DESIGN PROJECT III

DESIGN OF OVERLAY AUGMENTED REALITY WINDSHIELD FOR LONG HAUL TRUCKS

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MOBILITY AND VEHICLE DESIGN
(2018-2020)

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Arun Babu :
Date :

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

Heads-up display (HUD) systems can project information on the windshield, tell you where to turn, notify you of lane markings, identify how close the car in front of you and even give you restaurant information all right in front of your eyes — and while you're actually able to see those objects or places. It displays all the information you usually see on your dashboard like speed, engine revs, and various types of gauges, etc.

It's purpose is to provide all the crucial information in the field of view of the driver to facilitate reduce the distractions while driving. The idea is that the driver will get all the information where he needs to see them.

1 PRELIMINARY RESEARCH

Objective of this research was to understand the history of HUD, its present status and future possiblities in automotive context. For this, various types of HUDs in cars and its underlying technologies are studied. For understanding the future of HUD, a study was conducted on what automotive tech giants are doing in the same field.

1.1. ORIGIN OF 'HUD'

"IF YOU'RE DISTRACTED WHILE DRIVING, IT IS DIFFICULT TO SHOOT YOUR ENEMY. !!

"If you're distracted while driving, it is difficult to shoot your enemy. !!" During World War II — a notoriously distracting period in human history — this profound observation provoked the development of a variety of largely mechanical user aids that we now categorize as "head-up displays" (HUDs): effectively transparent information displays that allowed fighter and bomber pilots to keep their attention on the actual horizon, not the gauges or handheld maps inside the cockpit, the better to put bullets into enemies or bombs on top of their war stuff.

At the beginning of World War II, airplane armament was aimed using reflector sights and gyroscopically stabilized reticles that could "lead" a target — clever stuff, but not hugely advanced over technology used during the previous World War. By the end of WWII, some bombers had onboard microwave radar systems with television-based displays, although only a select number of specialized night flyers, like the zippy wooden-framed de Havilland Mosquito, were equipped with what we

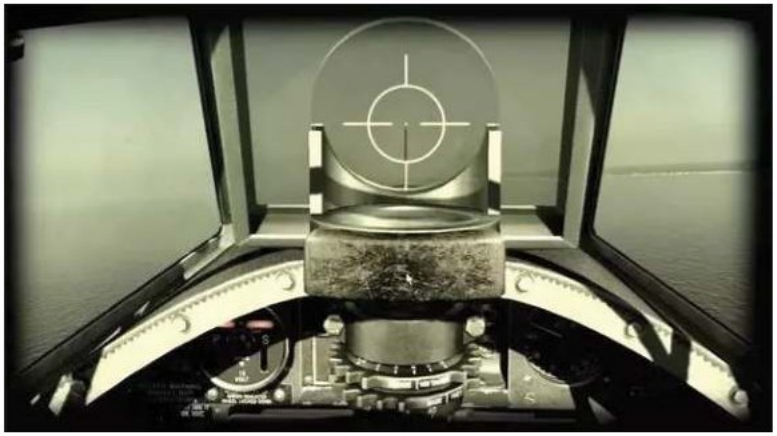


Fig.1:
Reflector sight in a WW2 fighter jet plane. This scope had adjustable crosshairs which were reflected from another mirror. As the source light was from reflected, we could illuminate the image, giving an illuminated crosshair.

would consider to be a true HUD, which reflected the radar information, including an artificial horizon, onto a piece of glass just in front of the pilot controls.

1.2. HUD IN AUTOMOBILES

While postwar engineers continued to develop the HUD for the burgeoning commercial aircraft market, it didn't take too long before automakers — staffed by many veterans themselves — began to see the utility of a HUD in a car, albeit at an abbreviated pace.

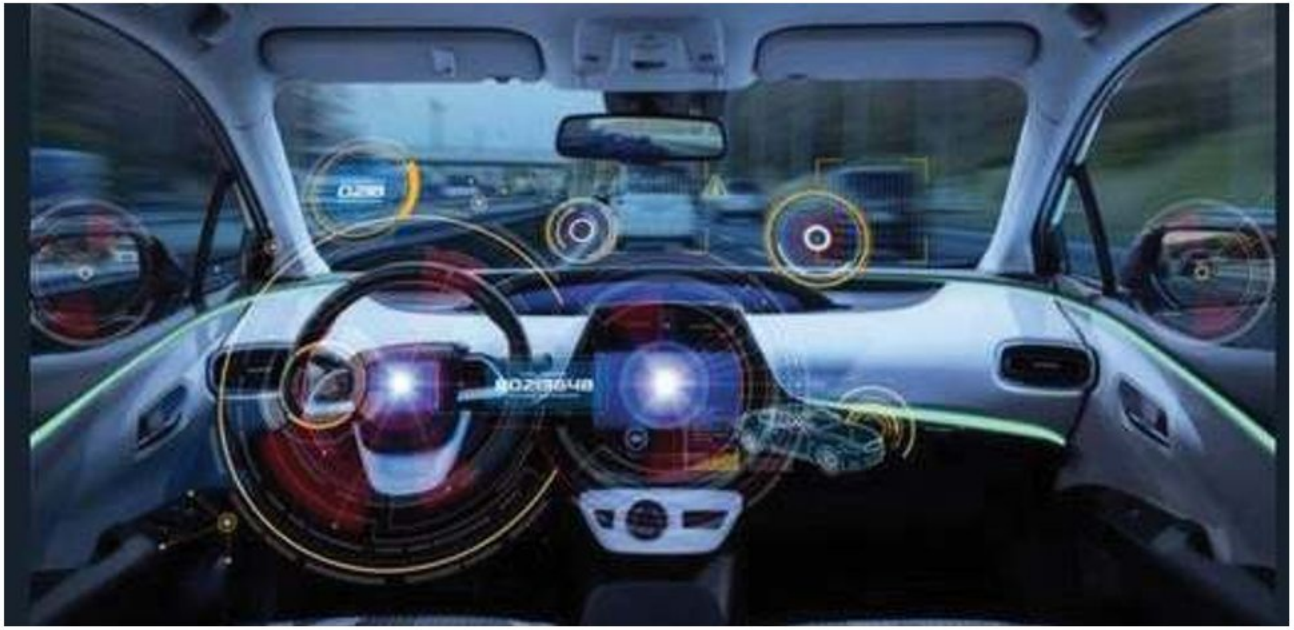
Designers at General Motors were at least sketching out the idea of putting a HUD in a vehicle by 1965, during the concepting for the Mako Shark II, a concept car that informed the curves of the late-'60s, early-'70s C3 Chevrolet Corvette. However, the HUD never made it off the page into any Mako Shark II concept car that was actually built.

Fig.2: (Left)
An early head-up display in a Chevrolet Corvette XP-856 Aero Coupe concept car from 1965 or 1966

Fig.3: (Right)
The HUD on the 1988 Oldsmobile Cutlass Supreme, Indy Pace Car Edition.

It would take over 20 years before a regular car buyer could actually purchase a car with a head-up display. After the acquisition of Hughes Aircraft by General Motors in 1985, and a subsequent merger with GM's in-house electronics division Delco, the faintly phosphorescent stars aligned: Fifty 1988 Oldsmobile Cutlass Convertibles (Indy Pace Car Edition) were equipped with a Hughes-derived head-up display that projected a digital speedometer and turn-signal indicators onto the windshield. (Full disclosure: I've done freelance work with General Motors in the past.) General Motors hired legendary test pilot Chuck Yeager to drive the drop-top Cutlass around the track to really tie together the whole aircraft lineage story during the car's launch, and soon began to offer a HUD as an option in cars across the company's various car brands (including Corvettes), although technically Nissan beat them to market for first mass-market car HUD, with the 1989 model 240SX and Maxima.

Fig.4:
Extreme futuristic HUD concepts like the image on right side could serve as entertainment hub in autonomous and semi autonomous vehicles



These days, almost every luxury car brand offers at least an optional head-up display that does pretty much the same thing: reflect some information from a small TFT panel onto the windshield, usually something similar to what is shown on the instrument cluster display — speed, GPS-guided turn-by-turn directions, maybe what song is streaming through Spotify.

All cars and trucks will one day display more information in the HUD, and it might extend much wider on the windshield. We'll have to adjust to this over time, because having data for current music playback, speed, navigation, lane-keeping, and other settings all displayed at the same time in a long row might be seriously distracting.

Fig.5:
HUD in modern day fighter jet aircraft. It is a combination of static and volumetric projection of data. The target lock symbol will always stay in the line of sight between the pilotand target by using head tracking.

1.3. TECHNOLOGY BEHIND AUTOMOTIVE HUD'S

"THE HEAD-UP DISPLAY MARKET IS ESTIMATED TO GROW FROM USD 1.3 BILLION IN 2018 TO USD 4.7 BILLION BY 2023"

In 2012 Pioneer Corporation introduced a HUD navigation system that replaces the driver side sun visor and visually overlays animations of conditions ahead; a form of augmented reality (AR).Developed by Pioneer Corporation, AR-HUD became the first aftermarket automotive Head-Up Display to use a direct-to-eye laser beam scanning method, also known as virtual retinal display.

In recent years, it has been argued that conventional HUDs will be replaced by holographic AR technologies, such as the ones developed by WayRay that use holographic optical elements (HOE). The HOE allows for a wider field of view while reducing the size of the device and making the solution customizable for any car model.

1.3.1 Static HUD display

As the name suggests static HUD reflects information onto the vehicle's windshield or a separate layer of glass. The reflecting glass panel will have a transparent phospor which reacts when a laser is shining on it. When the laser is off, you don't see anything, but when the light is on the information is projected on the glass. Others use a similar system but incorporate mirrors to project the images on the windshield.

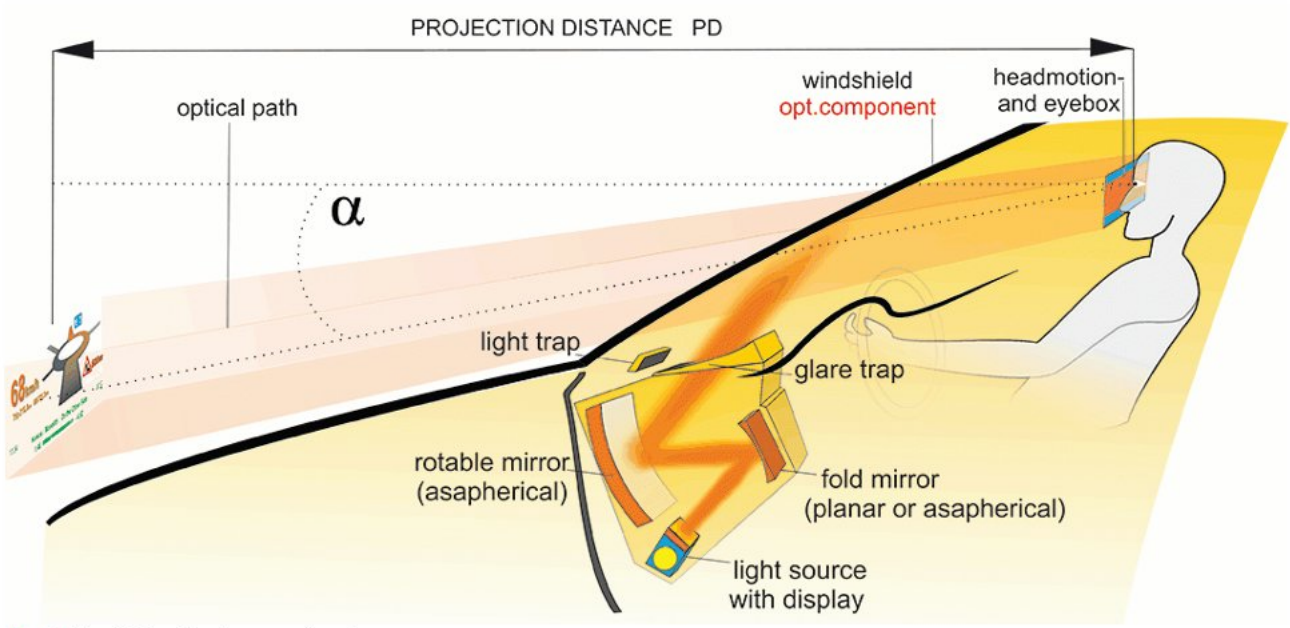


Fig.6: Heads Up Display mechanism

1.3.1.1 In-Car HUD

A display unit is installed below your dashboard which projects the information on a set of mirrors. A glare trap and a light trap are installed to minimize the distractions due to the glare of the external light sources while seeing the image. The set of mirrors consists of a plane mirror usually called the Fold Mirror and spherical mirror. The spherical mirror is rotatable is servers the purpose of magnifying the image to an extent to which it of the right size for the driver to see it properly.HUD NIGHT The spherical mirror then reflects the image on the optical component of the windshield. But there's a catch, the image projected on the windshield is not the final image that

a driver sees.

1.3.1.2 On-Board HUD

While only some of the high-end cars are privileged with an in-car HUD system, the regular car owners don't need to worry. Technology has always had your back. On-board HUD is a device which can be mounted on the top of the dashboard and projects information on its integrated transparent display. The working principle is basically the same. Just a minor difference that instead of displaying the image on the windshield, projects the image on its own transparent screen. Most on-board HUDs work by linking to either your phone's internal GPS or finding a signal of their own from a satellite to find out how fast your car is going at any given time, and

Fig.7: On- Board HUD

display the information back on the windshield. For now, HUDs made by individual companies for aftermarket use are only capable of displaying a rudimentary speedometer, often in mono-chromatic colours which aren't all too pleasing for the eye to be staring at for hours on end.

1.3.2. Volumetric HUD/ Augmented reality HUD

Systems evolved from current HUD technology will eventually transfer virtually all navigation, vehicle-system, informational and even performance-driving guidance onto a beautifully integrated melding of virtual and real-world visuals. Think directional arrows "projected" directly onto the pavement ahead of you, pulsating

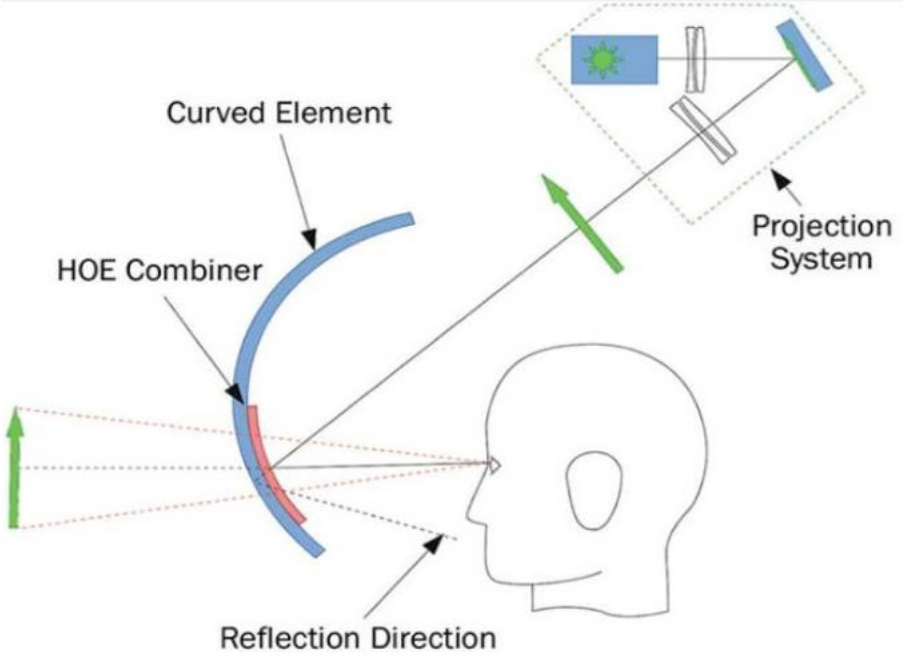


Fig.8: Holographic HUD mechanism

highlights of animals in the road ahead lighting up the windshield or even animated visual callouts of great coffee houses as they go by. All of this displayed on a car's large front glass or even the side and rear windows.

Pioneers in the field like WayRay and Falcon AR had been working on volumetric HUDs since 2012 and both have come up with their own technologies to deliver a truly immersive HUD which projects information onto environment.

The hud developedby wayray uses holographic optical elements to project virtual imagery far ahead of the car, through the windshield. Drivers and passengers view content at a focal distance set from 50ft (15m) to infinity, without having to readjust

Fig.9: AR Hud can project imagery onto real world objects which opens tremendous possibilities.

their eyes between the interface and the dashboard. Their display has an FOV (field of view) of 8^0 X 4^0 to 20^0 X 5^0. The larger the FOV. the more virtual object it covers and more natural the AR feels for driver's. In self driving cars, the display transforms into

Fig.10: Wayray Navion Holographic AR projector

a full-windshield AR infotainment system, with route information, pointsof interest, social media updates, and AR app content.

1.3.3. Radar vs Lidar

Most of the LIDAR system works on the time of flight principle, where laser in pulsed form is targeted onto the object and the reflected or the scattered pulse is measured using the detector. By measuring the time difference between the transmitted and reflected pulse, the distance between the objects can be calculated. Now, as the LASER beam has very low divergence (Less expansion with travel distance)and very short wavelength, it can also be used for scanning of the object. (For 3D mapping and surface scanning applications)

LIDAR	RADAR
Uses laser light rays (Shorter wavelength)	Uses radio frequency (Longer wavelength)
Can provide accurate surface measurements with 3d mapping.	Can fairly identify size and position of object.
Limited usability in harsh environments like fog, rain and snow	Can operate in harsh conditions.
Lower wavelength help in detection of very small objects.	Target size is limited by longer wavelength

1.3.4. V2V Communication system

Vehicular communication systems are computer networks in which vehicles and roadside units are the communicating nodes, providing each other with information, such as safety warnings and traffic information. They can be effective in avoiding accidents and traffic congestion. Both types of nodes are dedicated short-range communications (DSRC) devices. DSRC works in 5.9 GHz band with bandwidth of 75 MHz and approximate range of 300 m. Vehicular communications is usually developed as a part of intelligent transportation systems

1.4. FUTURE OF AR IN VEHICLES

Technology is improving at a faster pace than ever. With time, cost of holographic projects will reduce and also we will see a drastic reduction in its physical size as well. But AR display is only one among the possible applications of AR. In this section, some of the seemingly-crazy concepts of automotive HUDs are studied.

1.4.1. Nissan: Invisible to Visible

"INVISIBLE-TO-VISIBLE VISUALIZES REAL AND VIRTUAL WORLD INFORMATION THROUGH AUGMENTED REALITY TO CREATE THE ULTIMATE CONNECTED-CAR EXPERIENCE FOR DRIVERS AND PASSENGERS"

Invisible-to-Visible (I2V) uses a 3D, augmented reality interface that merges the real world and virtual world to make information visible which the driver would not otherwise see. By connecting to the virtual world (called the Metaverse), Invisible-to-Visible creates limitless possibilities for services and communications that will make driving more convenient, comfortable, and exciting.

Nissan is continuing with I2V research and development, with an initial forecasting of sometime beyond 2025 for the technology to fully emerge.

The I2V focuses on :

1. Visualizing invisible information for a more comfortable and exciting drive.
   Information collected by Nissan's Omni-Sensing Cloud technology, real-time traffic analysis by Nissan's Seamless Autonomous Mobility (SAM) technology, logged driving environment data, and other information is provided into the driver's field of view- allowing the driver to see "invisible" information.

2. Visualizing human-to-human virtual communication for a new connected-car experience.
   People joining through the Metaverse appear as 3D avatars in the real world through MR (Mixed Reality), letting people in both worlds share the experience of space and movement in real-time.

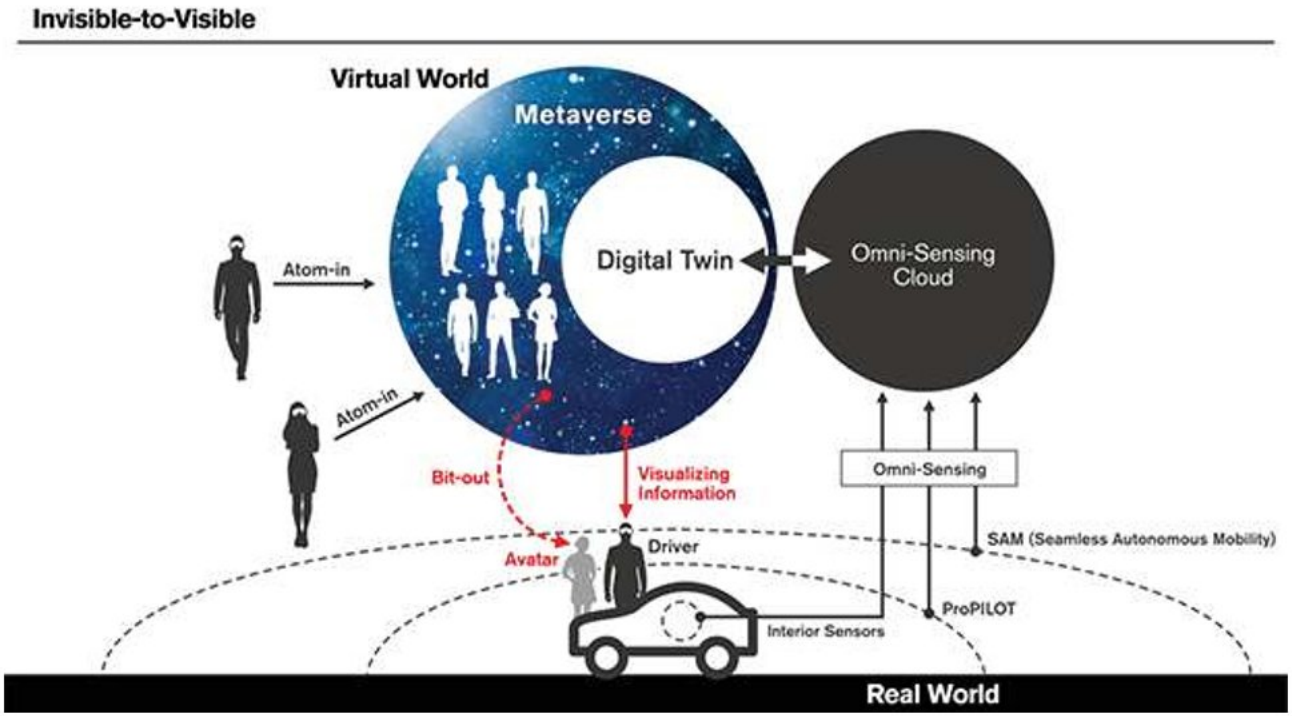


Fig.11: Nissan I2V Universe is more than driving asistance, it ehances the experience by providing a virtual twin of your friend or family to give a social experience.

1.4.2. BMW Natural Interaction

"IF THE DRIVER WANTS TO LEARN MORE ABOUT VEHICLE FUNCTIONS, THEY CAN ALSO POINT TO BUTTONS AND ASK WHAT THEY DO."

The BMW Natural Interaction allows the driver to use their voice, gestures and gaze at the same time in various combinations to interact with their vehicle. The preferred mode of operation can be selected intuitively, according to the situation and context. Voice commands, gestures and the direction of gaze can be reliably detected by the vehicle, combined and the desired operation executed.

This free, multimodal interaction is made possible by speech recognition, optimized sensor technology and context-sensitive analysis of gestures. Spoken instructions

Fig.12: Natural interaction gives the freedom to interact with vehicle and surroundings with gesture and voice commands.

are registered and processed using Natural Language Understanding. An intelligent learning algorithm, which is constantly being refined, combines and interprets the complex information so that the vehicle can respond accordingly. This creates a multimodal interactive experience geared towards the driver's wishes.

The driver decides how they want to interact with the car, based on their own personal preferences, habits or the current situation. So, when the driver is engaged in conversation, they would probably choose gesture and gaze control; when their eyes are on the road, better to rely on speech and gestures. In this way, for example, car windows or the sunroof can be opened or closed, air vents adjusted or a selection made on the Control Display. If the driver wants to learn more about vehicle functions, they can also point to buttons and ask what they do.

1.4.3. Wayray Navion

Navion's True AR is a virtual world around the car that moves and continuously changes in sync with the route. The information displayed in True AR is seamlessly integrated into the real world, allowing the driver to focus on the road and making driving safer.

The holographic optical element created by WayRay is the heart of the device. It's a photopolymer film that retains the properties of a periodic nanostructure after the recording process.

"NAVION RESPONDS TO SIMPLE GESTURES SO THAT THE DRIVER CAN EXECUTE COMMANDS WITHOUT PEERING AT THE DASHBOARD. GESTURE CONTROL LETS THE DRIVER SAFELY BROWSE THE MENU, PICK OR SWITCH ROUTES AND CHOOSE RELEVANT POINTS OF INTEREST."

The integral parameters of this nanostructure give WayRay's holographic optical element unique specifications.

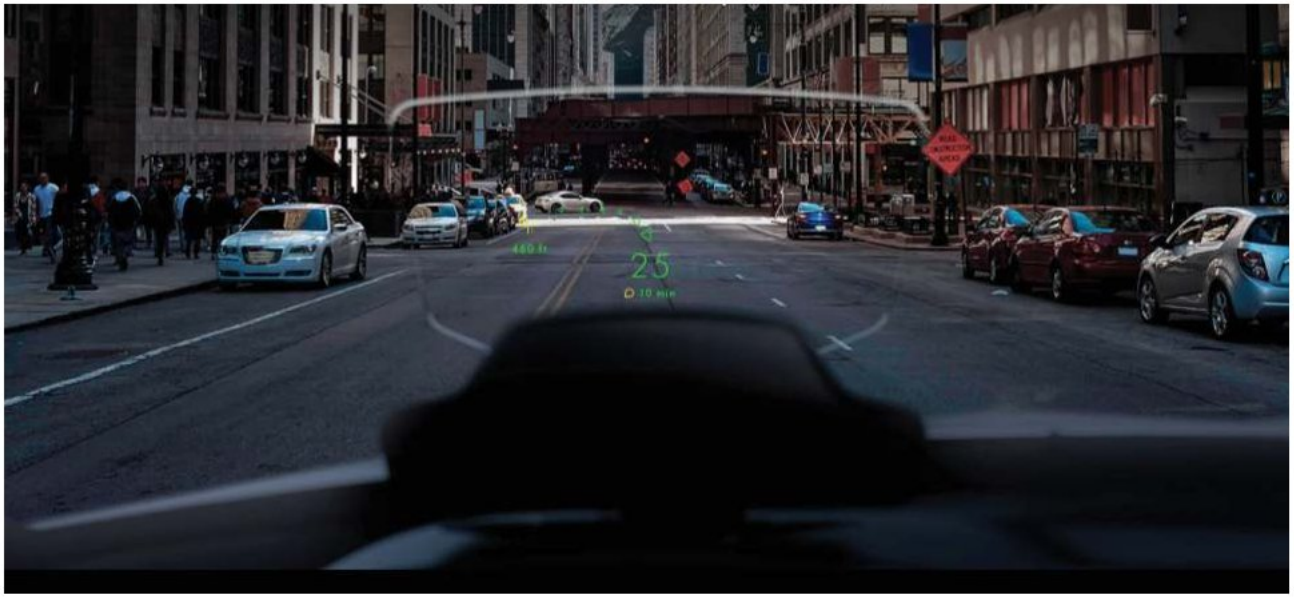


Fig.13: Unlike other concepts, wayray's navion is a more practical solution which really takes the limitations of technology into consideration

1.4.4.TESLA Autopilot

Although tesla autopilot is not an AR HUD, studying the technology which makes the car run on autopilot gave richer insights about how different components can come together to become a robust system.

LiDAR is similar to radar in that it is about judging the distance and relative movement

"LIDAR CAN IDENTIFY A MOVING OBJECT AND IF IT DETECTS ONE, IT WILL INSTRUCT THE CAR TO STOP. BUT IF THE OBJECT WAS A PLASTIC COVER, DO WE NEED THE CAR TO STOP?

THAT IS WHERE CAMERA & RADAR COMBINATION OUTSMARTS AN EXPENSIVE LIDAR"

Fig.14: Tesla's vehicle's currently uses several sources of data to acquire autonomous driving: radar, GPS, maps, ultrasonic sensors and more. But not lidar like some of Tesla's chief competitors.

of objects on the road. Like traditional cameras, it relies on detecting light radiation bounced back from the environment. The biggest difference is that the LiDAR unit itself generates the light source, whereas a camera sensor relies on reflected ambient light, the same as our human eyes do. LiDAR is better than cameras at judging distance and shape of obstacles, but it doesn't really provide incrementally more capabilities than the other three sensors combined. In most cases, it is just a very expensive and redundant backup device.

Despite being a fancy and expensive technology, LiDAR provides surprisingly little advantage over a combination of cameras and radar. Radar, for example, is much better in the rain and other limited visibility scenarios, because it is based on radio waves rather than light waves. Radio can penetrate through some objects and bounce back from others, thereby "seeing" the environment along a different dimension.

Human eyes are perfectly adequate to provide enough information for a sufficiently advanced neural network (e.g., the human brain) to navigate a car in near-real-time. Humans have stereoscopic vision that is pretty good at judging distances, especially when combined with some basic intuitive knowledge of how the physical world operates.

Cameras and silicon-based neural nets have all the information they need to do the same things that humans do when driving a car. AutoPilot is augmented by radar, that can see things that humans cannot see (e.g., the car ahead in heavy fog or rain). It is also augmented by ultrasonic sensors that can detect objects nearby that may not be visible in the cameras, or may be difficult for the cameras to judge distance. They are used primarily for parking, but also detect near proximity of other vehicles while in motion.

1.5. INFERENCE

Tesla has mastered the autopilot technology and today we have a system which can accurately scan the road more efficienty than a human eye. It scans the road, analyses the data and takes the appropriate action. But when it comes to AR technology, the analyzed data has to visually represente to the driver, and this technology is still not saturated as it has to deal with the cognitive workload of humans Some works are trying to establish technological dominance and some focus on the cognitive aspect.

From the preliminary studies, current technologies, limitations and possibilities were identified which gave a good insight of what all technologies we could use for this project.

2 METHODOLOGY

As the project deals with Automotive design, Cognitive sciences and visual ergonomics, it is essential to follow a trusted and proven scientific methodology. Following these methodologies will give a failproof design parameters as it analyzes all the different possibilities of the systm at any certain given scenario.

2.1. COGNITIVE WORK ANALYSIS (CWA)

Cognitive Work Analysis (CWA) is a framework that was developed to model complex sociotechnical work systems. The framework models different types of constraints, building a model of how work could proceed within a given work system. The focus on constraints separates the technique from other approaches to analysis that aim to describe how work is actually conducted, or prescribe how it should be conducted.

The CWA approach can be used to describe the constraints imposed by the purpose of a system, its functional properties, the nature of the activities that are conducted, the roles of the different actors, and their cognitive skills and strategies. Rather than offer a prescribed methodology, the CWA framework instead acts as a toolkit that can be used either individually or in combination with one another, depending upon the analysis needs. These tools are divided between phases. The exact names and scopes of these phases differ slightly dependent on the scope of the analysis; however, the overall scope remains largely the same. As defined by Vicente (1999), the CWA framework comprises five different phases work domain analysis, control task (or activity) analysis, strategies analysis, social organisation and co-operation analysis, and worker competencies analysis.

Although there are five different stages for CWA, for this project only first two phases of the framework was used as it is not a highly complex sociotechnical system. They are further explained below.

2.1.1. Work Domain Analysis

The initial phase within the Cognitive work analysis (CWA) framework, Work Domain Analysis, provides a description of the constraints that govern the purpose and the function of the systems under analysis. The Abstraction Hierarchy (Rasmussen, 1985; Vicente, 1999[1]) is used to provide a context-independent description of the domain. The analyses, and resultant diagrams, are not specific to any particular

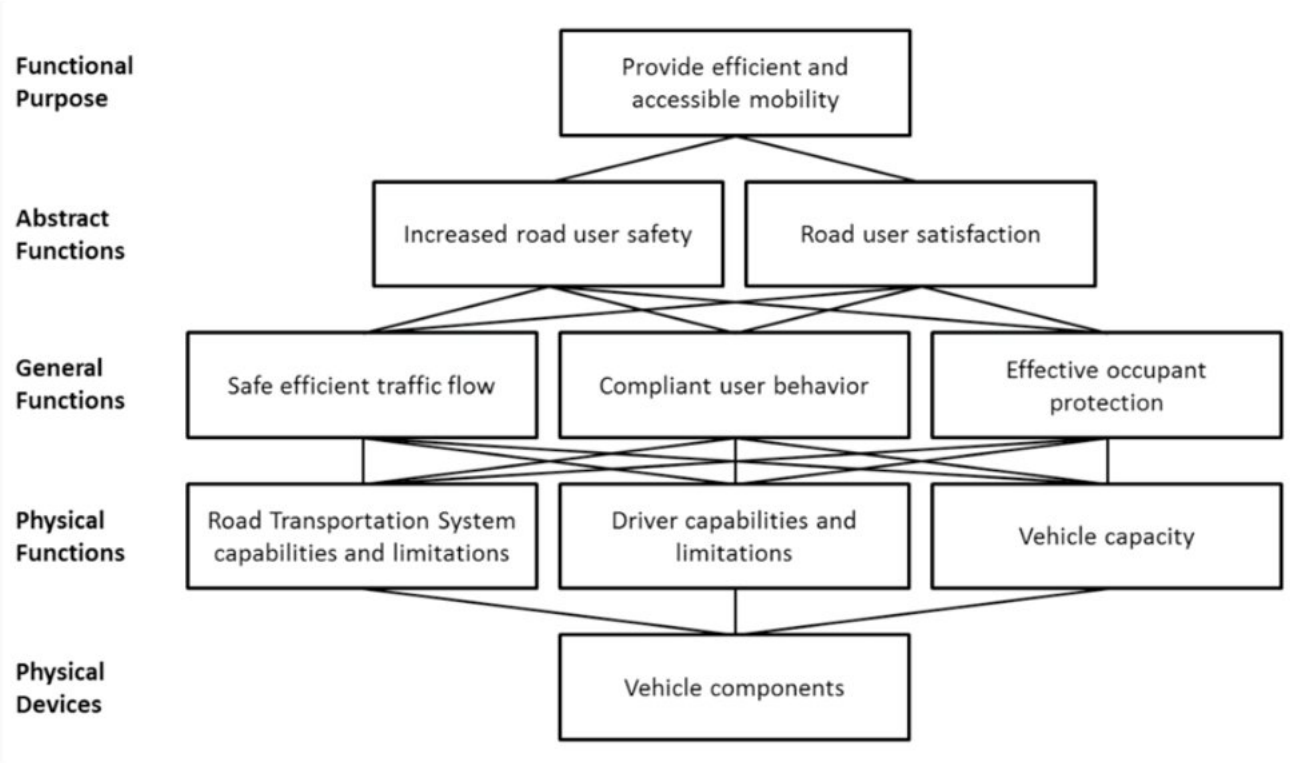


Fig.15: A sample WDA showing levels of abstraction hierarchy.

technology; rather they represent the entire domain. The top-three levels of the diagrams consider the overall objectives of the domain, and what it can achieve, whereas, the bottom-two levels concentrate on the physical components and their affordances. Through a series of 'means-ends' links, it is possible to model how individual components can affect the overall domain purpose. The abstraction hierarchy is constructed by considering the work system's objectives (top-down) and the work system's capabilities (bottom-up). The diagram is constructed based upon a range of data collection opportunities. The exact data collection procedure is dependent on the domain in question and the availability of data. In most cases, the procedure commences with some form of document analysis. Document analysis allows the analyst to gain a basic domain understanding, forming the basis for semi-structured interviews with domain experts. Wherever possible, observation of the work in context is highly recommended.

2.1.2. Control Task Analysis.

Work tasks can be described in terms of the cognitive states established during task execution and the cognitive processes used to effect the transitions between states. A task is something to be achieved, in other words, an outcome (Crandall, Klein & Hoffman, 2006). Work task analysis, also known as control task analysis (Vicente, 1999), is based on the assumption that tasks are accomplished, problems resolved and decisions made via transformations between cognitive states as induced by cognitive processes. Thus, work tasks can be described in terms of the cognitive states established during task execution and the cognitive processes used to effect the transitions between states. The usual product of work task analysis is a suite of decision ladders.

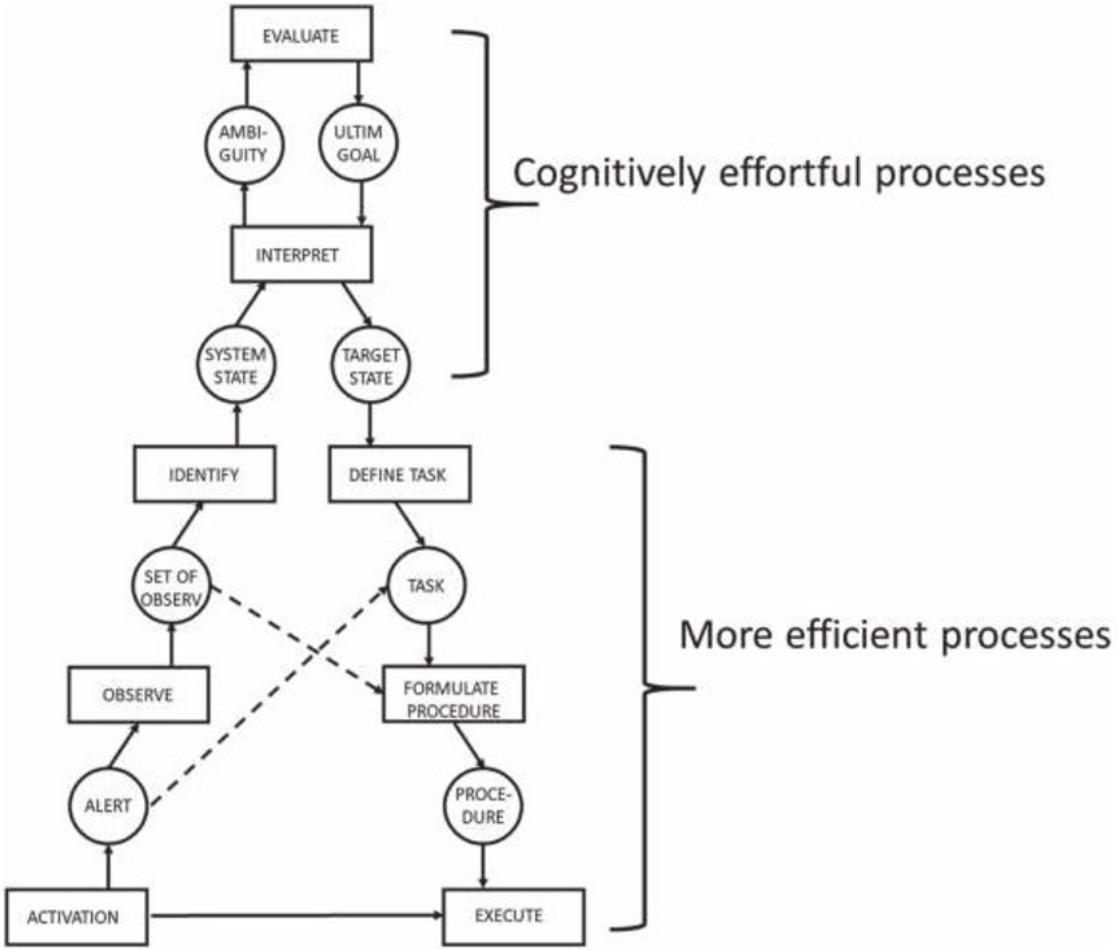


Fig.16: A decision ladder shows the various stages of decision making. A novice user will always the path linearly. But for an experienced user, he can actually skip certain steps. (Shown in dotted lines)

2.2. EXPERIENCE MAP

A user experience map is a method of visualizing the entire end-to-end user experience that an average user will go through in order to accomplish a goal. It's product and service agnostic, so it's used for understanding general human behavior in a larger context. It helps an organization visualize a baseline understanding of an experience prior to taking the particular product or service into consideration.

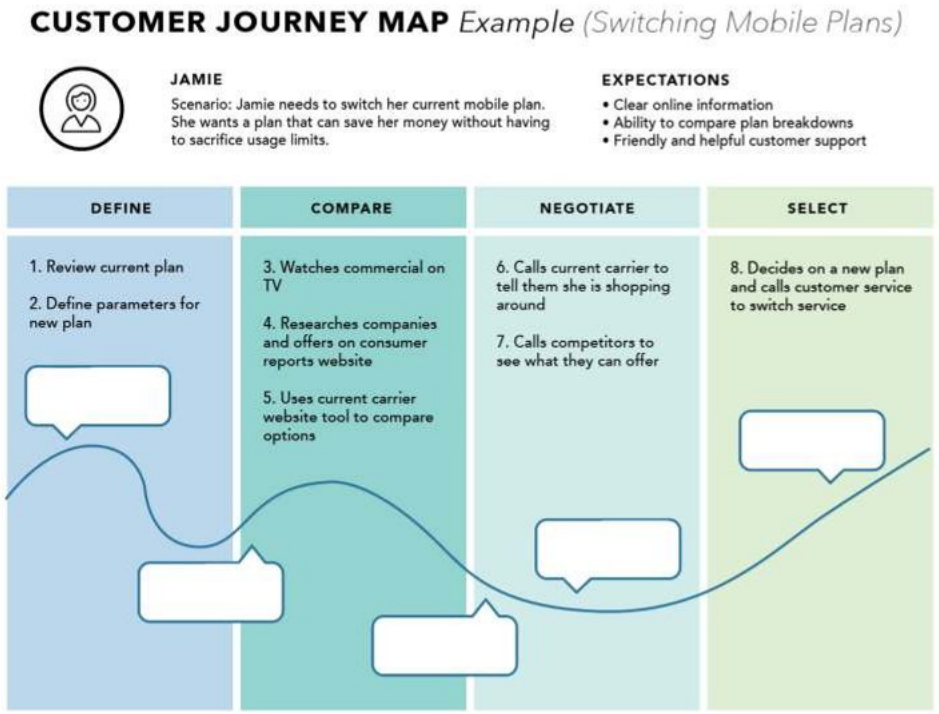


Fig.17: Experience maps focuses on the user experience surrounding a particular product or service as the user goes through the process of accomplishing a particular goal.

3 USER RESEARCH

The Indian truck drivers spend a large period of their life inside the trucks and most of them eat sleep and cook inside the truck. They consider the truck as their home and have an emotional attachment to the machine. For this project with such a context and scenario, it is essential understand how these drivers see the world while sitting behind the driving wheel of a truck, running on a deadline. What all are the issues they face? What can we do with the technology and what all are the design possibilities which could improve their lives?

INTRODUCTION

The research was conducted in truck yards in Vashi and (Cotton green) Wadala in Mumbai suburban. Instead of conducting research with a traditional questionnaire-based approach, it was decided to do it a more informal way. The first few days were spent on observing the whole ecosystem of trucking industry, which has a lot of stakeholders like the truck owner, the driver, the logistics company and parking lot. The first key understanding from the observation was the social structure and hierarchy of power. Drivers are the most ill-fated stakeholder in the system. They fall in the absolute lower tier of power hierarchy and are often cheated by all those above them in the hierarchy.

3.1. COTTON GREEN TRUCK YARD (WADALA)

This yard happens to be right at the brim of cotton green station on a barren land with a lot of warehouses. There are 6 different lanes with multiple entrances to it and each entrance are manned by parking lot officials. Still some drivers happen to enter the lot without a parking pass. Different lanes are for trucks from different locations. Apart from trucks, BMC vehicles and buses are also allowed to park in the lot.
The trucks in this yard are mostly running within Mumbai and the yard happens to be a warehouse for a steel company. Also, in February 2020, a murder happened inside the yard and because of the same, the entire yard is under surveillance.

3.2. VASHI TRUCK YARD

This yard is 4 kilometres away from the Vashi station and happens to be heavily organised place unlike the Wadala truck yard. It has only once entrance and one exit. It has an integrated petrol pump and food joints in the proximity. Also, there are a lot of truck repair shops in the yard making this a perfect place for drivers to stay for a long time safely. The trade-off is a higher parking fee. It became clear that the main issue with the system is lack of trust and lack of transparency. Drivers don't trust the companies and vice versa. Drivers does not know if the payment they are receiving for a consignment is legit or not. Here trucks going in long distance were found. People were playing cards all along.

3.3. STAKE HOLDER INTERVIEW

For understanding the complete system and the social hierarchy, all the stakeholders in the eosystem were identified and interviewed. Over the period of one month, around 35+ people were interviewed and they include,

1. Drivers
2. Cleaners
3. Setts
4. Logistics company

Fig.18: User interview 1

"After deducting the logistics company's profit, the drivers would be eligible to get a sum of say 12000 per trip. The instruction first goes to the seth and Mehta. They could take 2000 each and tell us that the final amount is 8000. These kinds of cheatings happen all around the place. But nobody will know whether it has happened"

Says Nimmat, co-driver of a truck running within Mumbai suburban.

Fig.19: User interview 2

"Gundu bhai, a mehta working for a transport company clearing the truck journal and passes for a truck. The driver is patiently waiting besides him and he was convincing the sett that he lost some amount due to police bribery. The cold approach of the mehta makes the
power hierarchy evident.
However, Gundu bhai claims that d`
Gundu Bhai works for 5 companies and he earns 5000 per day. In a day, he clears a minimum of 3 trucks."

A truck driver getting his papers cleared from Gundu bhai.

3.4. KEY UNDERSTANDINGS

3.4.1. How logistics businesses work?

The flow of goods can be explained in a very linear fashion. The supplier calls the logistics company for a consignment. The company colllects the goods and stores it in a warehouse. Later the consignment is asssigned to a truck/fleet of trucks. The trucks would then deliver the goods to the destination. But the system is so diverse hence there are a lot of complexities.

There are small suppliers, there are big suppliers. There are small logistics companies & there are big logistics companies. And when it comes to truck ownership, it gets even more complex.

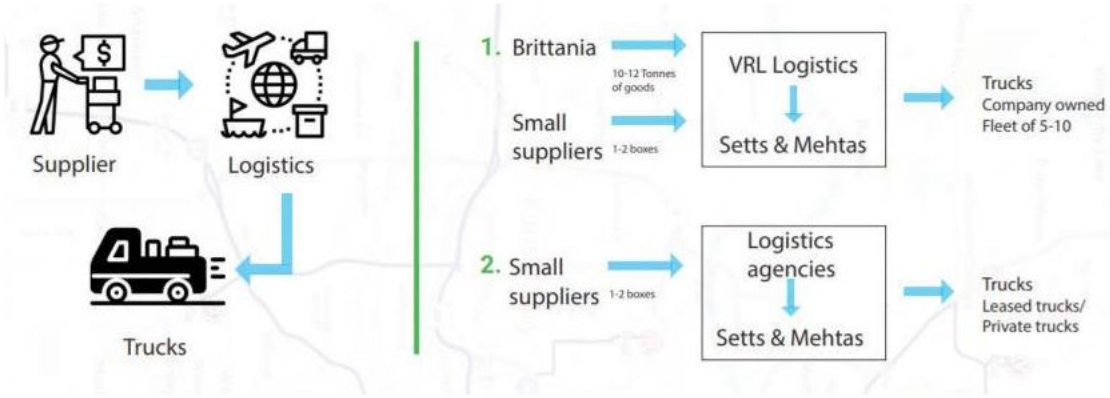


Fig.20: Flow of goods.

3.4.2. Types of truck ownership.

Logistics companies like VRL owns a large fleet of trucks and they give fixed salaries to their drivers. These drivers are carefree and at ease. But there are drivers who own their own truck. He has a to find a consignment on his own and the sooner he gets one, the more money he makes. He needs to pay the tax & insurance on top of monthly installment. The diversity increases the complexity.

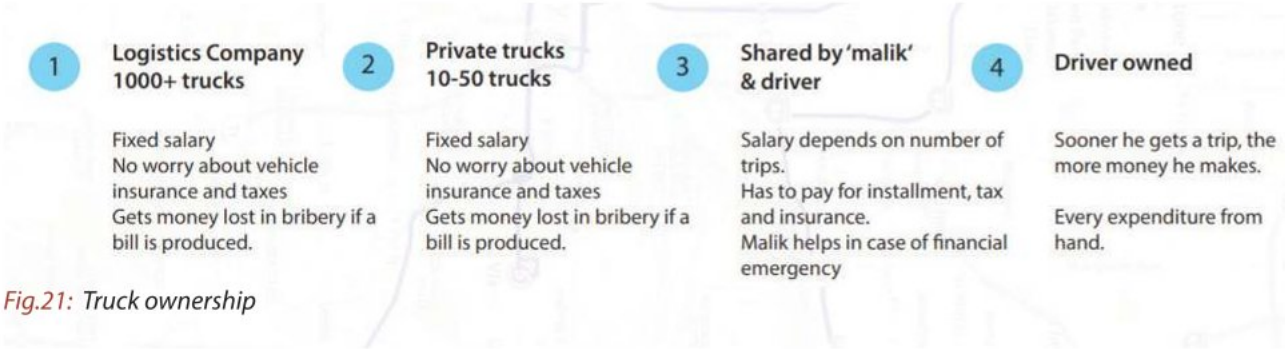


Fig.21: Truck ownership

3.4.3. Painpoints of stakeholders.

By talking to different type of truck drivers (based on truck ownership), their painpoints were identified. Similarly, the interaction with all the stakeholders revealed a lot of issues in the system and every stakeholder has his own pain points.!

For example, the VRL logistics company owns around 5000 trucks and on an average they would spend around 400 rs per truck for local guidance by providing a local guide to the truck. Assuming that half of their fleet drivers know the local routes, still they would be spending around 10 lakh per day just for local guidance.

Similarly, setts and mehtas have a difficult time in clearing the truck journals as they dont trust the drivers 'statistics of expenditure'. Similarly all the painpoints were identified and are listed below.

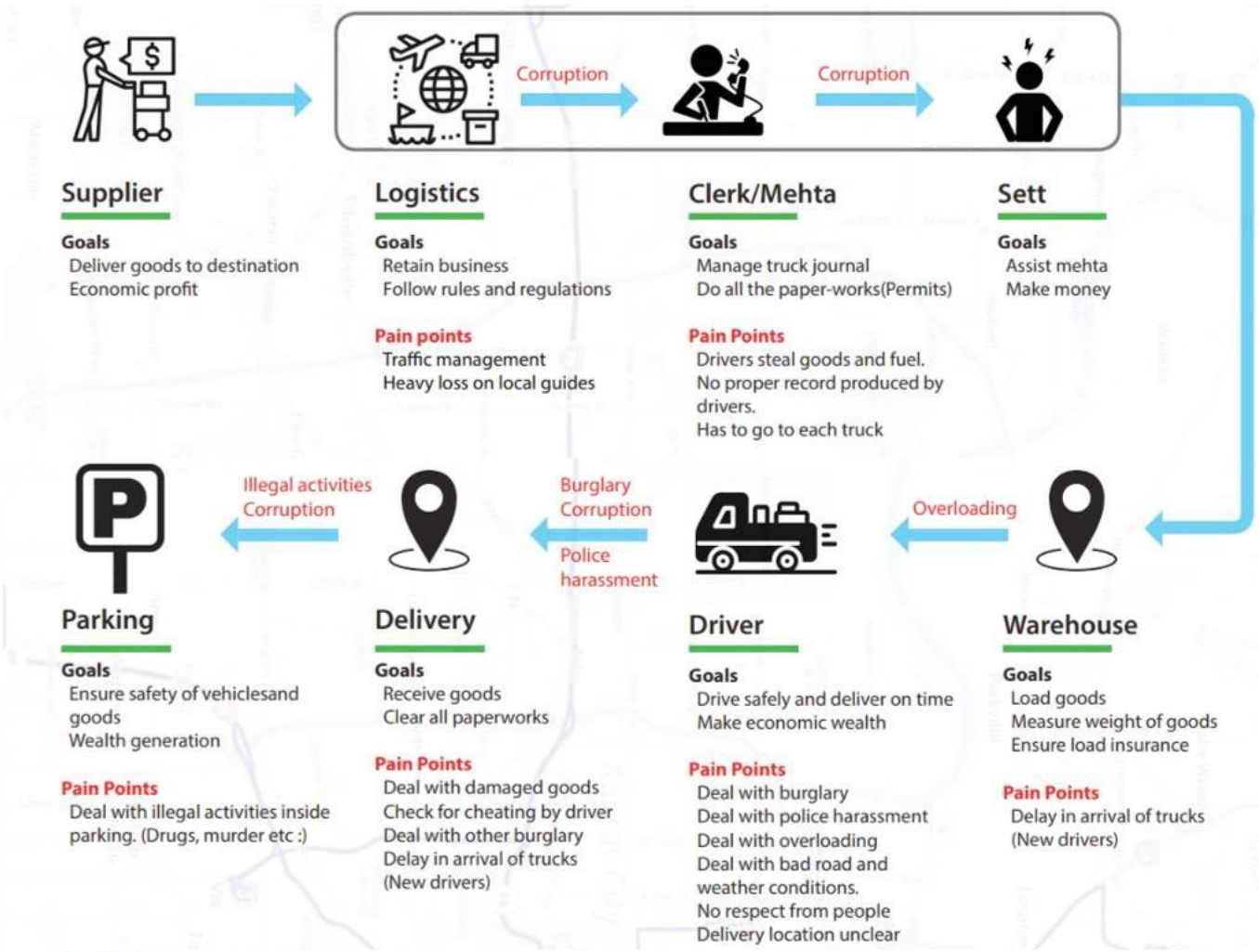


Fig.22: Pain points of stake holders

3.4.4. System level information flow issues : Truck journal, bribery and mistrust

When a driver is penalised by the police for some law infringement, he has to produce the receipt to the seth in order to get the amount not deducted from his payment (Provided the charge was not caused by his mistake). But this is not often the case. Police in India are infamous for bribery and the drivers are prime victims of this malpractice. All the drivers who were intervied told bribery as the worst issue in the system. Some policemen stops the trucks and by saying some random reason. he would ask for money. If the driver is not willing to pay, he wont be allowed to go. As drivers are running on a deadline, they pay the sum and go forward .Now this transaction does not have any receipt and drivers face a difficult time in convincing this to higher authorities.

Companies do not interact directly with the driver. The seths and mehtas, the so called middlemen usually cheat the drivers. As explained earlier, if a consignment is worth rs 12,000, the middlemen could easily steal 2000 each and tell the driver that the amount will be 8000. Nobody will ever know if something like this happened with them. Drivers say that these things happen on a daily basis all around.

3.4.5. Issue with consignment allocation

This is an issue faced by drivers who own their own truck. Such private truck owners would be registered with only one or two transport companies and most of the time they would wait for 5-7 days for a consignment. Some of the drivers had waited for more than 10 days.

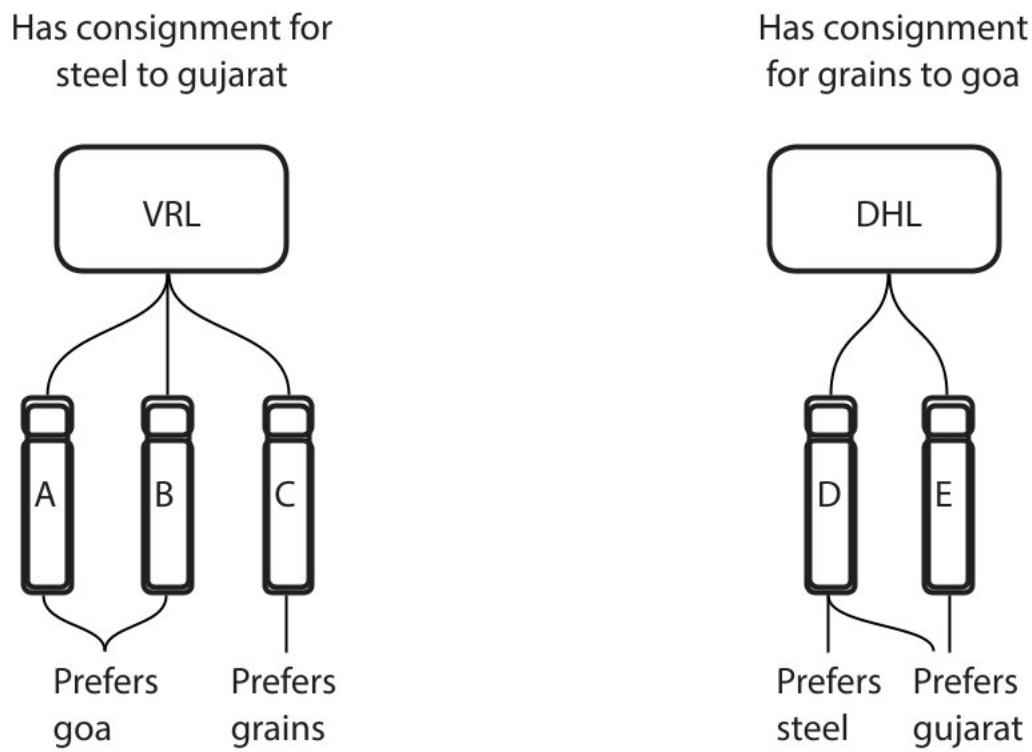


Fig.23: Existing consignment allocation system.

The diagram shows the issue with consignment allocation faced by trucks not owned by any companies. A driver could get a prefered consignment from another company but as he is not registered with them, he will not even know about such a consignment and this miscommunicattion happens on a reguar basis. Obviously. this will result in financial loss in such a business where time is of utmost importance.

3.4.6. Burglary and natural calamities.

Apart from all this issues, drivers have reported to have faced random burglary in remote and isolate roads. This usually happens in ghats in MP and Gujarat and truckers are often advised to go together.

One of the driver reported that he did face such an issue a while ago. All he could do at that time was to keep on driving while thugs wee stealing goods from a running truck. He was accompanied by his co-driver but they were heavily out numbered by the thugs.

Also, truckers had been stuck for 2-3 days in roads due to landslides which usually happen in southern ghats and northern India. Drivers would be unaware of this natural calamities and without taking a bypass route they will head on to the affected region and get trapped.

3.4.7. Navigation and driving issues

This is the most important part of the project and it was done by ineracting with drivers and by observing how they drive. In order to do the control task analysis, the act of driving was split into various modular components which would sum up to be a journey. And they are,

1. Cruising on highway
2. Taking turn on local highways.

3. Taking turn on local routes (Without traffic signals)
4. Braking (Static and predicted)
5. Braking (Dynamic and unpredicted)
6. Taking a reverse.
7. Taking a U-turn

Also some of the non- driving scenarios were also looked into, which were important to the ecosysytem

1. Getting consignment
2. Parking
3. Servicing
4. Ending a consignment.

3.4.8.Perceived importance of data

This chart gives an insight about the priority drivers give to them. Some informations turned out have very less priority.

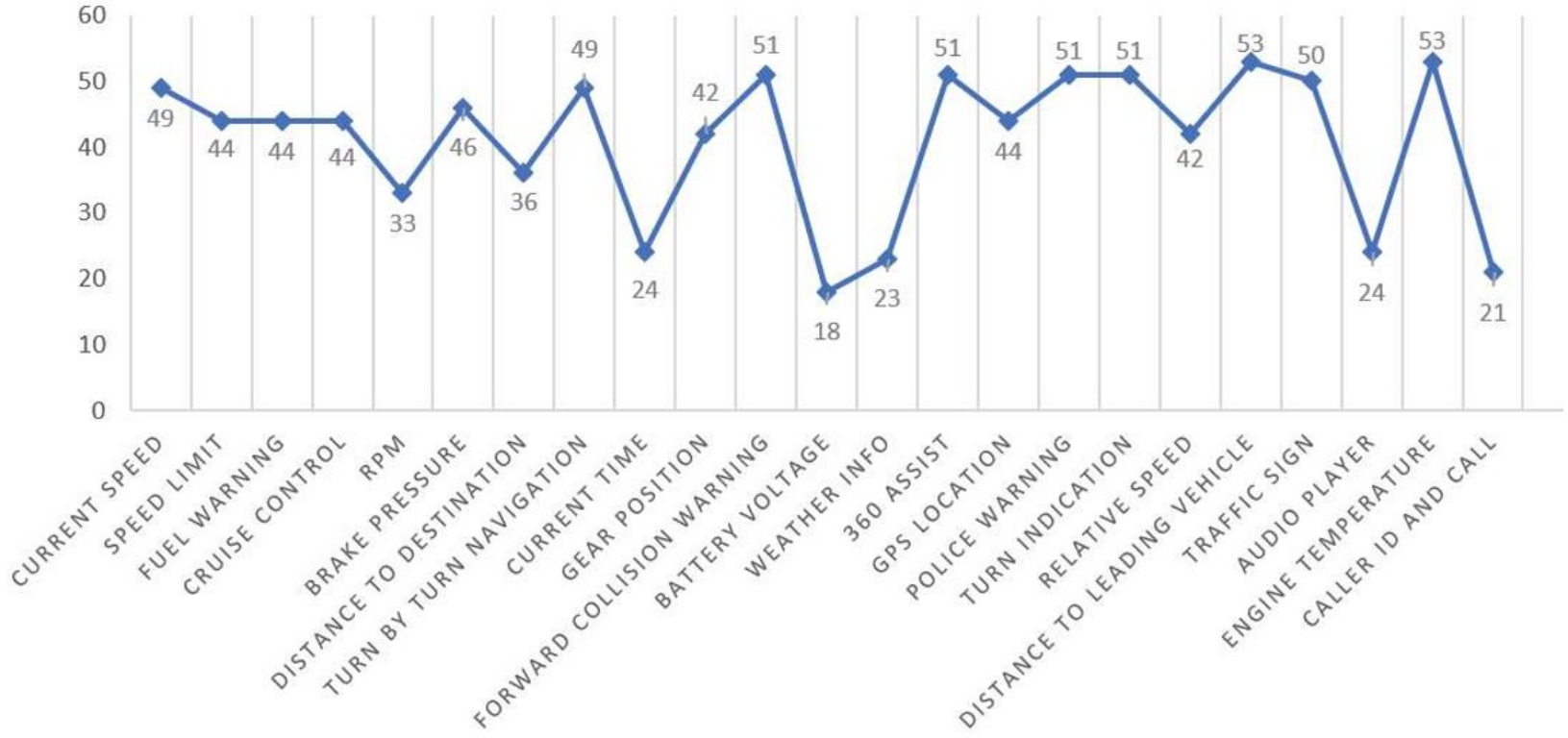


Fig.24: Perceived importance of data

3.5. INFERENCE

The field research opened up a lot of questions and issues which were not initially thought of. Drivers need assistance on the road. But with the technology available, the system can do more than navigational assistance. It can reach out far and improve their lives in other areas as well.

Visiting two different parking lots turned out to be benficial as I found thatthe experiences of drivers greatly vary from place to place. Both the spots were in Mumbai and one can only imagine the stories drivers in other parts of India has to say.

4 DESIGN REQUIREMENTS

Scientific analysis was done on the data gathered from the research. The analysis gave the required data for each scenario. CTA gave critical insights about all the possibilities for a scenario. Finally, the information architecture was developed which pinpoints data needed for situations.

4.1. WDA

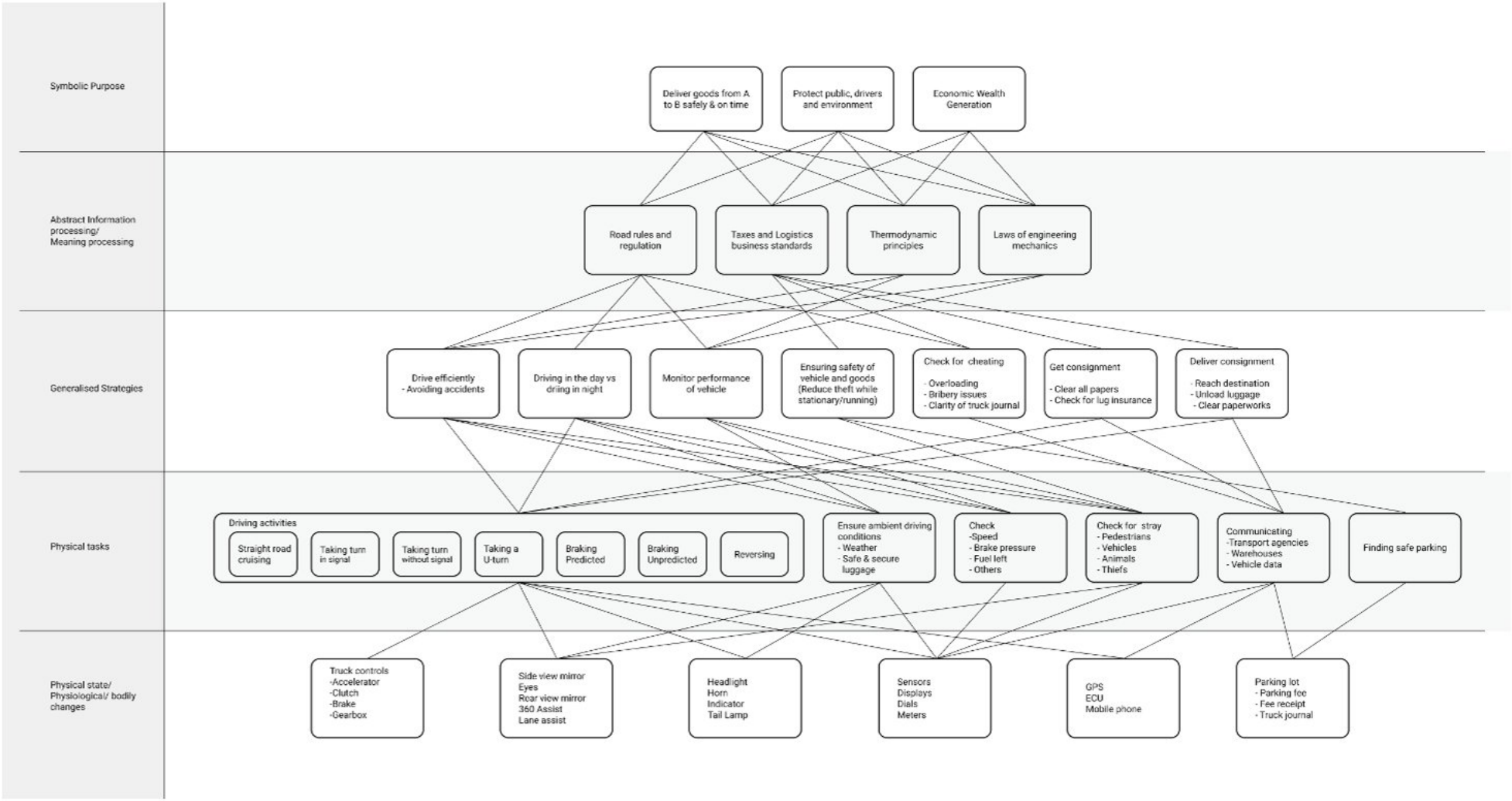


Fig.25: WDA

4.2. EXPERIENCE MAP

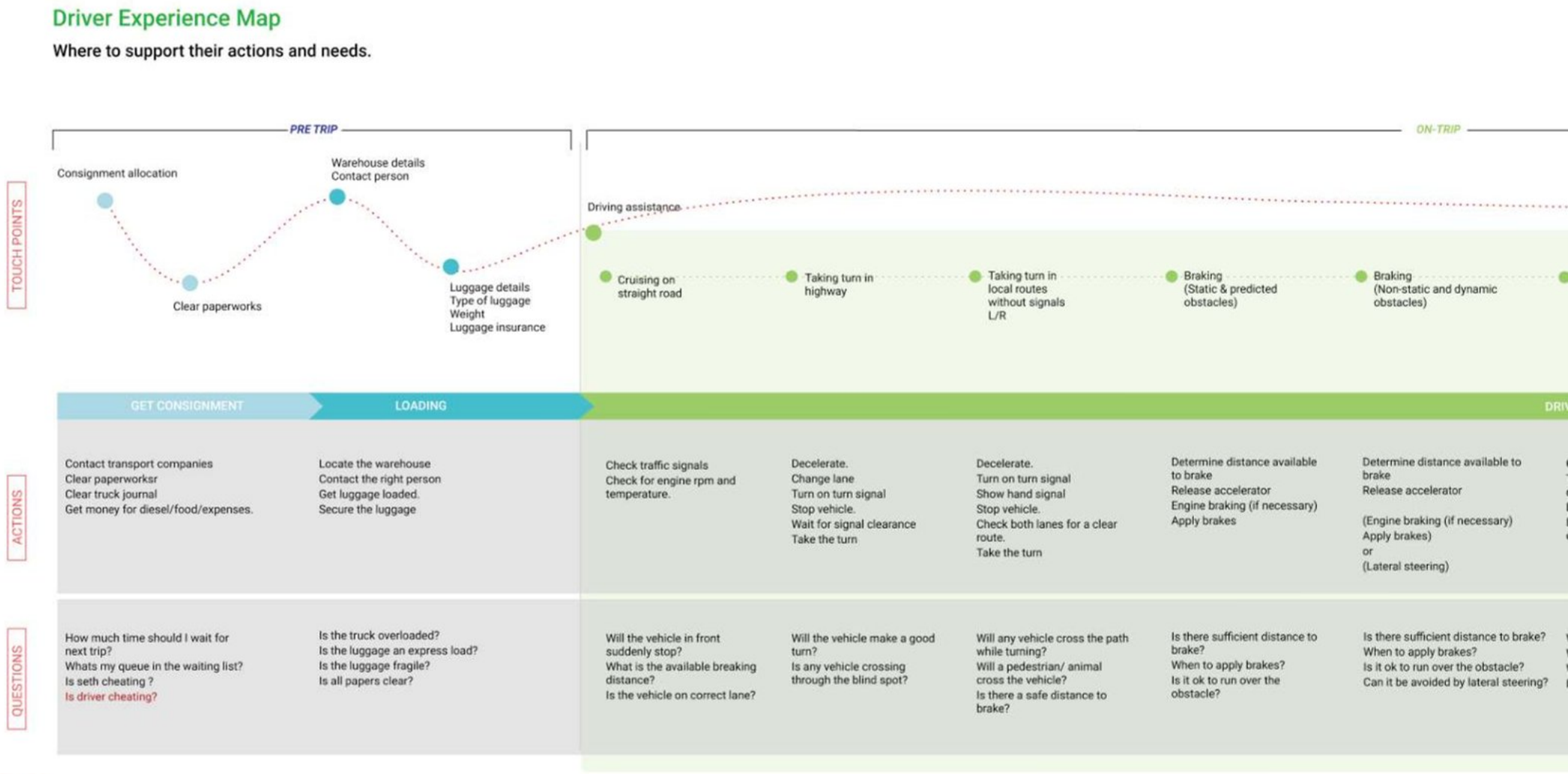
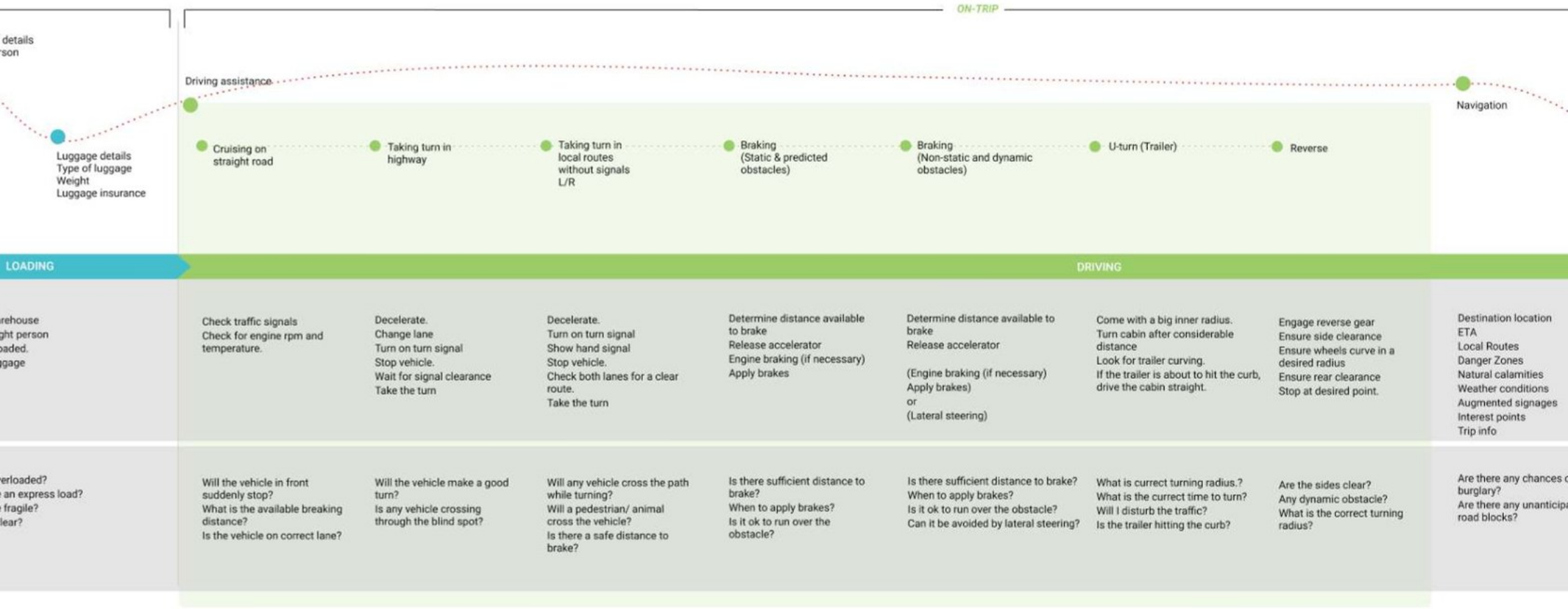
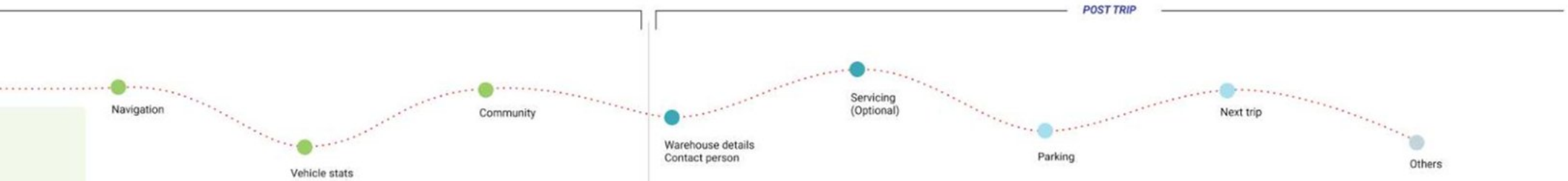


Fig.26: Experience Map

Each scenario was thoroughly looked into and cognitive load was identified in terms of questions asked.


ON-TRIP
details
rson
Driving assistance
Navigation
Luggage details
Type of luggage
Weight
Luggage insurance
Cruising on straight road
Taking turn in highway
Taking turn in local routes without signals L/R
Braking (Static & predicted obstacles)
Braking (Non-static and dynamic obstacles)
U-turn (Trailer)
Reverse
LOADING
DRIVING
rehouse
ght person
oaded.
ggage
Check traffic signals
Check for engine rpm and temperature.
Decelerate.
Change lane
Turn on turn signal
Stop vehicle.
Wait for signal clearance
Take the turn
Decelerate.
Turn on turn signal
Show hand signal
Stop vehicle.
Check both lanes for a clear route.
Take the turn
Determine distance available to brake
Release accelerator
Engine braking (if necessary)
Apply brakes
Determine distance available to brake
Release accelerator
(Engine braking (if necessary)
Apply brakes)
or
(Lateral steering)
Come with a big inner radius.
Turn cabin after considerable distance
Look for trailer curving.
If the trailer is about to hit the curb, drive the cabin straight.
Engage reverse gear
Ensure side clearance
Ensure wheels curve in a desired radius
Ensure rear clearance
Stop at desired point.
Destination location
ETA
Local Routes
Danger Zones
Natural calamities
Weather conditions
Augmented signages
Interest points
Trip info
erloaded?
an express load?
fragile?
lear?
Will the vehicle in front suddenly stop?
What is the available breaking distance?
Is the vehicle on correct lane?
Will the vehicle make a good turn?
Is any vehicle crossing through the blind spot?
Will any vehicle cross the path while turning?
Will a pedestrian/ animal cross the vehicle?
Is there a safe distance to brake?
Is there sufficient distance to brake?
When to apply brakes?
Is it ok to run over the obstacle?
Is there sufficient distance to brake?
When to apply brakes?
Is it ok to run over the obstacle?
Can it be avoided by lateral steering?
What is currect turning radius.?
What is the currect time to turn?
Will I disturb the traffic?
Is the trailer hitting the curb?
Are the sides clear?
Any dynamic obstacle?
What is the correct turning radius?
Are there any chances
burglary?
Are there any unanticip
road blocks?



			UNLOADING AND SERVICING		TRIP END		
e gear arance curve in a arance point.	Destination location ETA Local Routes Danger Zones Natural calamities Weather conditions Augmented signages Interest points Trip info	Observe the dashboard panel Look for anomalies Look for warnings about fuel and all	Look for other drivers in fleet Travel together in danger zones	Locate the warehouse Contact the right person Get luggage loaded. Secure the luggage	Locate service center Get the vehicle serviced	Locate the parking area Get the parking pass.	Wait for receiving next consignment	Pay vehicle installment Pay taxes
lear? bstacle? rect turning	Are there any chances of burglary? Are there any unanticipated road blocks?	Is the vehicle having enough pressure? What is engine temperature Fuel left?	Is that driver with us in the fleet?	Where is the warehouse? Is the inner routes wide enough?	Is there a need for servicing? How much time to wait before the next consignment?	Is the vehicle safe? Is the goods safe? Availability of food	How much time should I wait for next trip? Whats my queue in the waiting list?	Due date of next installment? Amount of cash in hand?

4.3. CONTROL TASK ANALYSIS

For each scenario, Control task analysis done and all the possible options for each scenario was identified.

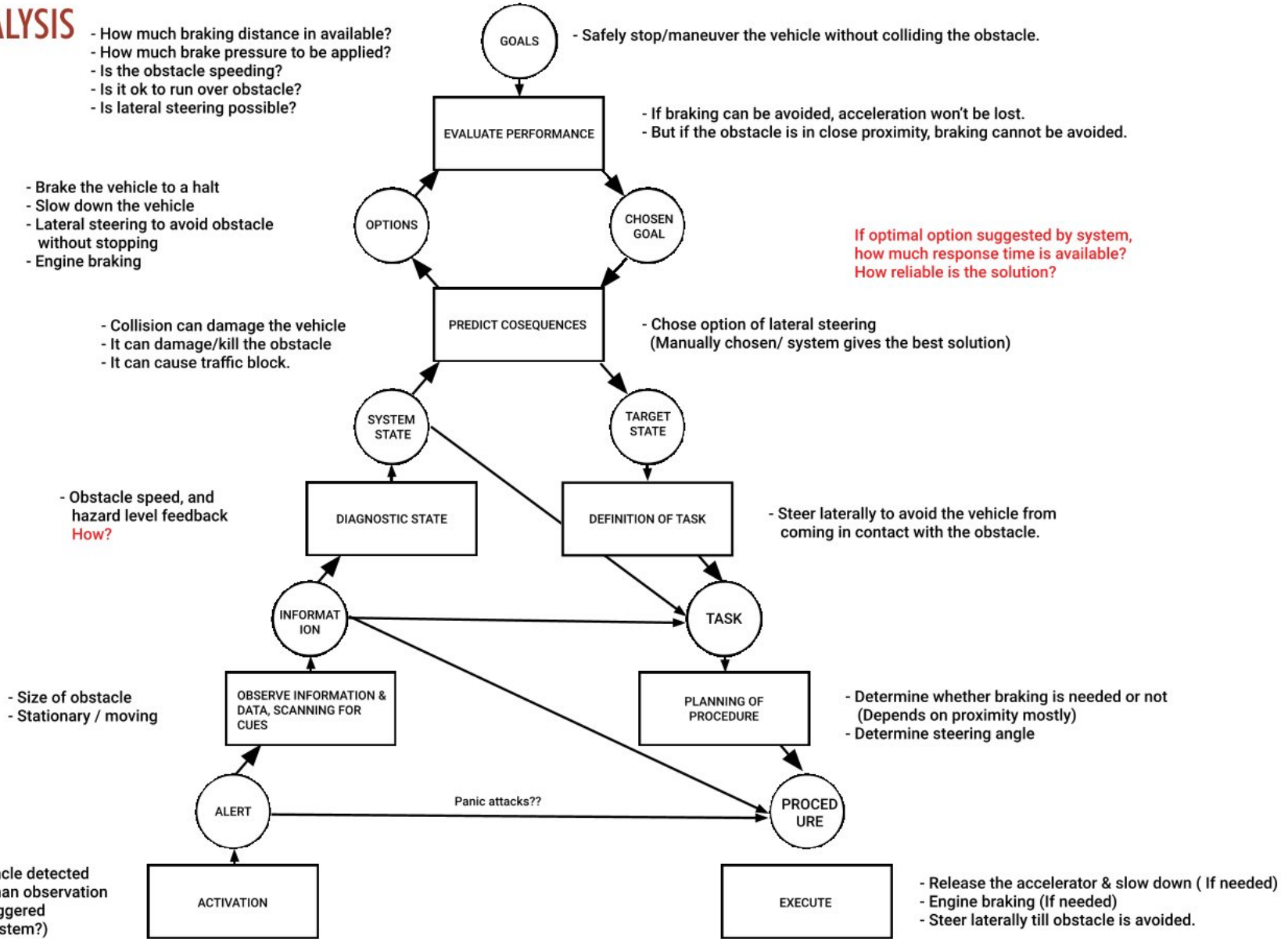


Fig.27: Control Task Analysis.

Rest of the scenarios are attached in the appendix section

4.4. INFORMATION ARCHITECTURE

After comparing the perceived importance of data chart and the experience map, the data required at each stages were identified and the information architecture was made.

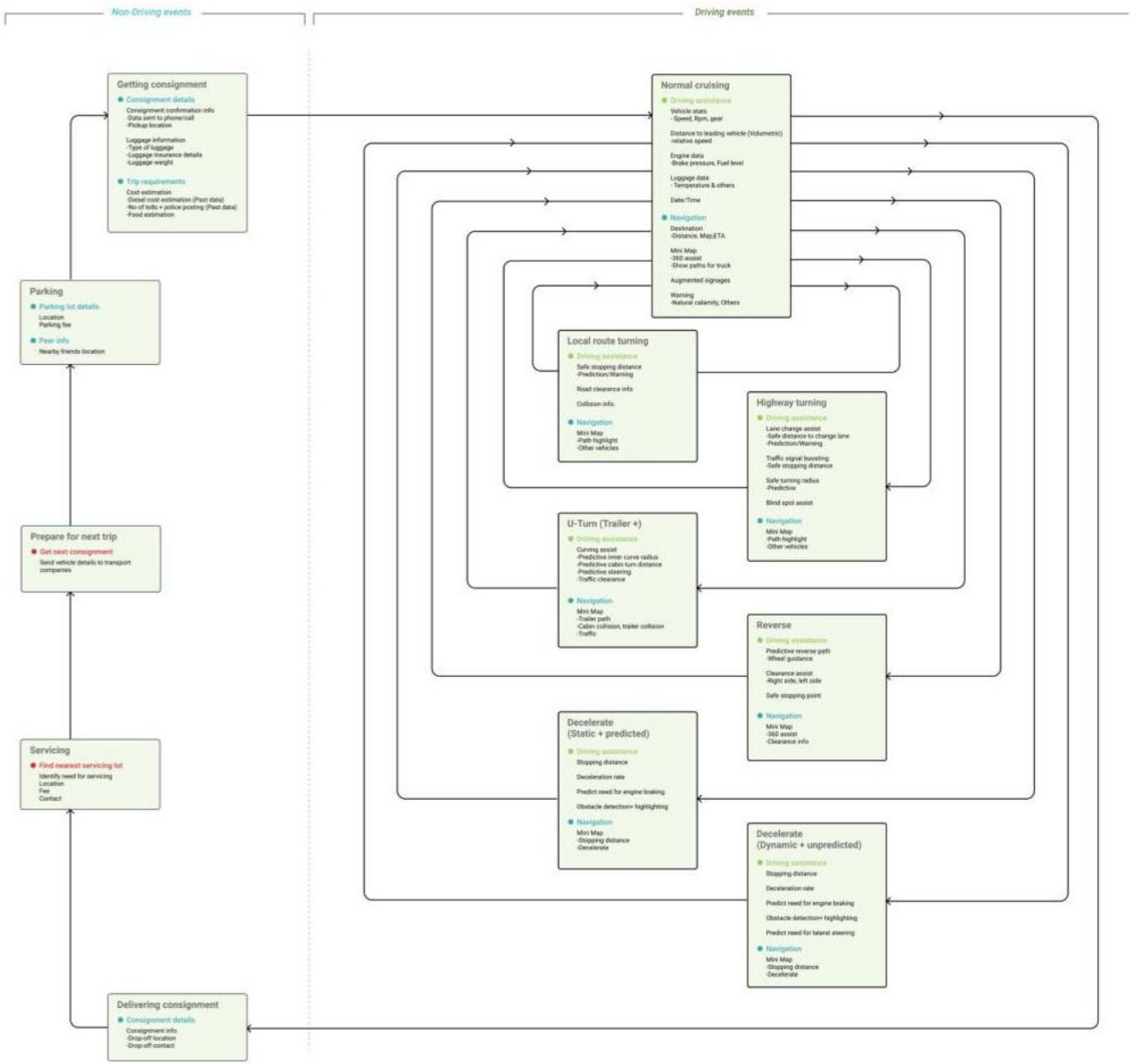


Fig.28: Information Architecture.

5 DESIGN

With all the design requirement developed, design is started. For each scenario, information was put on the screen with utmost importance to visual ergonomics and cognitive load. All scenarios were iterated to reach the final stage.

5.1 TECHNOLOGICAL REQUIREMENTS

All the designs are based on the assumption that the vehicle has the following technologies.

1. Radar + camera sensor system for seeing and analyzing the surroundings.
2. 3d holographic HUD
3. Static HUD
4. GPS Connectivity
5.V2V Communication system

5.2 DATA FLOW DESIGN

Issues mentioned in sections 3.4.3 to 3.4.6 are related to flaws in system level information flow. To mitigate the issues of mistrust and improved reliability, a new system was designed.

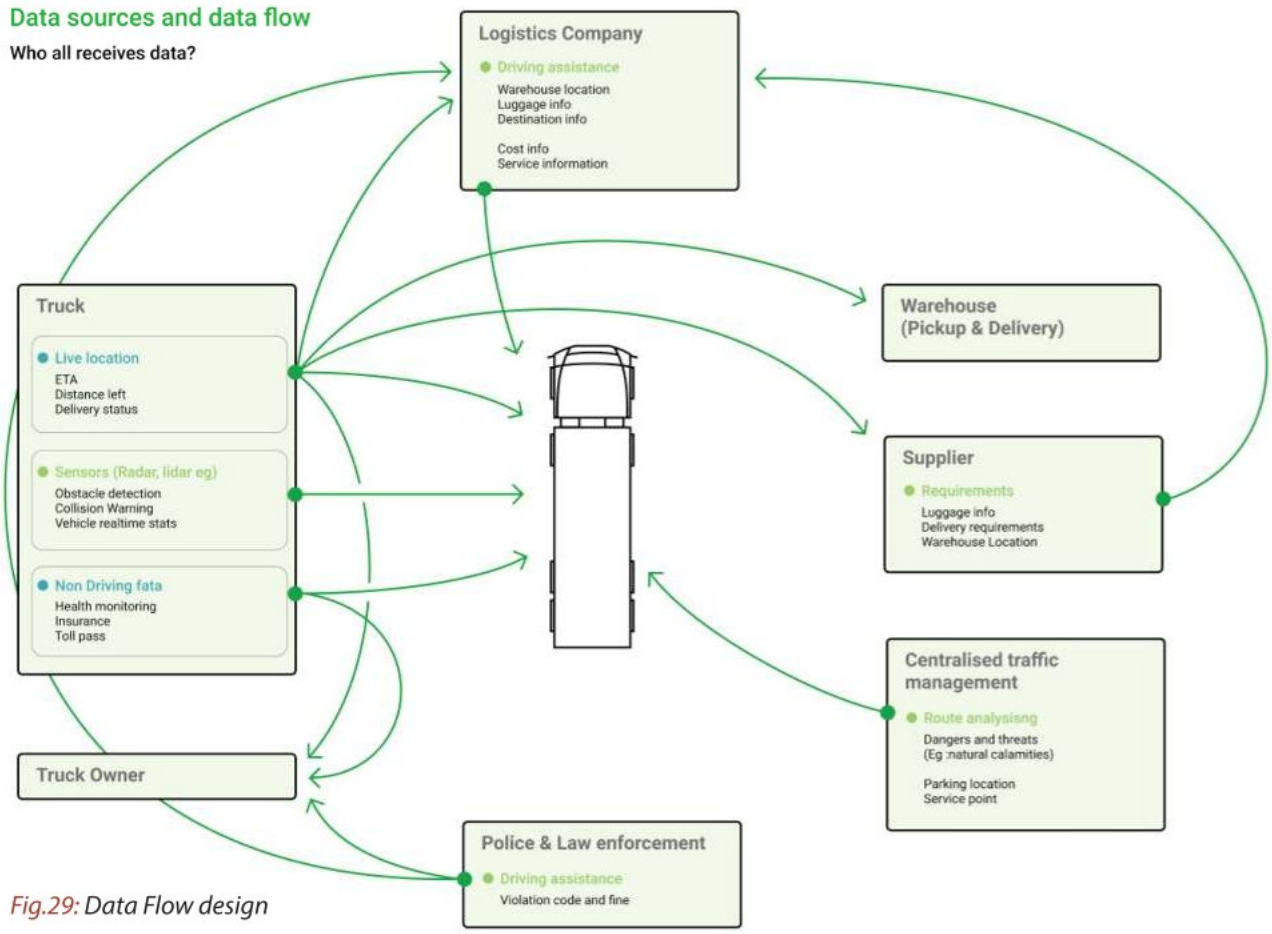


Fig.29: Data Flow design

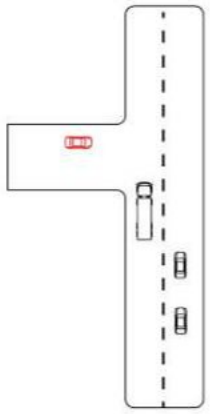
5.3 ITERATION 1

This iteration was a crude design which focused on getting the components in place. There was not much focus on visual ergonomics and cognitive load.

Rest of the scenarios are attached in the appendix section

Situation:

Speeding vehicle approaching from left side blind spot.
Co drivers usually help drivers in managing this situations



Step 1 : Warning about bump

No threat shown until the speeding car could hit the vehicle as it is not slowing down.

Step 2 : Threat detected

The lane is marked in red indicating that there is an imminent threat. The map highlights the approaching vehicles position and shows the gradient on left side.

Step 2 : Gradient tells threat intensity

Orange gradient showing threats seriousness. For more info, the driver can look nto the mini map.

5.4 ITERATION 1: REVIEW

After going through all the scenarios made in iteration 1, the following conclusions were made.

1.The system will not suggest an optimal action in any scenario. Instead it should aid in all the different options available for all scenarios.

2.The screens should be customizable. Novice drivers might need the guiding arrow all the time. But experienced drivers may not need it.

3. There should be a provision for interacting with the information. How to attend a call without picking up the phone?

4. The system should help a novice driver in getting familiar with the context. How to let him know the regulations and local conditions?

5. Avoid threat alert on the screen as it could possibly add to the blindspot caused by A-pillar.

5. Focus on certain key scenarios where the system will be greatly helpful.

5.5 ITERATION 2: WHAT MORE?

Abstraction:
This iteration also focuses on abstraction of entities.
1. The safe lane signal itself could show the predicted turn radius.
2. Lane violation signal can be shown only if the driver actually violates it instead of showing it all the time.

Interaction part:
A second screen with which driver can interact and set navigation for nearby petrol pump, food joint, truck yard and more such interest areas.
With these ideas in mind, the following scenarios were selected for second iteration.

1. **Highway right turn (Expressway crossing)**
   Lane cutting
   Overtake suggestion.
   Blind spot (Stray pedestrian/biker)
   Signal status
   Turn radius

2. **Braking**
   Addressing all options/choices in the scenario and aiding driver in all choices. (Derived from CTA)
   Video reference: blind spot accident (System can help)

3. **Getting consignment**
   Addressing overloading and ensuring transparency of data
   Effective consignment allocation

4. **Reverse**

ECOSYSTEM BASED (Novice & Experts)

5. Natural calamity & other dangers (MP Ghat attacks)

6. Intravillage/local routes suggestion based on traffic data

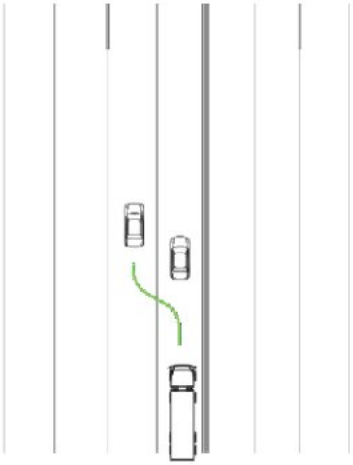
7. Nearest food joint/Truckers spot/parking spot/Vegetable market/Water source/Fuel estimation

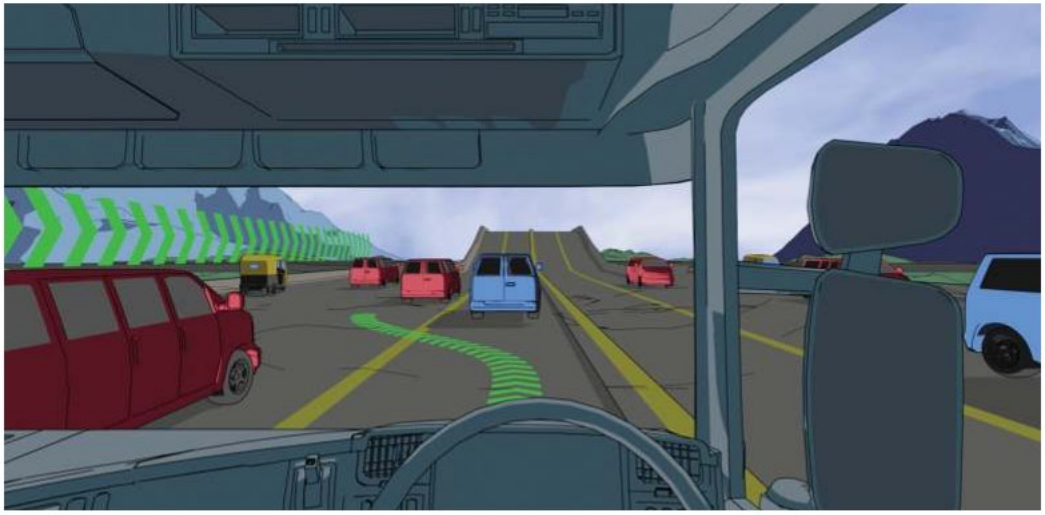
8. **E- journal**
   Digital transactions
   Police bribery

5.5.1 HIGHWAY RIGHT TURN

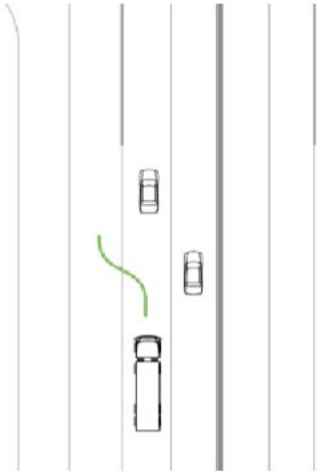
Situation

The truck needs to change the lane to the appropriate one prior to the the turn and navigate through traffic conditions to take a right turn. The driver has to be alerted about a possible threat while changing the lane. The obstacle can be a vehicle, pedestrian or stray animals.

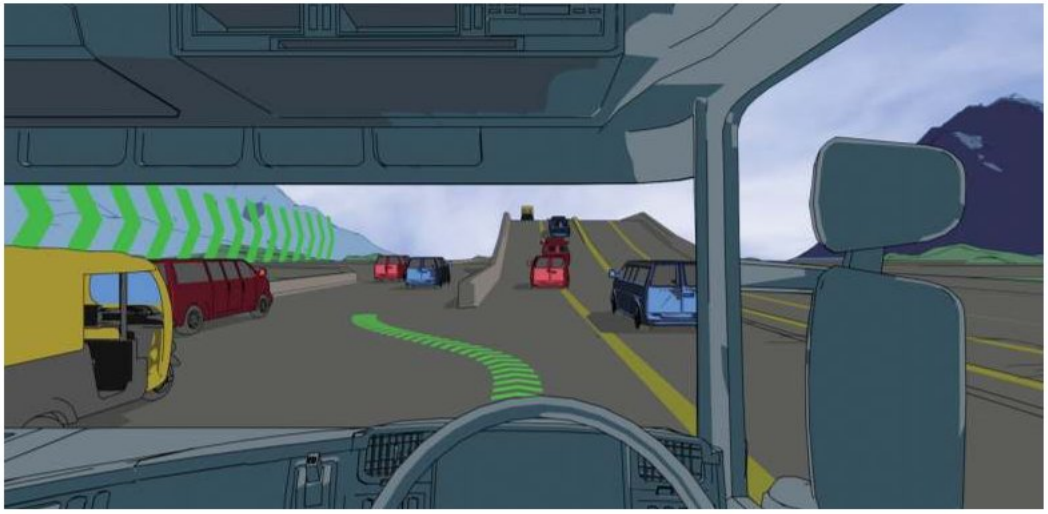




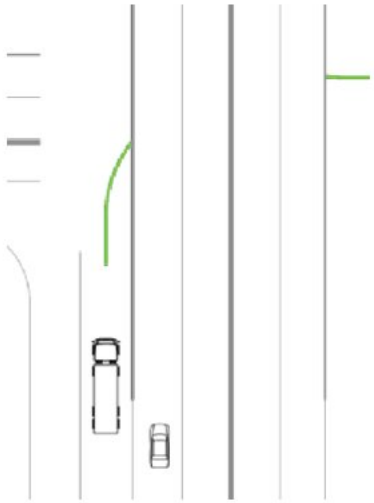
1 250 m before the turn, the driver is notified about the lane change with a projected green arrow.



2 In case of a possible threat, the system alerts the driver by changing the arrow color to orange.



3 Once the path is clear, driver can safely change the lane..



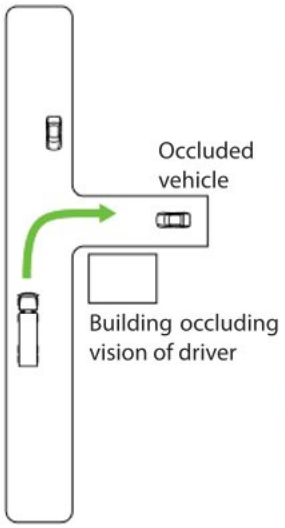
4 At signal, the display augments the traffic signal status by projectingthe guiding arrow with same color.

5 Once the signal is green and the situation is clear, the driver can followw the arrow which also shows the turn radius.

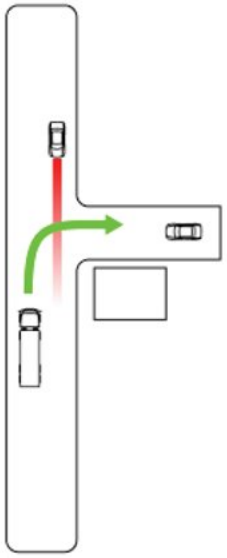
5.5.2 BRAKING

Situation

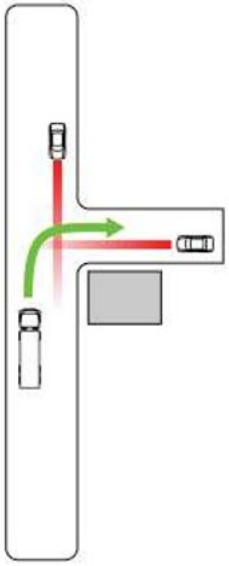
For truly leveraging the benefits of technology, this situation looks at a scenario in which the driver cannot actually see a threat because of an obstruction in his vision. The driver has to effectively warned about the approaching vehicle.



1 While approaching the turn, the traffic situation is shown on the mini map.



2 In case of a possible threat, the system alerts the driver by changing the arrow color to orange.

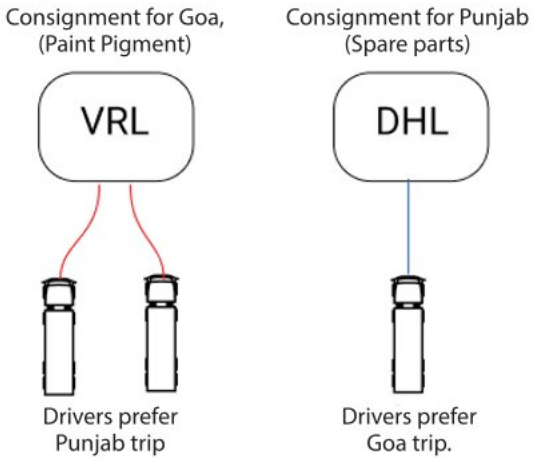


3 The path of threat is forecasted and if could cause an issue, the driver is alerted by projecting red arrow. Also, the position of the threat is shown in the mini-map

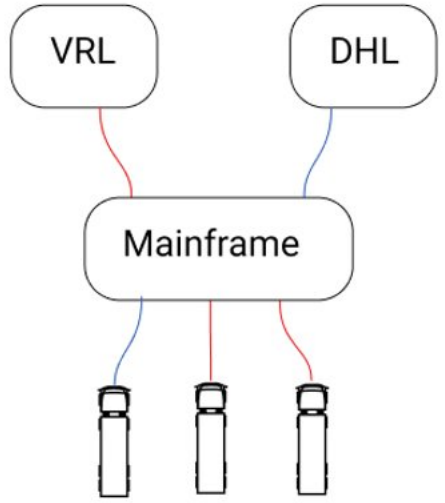
5.5.3 GETTING A CONSIGNMENT

Situation

The research gave some insights about the issues with consignment allocation. Due to lack of an effective system, drivers and transport agencies are not able to connectc with each other.



Existing communication issue.



New communication network.

By introducing an effective platform witht which all the transport companies and drivers interact, consignments can be allocated efficiently to drivers while giving priority to their preferences. Drivers, transport companies and the business itself as a whole will benefit from this system.

The trip details are sent to the second screen attached to the truck. The information will be shown as depicted in the image below.

The second screen will show all the deatils about the consignment like luggage tpe, delivery priority, location and weight.

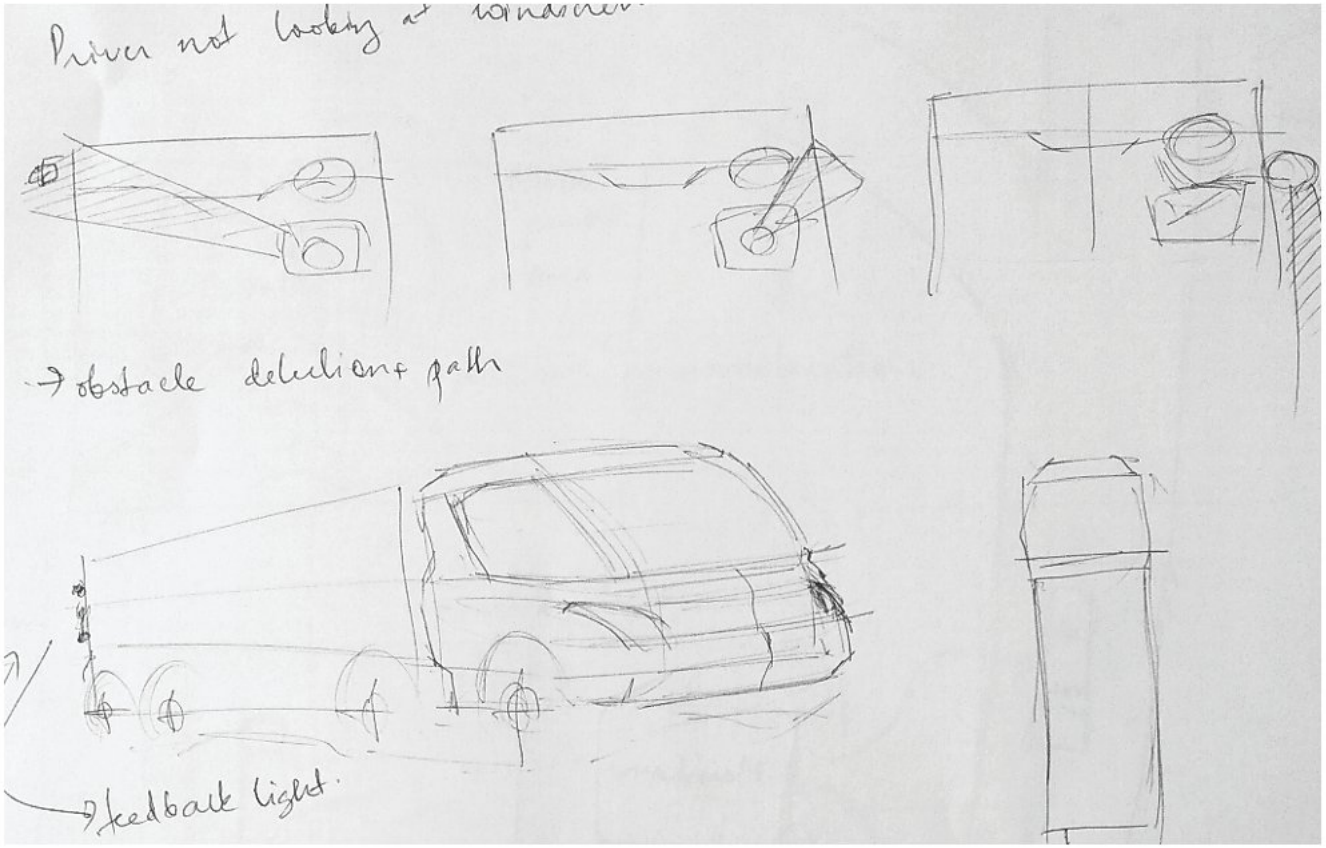
Truck drivers could be away from the truck at times and in usch cases, they will be notified through the phone.

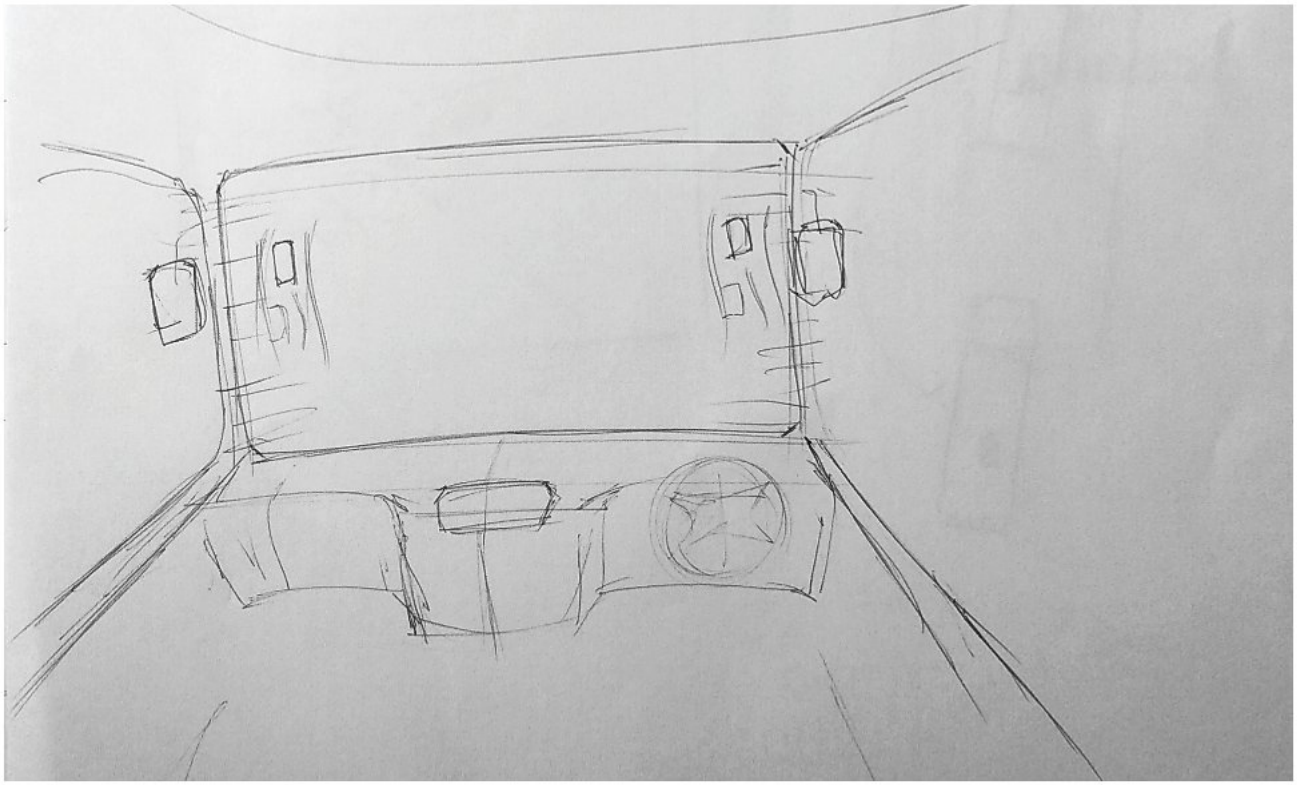
The driver has the option to accept or reject the consignment. If rejected, the consignment will be given to the next driver in waiting list and so on. If accepeted, the driver will be navigated to the warehouse from where he has to pick up the goods.

5.5.4 REVERSE

Situation

Driving in reverse comes with its own issues in truck and the major one being the possibility of pedestrians or small vehicles going unnoticed in the blindpot of the truck.

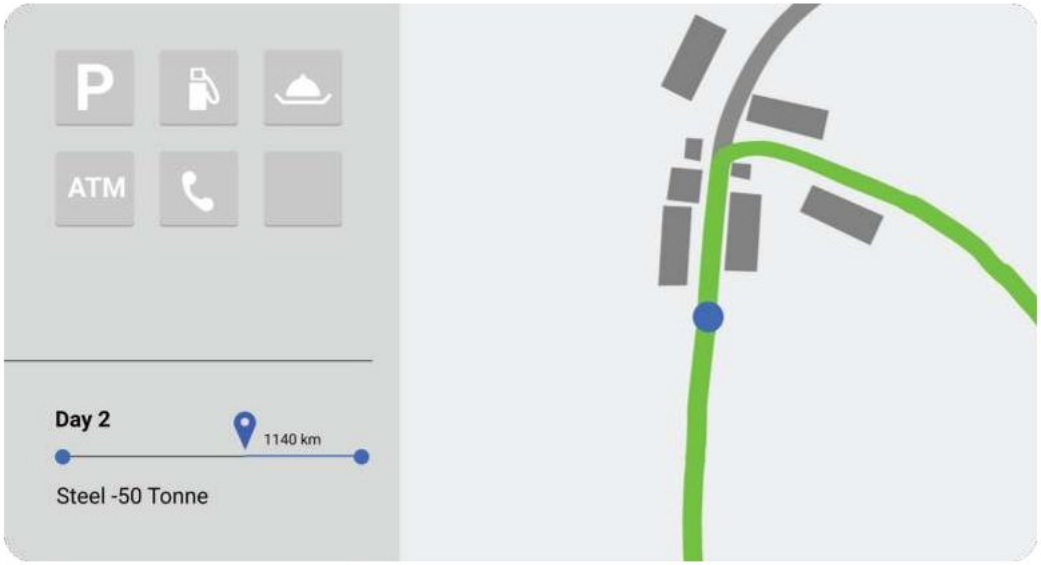




5.5.5 INTEREST AREAS -NEAREST FOOD JOINT,PARKING SPOT ETC

Situation

These are informations that driver does not require all the time and these interest points can be set via the second screen. It gives the information about the interst point and resirects driver to the location.

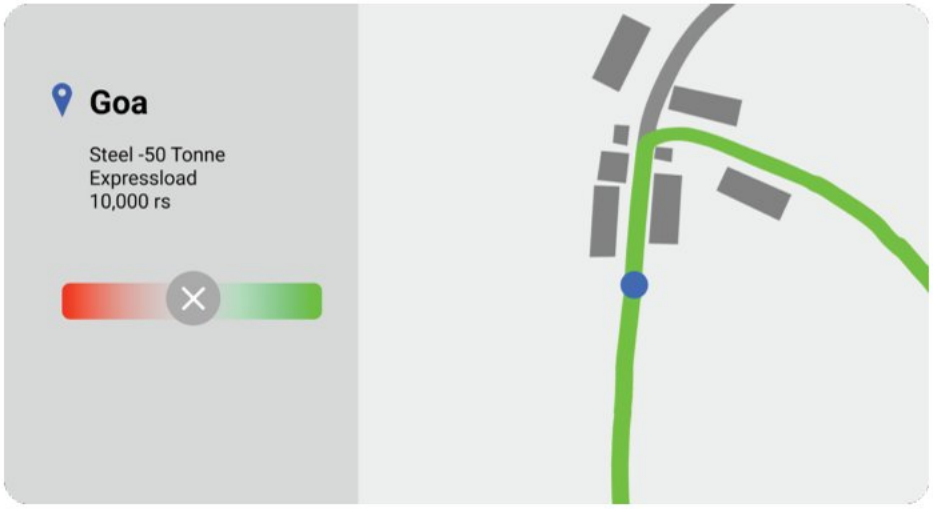


1 The second screen gives the information about the trip and the interface provied a provision to sellect different interest areas.

2 Upon selecting the parking, nearby parking lots are highlighted in the map alog with the rent per day.

3 From the available options, driver can select one and he will be redirected to the selected parking lot.

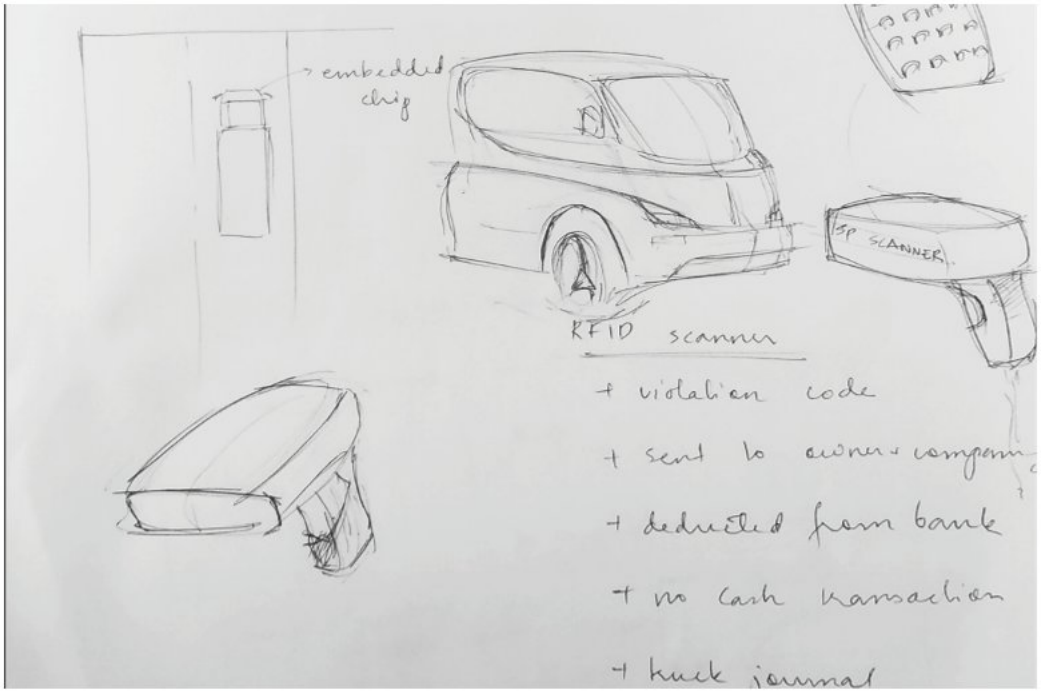
4 From the same screen, the driver is able to attend calls.



5 Consignment allocation

5.5.6 DEALING WITH BRIBERY AND ENSURING A TRANSPARENT E-JOURNAL

Another core non-driving issue that drivers has to deal with on a daily basis is police bribery. They find it really difficult to convince the setts that they actually lose money due to the same.



The proposed system for law enforcement includes a cashless transaction. A device will scan the vechilce number and according to the violation code, information is sent to police HQ, transportation company and truck owner. This way, unaccounted bribery can be eliminated.

5.6 ITERATION 2: REVIEW

1.The interface lacks a coherence in information flow. There should be more focus on visual cone of a driver.

2.Focus on impact of bright sunlight on interface/ augmented reality interfaces or challenges posed by them.

3. Benchmarking of newer interfaces- trains, buses, cars, aircrafts, video games and vehicle/flight simulator etc.

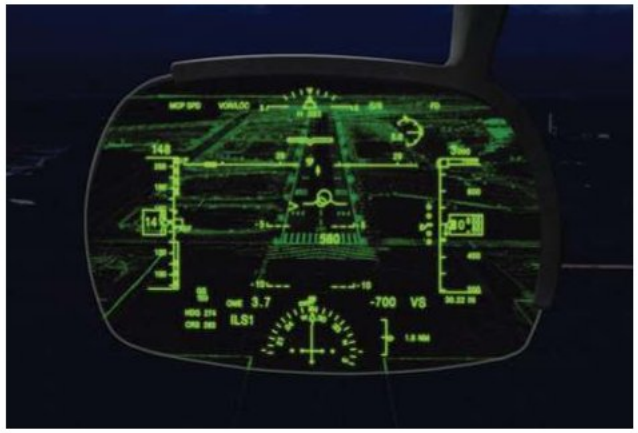
4. Proper development of guidelines needed for all the different scenarios

5. Need to develpo the visual style and icons for all the necessary data

5.7.1 STUDY OF HUD DISPLAYS

For better understanding ergonomics and visual design of interfaces, HUDs were studied. Aircrafts use advanced HUDs for helping the pilots to navigate the plane.

Actual flight path vector and optimal flight path vector.



Zero visibility mode

Flight HUDs show static projection for informations like altitude, speed and angle of attack. But flight path vector is a dynamic circle which helps in navigation. The optimal flight path is shown as a circle and for correct navigation, the pilot has to align the smaller circle(actual flight path vector) with the bigger one (optimal flight path vector)

Also, HUDs have became so reliable that nowadays pilots are allowed to land in zero visibility conditions (eg:dense fog). The HUD projects a virtual terrain on to the HUD and it also highlights the runway in the scenario.

Normal mode

Declutter mode

Aircraft HUDs have different modes which are automatically engaged by the system for specific scenarios. In normal flight conditions, only information necessary for flying i shown. When the landing gear is engged, the HUD switches to landing mode, showing the necessary informations for landing.

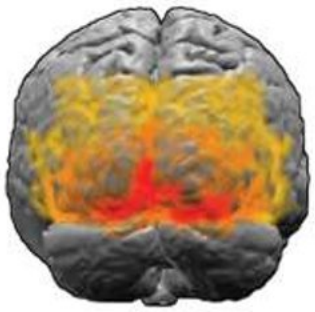
On top of that, there is a declutter mode for these HUDs which reduces the visual clutter caused by informations by showing them in a minimal way. This mode is susually prefered by experienced pilots who dont require all the information at all the times,

5.7.2 HUD DESIGN

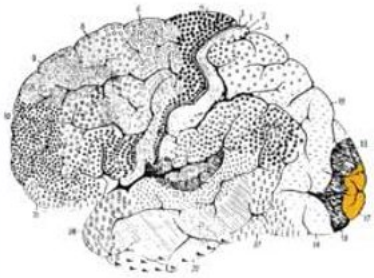
HUDs are designed for performing in all conditions. Be it in daylight or night, it has to deliver what it is supposed to deliver. In designing an interface that is primarily interacting with the visual stimuli, visual ergonomics plays a key role in deciding the effectiveness of the HUD.

Aircraft HUDs are capable of adapting to the ambient light condtions so that the contrast is not too high during low light conditions. There are scientifically tested and proved values for these level of contrast in brightness for HUDs.

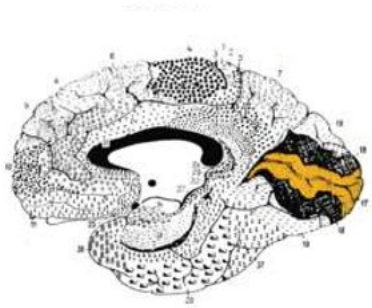
Other than contrast, the major design element in HUD is the usage of color. To understand that visual cortex and human eye is studied.



View of human brain from behind. Visual cortex highlighted in orange.



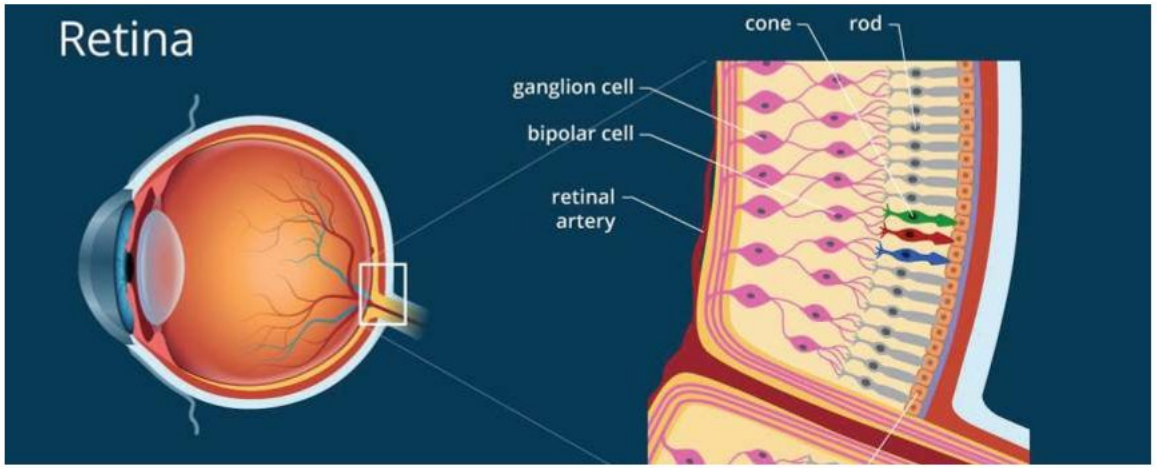
Side view



Cut through section

The visual cortex of the brain is that part of the cerebral cortex which processes visual information. It is located in the occipital lobe. Visual nerves run straight from the eye to the primary visual cortex to the visual association cortex.
Visual information coming from the eye goes through the lateral geniculate nucleus in the thalamus and then reaches the visual cortex. The part of the visual cortex that receives the sensory inputs from the thalamus is the primary visual cortex, also known as visual area 1.

Human eye has two photoreceptors namely rods and cones which have different purposes. THe major differences are shown in the table below.

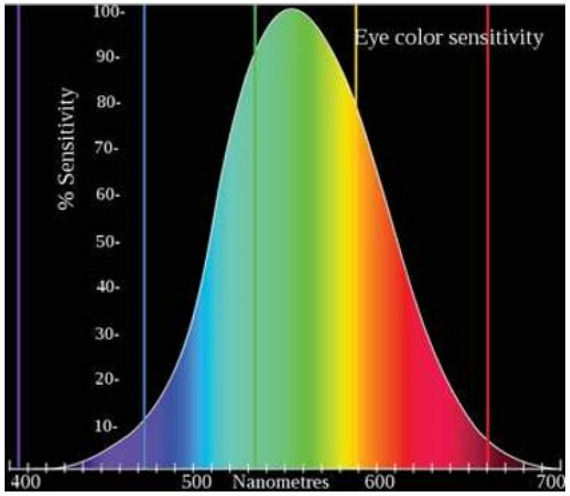


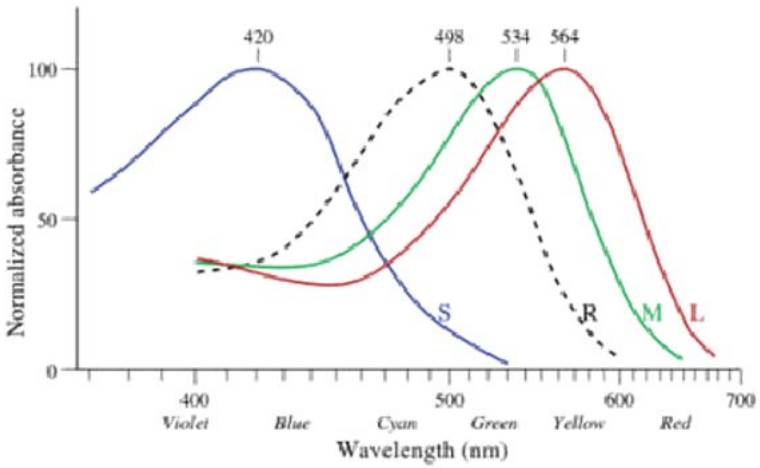
Rods	Cones
Light sensitive	Color sensitive
~120 million	~6million
Low light vision	Day light vision
Slow response to light	Fast response to light

Essentially this means that if a person loses rods cells, he could potentially lose his night vision capabilities. And if a person loses cones cells, he could become color blind.

Night Vision explained

From the above chart its clear that we require rods for night vision as the are more receptive to dim light. But if rods cannot see color, what does it actually respond to? Rods respond to wavelength and their peak reception is at a wavelength of 468nm.





From the second graph we can see that Rods are very less receptive to red and they are most receptive to green wavelength. At low light conditions, red is detected by the Red-cones itself which constitutes around 64% of total Cone cells.

Also rods are sensitive to blue color and they doesnt tax much on the visual cortex.

These variances in how we process light and color leads car designers to two opposing dashboard color philosophies: blue and red.

Receptor driven HDD design. Red and blue

Red wavelength affects mainly cones, leaving the rods unsaturated, which results in better night vision. On the other hand, red wavelength enters your brain from your fovea, which means you use more visual cortex resources to process for higher acuity. With blue dashboards, your cones don't require as much detail, which means you use fewer visual cortex resources to process. The trade-off is that your rods are processing light from two sources, the road and your dashboard, and therefore are working harder.

This red/blue configurations are not taxing for an HDD as you are not always looking at/through them. However for an HUD display, green is the optimal color for showing information.

Receptor driven design for AR navigation app

The colors are pleasing, modern, unobtrusive–but that's not the point of the colors. The color design helps field users visualize information more effectively and effortlessly by drawing attention to only what matters at present.

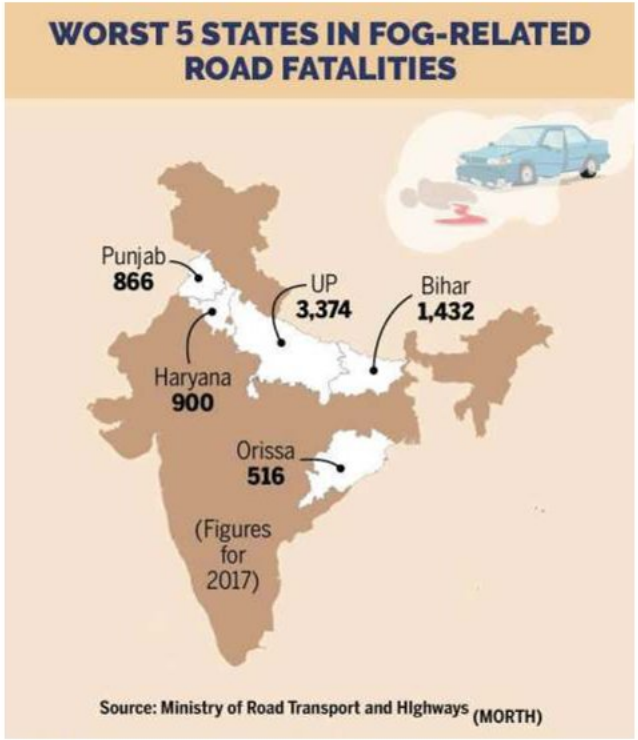
All buttons and elements are blue or white, so they are less taxing on our visual systems. We use green and red very sparingly since they fall right in our fovea. Red alerts us to where the problem is reported via data being uploaded to our system. Green directs our attention to the start and end of where we think our linear asset is experiencing trouble.

5.8. ITERATION 3

With the new insights about visual design gained from the additional research, iteration 3 was started. On top of the scenarios that were selected to develop, certain overlooked scenarios are also developed.

5.8.1. FOG ASSISTANCE

Fog realted accidents are common in India and trucks have a big share in this accidents.



The human eye cannot see through the fog, but the sensors inside the vehicle can recognise obstacles through fog and can efficiently warn the driver.

Top left: Without Fog
Top Centre: With fog
Top right: Warning overlay
Bottom: Warning overlay

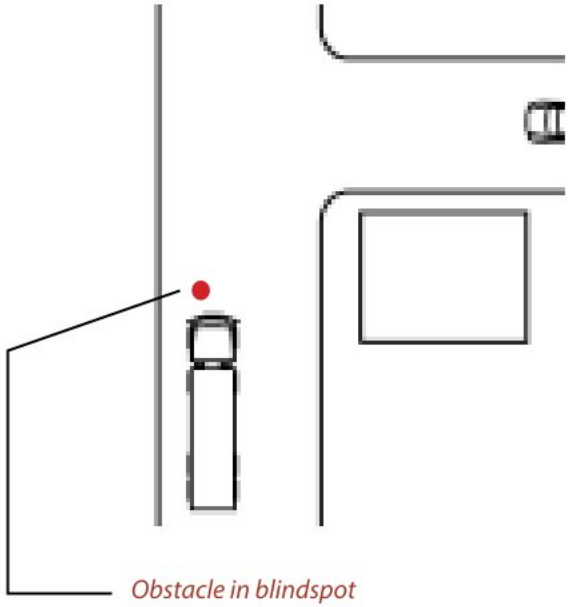
Night Driving scenario

Top left: Without Fog
Top Centre: With fog
Top right: Warning overlay
Bottom: Warning overlay

5.8.2. BLIND SPOT ASSISTANCE

Fog dulls the visibility of surrounding environment and cause accidents. Apaprt from fog, blindspots in vehicles also lead to severe crashes. And the blindspot effect significantly increases for a truck becuase of its sheer size and lack of rear viw mirror.

Top left: *Pedestrian warning*
Top right: *Shows movement of pedestrian*
Bottom: *Shows movement of pedestrian*



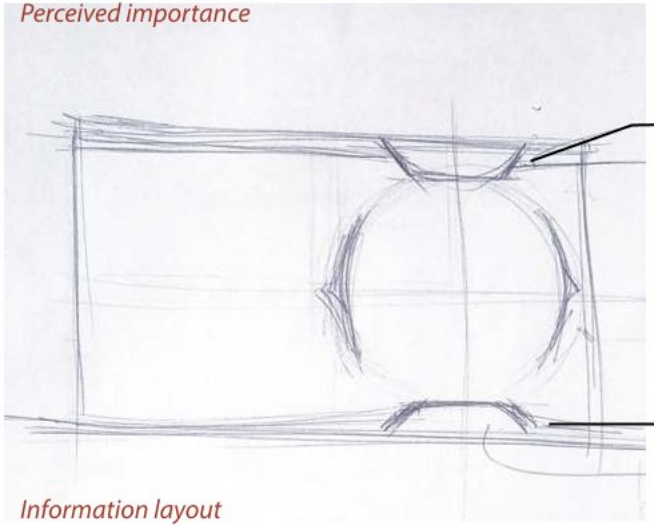
Obstacle in blindspot

5.8.3. VISUAL DESIGN

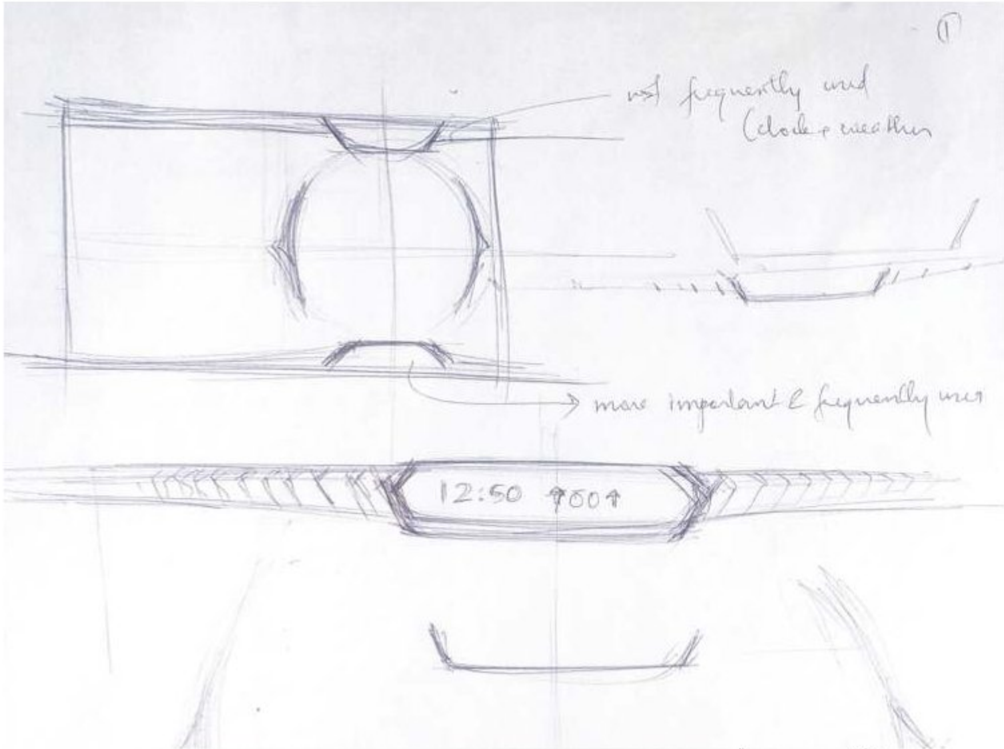
Now that all the elements werefalling into place, a visual theme for the interface had to be designed. For this data from perceieved importance chart was sorted into different categories and they were put on the screen.

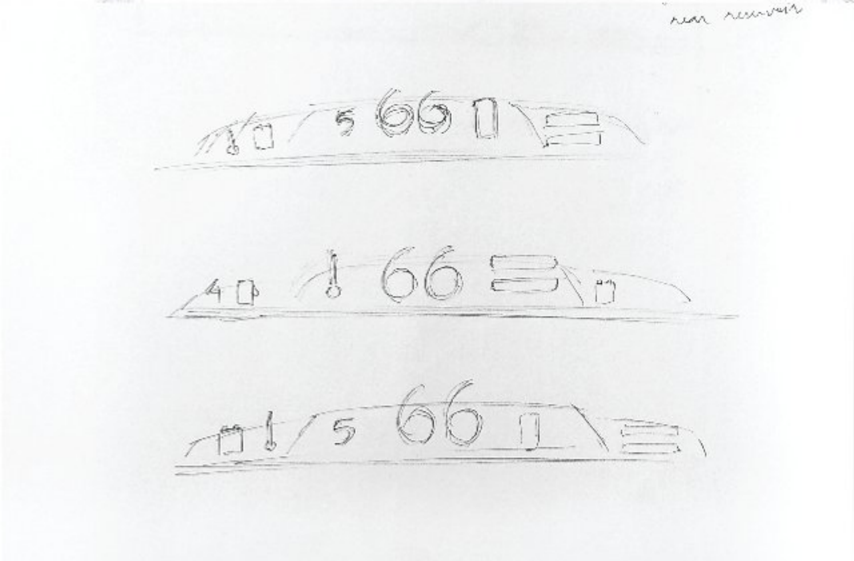
Dynamic & projected		Static & Important		Static & Less important	
Distance to leading vehicle	53	Engine temperature	53	GPS	44
Forward collision warning	51	Current Speed	49	Distance to destination	36
360 assist	51	Brake pressure	46	Audio player	24
Turn indication	51	Fuel guage	44	Current Time	24
Traffic sign	50	Gear Indicator	42	Weather	23
Turn by turn navigation	49	RPM	33	Caller ID & Call	21
Relative speed	42	Battery Voltage	18		

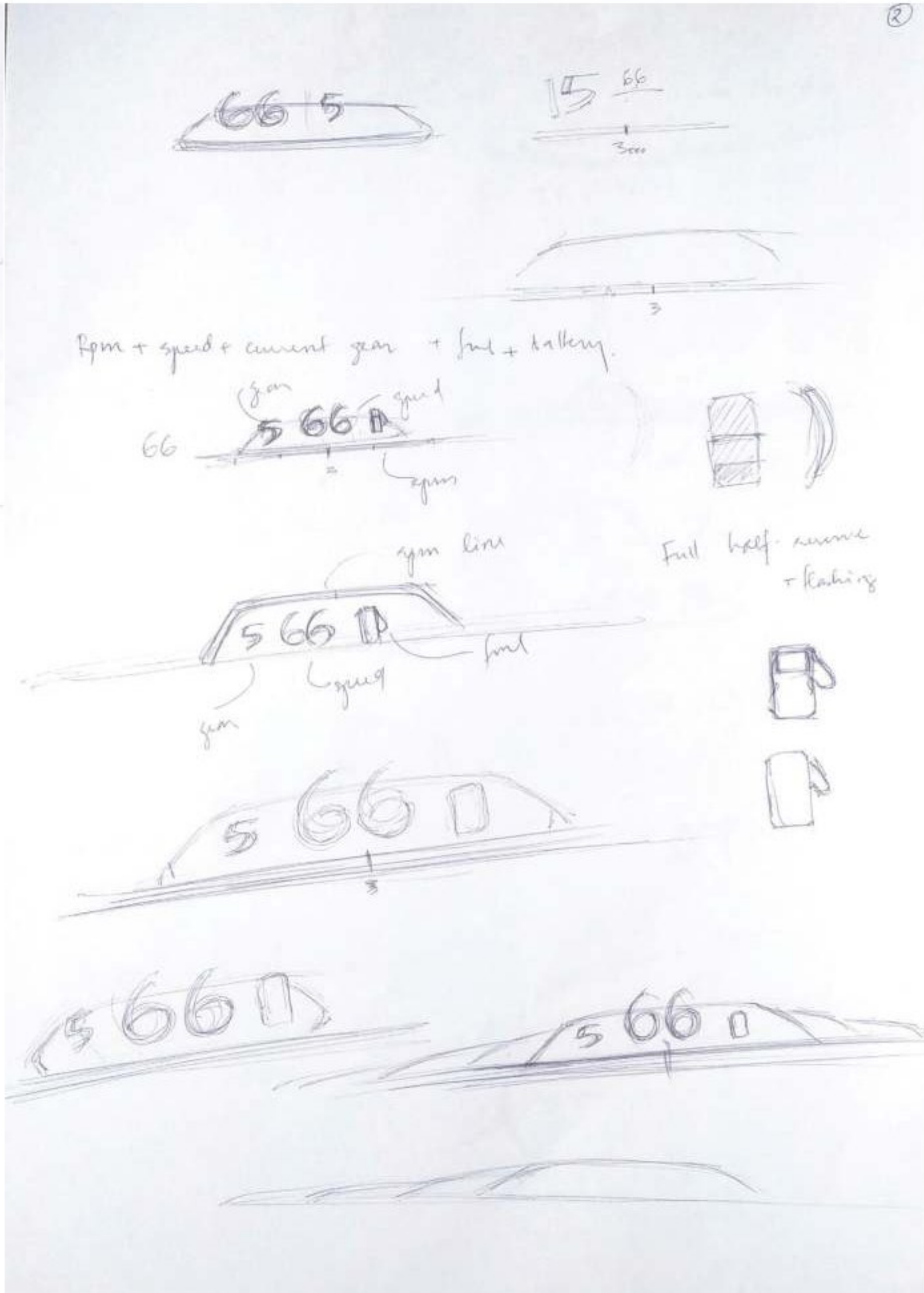
Perceived importance

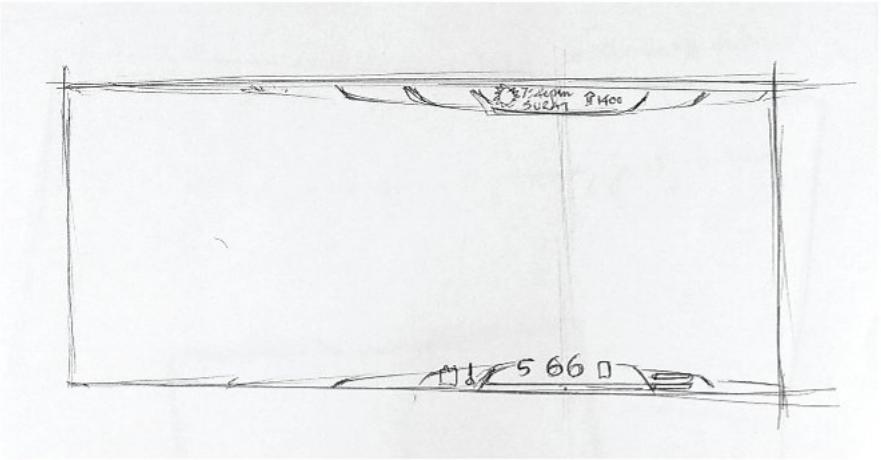


Information layout


most frequently used (clock + weather)
more important & frequently used
12:50




Rpm + speed + current gear + fuel + battery
gear
speed
rpm
rpm line
fuel
Full half reserve + flashing

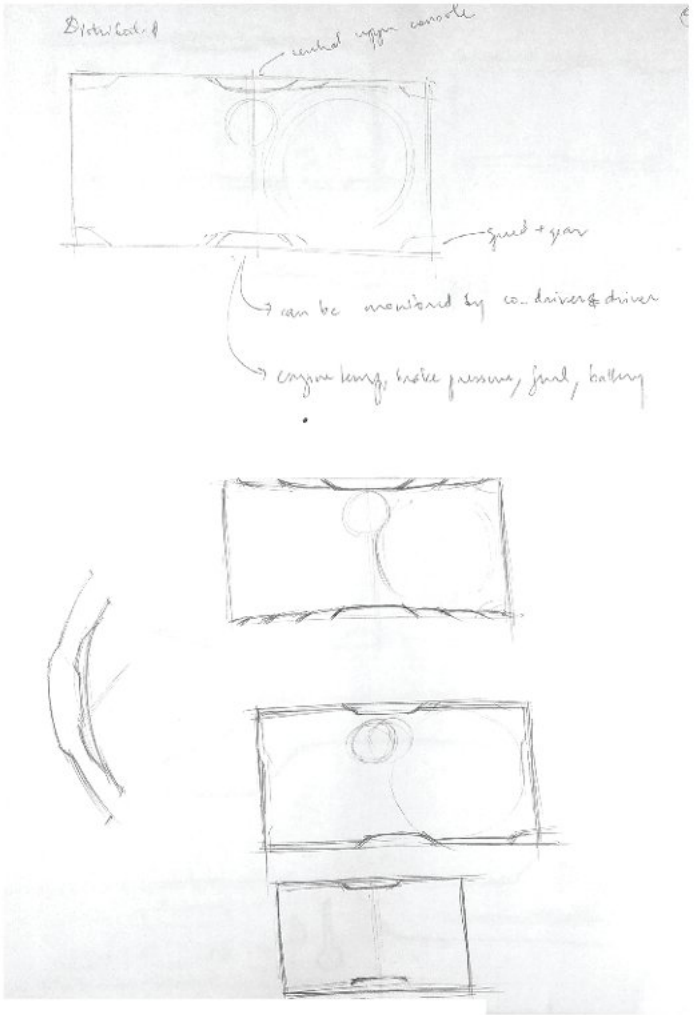


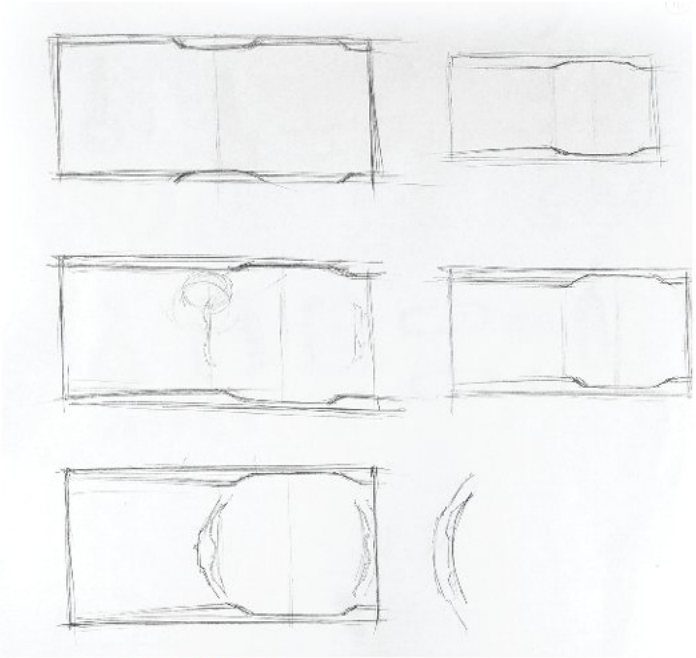
2d sketch

Photoshop overlay

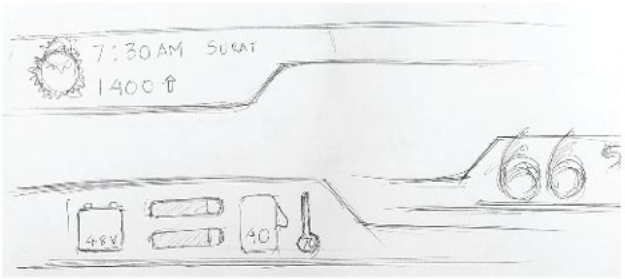
3d overlay

Although the design looked legible in a 2d space, it was found out that the information could not be actually visible as it can get occluded by the steering wheel assembly. A new layout was made in which the information is distributed around the drivers view cone.





Distributed layout



3d overlay

3d overlay

5.8.4. LANE CHANGE ASSIST

This system helps the drivers in correctly navigating into the desired lane in a proactive way. This system is useful for

- Detouring from main roads to sub-roads
- Redirecting to interest points like fuel stations, food joints etc.
- Redirecting to a correct toll booth in Highways

As the system is connected and is up-to-date about the laws and regulations, it can also help in

- Proactively help in changing a banned lane [1]
- Warn about lane rules [2]

[1] Some states in India bans trucks from using high speed lanes. When a driver crosses from a state which permits high speed lane to one which does not, the system will warn him proactively

[2] Different types of lane markings mean different rules.

Broken White Line	Change lanes, overtake and take U-turns.
Continuous White Line	No overtakes or U-turns
Continuous Yellow Line	Overtaking is allowed. Crossing line not permitted.
Double Continuous Yellow line	No overtaking, no U-turns or no lane changes.

Violations of the rules will be noted in the driver's profile record.

Guidelines:

- The lane change warning is given to the driver 1km before the threshold point for a single lane [1].
- There will be a buffer zone of 500 meters, within which the driver has to clear the lane.
- The buffer zone can increase to 700 m according to traffic conditions.
- Once the buffer zone starts, the driver is supposed to put on the indicator and if he fails to do so, a warning is provided after 100m.
- The speed of surrounding vehicles is monitored during this buffer zone and if there is a safe clearance window of 3 seconds, the driver is notified to change the lane.
- The surrounding traffic is shown to the driver in the mini map
- If the driver fails to change the lane within buffer zone or fails to put on the indicator, the authorities are notified.

[1] For a two double lane change, the warning starts at a distance of 3km, for triple lane change, warning starts at 4.5 km and so on.

Also the distance threshold will depend on the trucks approaching speed. A truck running at 80 kmph will see the warning at 2 km & a truck at 40 kmph will see the warning at 1 km.

Cruising in highway. UI is in cruising mode.

Lane change assist started

Safe to change the lane

Lane change done

5.8.5. ALLOTING A CONSIGNMENT

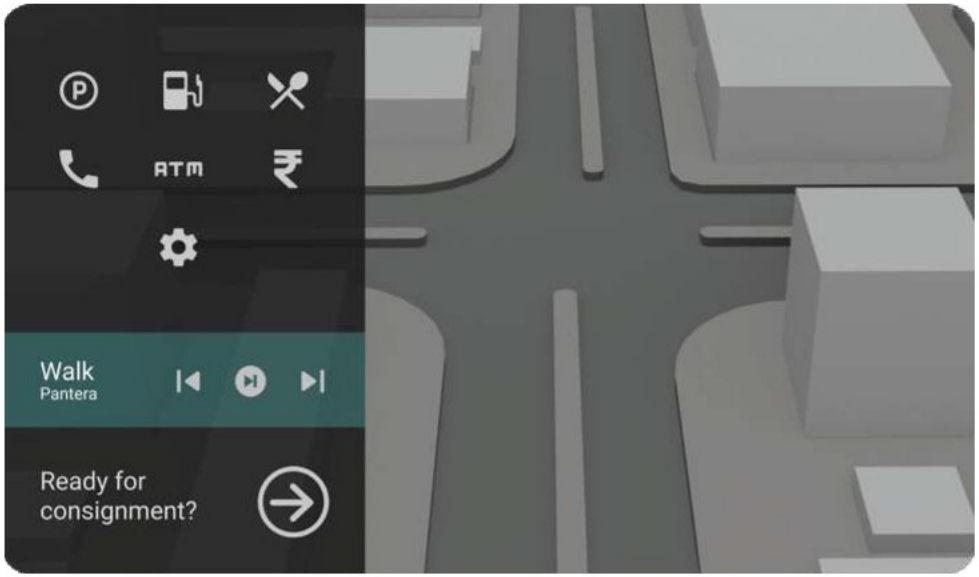
Guidelines:

-All transport should companies send their consignment details to the TruckAR server.
-A waiting list is created for truck drivers based on the time-stamp at which they hit 'ready for consignment' button.
-Based on the preferences [1] of truck drivers, the waiting list is further iterated.
-The consignment is offered via the second screen/call/TruckAR app. If rejected by the driver, the consignment will be forwarded to the next driver in the waiting list.
-The offer will state the cargo details, priority, destination, and trip amount offered by the company.
-The on board system will give an estimate expenditure of trip and gains to the driver

[1] Preferences include load type and destination.

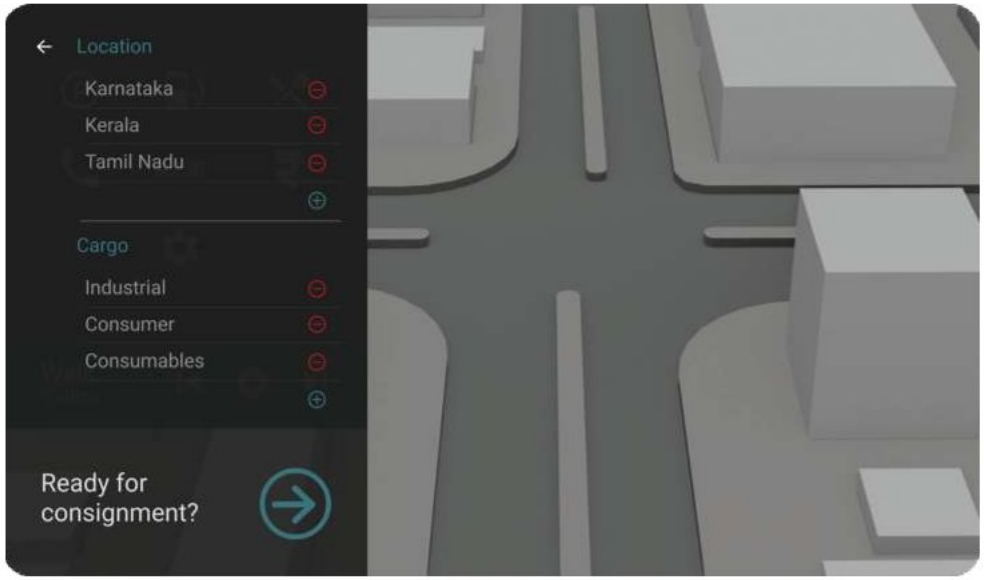
Note – Companies can again sort the list based on the driver rating.

Animation in progress.



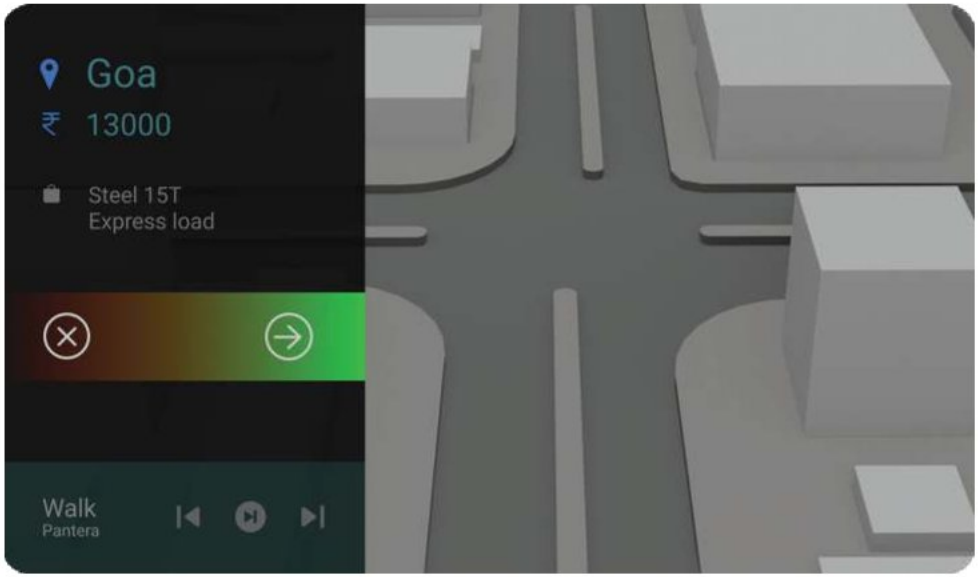
Step 1

Once the warehouse verifies the delivery of last consignment, driver will be able to see this interface on second screen.



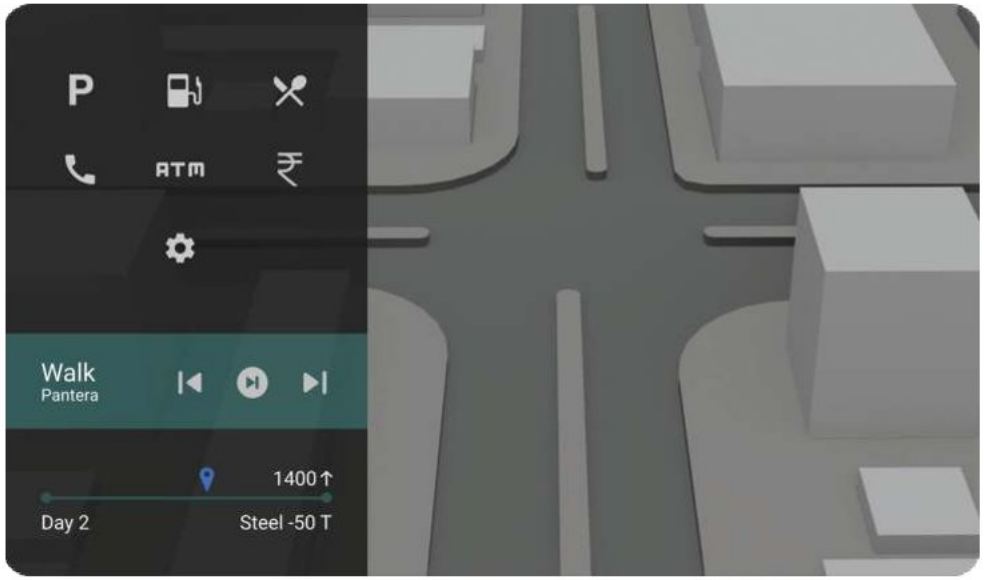
Step 2

The ready for consignment button will lead to apop up screen with option to set preferencecs for destination and load type. If left blank, system will suggest all locations and types of loads.



Step 3

Once the system finds a consignment with matching preferences, it is sent to the second screen with all the details about consignment. THe driver may accept or reject the consignment.



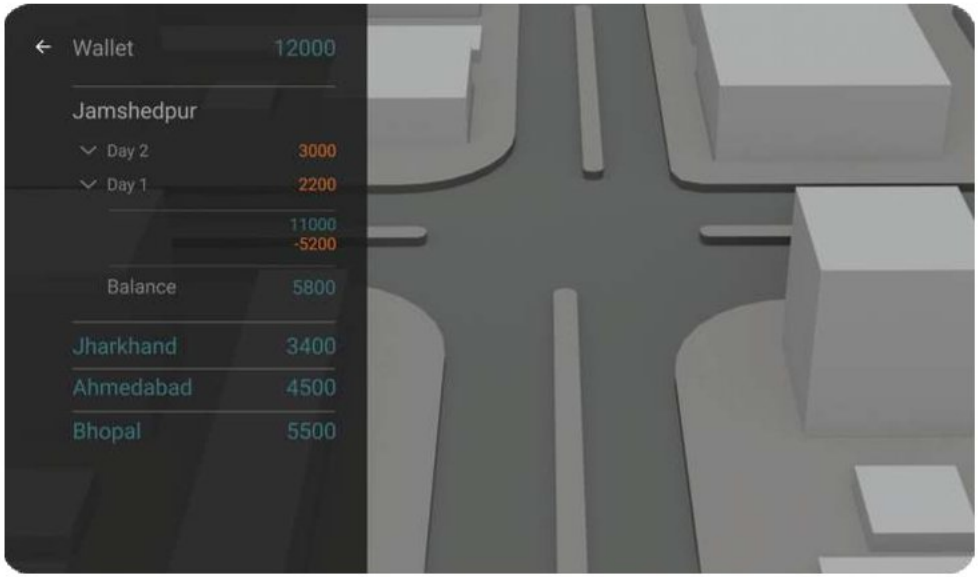
Step 4

Driver will be redirected to the warehouse from which he has to collect the load.

5.8.6. ENDING A CONSIGNMENT

Guidelines:

-Once a driver reaches the destination and delivers the cargo, the warehouse will send a confirmation to the TruckAR server notifying the consignment has ended.
-Once the confirmation has reached the server, it will automatically deduct the expenditure amount from the offering and send the remaining amount to the drivers account.
-The on-board vehicle diagnostics will notify the driver whether there is a need for servicing the vehicle and will be redirected to thepreferred/nearest service station.
-The driver can then set the preferences for next trip and click the ready for consignment button and he will be added to the waiting list.



The truck journal will have the detailed summary of all the expenditures of the trip. It will also have summary of past trips and the amount available in the drivers wallet.

5.8.7. BRAKING ASSIST

Braking is a very critical process in which lives are at stake. As explained in the research, there are different types of braking scenarios and the CTA for braking thoroughly studies all the possible option for all the cases.

Guidelines:

Static and predicted (Turns / bumps / blocks / static vehicles)

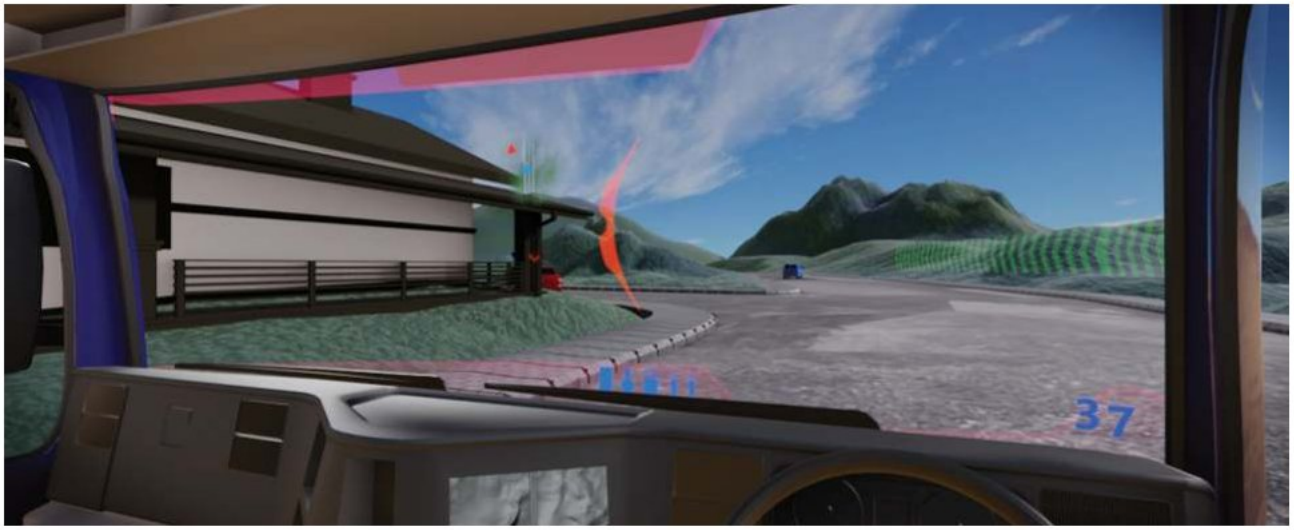
-Driver is given warnings about geographical elements (turns, bumps etc.) with GPS positioning data.
-Real-time monitoring of sensors will warn about other static obstacles [1] by approach speed estimation and distance left.

[1] These warnings are given only if the vehicles current path could possibly come in contact with the obstacle. Example: Driver won't be warned about a static vehicle on another lane.

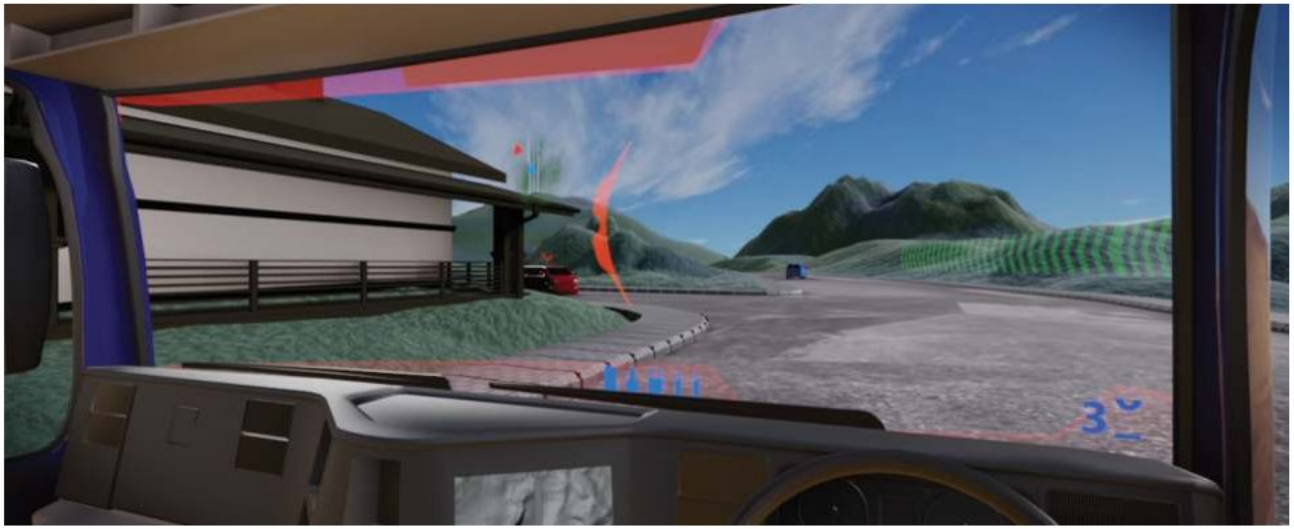
Dynamic and spontaneous (Stray vehicle / pedestrian / animal)

-Paths of dynamic obstacles are forecasted by the sensors and V2V communicationand if there is achance for imminent collision, a warning is given.
-This is applicable for speeding occluded vehicles which could hit the truck, pedestrians and two wheelers in blind spots.

Driver approaching a road from which a vehicle is speeding towards the truck.



Sensors/V2V communication system helps in warning the driver about the threa even before seeing it.



THe red indicator gives the direction of the threat.

This way, driver can stop/appropriate actions in advance.

5.8.8. REVERSE ASSIST

System will warn driver in case of violation of rules

-Driving on to a public road in the reverse direction.

-Driving backwards into a road designated as "ONE WAY".

Guidelines:

The virtual rear view mirror is always present on the windshield and when the reverse gear is engaged, it expands on the screen to provide detailed view of the rear side.

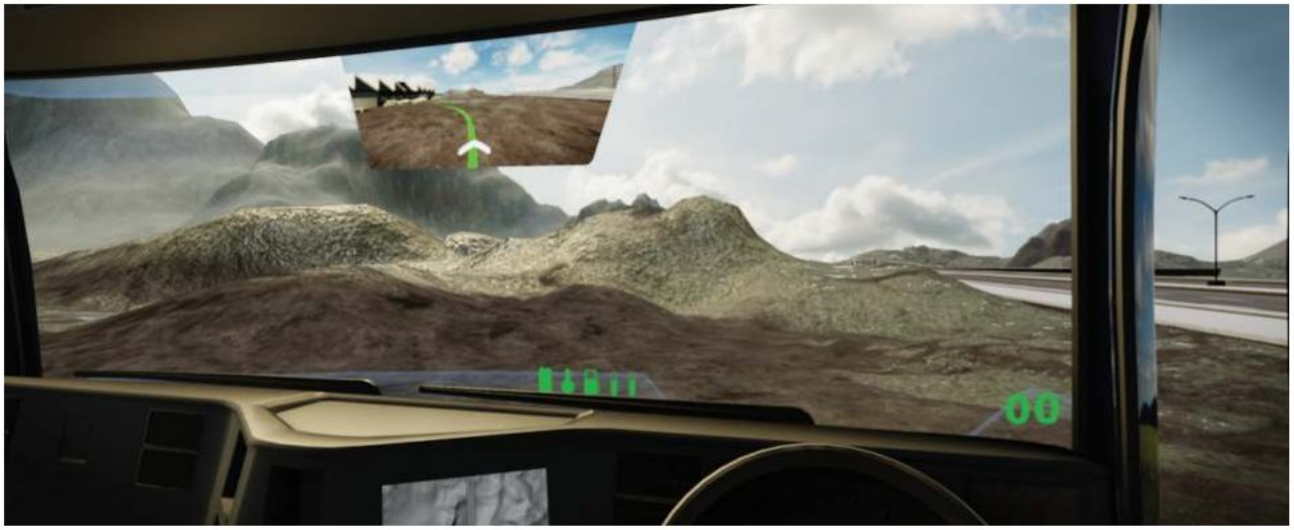
-The mini map expands to show the immediate surroundings and activities.

-The display will show the desired path to be followed and the driver has to match the vehicle path with the desired path (Useful for novice users driving a trailer truck)

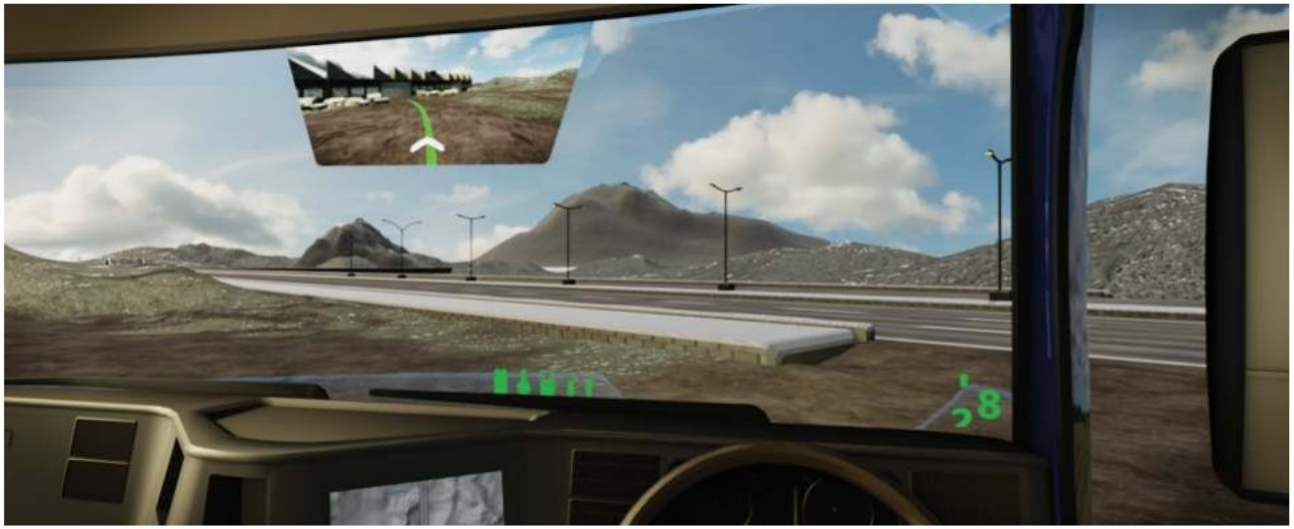
-In case of a possible threat [1], driver will be alerted on the screen. The threat will be highlighted on the 'virtual rear view mirror' as well as on mini map.

[1] Threat could be a stationary object, pedestrian, another vehicle, animals or overhead obstructions like electrical cables and trees.

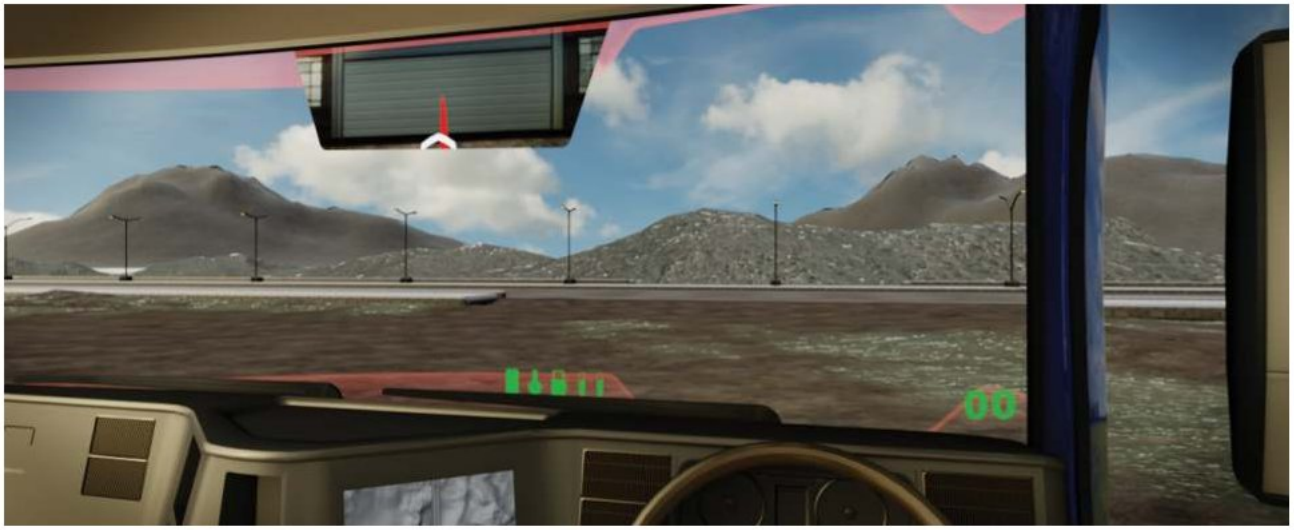
Driver ready to take the reverse



The virtual rear view mirror expands once the reverse gear is engaged.



The original path of vehicle is shown as White arrow and ideal path by Green arrow.



The arrow and the whole interface turns to red once the vehicle is close to some obstacle or has reached the destination.

5.8.9. NATURAL CALAMITY AND OTHER WARNINGS

Rerouting is often necessary because of various reasons and they could be a natural calamity, an accident, or even people protesting. If system can warn the drivers before they get trapped into the situation, they could be rerouted.

Guidelines:
Natural calamity, accidents and abnormal traffic blocks.

- The map system identifies traffic block data and if it is not clearing up within a stipulated time rerouting procedure will start.
- The trucks current position is analyzed and will be redirected to a road with enough width to accommodate a truck.

The map can identify if there is an abnormal traffic block which is taking too much time to clear. It may not be able to identify what the actual reason for the issue is. However, if the block continues for a long time, all the vehicles are rerouted.

If the reason for block is identified, it is projected on to the windscreen.

Driver will be given warning about the rerouting 500m beforehand.

Some remote regions in truck routes are infamous for burglary and armed attack by mob gangs and locals. Experienced drivers know this place and they often stop well before such spots and wait for other trucks and vehicles. Once there is enoough number of vehicles, they will move together so that they would not be attacked

Burglary Warnings

- Threat prone areas are continuously added to the map and when a driver is approaching a burglary prone area, he is warned in advance to wait for other vehicles.

The driver can stop and wait for other motorists after seeing the warning

5.8.10. INTEREST POINTS

Interest points are not always shown on the mini map as drivers do not need to navigate to this points at all the time. Navigating to interest points require setting custom markers to the areas.

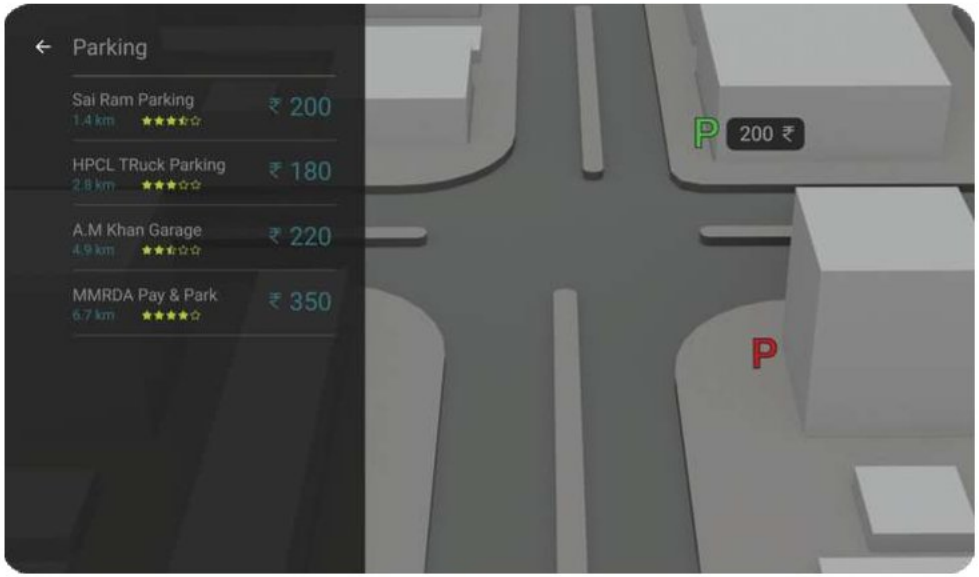
Guidelines:

Navigating to a parking lot

-When driver selects parking lot option from the second screen, he would be provided information about nearby parking lots and their respective fee and availability.
-Once driver selects a particular parking lot, he is redirected to the same.

Navigating to a fuel station

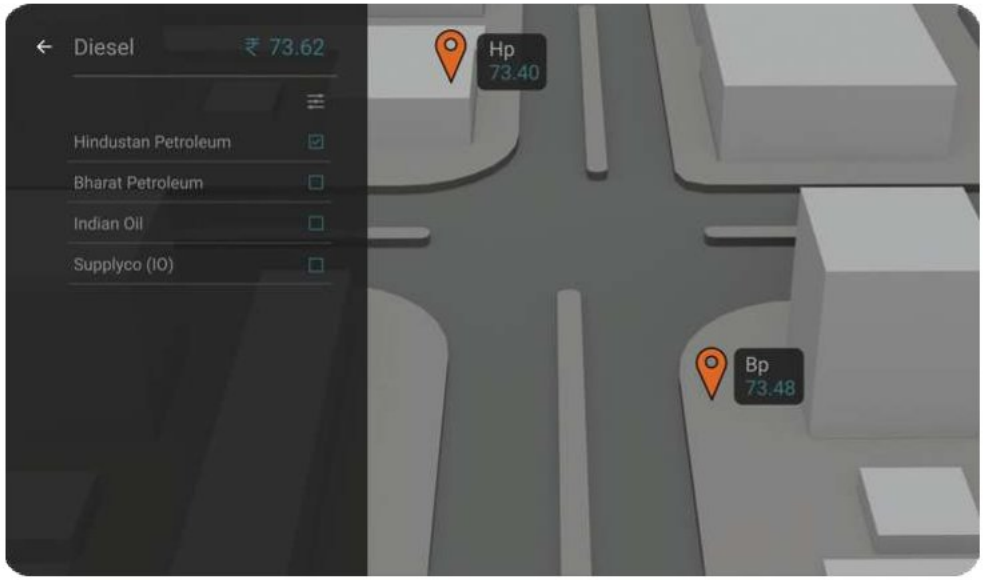
-Unlike other interest points, drivers will be automatically redirected to fuel stations based on the vehicles fuel level.
-Drivers will have the option to set preferences for a desired fuel station.
-System will give suggestion on the amount of fuel to be filled by forecasting consumption of fuel till next refilling.



Parking Lot

Clicking on parking lot Icon from on main screen will lead to this screen which shows all the nearby parking lots, respective fees and ratings.

Parking lots with no availability are highlighted in red.



Fuel Stations

Driver will be able to set preferences for desired fuel station and system will only show the selected fuel stations.

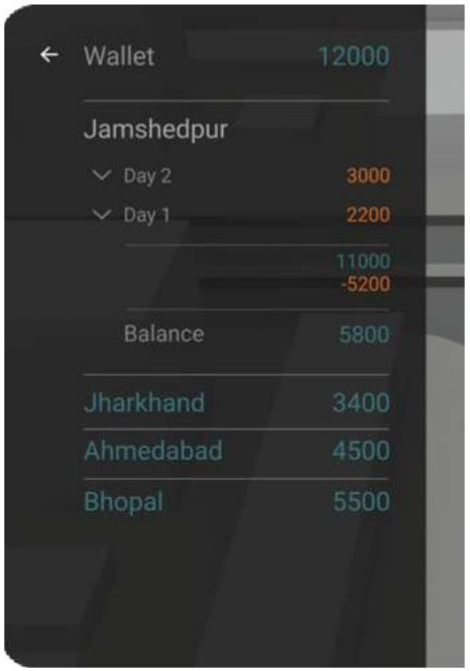
5.8.11. E- JOURNAL

Necessary system level changes

-Traffic police force is equipped with violation scanner which is connected to police DB.

-Fuel stations and parking lots should accept truck cards for payments.

Guidelines:



-Traffic police force will scan the vehicle number and enter the violation code into the device if the driver has violated any rule. The same data would be sent to police DB, truck owner and transport company. The data from the vehicle sensors at that time stamp is also sent to the Police DB, owner and transport company.

-This ensures that there is no solid cash transaction. The violation penalties are added to the vehicle records and the amount has to be cleared in a fixed interval of time.

-The same system is used by truck repair shops and the amount is transacted digitally.

-If police, fuel stations and truck yards all accept digital mode of transactions, the driver, truck owner and transport company will have clear understanding about the expenditure.

6.CONCLUSIONS

The final designs has tried to address all the key scenarios in the best way possible. For the proper evaluation of the project, a depth based simulation is necessary as it is difficult to evaluate the Interface on a 2d screen. However, within the time limit, the video simulations helped in evaluating the dynamic elements of the interface and also how the elements would appear and their visual style.

From this project, key learning was understanding the cognitive aspect of design where human lives are at stake. The design was iterative and with each iterations, more issues were addressed and I believe that there is still a room for massive improvement in every aspect. However, I beieve that I did my best within the stipulated time. Again, the designs do need a proper field testing to be implemented on the road.

The scientific methodologies used in the project were extremely useful and they helped in understanding all the scenarios to the root.

The design also had an angle where it had to take the interests of various stakeholders into account for dealing with social issues. That was also a good learning experience in terms of system design.

7.REFERENCES

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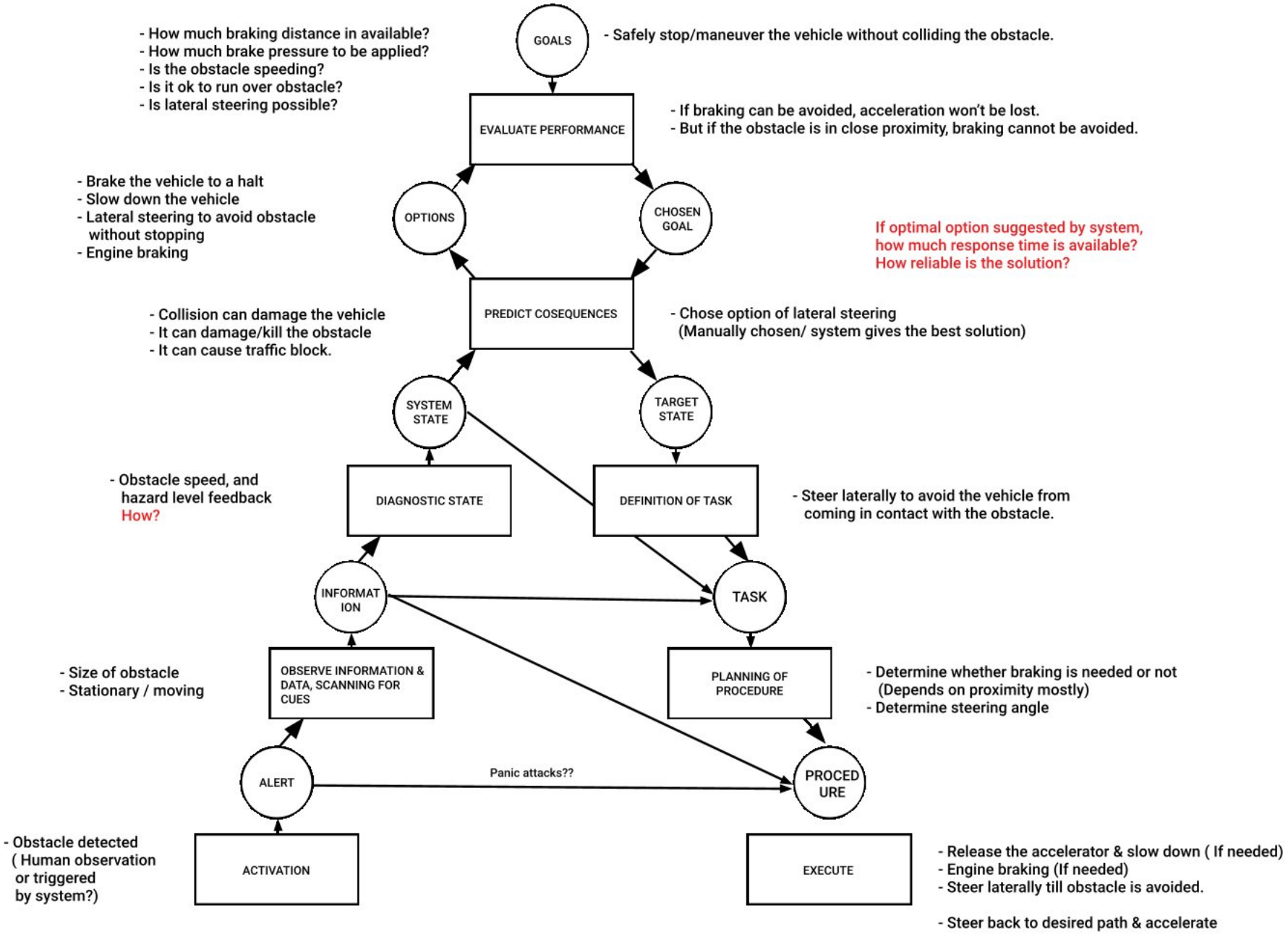
8 ANNEXURE

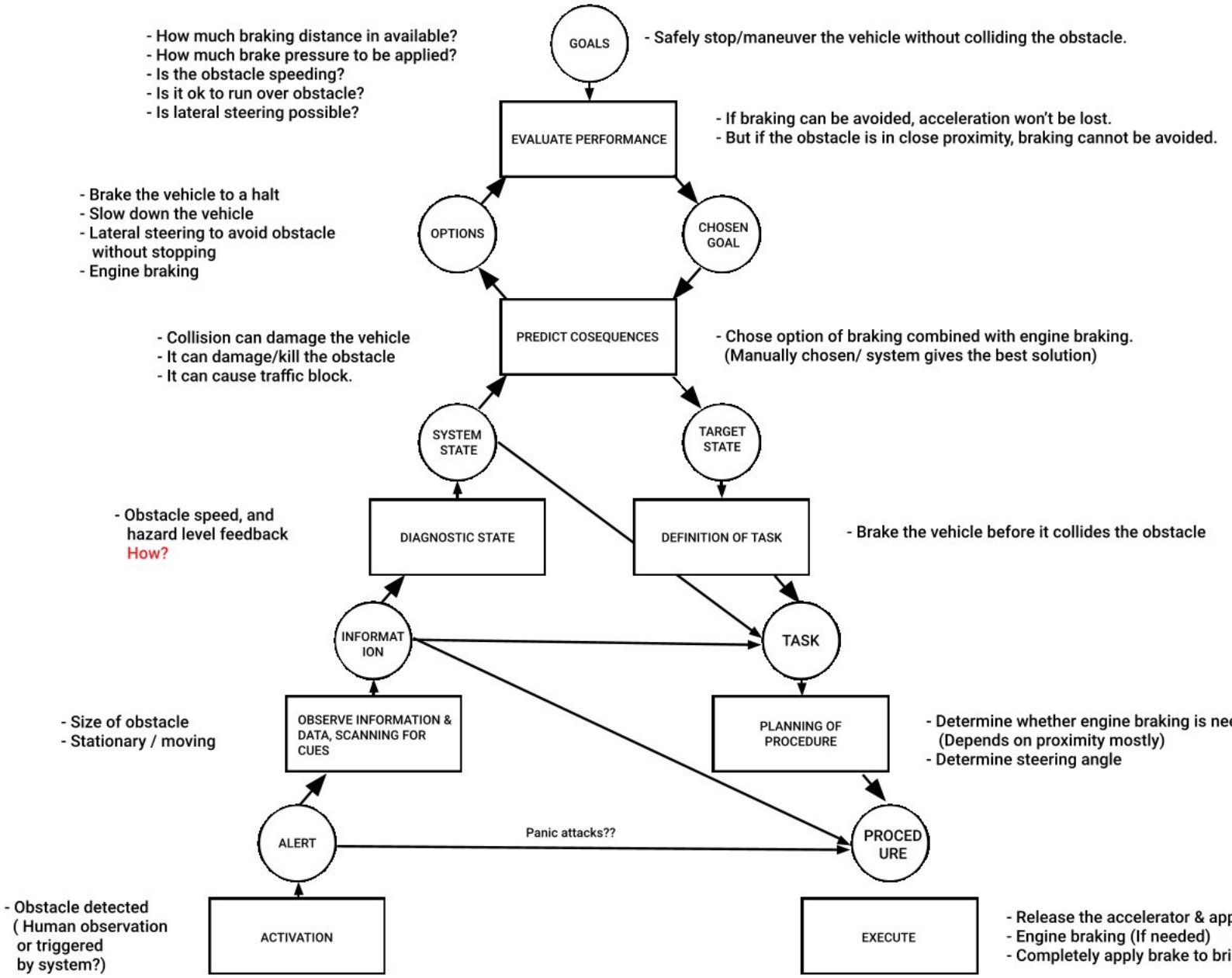
Control task analysis of scenarios and iteration 1 scenarios are added here.

8.1 CTA FOR SCENARIOS

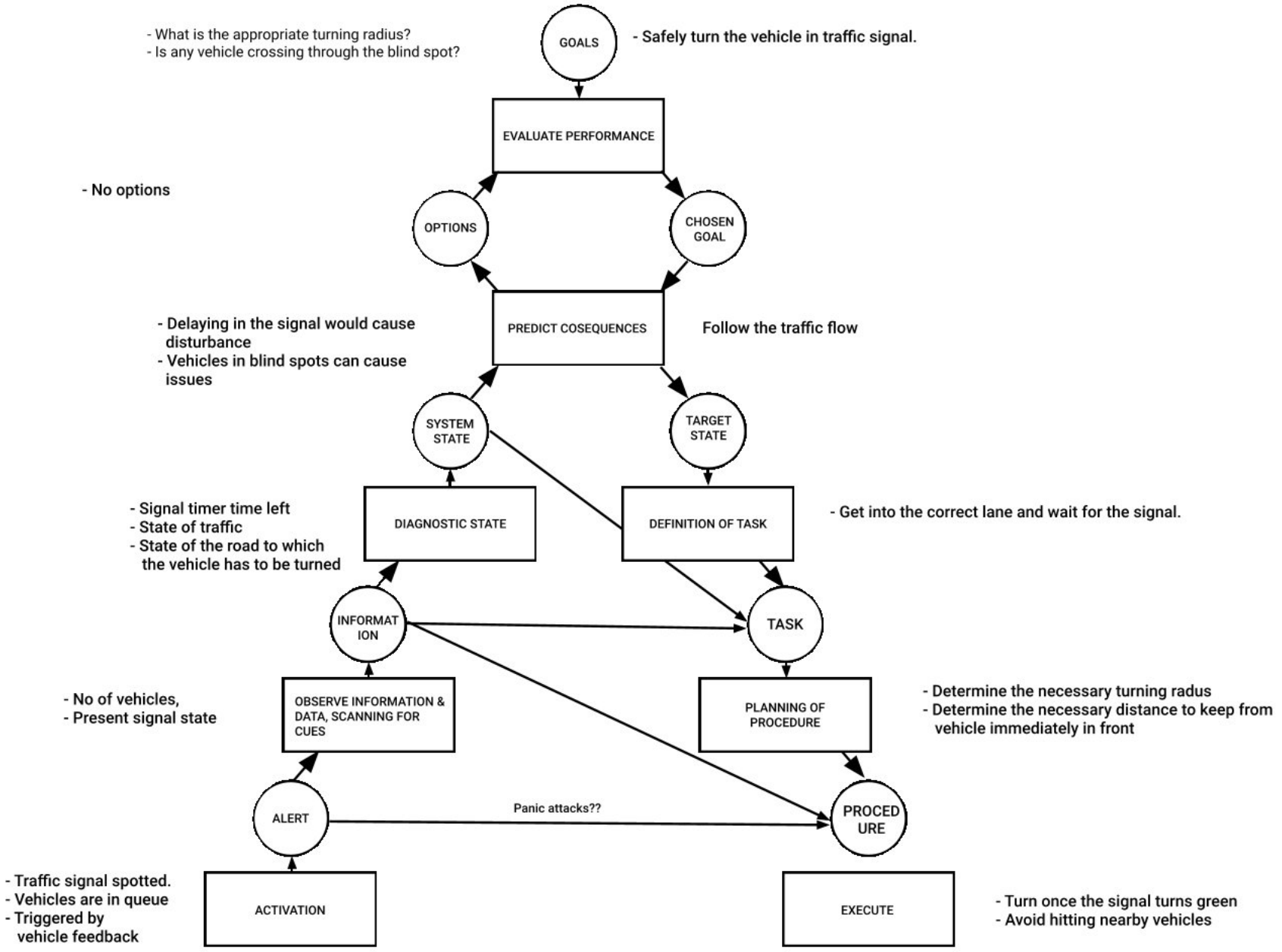
Braking (Static obstacles Eg: potholes, debris, other vehicles)

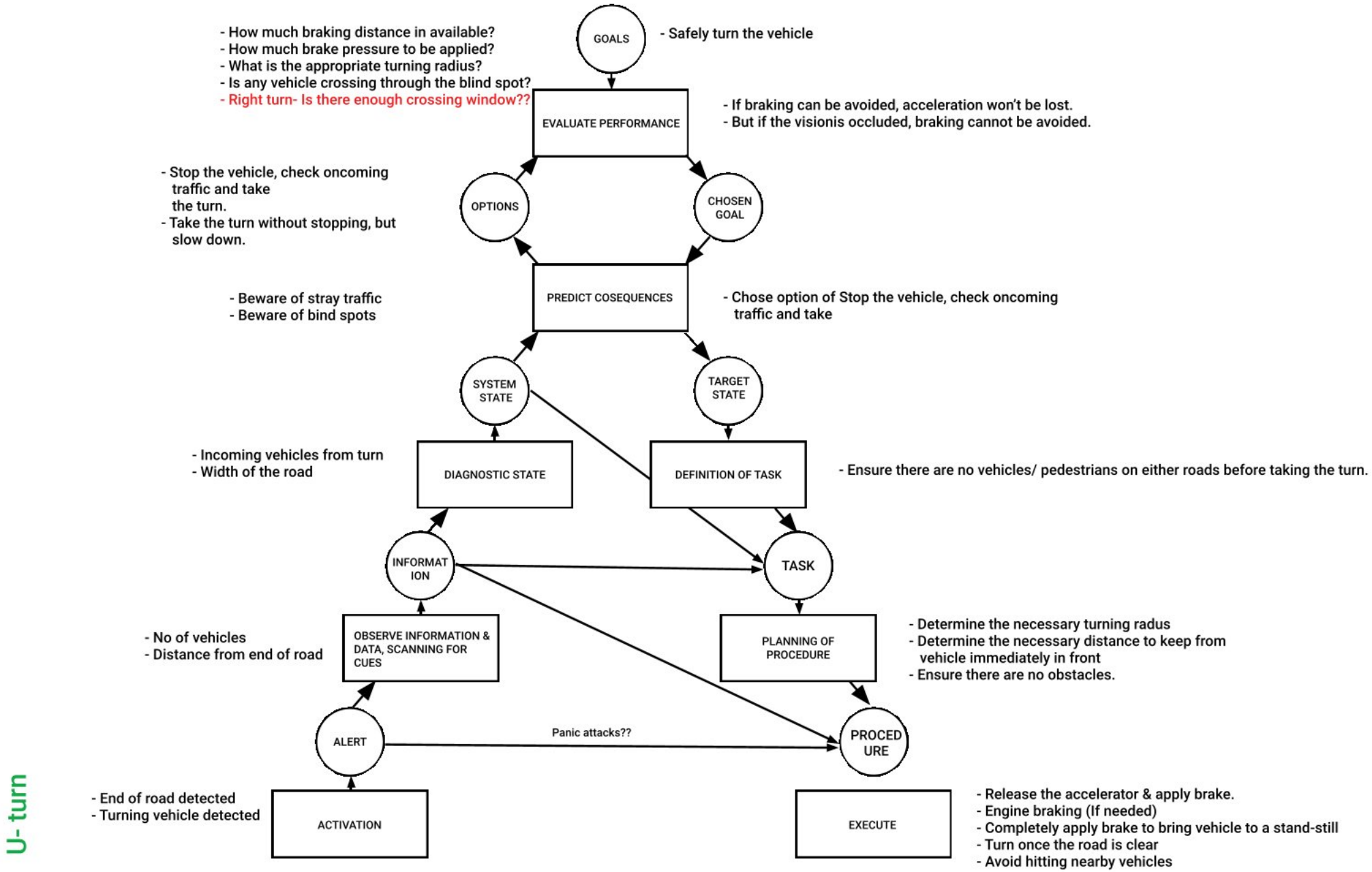


Braking (Moving & unpredicted obstacles
Eg: Stray vehicles, pedestrians, animals)

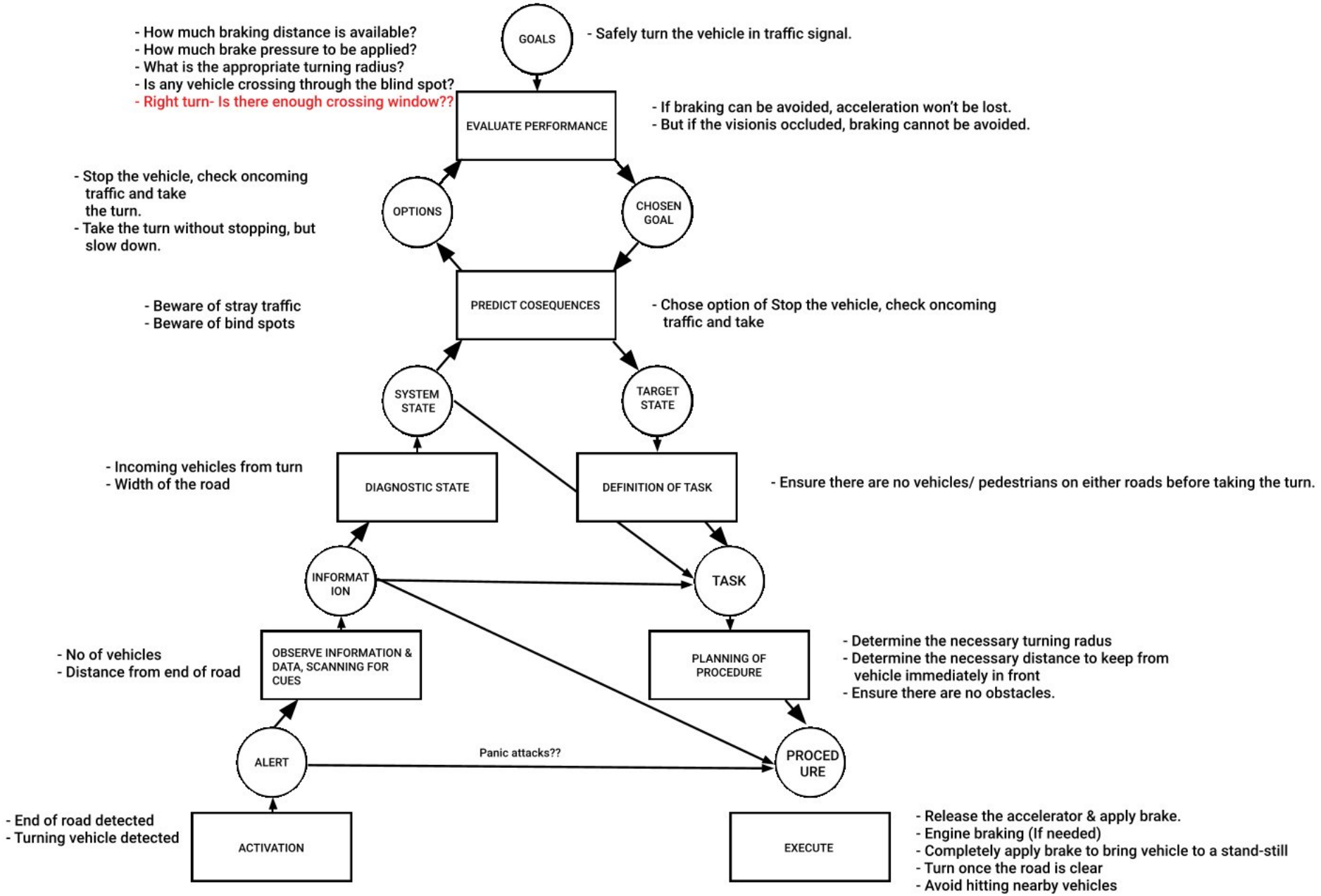


Turning in highway (Traffic signal.)

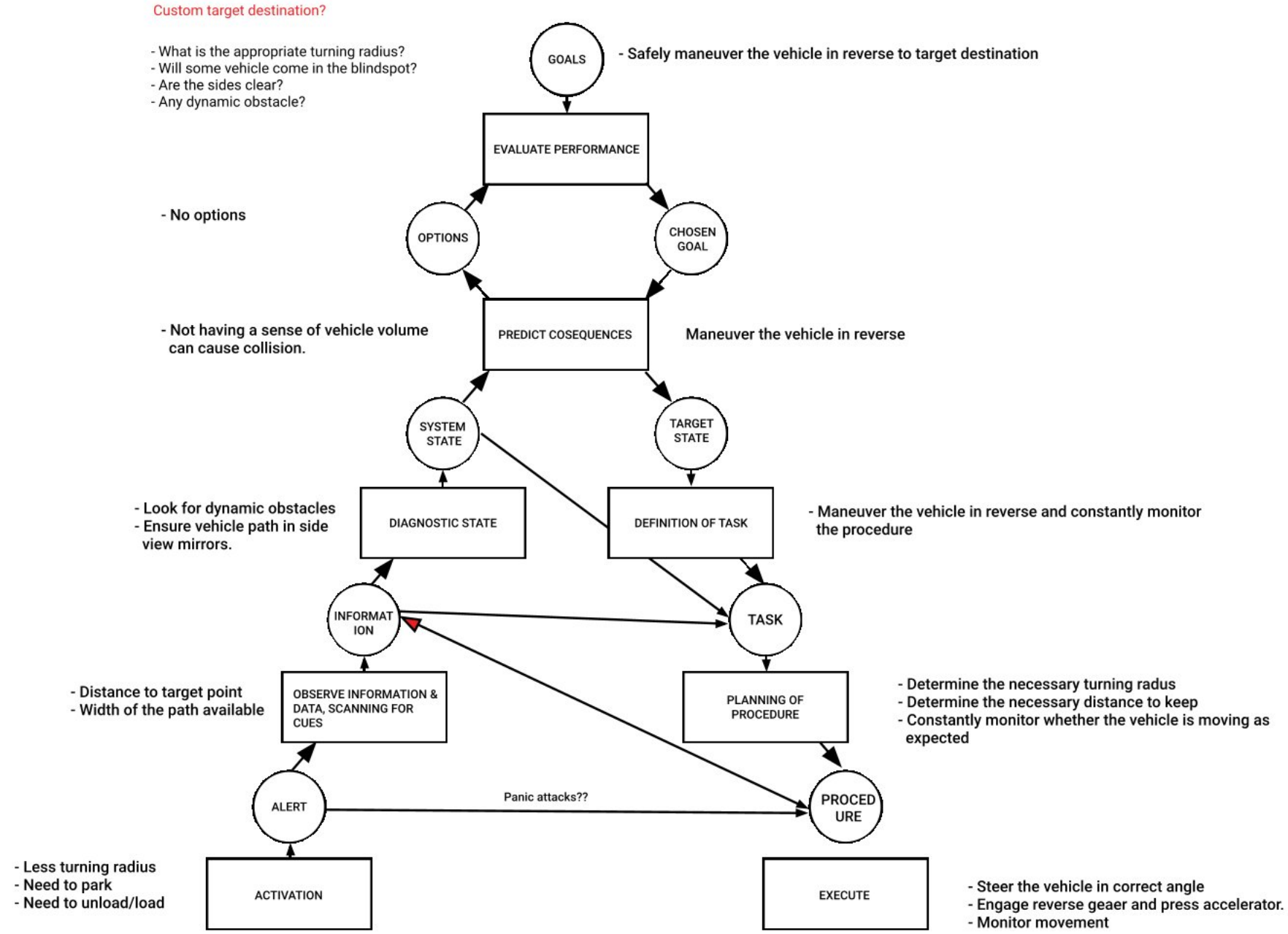



U- turn
GOALS
- Safely turn the vehicle
- How much braking distance in available?
- How much brake pressure to be applied?
- What is the appropriate turning radius?
- Is any vehicle crossing through the blind spot?
- Right turn- Is there enough crossing window??
EVALUATE PERFORMANCE
- If braking can be avoided, acceleration won't be lost.
- But if the visionis occluded, braking cannot be avoided.
OPTIONS
CHOSEN GOAL
- Stop the vehicle, check oncoming traffic and take the turn.
- Take the turn without stopping, but slow down.
PREDICT COSEQUENCES
- Beware of stray traffic
- Beware of bind spots
- Chose option of Stop the vehicle, check oncoming traffic and take
SYSTEM STATE
TARGET STATE
- Incoming vehicles from turn
- Width of the road
DIAGNOSTIC STATE
DEFINITION OF TASK
- Ensure there are no vehicles/ pedestrians on either roads before taking the turn.
INFORMAT ION
TASK
- No of vehicles
- Distance from end of road
OBSERVE INFORMATION & DATA, SCANNING FOR CUES
PLANNING OF PROCEDURE
- Determine the necessary turning radus
- Determine the necessary distance to keep from vehicle immediately in front
- Ensure there are no obstacles.
ALERT
Panic attacks??
PROCED URE
- End of road detected
- Turning vehicle detected
ACTIVATION
EXECUTE
- Release the accelerator & apply brake.
- Engine braking (If needed)
- Completely apply brake to bring vehicle to a stand-still
- Turn once the road is clear
- Avoid hitting nearby vehicles

Turning in country roads (No Traffic signal.)



Reverse

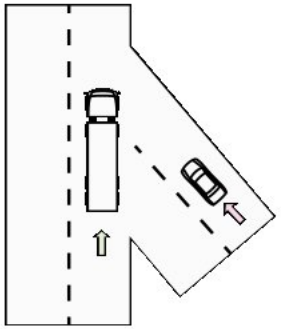

Custom target destination?
- What is the appropriate turning radius?
- Will some vehicle come in the blindspot?
- Are the sides clear?
- Any dynamic obstacle?
GOALS
- Safely maneuver the vehicle in reverse to target destination
EVALUATE PERFORMANCE
- No options
OPTIONS
CHOSEN GOAL
- Not having a sense of vehicle volume can cause collision.
PREDICT COSEQUENCES
Maneuver the vehicle in reverse
SYSTEM STATE
TARGET STATE
- Look for dynamic obstacles
- Ensure vehicle path in side view mirrors.
DIAGNOSTIC STATE
DEFINITION OF TASK
- Maneuver the vehicle in reverse and constantly monitor the procedure
INFORMAT ION
TASK
- Distance to target point
- Width of the path available
OBSERVE INFORMATION & DATA, SCANNING FOR CUES
PLANNING OF PROCEDURE
- Determine the necessary turning radus
- Determine the necessary distance to keep
- Constantly monitor whether the vehicle is moving as expected
ALERT
Panic attacks??
PROCED URE
- Less turning radius
- Need to park
- Need to unload/load
ACTIVATION
EXECUTE
- Steer the vehicle in correct angle
- Engage reverse geaer and press accelerator.
- Monitor movement

8.2 ITERATION 1 SCENARIOS

Warnings

Situation:

A speeding vehicle is approaching towards the truck from the right side.



Normal scenario

When there is no threat, the mini map outline is green.

1

The green ring around mini map changes color to red, catching the drivers attention. The speeding vehicle is highlighted in red.

2

Instead of completely changing the color, only certain area is changed to red, which essentially shows the location of the speeding vehicle. Does it increase understanding?

3

If something is happening on right side of vehicle, drivers naturally look in the right side view mirror. By giving a side bar with color indication, will it be easy to catch drivers attention?

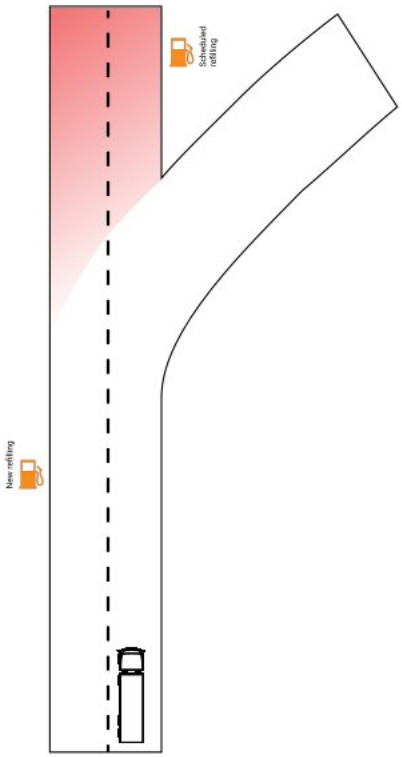
4

This is a combinatin of idea 2 & 3.
First the driver comes to know that something is happening on the right side. Then he will look into the mini map to see what is actually happening around the vehicle.

Natural Calamity Warning

Situation:

There is a land slide happeing across the path and vehicle needs to be rerouted. Vehicle is also running low on fuel.



Critical Fuel Warning

In case of natural calamities, the system gives warning ahead of time and reroutes the trip. New added distanceand time is added.

Data fromprevious trips helpsin estimating the ETA.

Flashing animation

Critical Fuel Warning

As per the driving pattern and fuel estimation, a refill was scheduled in a pump which cannot be accessed due to the land slide now. The system calibrates the fuel requirement and suggests a new pump

New route does not have a pump.

All this data is sent to the company and owner.

Low Fuel Warning

Situation:

The vehicle is running low on fuel

Normal scenario

When there is no threat, the mini map outline is green.

Low fuel warning

Warning comes only when the fuel falls under a threshold value. Mini map shows shows nearest petrol pump as an interset point

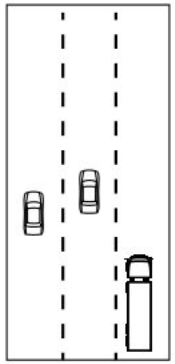
Critical Fuel Warning

For critical fuel limit, color changes to red. Flashing animation?

Highway Cruising

Situation:

Moderate traffic. Signages are hard to read/ in another language(Written signages).



Relative speed constant/ increasing

In such cases, it is safe for truck to follow the leading vehicle. It is shown by giving a green overlay in the lane.

The overlay is subtle and does not cause any discomfort to the driver.

Relative speed decreasing

In suchcases, it is no longer advised to follow the leading vehicle and the driver can switch lane to keep the same speed. The lane is marked as red according to relative speed.

Relative speed constant/ increasing

In such cases, it is safe for truck to follow the leading vehicle. It is shown by giving a green overlay in the lane.

The overlay is subtle and does not cause any discomfort to the driver.

Relative speed decreasing

In suchcases, it is no longer advised to follow the leading vehicle and the driver can switch lane to keep the same speed. The lane is marked as red according to relative speed.

Augmenting signages

Signages are augmented by projecting info on signage. For eg; an animationof school kid is played along with the targeted speed limit. The mini map turns orange, giving a sense of caution.

The static warning could have a flashing animation.

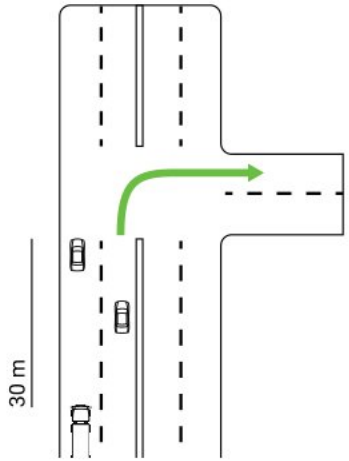
Combining warnings

New warning is added along with the existing warnings.

Taking turn in highway - R

Situation:

The navigation is assisting the vehicle in taking a right turn in highway. The vehicle is in a lane not suitable for taking the turn.



Step 1 : Lane change

30 m prior to the turn, the suitable lane for taking the turn is highlighted. Also, a turn warning is also displayed.

Step 1 : Lane change

The mini- map zooms in to give a clearer picture of events.

Step 1 : Lane change

If the vehicle ahead is decelerating, the green signal could cause confusion. Here the mini-map will come in handy.

Step 1 : Lane change

The mini- map zooms in to give a clearer picture of events.

Step 1 : Lane change

A green arrow could highlight the lane.

Step 1 : Lane change

The mini- map zooms in to give a clearer picture of events.

Step 2 : Stop at signal

When the vehicle reaches the signal, the traffic signal status is augmented and shown in the warning area.

Step 3 : Taking the turn.

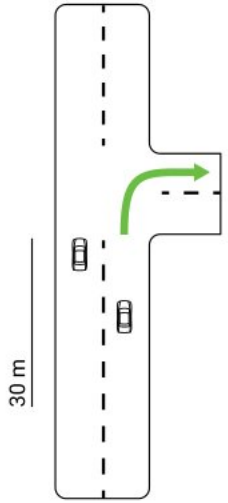
The turning radius is projected on to the path. The driver just needs to follow the path.

The arrow will be directly in front of drivers vision.

Taking turn in local routes

Situation:

The navigation is assisting the vehicle in taking a right turn in local route. The vehicle is in a lane not suitable for taking the turn.



Step 1 : Lane change

30 m prior to the turn, the suitable lane for taking the turn is highlighted. Also, a turn warning is also displayed.

Step 1 : Lane change

If the vehicle ahead is decelerating, the green signal could cause confusion. Here the mini-map will come in handy.

Step 1 : Lane change

If the vehicle ahead is decelerating, the green signal could cause confusion. Here the mini-map will come in handy.

Step 2 : Virtual signals

Even though there is no traffic signl, the system can look at the surroundings and give a suggestion bout when to take the turn and when not to.

Step 2 : Virtual signals

System gives a red signal as a vehicle approaching from behind is trying to overtake the truck.

Step 2 : Virtual signals

Even though there is no traffic signl, the system can look at the surroundings and give a suggestion bout when to take the turn and when not to.

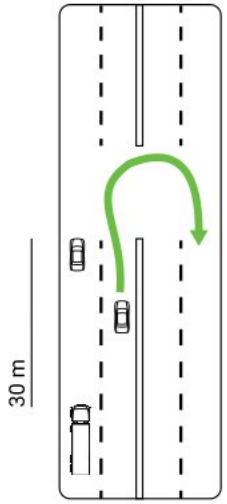
Step 3: Warning info

When driver is not following the curve guide, it turns to red

Taking U turn

Situation:

The navigation is assisting the vehicle in taking a right turn in local route. The vehicle is in a lane not suitable for taking the turn.



Step 1 : Lane change

30 m prior to the turn, the suitable lane for taking the turn is highlighted. Also, a turn warning is also displayed.

Step 1 : Lane change

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System gives a red signal as a vehicle approaching from behind is trying to overtake the truck.

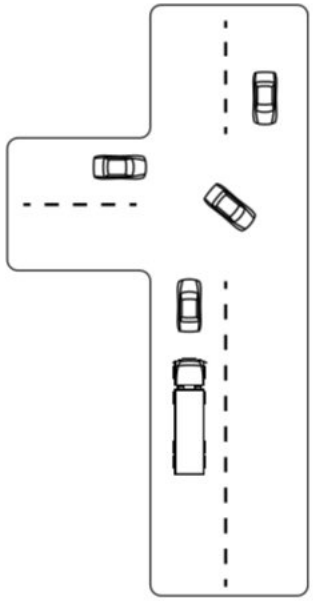
Step 2 : Virtual signals

Even though there is no traffic signl, the system can look at the surroundings and give a suggestion bout when to take the turn and when not to.

Decelerate (Dynamic & predicted)

Situation:

Stopping behind a vehicle in signal



Step 1 : Warning about bump

No threat shown until the speeding car could hit the vehicle as it is not slowing down.

Step 2 : Threat detected

The lane is marked in red indicating that there is an imminent threat. The map highlights the approaching vehicles position and shows the gradient on left side.

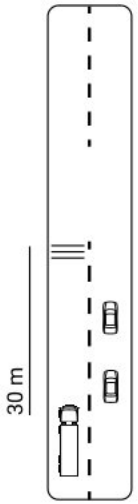
Step 2 : Gradient tells threat intensity

Orange gradient showing threats seriousness. For more info, the driver can look nto the mini map.

Decelerate (Static & predicted)

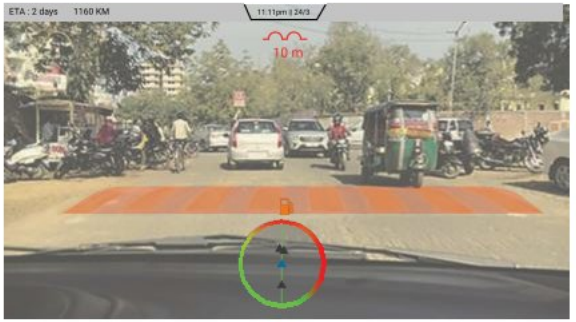
Situation:

Static/predicted obstacles can be bumps and vehicles moving in front. In this example, we are looking at a speed breaker/bump.



Step 1 : Warning about bump

30 m prior to the bump, a warning is provided on the screen



Step 2 : Bump approached

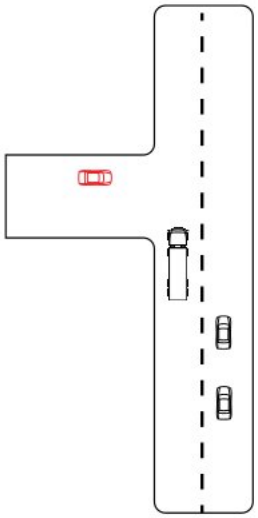
Speed bump is projected on to tenscreen with highlight. A small projected animation can catch drivers attention

Step 3 : Bump cleared

Decelerate (Dynamic & unpredicted)

Situation:

Speeding vehicle approaching from left side blind spot.
Co drivers usually help drivers in managing this situations



Step 1 : Warning about threat

No threat shown until the speeding car could hit the vehicle as it is not slowing down.

Step 2 : Threat detected

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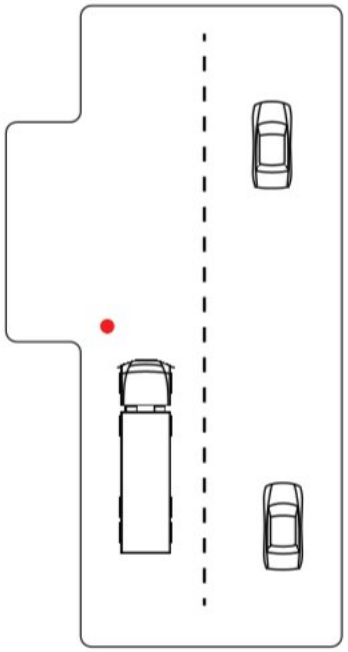
Step 2 : Gradient tells threat intensity

Orange gradient showing threats seriousness. For more info, the driver can look nto the mini map.

Decelerate (Dynamic & unpredicted)

Situation:

Pedestrian/animals in blind spot



Step 1 : Warning about bump

No threat shown until the speeding car could hit the vehicle as it is not slowing down.

Step 2 : Threat detected

The lane is marked in red indicating that there is an imminent threat. The map highlights the approaching vehicles position and shows the gradient on left side.

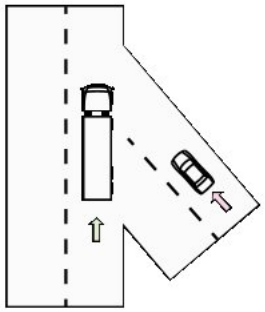
Step 2 : Gradient tells threat intensity

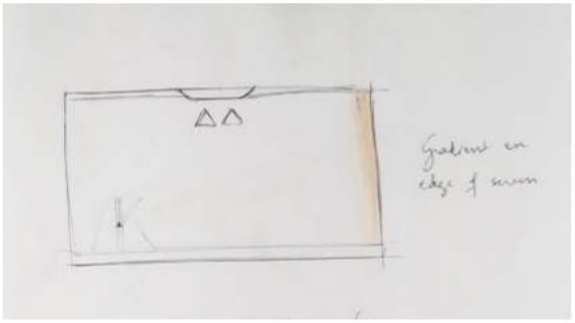
Orange gradient showing threats seriousness. For more info, the driver can look nto the mini map.

Collision warning Re-exploration

Situation:

A speeding vehicle is approaching towards the truck from the right side.





Warning

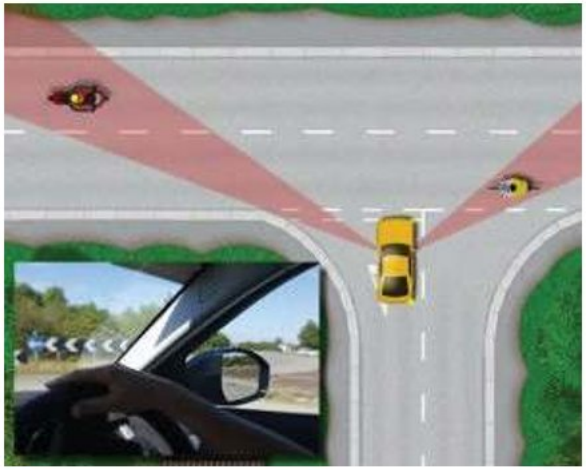
If something is happening on right side of vehicle, drivers naturally look in the right side view mirror. By giving a side bar with color indication, will it be easy to catch drivers attention?

A pillar blind spot

Situation:

A pillars on vehicles creates blinspots and the effect increases with distance.

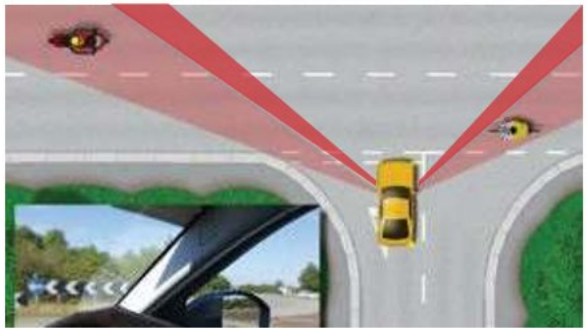
Due to safety regulations about rollover incidents. A-pillars are gettig thicker for better inside protection



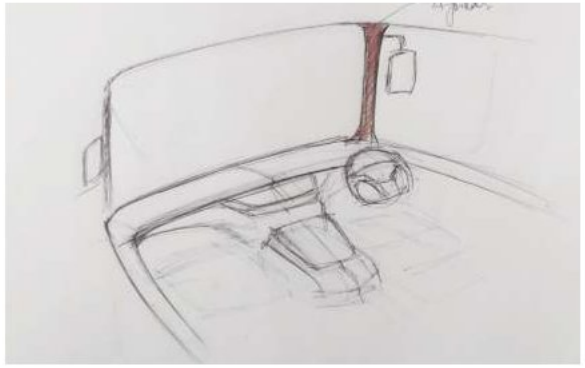
A-pillars can mask three square feet's worth of area at a distance of 12 feet from the vehicle.

Source: Industry Supplier Continental, which is developing cameras to see "through" the A-pillars.

Collision warning Re-exploration



The gradient warning can create another blindspot no matter how transparent is and it can add to the apillar blind spot effect



Solution Idea 1

The warning gradient could appear over the A pillar itself, avoiding further buildup of blind spot.

The pillar could be overlayed with a screen to make it 'Invisible'.

Solution Idea 2

Instead of showig gradient on the screen and A pillar, the gradient can appear over the side view mirror. The a pillar can be made Invisible.

Ultimately, if something is happpening on the right side, driver has to made aware of this and he would end up looking at the side viw mirror tounderstand more about the situation. Overlaying on the side view mirror itself could reduce the response time.