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Industrial Application

Safe Car System

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Contents

1 Introduction

Keeping the car safe inside has now become a goal of many car manufacturers. More and more devices are being implemented in the cockpits to make driving as safe as possible. With the passage of time and the advent of artificial intelligence, solutions have become more and more numerous. The solutions proposed within this study, allow the development of a 360 degree safety system, not only considering the moment of driving but also the situations in which the car is in a state of arrest. The project deals with trying to develop a system that through the use of artificial intelligence is able to categorize different situations within the car. The aspect that is always kept at the center of the development is the safety of those who are inside, therefore considering both people and pets. The system will try to adapt to different situations of danger through the devices, for example sound signals or activation of controllers to always maintain the highest level of safety. The main objective is to try to constantly control the driver and try to classify situations in which the driver may be distracted.

2 Market Analysis

Market analysis permits to understand segments where the product can be inserted. The system is a *safe car system*, that is partially covered already from other car brands. However, all the solutions adopted by them lacks in some consideration. The following table show, the main competitors on this field, with their system.

Driver monitoring system		✓			
Tired alerting control	✓		✓		✓
Dog mode				✓	
Cabin Camera		✓		✓	✓

Figure 1: competitor

As the image shows the brands that are taken into account are:

- volkswagen
- volvo
- audi
- tesla
- bmw

The system that need to be considered are:

- Driver monitoring system
- Tierd alerting control
- Dog Mode
- Cabin camera

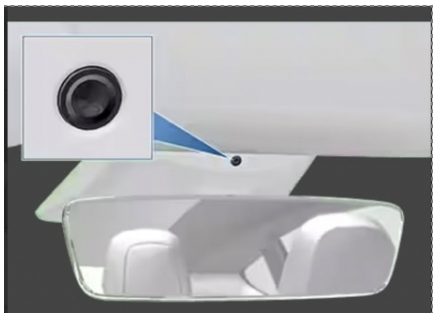
2.1 Tesla Dog Mode

- The car will control the HVAC to keep the vehicle at the selected temperature.
- Once activated, a message will display on the car's screen.
- Active if your car charge level is above 20%. If battery reaches 20% and Dog mode is active, Tesla will send you a notification on your phone.
- The heater or air conditioner is getting power directly from your car's battery.

`https://www.notateslaapp.com/tesla-reference/603/tesla-dog-mode-everything-you-want-to-know`

This system has been appreciated from the community, but it is still a beta and to set the system it isn't so simple, the overall accessibility needs some skill on the interface that they propose.

2.2 Tesla Cabin Camera



- Can determine driver inattentiveness and provide you with audible alerts.
- Images and video from the camera do not leave the vehicle.
- No facial recognition or other method of verification.
- Setting: Controls > Software > Data Sharing > Allow Cabin Camera Analytics.

This system provide an alert and monitoring system that performs well but the camera is not always able to works and recognize different situation but it works only under certain situation, for example due to sharp changes in angular speed, or in the event of collisions.

2.3 Volvo and BMW Driver monitoring System

- Detects signs of fatigue and distraction using a small infrared camera the size of a webcam.
- Driver's face analysis
- Limiting the car's speed, alerting the Volvo on Call assistance service and actively slowing down and safely parking the car.

As the history of these brands confirm, they are often precursors of new technologies as in this case. This system has the ability to detect the driver's status through images.
`https://www.media.volvocars.com/global/en-gb/media/pressreleases/250015/volvo-cars-to-deploy-in-car-cameras-and-intervention-against-intoxication-distraction`

2.4 Volkswagen Audi and BMW Tired alerting control

- At the beginning of each trip, the system analyses factors such as the driver's characteristic steering behavior.
- Continuously evaluates signals such as the steering angle.
- Deviations from the steering behavior registered at the beginning of the trip, optical and acoustic alarms are initiated.

This type of solution is wide spread because it is cheap considering that is a mechanic solution and for this reason also very effective. The main drawbacks is that it use only analog signals, so the situation that can be discovered and handled are not to much.

2.5 Pricing

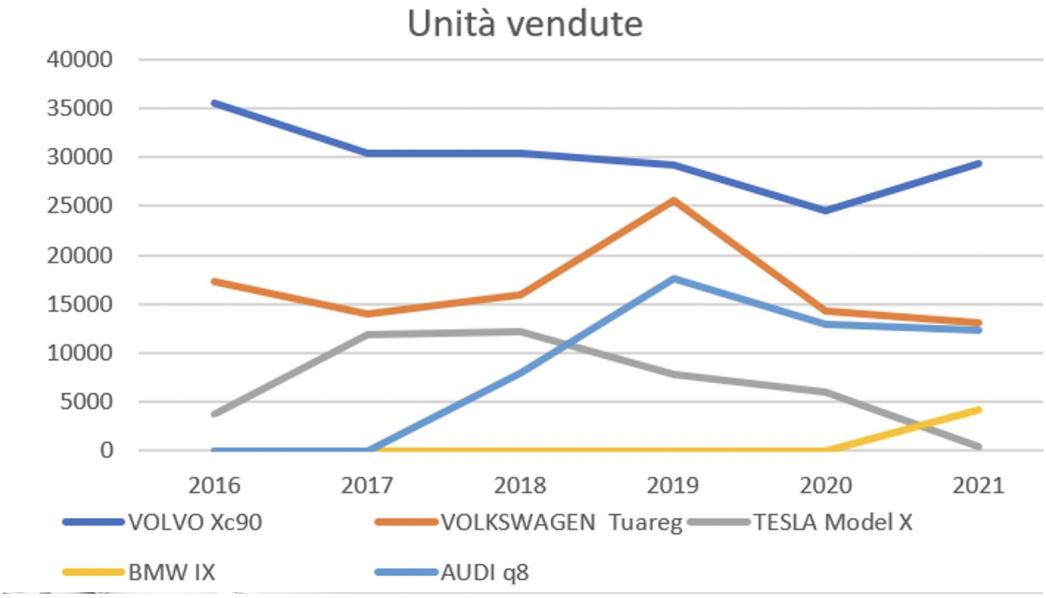
The solutions analyzed so far underline that only t*top* brands implement these type of systems. It is important to understand the pricing strategy to create a system that can enter in a easy way in the market. The cars that implement safe car system for these top brands are:

- Volkswagen passat : 33.000€
- Volkswagen tuareg : 76.000€
- Bmw ix : 84.000€
- Volvo xc40-xc60 : from 30.000€ to 70.000€
- Audi Q(classes) : from 40.000€ to 90.000€
- Audi Model(classes) : from 55.000€ to 120.000€

To understand the price of the safe system a backwards strategy it is applied.
The cost show above are cost applied on the market, so the real cost that the brands pay to create their car is roughly the 60% of that. Removing cost for mechanical part and other services the cost for a safety system are the following:

	Upper Bound Price
Audi	4 500 – 9 000
	3 000 – 7 200
VOLVO	3 600 – 8 400
BMW	9 720
TESLA	8 250 – 18 000

The real cost are not available and open source so the number reported on the table are only estimates. Together with these numbers to complete the analysis it is important to consider the volumes of sales of the different brands.



`https://carsalesbase.com/europe-aiways/` The plot show the volume of cars sold in Europe during the last six years. Volvo is the brand that dominate over all the others, and their car cover a large range from cars to SUVs and the price are not so expensive. Indeed, Volvo represents the major creators for safety system. Considering that the segment in which our product must be inserted is that relating to the bands covered by Volvo, therefore medium-high, considering also the approximate price of their safety system.

2.6 Quality of Service

The system must represent and give to users an high sentience of quality. Considering the caregory of the system and the main indicators of quality `https://www.istat.it/it/files/2018/06/approfondimento-metodologico.pdf`

Accessibility	high accessibility allows the user to easily use the system
Classification Results	excellent performance at the classification level are necessary although annoying for the user, but are quality index
Notification System	maintain high reliability for the notification system
Portability	develop a portable system that can be easily used via app or integrated with car application

The image show the main features that the system must optimize as much as possible to encounter and match the standard of quality. Portability, Classification Results and Notification System must consider as indicator **Allocation rate (for main variables), Timeliness of final data and Punctuality** Accessibility, instead, must respect the standard of simple application that can be widely used from different category of person.

TASSO DI MANCATA RISPOSTA TOTALE

La mancata risposta totale rappresenta un tentativo fallimento completo nell'ottenere l'informazione desiderata da una unità eleggibile

$$\text{Tasso di mancata risposta totale} = \frac{\textit{Unità non rispondenti} + \alpha \cdot \textit{Unità non risolte}}{\textit{Unità rispondenti} + \textit{Unità non rispondenti} + \alpha \cdot \textit{Unità non risolte}} \cdot 100$$

dove:

Unità non risolte: un'unità è non risolta se in corso di rilevazione non è stato possibile accertare nemmeno se era eleggibile o meno (spesso chiamate anche unità con eleggibilità sconosciuta)

Rispondenti: unità eleggibile per la quale è stato possibile rilevare l'informazione

Non Rispondenti: unità eleggibile per la quale non è stato possibile rilevare l'informazione

α (alpha) = frazione delle unità non risolte che si stimano essere eleggibili. Eurostat raccomanda di porre *α=1.*

TEMPESTIVITÀ

Per "tempestività" si intende il periodo temporale, misurato in giorni di calendario, che intercorre fra l'evento o il fenomeno descritto dai dati e quando essi vengono resi disponibili agli utenti.

$$\text{Tempestività dati provvisori (gg)} = \textit{Data Pubblicazione Dati Provvisori} - \textit{Data di Riferimento dei dati}$$

$$\text{Tempestività dati definitivi (gg)} = \textit{Data Pubblicazione Dati Definitivi} - \textit{Data di Riferimento dei dati}$$

dove:

Data di Pubblicazione Dati Provvisori: data di pubblicazione dei dati provvisori che possono essere resi disponibili in vari formati (come ad esempio volumi, dati online, etc.). Ci si riferisce alla prima versione dei dati provvisori resa disponibile

Data di Pubblicazione Dati Definitivi: data di pubblicazione effettiva dei dati definitivi che possono essere resi disponibili in vari formati (come ad esempio volumi, dati online, etc.). Ci si riferisce alla prima versione dei dati definitivi resa disponibile

Data di Riferimento dei dati: ultimo giorno del periodo di riferimento a cui sono riferiti i dati resi disponibili.

INDICATORE DI COERENZA

L'indicatore di coerenza permette di confrontare il risultato ottenuto dal processo statistico di riferimento con quello proveniente da una fonte esterna, qualora disponibile.

$$\text{Indicatore di Coerenza} = \frac{\text{Valore della stima nel processo di riferimento} - \text{Valore della stima nella fonte di confronto}}{\text{Valore della stima nella fonte di confronto}} \cdot 100$$

3 Specifications of the system

3.1 Functional Requirements

Considering the Unconscious abandonment features baby, dog and Distraction caused by dialogue.

1. The user can activate the functions provided by Safe Car System at will.
2. When the car is switched off, the Safe Car System identifies situations of abandonment of an animal or child in the passenger compartment.
3. Safe Car System records the dialogues inside the passenger compartment.
4. Safe Car System observes the driver's mood mode through its dialogues.
5. Mood mode labeled negative driver involves the activation of a sound inside the passenger compartment.

3.2 Non-functional requirements

1. Software highly portable.
2. Any malfunction of Safe Car accessory devices (AI, microphones, led ...) must not be a source of danger to persons inside the passenger compartment.
3. The devices implemented in the machine do not need to carry out any maintenance for the first 5 years of life.
4. A service of Safe Car intervenes on cases of evident danger, few False Positives are admitted ($<$ 1
5. The software must be remotely upgradable to resolve any bugs or implement performance improvements.
6. The energy consumed by Safe Car system must not exceed 10Wh.
7. Dialogues and images collected during the activity of Safe Car system must be protected from privacy
8. The UDB system will be operated by its own battery which will power the system when the machine is switched off, and will be recharged by the main battery while the machine is moving.
9. The battery that will support the UDB system, according to analysis, with a minimum amperage of 15Ah and maximum 20ah.
10. The UDB system must have a maximum consumption of 200mah.
11. The cost of the Safe Car System product must not exceed 1500€.
12. The system must be based on a computerised system with response times in the order of tenths of a second.
13. When the machine is switched off, the system must be based on a 10kw rechargeable battery.

14. Make available an interface for the categories of users Mechanic (A), Car Renter (C), installer/manufacturer (A), law enforcement (B) and health services (B). [correction: introduce features for each specific category]
15. The electronic devices implemented in the passenger compartment (microphones, video cameras) must be difficult to reach by common vehicle users, so as to minimize the likelihood of accidental tampering or damage that would lead to an overall malfunction of the entire Safe Car product.

3.3 General Settings

1. The user must access the application of the car to register and provide information necessary for the setting of the Safe Car System.
2. The required information will require a face/face mapping drivers and their voices.

3.4 Unconscious abandonment baby, dog (UBD)

System for detecting the presence of animals or children in the car.

1. The system is activated when the car is switched off and stopped.
2. The threshold is initially maintained on 50db.
3. Once the threshold is exceeded the system will lower it to 5db.
4. The system accepts a false positive rate of less than 3
5. Using a voice detection system, spectrograms are compared recorded by the microphone with spectrograms stored (DB on-board computer) of voices that classify situations of danger by artificial intelligence that will offer as output "danger" "not danger". [1]
6. In case of "danger" send a notification on smartphone.
7. In case of "danger" the user can activate the camera of the car.
8. In case of "danger" the system registers a new entry in the file "UBD" containing:
   - timestamp
   - GPS position
   - internal temperature
   - filename recorded since the current threshold was exceeded, in order to be analysed by categories of users specified in X of functional requirements
9. The GSM module is connected to the control board (e.g. Arduino) and serves as a means of sending notifications to the stored mobile phone number.
10. The UDB system battery will provide the amps needed to keep the system running.

[1] The pretrained network: `https:///github.com/flashlight/wav2letter`. For more details there is the documentation `https://github.com/flashlight/flash/light/tree/main/flash/app/asr/tutorial`
[2] The system architecture will be as follows (https:///www.irjet.net/archives/V4/i3/IRJET-V4I3638.pdf).

3.5 Distraction caused by dialogue

System that can detect whether the driver is talking to a passenger inside the car. Such action involves a significant lowering of concentration that can lead to accidents and harm to people both inside and outside the car. This system uses a microphone to detect the presence of multiple voices inside the car to determine if a dialogue between people is going on while driving.

1. The microphone responsible for listening to dialogue from the driver is activated when the machine has a speed greater than 20km/h.
2. Initial setup using the car application. Enable microphone and wait for reading of the voice configuration text
3. The microphone, with a cadence of 2 minutes, listens for 20 of any dialogues inside the machine.
4. If the driver's voice and a passenger's voice with an average signal strength of 5db are detected, the mood mode verification shall be activated.
5. The mood mode, for 30 seconds, shall verify whether the current dialogue is compromising driver driving according to the pretrained neural network [2] trained with the data-set [3].
6. If the dialogue has been labelled as "intense", "lively", "angry" [4], the sound box inside the passenger compartment is activated by issuing an alarm signal with an intensity of 5db for 6 seconds.
7. if the dialogue has been labelled as "intense", "lively", "angry" [4]; the system registers a new entry in the file "DCD" containing:
   - timestamp
   - GPS position
   - internal temperature
   - filename recorded since the conditions specified in 3 were met in order to be analysed by
8. Otherwise, we return to point 3.

[1] The car owner is made to read a specific text so that the system learns to distinguish the driver's voice from other voices

[2] The pretrained network: `https:///github.com/flashlight/wav2letter`. For more details there is the documentation `https://github.com/flashlight/flash/light/tree/main/flash/app/asr/tutorial`

[3] The neural network has been trained on the Multilingual LibriSpeech (MLS) data-set is a large multilingual corpus suitable for speech research. The data-set is derived from read audiobooks from librivox and consists of 8 languages - English, German, Dutch, Spanish, French, Italian, Portuguese, Polish. It is available at OpenSLR.

[4] Potential labels that could return our audio recognition AI.

3.6 Drivers's illness

Driver status recognition functionality.

1. Load control on the pedals. If the load on the brake pedal accelerator is greater than 3kg and the load frequency is continuous for more than 10 seconds, the cameras are activated to check 100frames.
2. Hand position control on steering wheel. Hand position scan every 5 seconds if the position of the hands on the steering wheel is completely missing send message on board computer to the 3 message ignored activate rooms and alert sound of 10db.
3. If one of the two previous checks is successful, start the analysis of the rooms.
4. Rooms can be activated due to a call from the 1 or otherwise they will be activated every 10 seconds for a period of 2 seconds to get 100 frames to process.
5. The mood mode, for 30 seconds, shall verify whether the current driver status is compromising driver according to the pretrained neural network [2] trained with the data-set [3].
6. If the driver status has been labelled as "sleep", "drunk", [4], the car will automatically start to decrease the speed until it will not be completely stopped
7. If the driver status has been labelled as "sleep", "drunk", [4], the system registers a new entry in the file "DCD" containing:
   - timestamp
   - GPS position
   - internal temperature
   - filename recorded since the conditions specified in 3 were met in order to be analysed by
8. Otherwise, we return to point 3.

[4] Potential labels that could return our image recognition AI.

4 Technology Devices and Enabling Technologies

The system is represented by a series of closely interconnected modules. Need therefore enabling devices able to communicate with each other via bluetooth and GSM.

4.1 Enabling Technologies

In the study of the enabling technologies necessary for the development of the system:

1. **INTERNET OF THINGS**, use of technologies that permit to communicate over the different modules of the system using the classical protocol that are defined for low pan and lossy network.
2. **CYBER-SECURITY AND BUSINESS CONTINUITY**, new security rules to protect data, increasingly exposed to the risk of compromise for the many internal and external interconnections.
3. **BIG DATA AND ANALYTICS**,analysis of data to optimize execution processes.
4. **SIMULATION**, simulation between intelligent and interconnected machines to increase productivity and optimize processes

How to use simulation?

- Monitor how it works, day by day, minute by minute, the flow of materials and tools of a your department or your entire factory.
- Design, prototype and engineer the products, also performing specific tests such as analysis of data stream, network and mechanical system.
- Simulate industrial environments to optimize work processes, to understand the situations of risk or to train employees to manage and interact with the workspace.

How to use the Industrial Internet of Things?

- Connect machines of different lines via sensors, collect data in real time, and analyze them in real time to predict upcoming problems and schedule an intervention before it crashes the plant.
- Connect the data of the production machine to an application that, from the machine console, provides telemetry data and production metrics designed to be understood and managed directly by the operator.
- Equip machines with sensors capable of performing remote actuation operations, such as adjustment of production parameters.
- Equip the system with sensors that anticipate a fault and keep track of usage and performance, in order to plan and improve more and more the after-sales assistance and the management of spare parts.

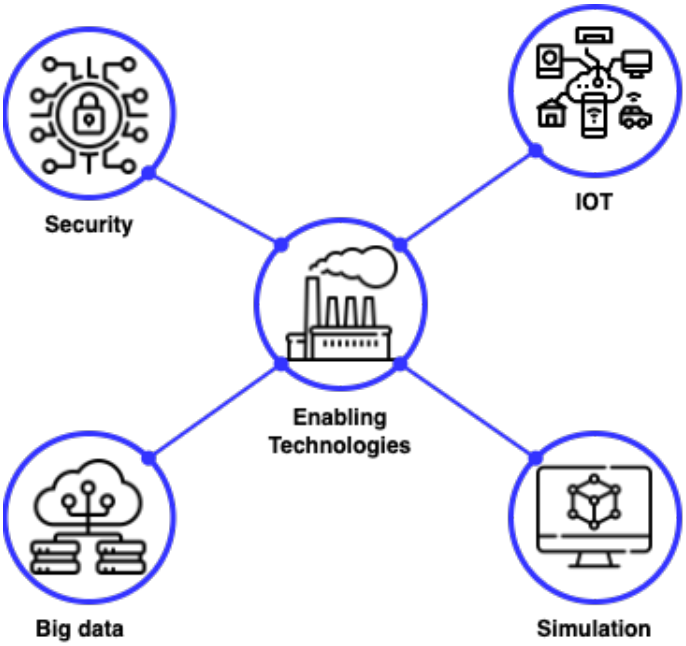
How to use Cyber security?

- Use up-to-date and comprehensive security software for both the office and office environment production.
- Train staff in the proper management of digital activities and identities.

- Reduce the risk of human error and personal data theft, with solutions such as Cloud or Signature Digital.

How to use Big Data?

- Use algorithms on plant data to minimize stops, optimize processes and identify likely critical issues.
- Study user behavior data emerging from Google Analytics.



4.2 Devices

To perform properly, the system needs some devices. The devices are selected considering their properties and the integration with the Specifications.

1. Use of a wide-angle camera, 170 vol. arranged.
2. Microphones.
3. Mini PC low cost
4. Mini PC other cost following high reliability certifications EN 1090-1:2009+A1:201

4.2.1 Mini Pc

(a) pc-architecture

Tecnologia di memoria	LPDDR4
Tipologia di memoria computer	DDR4 SDRAM
Memoria massima supportata	8 GB
Clock di Memoria	2133 MHz
Dimensioni Hard-Disk	128 GB
Descrizione Hard-Disk	HDD
Interfaccia Hard-Disk	USB 3.0
Velocità di rotazione disco rigido	1.00
Interfaccia scheda grafica	Integrato
Tipo di connettività	Wi-Fi
Tipo wireless	802.11a/b/g/n/ac
Wattaggio	8 watt
Piattaforma Hardware	Linux, Windows
Sistema operativo	Windows
La vita media della batteria (in ore)	5 Anni
Le batterie sono incluse	Si
Capacità della batteria al litio	0.66 Wattora
Confezione della batteria al litio	Batterie imballate con l'apparecchiatura
Voltaggio della batteria al litio	3 Volt
Peso della batteria al litio	1 Grammi
Numero delle celle ai metalli di litio	1
Peso articolo	220 g

Marca	Mele
Produttore	MeLE
serie	Quieter 2Q
Dimensioni prodotto	8 x 2 x 13 cm; 220 grammi
Pile	1 CR2032 pile necessarie. (incluse)
Numero modello articolo	Quieter2Q J4125
Fattore di forma	Fattore di forma ridotto
Risoluzione schermo	3840 x 2160
Marchio processore	Intel
Tipo processore	Celeron
Velocità processore	2 GHz
Numero processori	4
Dimensioni RAM	8 GB

https://www.amazon.it/dp/B09TKMP6QS/ref=sspa_dk_detail_5?pf_rd_p=7d53b420-4ab4-47bf-9f3c-0af37b169282&pf_rd_r=0F2TTM1SMEEN3DHE5SPH&pd_rd_wg=okPeI&pd_rd_w=NmAh0&content-id=am

zn1.sym.7d53b420-4ab4-47bf-9f3c-0af37b169282&pd_rd_r=c01489e1-daa1-4178-8e1c-4821e5a6b3b9&s=pc&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWw&th=1

4.2.2 Camera

Campo visivo	Diagonale da 110°
Risoluzione video	Registra e visualizza video in HD a 1080p sia di giorno che di notte grazie alla visione notturna a infrarossi in HD.
Risoluzione delle foto	Visualizza le immagini acquisite in 630 x 360 nHD.
Frequenza dei fotogrammi	Fino a 30 fotogrammi al secondo
Dimensioni	71 x 71 x 31 mm
Peso	48 grammi
CPU	Brevetto Immedia – AC1002B, 4 core / 200 Mhz
Alimentazione	Batteria della videocamera: 2 batterie AA al litio metallico da 1,5 V (non ricaricabili). Alimentazione del Sync Module 2: Trasformatore da 100-220 V CA a 5 V CC incluso *Durata della batteria fino a 2 anni, basata su 5.882 secondi di Live View, 43.200 secondi di registrazione attivata dal movimento e 4.788 secondi di comunicazione bidirezionale. La durata della batteria varia in base alle impostazioni del dispositivo, all'uso e ai fattori ambientali.
Requisiti	Connessione a Internet ad alta velocità (p. es. a banda larga, fibra o DSL) sempre attiva Rete Wi-Fi: 2,4 GHz 802.11b/g/n
Colori disponibili	Nero

After careful analysis, the camera system will be managed using the model applied by the **mini** brand.
INSTALLATION:

- *Adaptation time*: 120 Minutes
- GPS*Information from the MINI Centre*position

4.3 Milesight 4G Industrial Router UR32 Lite

Hardware System	CPU	ARM Cortex-A7, 528 MHz
	Memory	128 MB DDR3 RAM and 128MB Flash
Cellular Interface	Antenna Connector	1 × 50 Ω SMA Connectors (Center PIN: SMA Female)
	SIM Slots	1(Mini SIM-2FF)
Ethernet Interface	Numbers	1 × WAN + 1 × LAN or 2 × LAN
	Property	1(Mini SIM-2FF)
	Mode	Full or half-duplex (Auto-Sensing)
	PoE	2 × 802.3 af/at PoE PSE on LAN Ports (Optional)

Software	Network Protocols	IPv6, PPP, PPPoE, SNMP v1/v2c/v3, TCP, UDP, DHCP, RIPv1/v2, OSPF, DDNS, VRRP, HTTP, HTTPS, DNS, ARP, QoS, SNTP, Telnet, VLAN, SSH, etc.
	VPN	DMVPN, IPsec, OpenVPN, PPTP, L2TP, GRE
	Security	Access Control, DMZ, Port Mapping, MAC Binding, SPI Firewalls, DoS&DDoS Protection, Filtering(IP&Domain), IP Passthrough
	Management	Web, CLI, SMS, On-demand dial-up, SNMP v1/v2/v3, DeviceHub
	AAA	Radius, Tacacs+, LDAP, Local Authentication
	Multilevel Authority	Multiple Levels of User Authority
	Reliability	VRRP, WAN Failover
Power Supply	Power Connector	2-pin 5.08 mm Terminal Block
	Input Voltage	9-48 VDC, with Surge-Protection and Reverse Polarity Protection
Physical Characteristics	Ingress Protection	IP30
	Housing	Metal
	Dimension	108 x 90 x 26 mm (4.25 x 3.54 x 1.02 in)
	Installation	Desktop, Wall or DIN Rail Mounting

Environmental	Operating Temperature	-40°C to +70°C (-40°F to +158°F) Reduced Cellular Performance Ab
	Storage Temperature	-40°C to +85°C (-40°F to +185°F)
	Ethernet Isolation	1.5 kV RMS
	Relative Humidity	0% to 95% (non-condensing) at 25°C/77°F

After careful analysis, the camera system will be managed using the model applied by the **mini** brand.

https://www.milesight-iot.com/cellular/router/ur32l/

4.3.1 Car Microphone

https://www.amazon.com/FingerLakes-Microphone-Assembly-Vehicle-Bluetooth/dp/B015KY5J7Y

5 Architecture

Depending on the devices and enabling technologies, the system will need a pc placed in the dashboard of the car. Three cameras, one placed in the opposite side of the driver able to clear the situation in the front seats, one in front of the driver to control its status while driving and one arranged in parallel able to view the situation in the rear seats. As for the microphone and considering the listening range, you will need three. One placed close to the driver, in the opposite part of the first camera, while the second and third positioned on the sides of the front seats directed towards the rear seats.

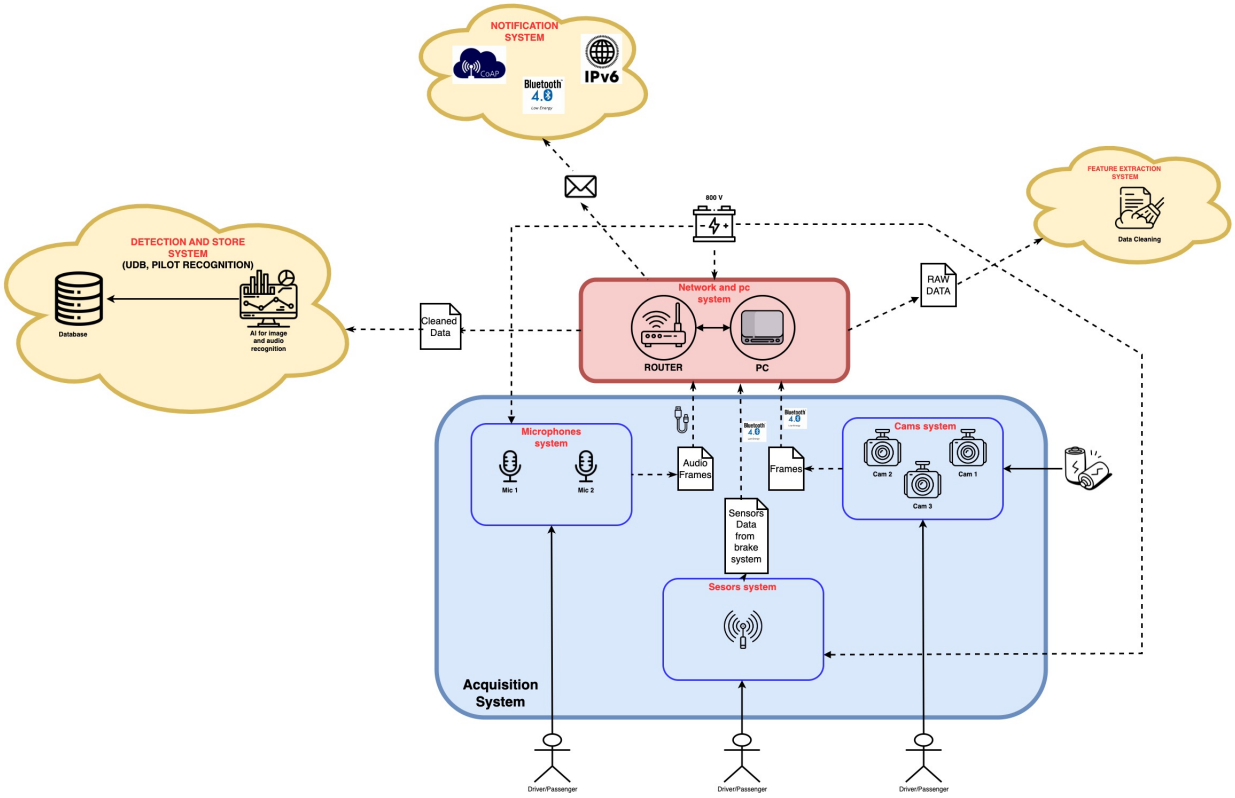


Figure 6: architecture schema

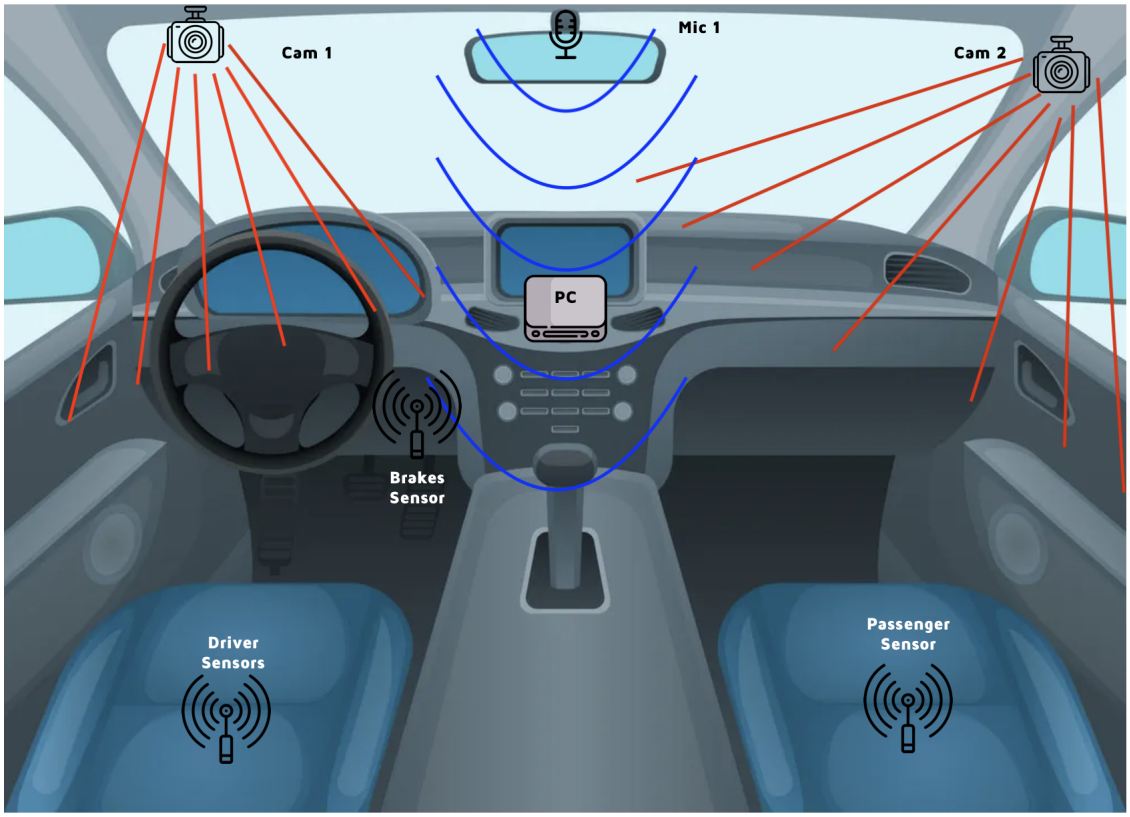


Figure 7: front sits architecture

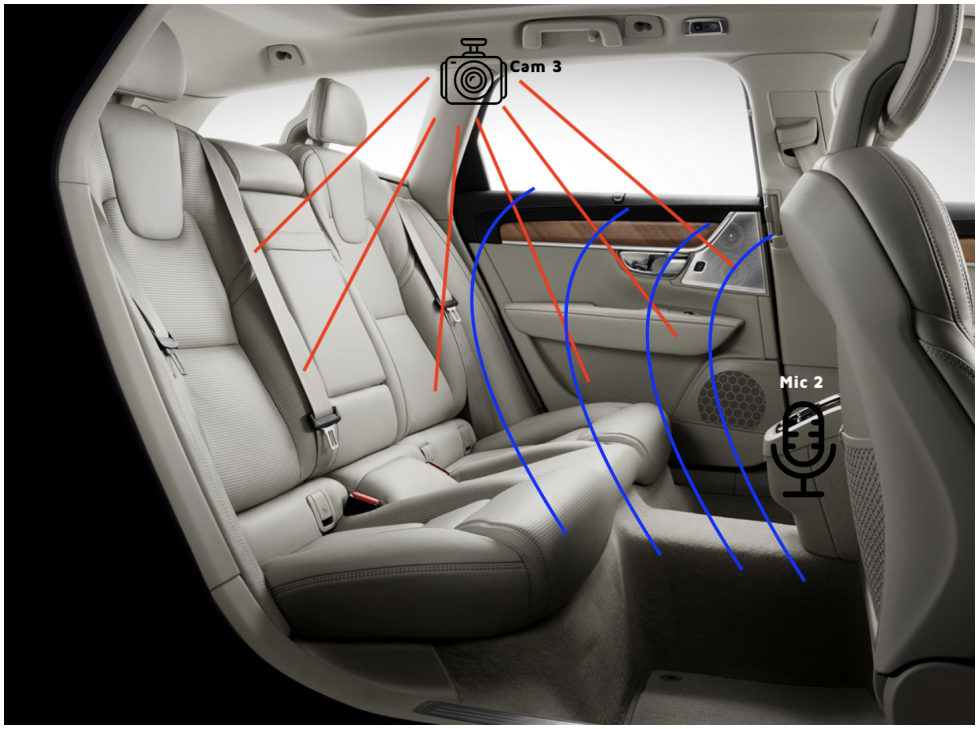


Figure 8: rear sits architecture

The defined architecture will be that of the final model. In the previous images is represented the vision at

the instrumental level of the machine, with the best arrangement according to the metrics described and chosen for rooms, microphones and pc.
As for the power system, the latter will be directly connected to the PC on board, to which are connected microphones, the total fully supported by a battery of 800v and 70 amperage.
During the stop of the vehicle, with the engine off, the system will enter low power mode, which will save on the consumption of the pc. The rooms are powered by own power and communicate via bluetooth with the pc. The batteries are self-contained for 4 years according to the specifications of the chosen devices. The sensor system is the one adopted by volkswagen.
Going deeper(image 5), architecture will consist of a series of autonomous systems.

- **Capture system**(video and audio)
- **Sensor system**
- **Network system and PC's**

The latter, as you can see from the diagram, is divided into sub-systems for network management, data analysis and data computation. The architectural model also shows the user (driver) interaction with the system. Interactions that are always implicit can occur via the two acquisition and sensor systems. The system will also be able to communicate, using the router connected directly with the pc. In this case the router will receive the packets that must be sent to the user when the latter is away from the car for example if the *dog detection* system is activated, or to send notifications by sensors to the pc directly via bluetooth or protocols for low pan and lossy network. The microphones are connected via USB directly to the PC, which will also provide power. Audio data are sent directly via usb connection to the pc. The information that arrives at the PC is then processed to be used by the models loaded on it to carry out the different classifications.

6 Risk Management

Risk management is the process by which risk is measured or estimated and subsequently strategies are developed to manage it. Typically, the strategies employed include transferring the risk to a third party, avoiding the risk, reducing the adverse effect, and ultimately accepting some or all of the consequences of a particular risk.

The nature of the risks depends on the context in which the company operates, in our case we are dealing with sets of technologies necessary to create a product. The final product we want to create is the Safe Car System which corresponds to a mix of technologies deriving from different sectors: Automotive, Artificial Intelligence, Internet of Things, Embedded Systems.

6.1 Risk Identification

The identification of the risks that can influence the operations of the company have been classified according to two categories: **Internal risks** and **External risks**.

6.1.1 Internal Risks

Internal risks, due to problems that occur within the company dynamics.

1) The risk related to the **schedule of tasks** to be developed is related to the non-delivery by a team of a specific result in a certain time interval that has been decided through gaant analysis. The main problem in this situation may depend on a choice of personnel that is not considered suitable for performing that task or for problems within the teams. Considering that the selection of staff will be entrusted to the team of "staff evaluation" directly controlled by the PM who will play a central role in the selection of candidates, The main problem remains that of complicated situations within teams and possible early abandonment by some people. This risk has a **low probability** but the **impact could be big**. The risk is classified at the level of low probability and medium-high impact. The possible solutions adopted in this case are mainly the use of a well-defined project development strategy such as "AGILE", evaluating different delay scenarios and looking for a very accurate schedule through the use of estimation techniques such as GAANT. Risk management will delay the delivery of the results as well as the need to research new figures for the team. The total cost can be estimated considering the hours of work lost and the hours to pay for other teams. If we consider the average salary of a worker within a team that is around 1500 € and the number of working hours needed to complete a task, in case of delay and then delay of the entire project the estimated cost will be:

1500€*(Effectivetime - timeSchedulated)

The costs of employing new workers will be the same as those they will replace.

2) Software Development Environment. With this type of risk risks are considered during the development of the software part of the project. The system that will be developed will be mainly software, so the choice of hardware, development tools and workers' skills will be a crucial point to avoid problems in the creation of the system. The problems that can arise related to this segment are mainly temporal, with delays in the delivery of checkpoints in case of incorrect choices in the choice of tools, hardware or lack of skills by workers. In this

case, in addition to the missed deliveries and therefore delay in the final delivery of the project, there will be to be reconsidered any implementation and analysis choices as well as a new choice of tools to use. The software analysis for the choice of tools and hardware to use will be carried out always considering the latest development technologies and with greater accessibility on the market, the skills by candidates will be considered through reports to know their backgrounds. The system to be developed does not require any particular functionality, it is mainly to develop AI systems that can be managed only with a few tools in the market that use well-known programming languages. Hardware choices can be more complicated as the system will be an embedded system so it will have to interface with external components. However, the main interest will be in the management of the power supply of the system that will take place via the car battery. Batteries in this period, with the advent of the electric, have become very powerful able to deftly support different systems. The estimated consumption by the system can be made considering the consumption of a classic PC on board.
The **probability of this risk will be low, while the impact will be high.** In case of problems due to this situation, the solutions are to carry out a new analysis at the hardware and software level that will impact directly in the delivery time of the product, as well as in a staticity of the various parts of the project. The costs as before regarding the delays can be estimated considering the delay times, while regarding the costs due to hardware and software changes will also be considered the whole part of new instrumental analysis and tools. The new choices will entail costs proportional to the design time of the components of the new system. Considering the expected time for the analysis about 1 month and considering the expenditure due to the analysis team, that will be composed by 4 pepole that are mainly assessor(5000€/months) the final time will be:
1500€*(timeSchedulated - Effectivetime) + 20000€

3) Software Project Requirements. This type of risk is mainly related to the development phase. Considering that the chosen systems are corrected, eventual bugs can incur during the planning. The main problem in this case is due to the lack of choice of programming technologies. To avoid this problem many design patterns are implemented and defined. The number of bugs causes problems in delivery times, as new testing steps will be necessary to confirm the validity of the code. Medium to high probability, low impact. This is a classic problem that occurs in the field of computer development. However, the impact is never very great as experienced workers possess skills to overcome development bugs. In addition, the code will be written using very accessible languages that allow debugging efficiently with software offered by the IDEAS themselves used to program. So if this problem were to arise it would affect the timing but with the techniques explained above the solution will never take too long. In case of excessive extension backup will be use to go and rewrite the part of code that will contain the bug. The cost in this case will be calculated considering the additional time for the delivery of the checkpoint that will hardly ever exceed the week.

6.1.2 External Risks

External risks, i.e. any risk that does not depend on company dynamics but on external factors.
1) **Variation of the General Data Protection Regulation (GDPR)**

The users inside the car contribute to generating data over time, a part of these are useful for diagnosing the functioning of the devices in the car, a part corresponds to personal data. The GDPR regulation and Legislative Decree 101/2018 do not specify specific techniques for data processing. The risk is that in the next few years, the regulation will become more stringent and protective as regards privacy by introducing cryptographic techniques or strong pseudonymisation. The risk is to redesign the data processing mechanism used in the software that manages the Safe Car System. **Solution**: rewrite the packages that make up the data processing software. Extend software development time and testing. Finally, pay a data-processing consultant to ensure that the software complies with the new personal data regulation. **Probability medium impact high.**
The delivery times will lengthen causing delays and therefore additional costs as well as an expense due to the writing of new sections in compliance with the new regulations. The main cost will be due to the search for a supervisor who is able to understand if the new software complies with the regulations. Considering that the salary of a supervisor is around 3000€/month and supervision could take about a month in the worst case the total cost will be: **1500€*(timeSchedulated - Effectivetime) + 3000€**
2) **Silicon price increase.**
The technologies and devices chosen for mass production of the Safe Car System can be rethought due to their excessive price increase. Since we don't want the cost of the marketed product to exceed a certain threshold, we have to rethink replacing those devices that are susceptible to variations in the price of silicon with other devices that are less influenced by the political and commercial tensions of the moment. (eg: the war in Ukraine or the trade squeeze on TaiWan). Solution: designate a set of alternative technologies to those initially designated. Study new technologies suitable for guaranteeing the functional and non-functional requirements of the Safe Car System. Starting over with the tasks related to the development and testing of the Safe Car System. this could be the biggest problem as it would practically block the development of the whole system, to leave room for the search for new technologies. For this reason the probability is high and impact high. **The costs of developing new technologies to replace common hardware are not quantifiable.**

6.1.3 Cost Risk evaluation

Let's estimate the cost to implement the proposed solution to solve the problem of a bad AI (Pilot Health Recognition).

An external consultant has been added to the corporate team. The team is composed as follows:

- 2 Image Data Analys
- 2 Senior ML
- 2 Junior ML
- consulent AI engineer

Indicative daily cost for professional figure:

- Senior Data Analyst, 200 €/d
- Senior Machine Learning Engineer, 264 €/d
- Senior Machine Learning Engineer, 160 €/d

- Artificial Intelligence Consulent, 2500 €/d

Total time to complete the task composed of all related sub-tasks: 95 days.
(1) high quality dataset with low bias cost
(2) ML Consultant Cost
(3) Company Team Cost
(4) Total cost

$$C_1 = 100\,000 \tag{1}$$

$$C_2 = 60 \times 2\,500 = 150\,000 \tag{2}$$

$$C_3 = 200 \times 2 \times 20 + (264 + 160) \times 2 \times 75 = 70\,000 \tag{3}$$

$$C = C_1 + C_2 + C_3 = 320\,000 \tag{4}$$

7 Profiles

The human profiles that will compose the safe-car company are:

- Audio/Image Data Analyst
- AI architect Engineer
- AI Senior Benchmark Assessor
- Junior/Senior Tester Engineer
- Market analyst
- Senior System Requirement Engineer
- Market jurist
- Junior/Senior Machine Learning Engineer
- Audio Engineer
- Junior/Senior SW Engineer
- Senior UIX Designer
- Junior/Senior Data Analyst
- Junior/Senior Front-end Engineer

In particular, since our safe-car system rely on the AI applied in automotive environment the Senior Machine Learning Engineer in Safe-Car will have a solid mathematical background, experience working on a range of classification model, informational retrieval technique in particular for audio and images,clustering, and optimization problems, establishing scalable, efficient, automated processes for large scale data analysis, model development, model validation and model implementation.
The Senior Machine Learning Engineer will work alongside experienced Data Scientists, Data and ML Engineers to identify business opportunities, design and create new data pipelines from scratch, from experiments to deploying them in production.
He/She will be responsible for multiple projects, leading the ML Engineers

8 Work breakdown structure

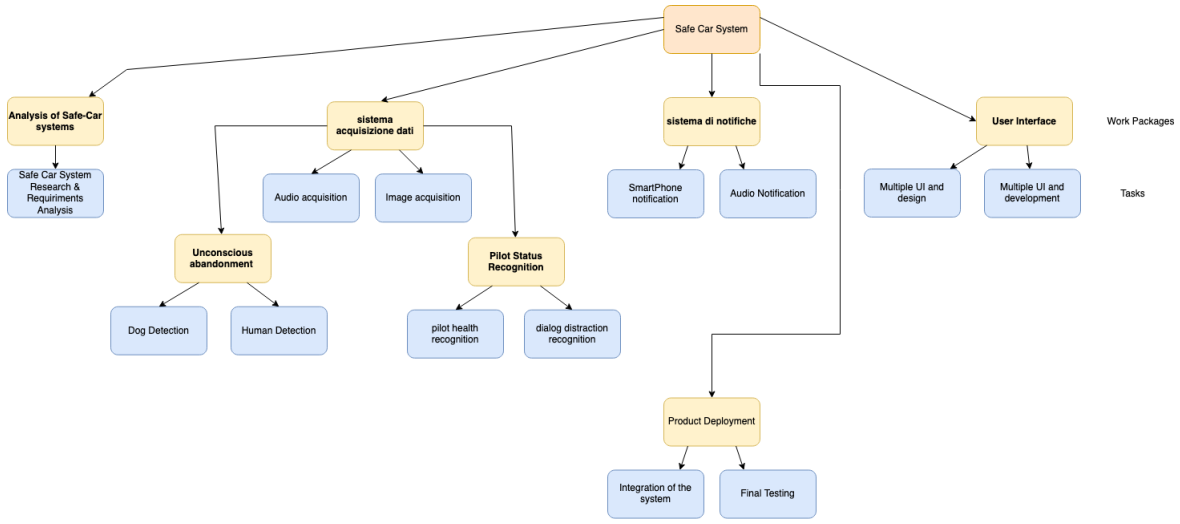


Figure 9: WBS higher layers

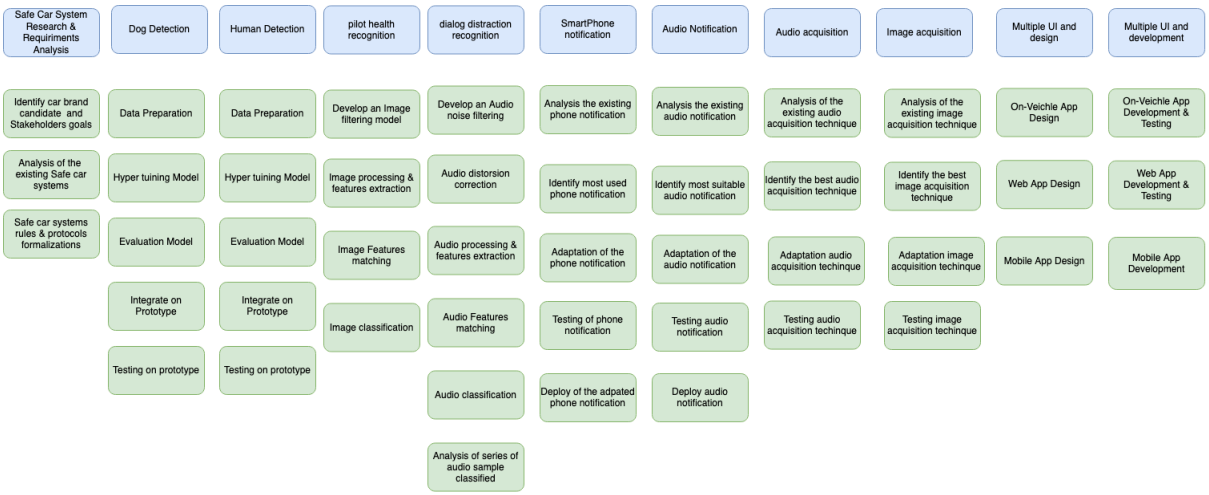


Figure 10: Tasks and their sub-tasks

There will be a Project manager for each Work-Package with the goal of coordinating each task composing and the resource involved in the corresponding work package.
All the costs reported below are retrieved from the `https://www.payscale.com/research/US/Job`

8.1 Safe car systems research and requirement analysis

Objectives : Determine the required certification and regulatory compliance and the functional and non functional requirements of the safe care system.
General Description: Creating a Safe Car system requires help of expert in search for the correct segment and which car brand could support, in term of money our system. Therefore a team of market analyst will help for in-depth analysis. Determine which are the main objective of stakeholders. Analyze the state of the art of existing Car Safe system, considering the main aspect of AI technologies and modern solution using that. Finally, understand type of certification are necessary ad which regulations, rules or standard that must be respected.
In order to visualize rules and market segmentation to develop a Car Safe System a team of legal expert and market analyst must be established.

- User privacy
- User security
- User safeness
- Normative rules for the develop of an AI system

Sub-Tasks	Days	Resource
Identify car brand candidate	30	2x Market Analyst
Analyze existing Safe-car systems	40	4x Senior System Requirement Engineer
Safe-car systems rules & protocols formalizations	10	2x Market jurist

Costs

- Market analyst: 2000€
- Senior System Requirement Engineer: 3500€
- Market jurist: 3000€

8.2 Dog detection

Objectives : Dog detection mode will be develop considering data-set available from prepared data-set. Integration with other information will be done during the test of prototype.
General Description: Creating the Dog Detection implies a team of IA engineers, both data analysts and network developers. Considering the state of the art of Car Safe system, they have to search for data that can be adapted for this system and networks that must fulfill both functional and non functional requirements that are explained on the state of the art.

Sub-Tasks	Days	Resource
Data Preparation	20	2x Audio Data Analysts
HyperTuning Model	15	2x AI architect Engineer
Evaluation Model	5	AI Senior Benchmark Assessor
Integrate on Prototype	25	2x Senior Tester Engineer 2x junior Tester Engineer
Testing on prototype	30	2x Senior Tester Engineer 2x junior Tester Engineer

Costs

- Audio Data Analysts: 2500€
- AI architect Engineer : 3000€
- IA Senior Benchmark Assessor: 5000€
- Junior Tester Engineer: 1500€
- Senior Tester Engineer: 3000€

Tool: Testim for testing; Digital Audio Workstation software for audio manipulation; MatLab, Python, Tensorflow, Keras for AI model

8.3 Human detection

Objectives : Human Detection mode will be developed considering available data-set developed considering data-set from prepared data-set, from sentiment analysis benchmark. Integration with other information will be done during the test of prototype.

General Description: Creating the Human Detection implies a team of IA engineers, both data analysts and network developers. Considering the state of the art of Car Safe system, they have to search for data that can be adapted for this system and networks that must fulfill both functional and non functional requirements that are explained on the state of the art.

Sub-Tasks	Days	Resource
Data Preparation	20	2x Image Data Analysts
HyperTuning Model	15	2x AI architect Engineer
Evaluation Model	5	AI Senior Benchmark Assessor
Integrate on Prototype	25	2x Senior Tester Engineer 2x junior Tester Engineer
Testing on prototype	30	2x Senior Tester Engineer 2x junior Tester Engineer

Costs

- Image Data Analysts: 2500€
- AI architect Engineer : 3000€
- IA Senior Benchmark Assessor: 5000€
- Junior Tester Engineer: 1500€
- Senior Tester Engineer: 3000€

Tool: Testim for testing; MatLab for image manipulation; MatLab, Python Tensorflow, Keras for AI model

8.4 Pilot health recognition

Objectives : Determine the different systems that are able to perform a User recognition with the source of data that the car can generate.
General Description: To create a Pilot Health Recognition a team of expert will collaborate to determine the models that compose the entire system, modelling the different sub-parts. Teams that will be involved on this system must be composed of experts on Image analysis to consider the number of frames that must be used for apply features extraction.
Based on the features extracted a group of Machine learning Engineers develop the classification models to classify correctly the situations.

Sub-Tasks	Days	Resource
Develop Image filering model	20	2x Senior Image Data Analyst
Image processing & features extraction	30	2x senior Machine learning engineer 2x junior Machine learning engineer
Image features matching	25	2x senior Machine learning engineer 2x junior Machine learning engineer
Image classification	20	2x senior Machine learning engineer 2x junior Machine learning engineer

Costs

- Image Data Analysts: 2500€
- Junior Machine Learning engineer : 2000€
- Senior Machine Learning engineer: 3000€

Tool: Testim for testing; MatLab for image manipulation; Matlab, Python Tensorflow, Keras for AI model

8.5 Dialogue distraction recognition

Objectives : Implementation of a model that is able to perform a User voice recognition with the source of data that the car can generate.
General Description: To create a Dialogue Distraction Recognition a team of expert will collaborate to determine the models that compose the entire system, modelling the different sub-parts. Teams that will be involved on this system must be composed of experts on Audio analysis to consider the number of frames that must be used for apply features extraction.
Based on the features extracted a group of Machine learning Engineers develop the classification models to classify correctly the situations.
The task, in particular, focuses on the so-called "audio matching" property of the audio acquisition technique that are analyzed, because we need a medium similarity among the audio samples and the Audio-based DB data. We focus on the audio matching technique because it's important to identify audio samples that are very different from each other but belong to the same class of audio, namely the same human voice but also a person who has health problems, such as breathing difficulties or heart attack. The identified audio acquisition technique must be adapted to the specific audio-sample-kind that have been previously listed. Finally the adapted audio acquisition technique must be tested locally with some audio-example of the safe-car environment.

Sub-Tasks	Days	Resource
Develop audio filtering model	20	2x Senior Audio Engineer
Audio processing and dialogue's features extraction	30	2x senior Machine learning engineer 2x junior Machine learning engineer
Dialogue features matching	25	2x senior Machine learning engineer 2x junior Machine learning engineer
Dialogue classification	20	2x senior Machine learning engineer 2x junior Machine learning engineer

Costs

- Audio engineer : 4800€
- Junior Machine Learning engineer : 2000€
- Senior Machine Learning engineer: 3000€

Tool: Testim for testing; Digital Audio Workstation software for audio manipulation; Python Tensorflow, Keras for AI model; Matlab for audio processing (Fourier Trasformation, spectogram, costellation map, cromagram)

8.6 Smartphone notification

Objectives : Analysis of the existing smartphone notification, Identification adaptation testing and deployment of the smartphone identification

General Description: Evaluation of the several smartphone notification procedures used for safety-critical system and emergency system, identification of the most suited smartphone notification for the emergency-case that the safe-car system wants to handle according to the degree of emergency the safe-care system has detected. Then local testing for each emergency degree case in order to measure the effectiveness and efficiency of the entire smartphone notification system

The Smartphone notification system must handle also the automatic call to police and /or hospital in case of emergency notification has been triggered

Tasks

- Analysis of the smartphone notification technique
- Identification of the best smartphone notification system
- Adaptation to the safe-car system
- Local testing of the audio notification system

Sub-Task	Days	Resource
Analysis of the smartphone notification technique	35	3x senior UIX designer (30 days) 3x junior sw engineer(30 days)
Identification of the best smartphone notification system	20	3x senior UIX designer (20 days) 3x junior sw engineer(20 days)
Adpatation to the safe-car system	30	3x senior UIX designer (30 days) 3x junior sw engineer(30 days)
Local testing of the smartphone notification system	40	3x senior UIX designer (40 days) 3x junior sw engineer(40 days)

Costs

- Junior SW engineer : 6500€
- Senior UIX Designer: 5400€

Tool: Testim for testing; Android Studio for Android smartphone, XCode for iPhone

8.7 Audio notification

Objectives : Analysis of the existing audio notification, Identification adaptation testing and deployment of the audio identification

General Description: This phase is essential to determine the most effective way of alerting the neighborhood of the car. We need to caught the attention of anyone who is in the nearby.

Analysis of the already existing audio notification technique used by the already existing car companies. Subsequently the identification of the most suited audio notification system able to fulfill the requirements of the safe-car-system in case of baby/dog abandonment and Health problems of the driver.

The designed audio notification system is developed and adapted to the several car companies clacson.

Finally a local testing of audio notification technique will be conducted in order to measure the stability and effectiveness of the entire audio notification system

Tasks

- Analysis of the audio notification technique
- Identification of the most suited audio notification technique
- Adaptation to the car audio ecosystem
- Local testing of the audio notification system

Sub-Task	Days	Resource
Analysis of the audio notification technique	35	3x senior Audio engineer (30 days) 2x senior sw engineer(30 days)
Identification of the most suited audio notification system	20	3x senior Audio engineer (20 days) 2x junior sw engineer(20 days)
Adpatation to the car audio ecosytem	30	3x senior Audio engineer (30 days) 2x junior sw engineer(30 days)
Local testing of the audio notifcation system	40	3x senior Audio engineer (40 days) 2x junior sw engineer(40 days)

Costs

- Junior SW engineer : 6500€
- Senior Audio Engineer: 4800€

Tool: Testim for testing; Digital Audio Workstation software and MatLab for audio manipulation in car environment

8.8 Audio acquisition

Objectives : Analysis, Identification, adaptation and testing of the audio acquisition
General Description:This is the initial phase of the audio processing of the Safe-car system. First of all there is the Analysis of the already existing audio acquisition technique in order to identify the best candidate to be embedded in the Safe-car audio-based tool.
The analysis, in particular, focuses on the audio-quality of the audio acquisition technique that are analyzed, because our audio acquisition system has to cop with the noise present in audio cabinet during the drive caused by the possible high-speed of car.
the audio acquisition technique we are looking for must be able to isolate noises, sounds coming from outside the car because the car can be placed in very crowded and therefore noisy places but also quiet and away from external noise.
It must be an effective technique without too much loss of information as the features that we implement deal with situations that occur rarely and without continuity, a sound, lost information would cause a failure to analyze and then a failure to alert via notification system and this could be fatal for those who are inside the car.

Tasks

- Analysis of the audio acquisition technique
- Identification of the most suited audio acquisition technique
- Adpatation to the Safe-car environment tool
- Local testing of the adapted audio acquisition technique

Sub-Task	Days	Resource
Analysis of the audio acquisition technique	35	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Identification of the most suited audio acquisition system	20	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Adpatation to the Safe-car enviromental tool and cases	30	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Local testing of the audio acquisition system	40	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)

Costs

- Junior Data analyst: 5400€
- Senior Data analyst: 7250€

Tool: Testim for testing; Digital Audio Workstation software and MatLab for audio manipulation (Fourier Trasformation, spectogram, costellation map, cromagram)

8.9 Image acquisition

Objectives : Analysis, Identification, adaptation and testing of the image acquisition
General Description:First phase of the image processing of the Safe-car system. First of all there is the Analysis of the already existing image acquisition technique in order to identify the best candidate to be embedded in the Safe-car image-based tool. Since it is car-embedded system we cannot have huge image processing computation, we need to identify techniques that allow to efficiently retrieve images inside car without using too much energy and computation effort which ensures to gather mid-quality images of the driver in order to perform a classification of the status of the driver.
The identified image acquisition technique must be adapted to handle the feature of the safe-car system scenario/environment since we have to deal with huge range of car size and comfort-ability and visibility, we have to deal with the car-in-movement vibration and solicitation. Finally the adapted image acquisition technique must be tested locally with some example of the safe-car environment and scenario

Tasks

- Analysis of the image acquisition technique
- Identification of the most suited image acquisition technique
- Adaptation to the Safe-car environment tool
- Local testing of the adapted image acquisition technique

Sub-Task	Days	Resource
Analysis of the image acquisition technique	35	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Identification of the most suited image acquisition system	20	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Adpatation to the Safe-car enviromental tool and cases	30	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)
Local testing of the image acquisition system	40	3x senior Data Analyst (30 days) 3x junior Data Analyst (30 days)

Costs

- Junior Data analyst: 5400€
- Senior Data analyst: 7250€

Tool: Testim for testing; MatLab for image manipulation (generation of SIFT descriptotr for feature identification, matching)

8.10 Multiple UI Design

Objectives : Establish the design of different multi-modal, flexible and adaptive user interface to implement an effective and ubiquitous interface for Safe-car system users

General Description:First activity will be focused on the identification of main functional and non-functional requirements and technologies to realize each one of the modalities composing the Safe-car system. Subsequently, specification and design documentation will be deployed through a process of derivation starting from the analysis documentation.

Sub-Task	Days	Resource
Ui requirements analysis	20	2x Front-end analysit(15 days)
UI modality & Design specification	25	Senior sw engineer (10 days) 2x Front-end engineer (15 days)

Costs

- Senior Front-end Engineer: 10'000€
- Junior Front-end Engineer: 6500 €

Tool: Overflow, Draw.io

8.11 Multiple UI App Development

Objectives : Implementation and local testing of various client applications for each different specified modality to provide an ubiquitous and pervasive interaction with Safe-car system.
General Description: The entire process of UI APP development will be decomposed in 3 major client application :

- **On-vehicle App:** this client application will be supported by most common widespread infotainment platform, in the context of the future automotive industry, characterized by high performance computing and communication capabilities. This application framework is aimed to provide an easy interaction with the Safe-car on board the vehicle. On-vehicle App contains a branch designed for mechanism and electrician, in order to provide an easy-access to the whole network of sensors and devices composing the whole safe-car system and their status during the review of the car and the safe-car system
- **Web App:** a Web portal designed to provide to the public institute such as police and hospital access to analyze possible data that can be used to retrieve data after an emergency
- **Mobile App:** This application (both Android and IOS version), in addition to extend and make more accessible Safe-car System functionalities for the car owner, is aimed to provide a Quick access to the remote-control functionalities of the safe-car system, in particular the notification system

Each client application development activity will be assigned to a different developer team, under responsibility of assigned senior software engineer, the labour leader.

Tasks

- On-Vehicle App Development & local testing
- Web App Development & local testing
- Mobile App Development & local testing

Sub-Task	Days	Resource
On-Vehicle App Development & local testing	35	2x senior front-end eng. (30 days) 2x junior front-end eng. (30 days)
Web App Development & local testing	20	2x senior front-end eng. (30 days) 2x junior front-end eng. (30 days)
Mobile App Development & local testing	30	2x senior front-end eng. (30 days) 2x junior front-end eng. (30 days)

Costs

- Senior Front-end Engineer: 10'000€
- Junior Front-end Engineer: 6500 €

Tool: CSS, Adobe PhotoShop and Illustrator, Figma, Overflow, Draw.io, Java IDE such as NetBeans, IntelliJ

9 GANTT Chart

Figure 11: GANTT Chart