columna 20	7	32	4.571428571	0.285714286

Analysis of variance

Origin of variances	Sum of squares	Degrees of freedom	Average of squares	F	Probability	Critical value for F
Rows	52.44285714	6	8.74047619	7.183953033	1.62324E-06	2.179099851
Columns	56.25	19	2.960526316	2.433309301	0.00201925	1.678509757
Error	138.7	114	1.216666667			
Total	247.3928571	139				

Cronbach´s alpha 0.860800872

For section 3, the following results were gotten.

Table 8. Data achieved in the study-survey section 3

Section 3	Yes	Not
Q20. Have you ever driven after receiving bad news?	**71.43 %**	28.57 %
Q21. Have you ever driven after an discussion at work?	42.86 %	**57.14 %**
Q22. Have you ever driven after receiving bad news?	**66.67 %**	33.33 %

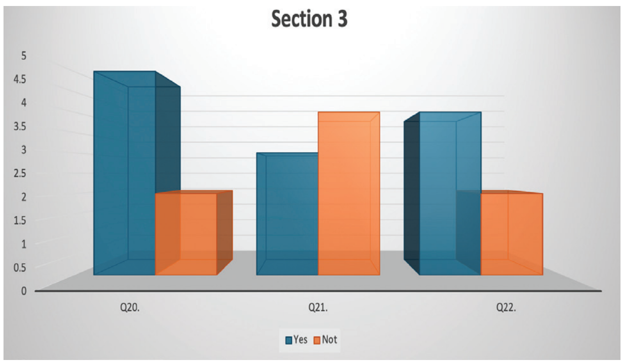

Figure 11. Data achieved in the study-survey section 3

Table 9. Data achieved in the study. Cronbach's alpha section 3

Two-factor analysis of variance with a single sample per group

Summary	Account	Sum	Average	Variance
Row 1	3	3	1	0
Row 2	3	6	2	0
Row 3	3	3	1	0
Row 4	3	4	1.333333333	0.333333333
Row 5	3	6	2	0
Row 6	3	3	1	1
Row 7	3	3	1	0
Column 1	7	9	1.285714286	0.238095238
Column 2	7	11	1.571428571	0.285714286
Column 3	7	8	1.142857143	0.476190476

Analysis of variance

Origin of variances	Sum of squares	Degrees of freedom	Average of squares	F	Probability	Critical value for F
Rows	4	6	0.666666667	4	0.019661637	2.996120378
Columns	0.666666667	2	0.333333333	2	0.177978516	3.885293835
Error	2	12	0.166666667			
Total	6.666666667	20				
	Cronbach´s alpha			0.75		

Analisys phase: Software requirements specifications

The following requirements and use cases definition were implemented according on results of systematic literature review, and the results gotten through surveys application to collect and analyze data, proposing a technological solution through scrum, to design a smart automotive dash instrument to reduce those distractors. This technological solutions should be developed under the automotive standard ISO 26262 since they are critical mission systems.

The smart automotive dash instrument proposal will be built, taking into consideration current requirements updates and functions which will be complemented based on the second survey application.

According to the information obtained during the second phase of the survey's application and extending it to other countries. The following phases for smart automotive dash instrument will be developed:

- Update functional requirements.
- Carry out the technology solution design.
- Prototype elaboration.
- It is assumed the automobile must have necessary sensors installed on it to be able to carry out all features.
- It is assumed the smart automotive dash instrument will be able to detect failures during driving.
- The smart automotive dash instrument will not function if the primary energy source has been disabled.
- The smart automotive dash instrument functionality cannot be realized, if some of car's physical sensors are damaged, preventing the correct reading information.
- The smart automotive dash instrument will be focused on actions to decrease distracted driving caused by visual, auditory, physical, and cognitive distractors.
- The smart automotive dash instrument will function autonomously, without user intervention.
- The Smart automotive dash instrument will respond in conditions detected by the sensors and will carry out their functions according to their input analysis.

Use Cases and Characteristics:

- The smart automotive dash instrument read the different sensors which determine the vehicle status while driving.
- The smart automotive dash instrument will work based on requirements established for each scenario.
- Switching off indicators while driving.
- Only the necessary indicators based on a vehicle fault monitored by the smart automotive dash instrument triggering.
- Sending an audible alert for critical vehicle faults.

Requirement Analysis Process:

In this work, only the functional requirements are shown:

- For requirements representation for the proposed system, a semi-formal notation has been used to comply with the ISO 26262 recommendations and the SysML (Systems Modeling Language) modeling language is used.

Functional requirement 01:

REQ001 Startup System. As per driver's voice smart automotive dash instrument shall perform initial internal diagnostics. Next functional requirements shall be validated:

- *REQ003:* Oil Pressure validation.
- *REQ004:* Fuel Level Validation.
- *REQ005:* Temperature Monitor.
- *REQ006:* Tires Pressure.
- *REQ007:* Battery Level.
- *REQ008:* Brakes Fluid Level.
- *REQ009:* Speed Control.

Based on each functional requirement's result, the final status about functionality on smart automotive dash instrument, the main indicator shall be defined as:

- *LED Green:* The smart automotive dash instrument is working properly.
- *LED Yellow:* The smart automotive dash instrument is getting warning issue with some monitoring indicators, in this case the required action is, maintain LED indicator ON.
- *LED Red:* smart automotive dash instrument is getting a critical situation with some monitoring indicators, in this case the required actions are, maintain LED indicator ON and an auditory alarm shall be generated during 10 seconds for 3 times (Figure 12).

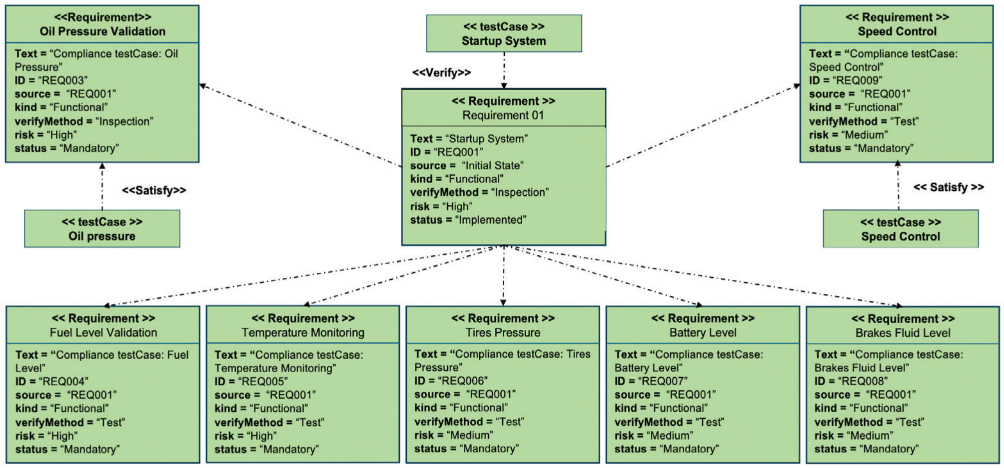

Figure 12. Functional requirement 01-system startup

Warning functional requirements:

For each of the next requirements defined as warning. This is, *REQ004, REQ006 and REQ009.* One functional requirement was created as follow. Monitor from smart automotive dash instrument system shall take basic information analogously from this kind of sensors.

If the smart automotive dash instrument could get analogous information from its sensor, then OK status shall be defined in green status, otherwise NOT OK status shall be defined in yellow status. An example is shown in Figure 13 and its State Machine Diagram is shown in Figure 14.

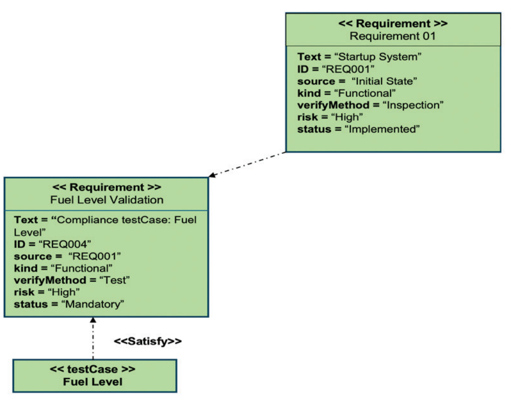

Figure 13. Warning functional requirement

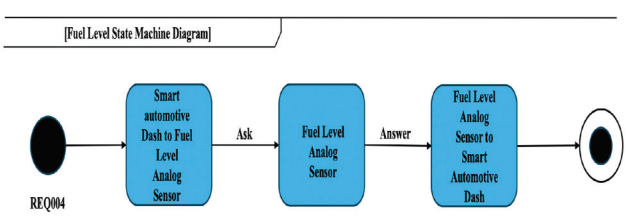

Figure 14. State machine diagram example for warning functional requirement

Critical functional requirements:

For each of the next requirements defined as critical. This is, *REQ003, REQ005, REQ007 and REQ008.* One functional requirement was created as follow. Validation monitor from smart automotive dash instrument system shall take basic information analogously from this kind of sensors.

If the smart automotive dash instrument could get analogous information from its sensor, then OK status shall be defined in green status, otherwise NOT OK status shall be defined in red status. An example is showed in Figure 15 and its State Machine Diagram is showed in Figure 16.

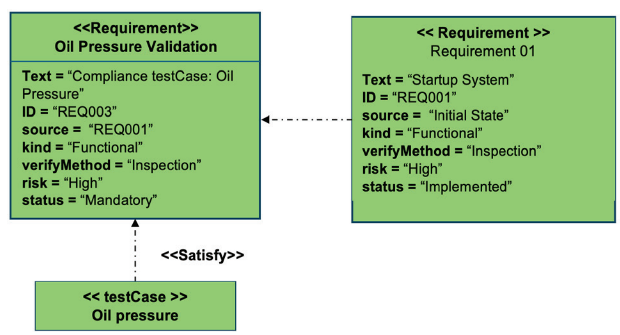

Figure 15. Example of critical functional requirement

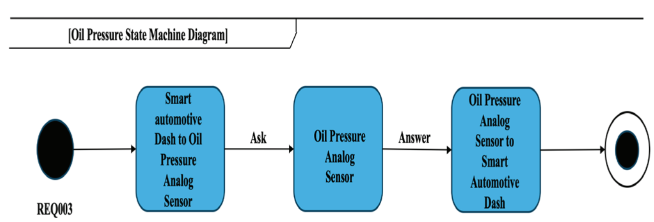

Figure 16. State machine diagram example for critical functional requirement

https://doi.org/10.22201/fi.25940732e.2024.25.2.016

Use cases:

In this section, the requirements details are added through the basic flow and the alternative flow to each use case shown (Tables 10, 11, 12 and Figures 17, 18, 19).

Table 10. Use case 01

Use case	UC01
Description	System Activation - Vehicle Parked
Pictogram (*car dashboard icons - Bing,* s/f) (*What Do Dashboard Warning Lights in My Car Mean?*, s/f)	
Basic flow	Voice prompts the start smart automotive dash instruments: REQ001, REQ002, REQ003, REQ004, REQ005, REQ006, REQ007 and REQ008 Internal execution If the Smart Automotive Dash LED is Green, then the system is up and running If the Smart Automotive Dash LED is Yellow, then system has an internal warning error
Alternative flow	If LED Green, then smart automotive dash instrument shall work during drivers' conduction If LED is Red, then car's sensors shall be reviewed

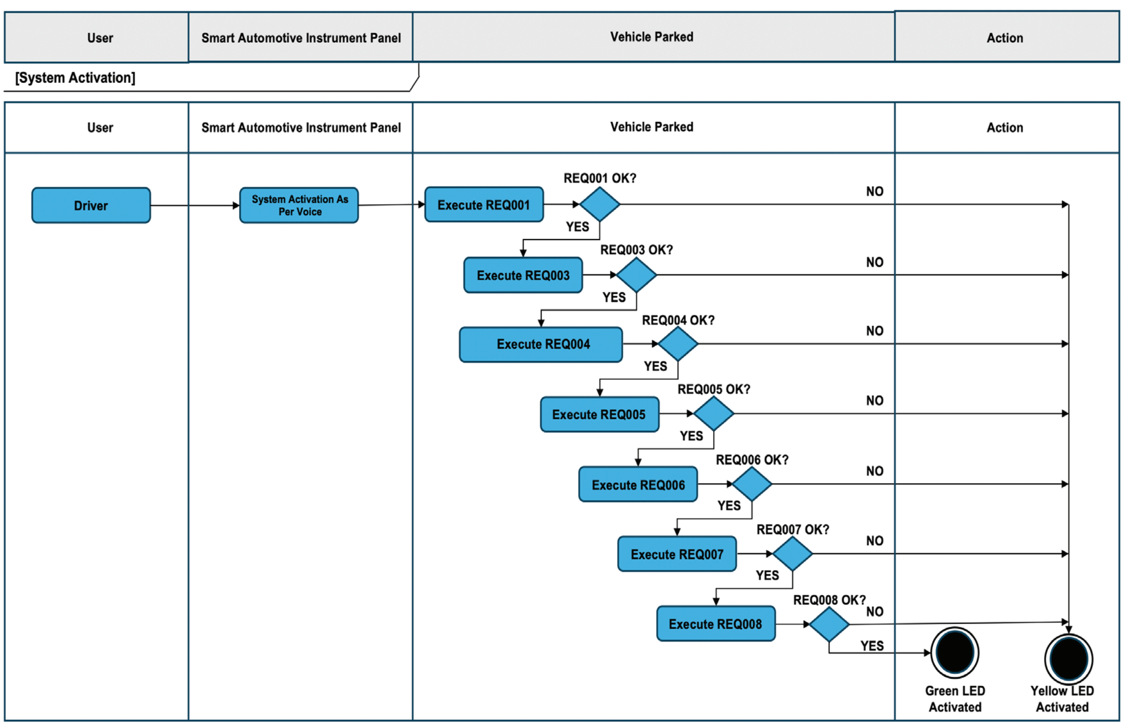

Figure 17. Activity diagram use case 01

Table 11. Use Case 02

Use case	UC02
Description	Starting the vehicle
Pictogram (*car dashboard icons - Bing*, s/f) (*What Do Dashboard Warning Lights in My Car Mean?*, s/f)	
Basic flow	Smart automotive dash instrument shall hide all parameters when vehicle is in motion: REQ001, REQ002, REQ003, REQ004, REQ005, REQ006, REQ007 and REQ008 perform internal execution If the Smart Automotive Dash LED is green, then Icon Lights from REQ001, REQ002, REQ003, REQ004, REQ005, REQ006, REQ007 and REQ008 shall Off
Alternative flow	If smart automotive dash instrument detect a malfunction during the travel path: If the Smart Automotive Dash LED is Yellow, then Icon Light from REQ004, REQ006, or REQ009 shall ON If the Smart Automotive Dash LED is Red, then Icon Light from REQ003, REQ005, REQ007 or REQ008 shall ON & auditive alarm shall sound

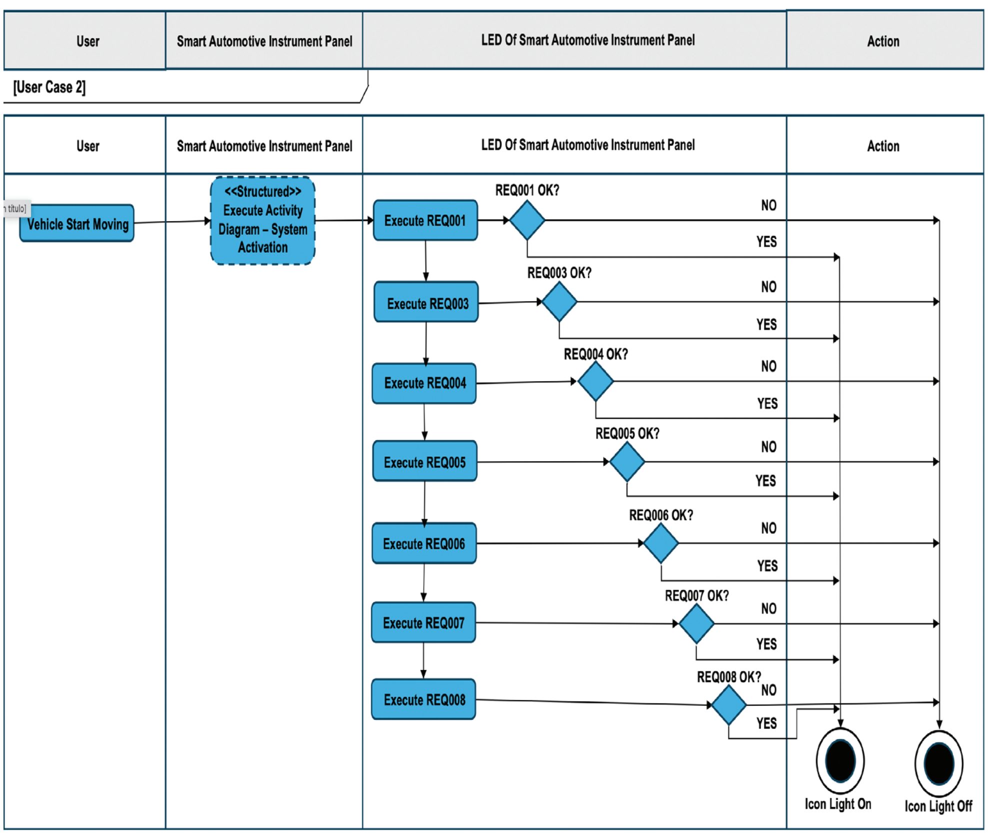

Figure 18. Activity diagram use case 02

Table 12. Use Case 03

Use case	UC03
Description	A warning or critical condition generation while driving
Pictogram (*car dashboard icons - Bing*, s/f) (*What Do Dashboard Warning Lights in My Car Mean?*, s/f)	
Basic flow	Smart automotive dash instrument shall unhide all parameters when the vehicle is in motion, in case of:
	REQ001, REQ002, REQ003, REQ004, REQ005, REQ006, REQ007 and REQ008 perform its internal execution, and everything is working properly
	If the Smart Automotive Dash LED is green maintain hide the icon
Alternative flow	If the Smart Automotive Dash instrument detects a malfunction during the travel path.
	Depending on the failure severity level:
	If the Smart Automotive Dash LED is Yellow, this for REQ004, REQ006, or REQ009 then Icon Light shall ON
	If the Smart Automotive Dash LED is Red for REQ003, REQ005, REQ007 or REQ008, then additional to Icon Light shall ON and the smart automotive dash instrument shall generate an auditory alarm 3 times
	On the third time the system shall enter in emergency mode where the vehicle shall not accelerate more than 40 kilometers per hour only for REQ003 and REQ005

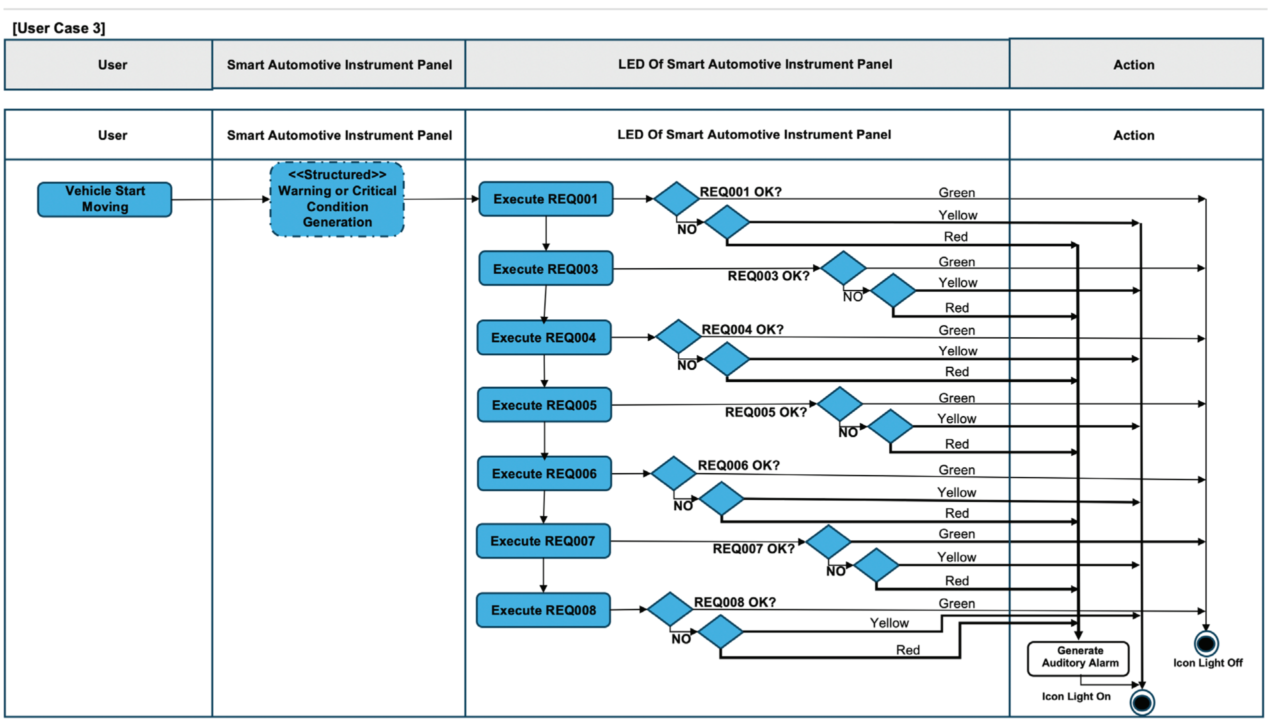

Figure 19. Activity diagram use case 03

Discussion

The discussion of the results obtained from the systematic literature review process and the initial survey application will be detailed in this section. Both studies provided answers to the following research questions:

RQ1: What are the factors that generate distracted driving?

It was identified that there are activities that generate distractions while driving, as described in section results.

RQ2: What are the consequences with distracted driving?

High number of deaths caused by auditory, visual, physical and/or cognitive distractions while driving and high number of temporary and permanent physical injuries to drivers and passengers caused by distractions while driving.

RQ3: What kind of alternatives could decrease distracted driving?

From the systematic literature review. The references consulted number shows the need to generate development proposals to reduce distracted driving, because although there are currently several technological solutions to prevent accidents, it was identified those solutions are reactive, this is, solutions that act during an accident or after an accident, such as speed reduction systems or road departure warning, other solutions send warnings and help messages when a person has crashed, but in general, those technological solutions are activated to help drivers during or after the accident occurs.

This research paper is proposing a proactive solution to reduce distracted driving.

With both results gotten, the scrum methodology was selected for the technological proposal generation, It is worth mentioning that the present work only focused on design of the smart automotive dash instruments, so this work was focused on the functional requirements, the functional design of the system; the modeling of the solution via SysML; the state machine diagrams; the components specification; and the generation of use cases to define of the sequence of actions.

To reduce distracted driving, the smart automotive dash instrument will hide its information to avoid visual and physical distraction, however, the car main system monitoring will be in full operation by the smart automotive dash instrument. When a problem is detected in the vehicle, it will only send the minimum necessary information to the driver, in case of failures at warning level only the corresponding indicator will light up and in case of critical alerts, the smart automotive dash instrument will also send an audible alarm for three times according to the requirements defined.

Conclusion

After following the systematic literature review process, we can conclude that despite the existence of technological solutions developed to date, automotive accidents continue to increase day by day due to distractors that generate many accidents.

The survey's results showed that the greatest distractors are cognitive, visual and physical. As described in section methodology.

Future work

The present work is focused to design a technological solution through scrum methodology to design a smart automotive dash instrument with the purpose to reduce distracted driving caused by visual, auditory, physical or cognitive distractors.

As future work, the scrum methodology will continue to be applied to work on the implementation and testing phases of the smart automotive dash instrument.

The objectives will be to have the smart automotive dash instrument prototype up and running.

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