

Drowsiness Prevention System

Design Project III

under the guidance of

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Introduction

- Drowsiness is one of the major reason of accidents on the highway driving at night time.
- Road accidents caused due to drowsiness lead to huge amount of economical and infrastructural loss and manpower too.

21%

in the world

57%

in India for
Trucks

Relevance of the project

SWOT Analysis of this project will help to figure out the importance and probability of success.

Strength

- (i) There is a huge potential to save thousands of drivers' life who risk their life everyday for economic and occupational hazards
- (ii) There not so much usable product in the global market which fits in driving scenario from the point of ergonomics and usability function
- (iii) There are lots of research is going on but unfortunately no Indian product is existing in the market

Weakness

- (i) Indian drivers are very reluctant to use automated system and gamified driving experience as this is very new to them. Even it is very hard for low educated drivers. So it is very hard to design and convince them for using it.

Relevance of the project

Opportunities

- (i) There can be different level of solution to serve different group of users - different categories of drivers

Threats

- (i) It must be a integrated system, so that any driver can't skip this system; otherwise respective vehicle will not start. But for this reason, few drivers might not install this system in the vehicle. So there is need of mandatory rules to implement in the large scale, otherwise it will very hard to implement.

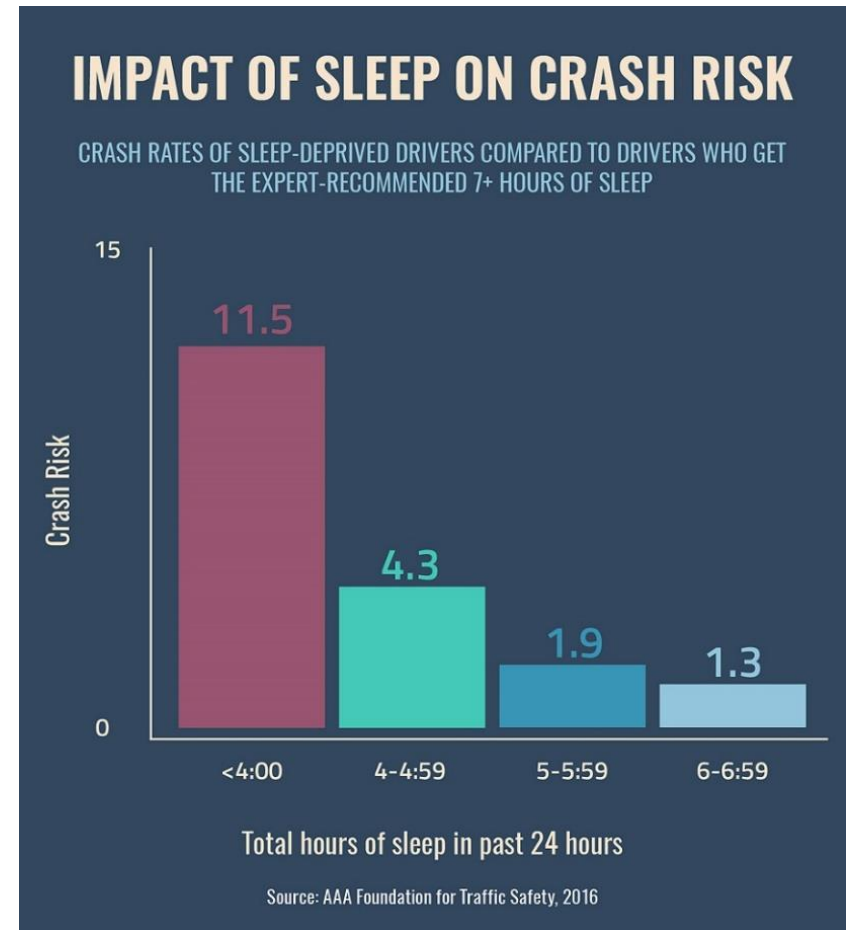
Fatigue

Extreme tiredness resulting from mental or physical exertion depends on Work load, work stress and work performance and leads to these one after another

- Fatigue (work related)
- Tiredness (physical condition)
- Drowsiness (effect that causes accidents)

Types of Fatigue

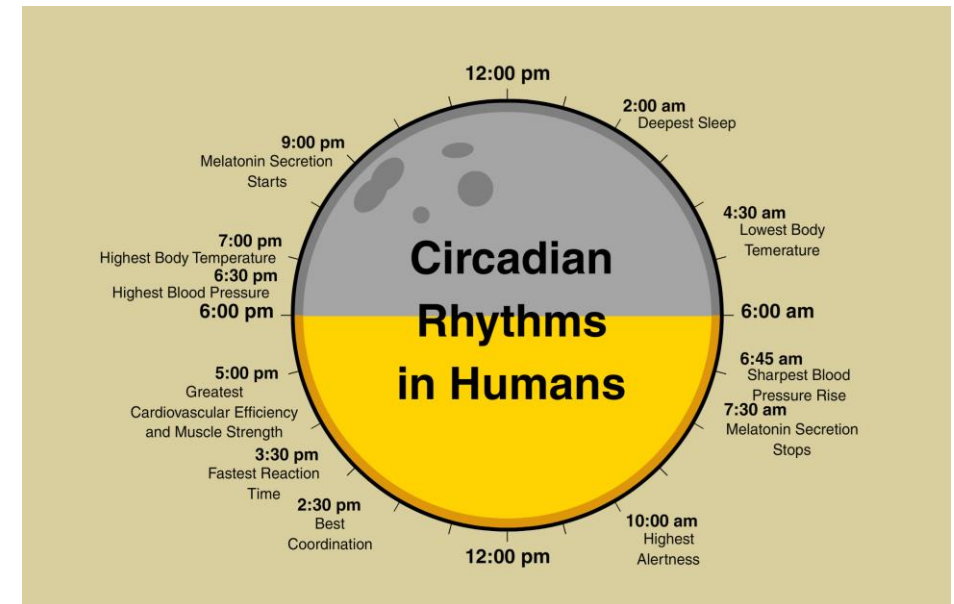
- Task Related (for Work Load, Work Stress, Work Performance)
- Sleep Related (for Circadian Rhythm)



Causes of Drowsiness

There are lots of probable reasons for drowsiness which generally caused from fatigue during driving car for a long journey

- Low volume of traffic
- No visual stimuli (like Darkness at night)
- Monotonous route
- Continuous flow of traffic with almost same density
- Predictability of Driving Tasks
- Constant Noise of same intensity
- Circadian Rhythm



Symptoms of Drowsiness

- Yawning frequently
- Trouble to keep head up
- Difficulty for focusing
- Frequent eye blinking with heavy eye-lid
- Unable to remember last few miles
- Miss exits and traffic signage
- Drifting from lanes

Ways to reduce drowsiness

There are is no specific way as it depends on different user condition and context. But as a whole we can develop a system which can counter most the reasons.

Some of the possible ways are

- Change of Driving Environment
- Anxiety Information/Alarm Generation
- Draw attention by new information
- Change of the affective mood
- Replacing the tiring activity by others tasks (preferably driving related) which will reduce monotony & also give a Feeling of a **Virtual Co-driver**

Drowsiness Manipulation Study

One of the challenges in developing an efficient drowsiness detection system is how to obtain proper drowsiness data. Due to safety reasons, drowsiness cannot be manipulated in a real environment; thus, the drowsiness detection system has to be developed and tested in a laboratory setting.

However, in a laboratory setting, the most reliable and informative data that pertains to driver drowsiness relies only on the way in which the driver falls into the drowsy state.



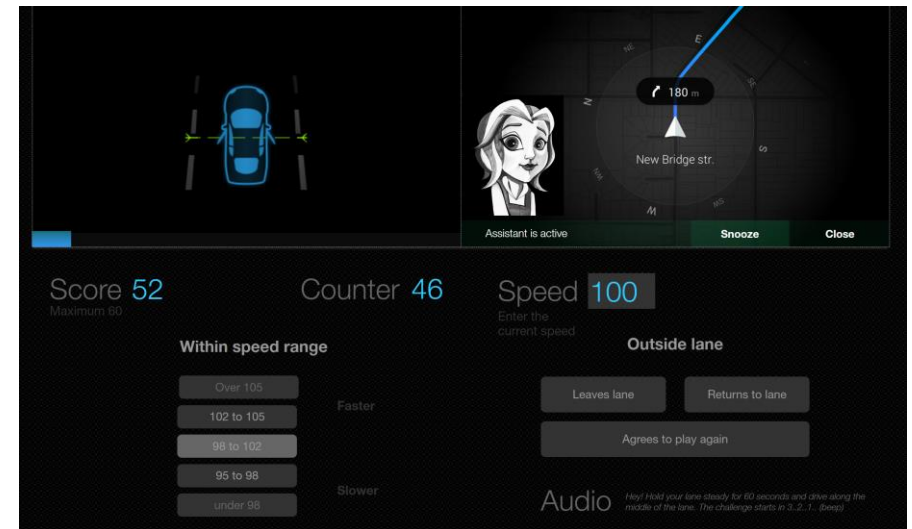
Gamified Driving Experience

It is found that conversation with passengers or co-driver helps at the time getting monotonous and drowsy at the time of driving at highway for a long time.

Besides this, it is also found that young drivers are more prone to get drowsy but they love driving games.

So it will be good to introduce a Virtual Co-driver, who will make conversation and keep the driver awake and also should not distract from the driving. Upon this concept, different driving oriented games are generated.

HOLD THE LANE **HOLD THE SPEED**
HOLD THE DISTANCE **DRIVING RELATED QUIZ**



Scope of Intervention

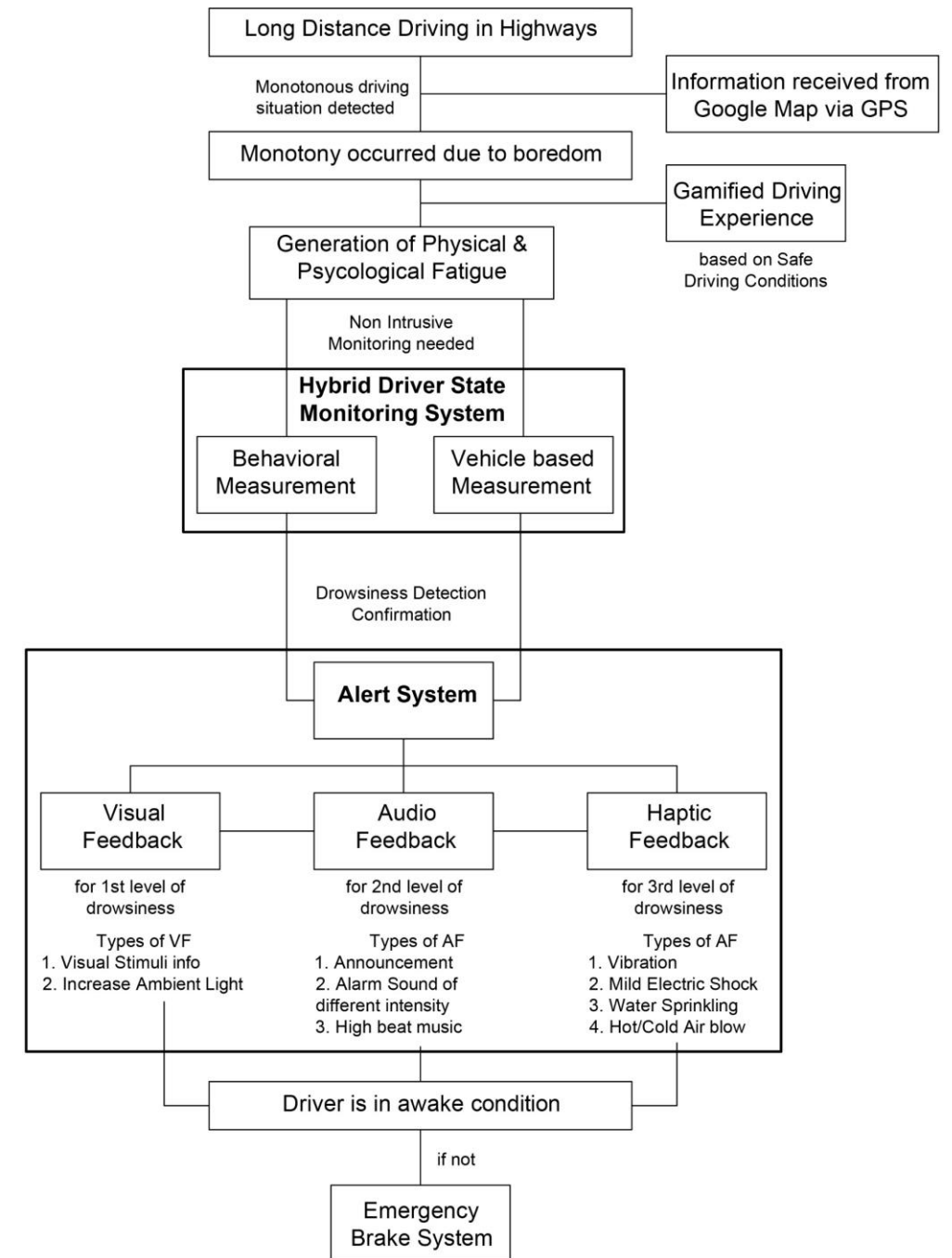
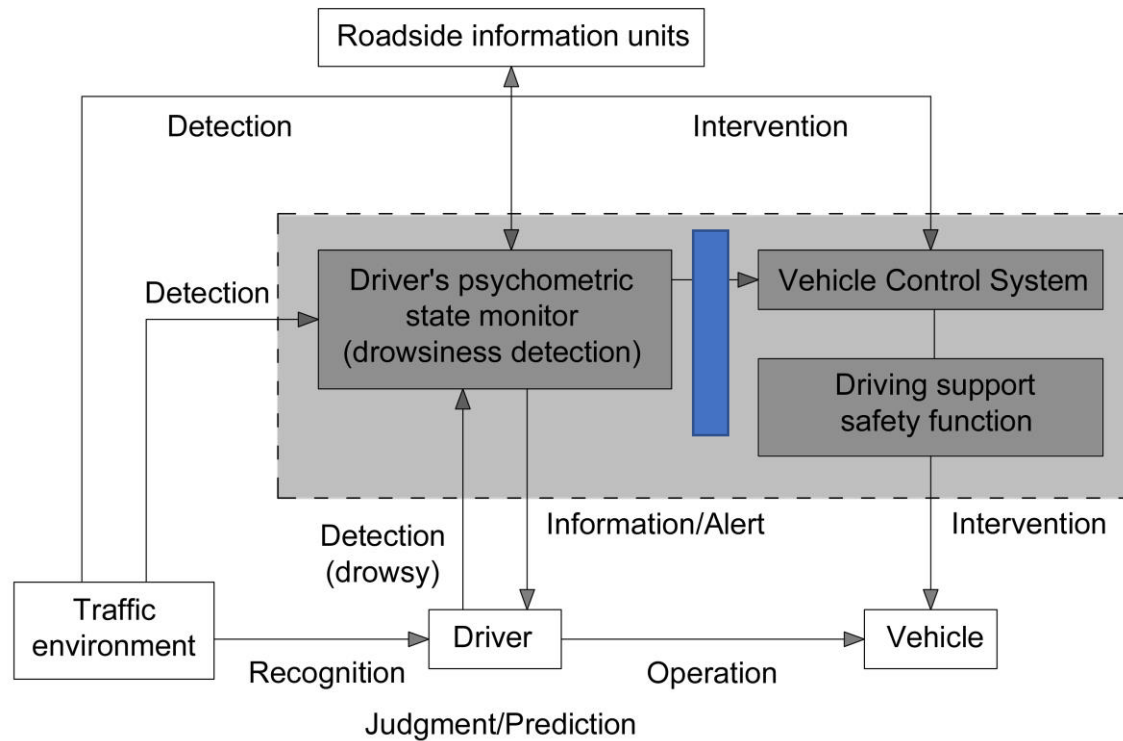
There can be two types of intervention

- (i) Driver level intervention
- (ii) Vehicle/System level intervention

Issues can be covered

- (i) Safe Driving – safety factors and to develop driving skills
- (ii) Avoid monotony and fatigue (including drowsiness) – both physical and psychological
- (iii) Fuel efficiency Eco-driving
- (iv) Enriching overall experience
- (v) Restrict misuse of the car and different driving system
- (vi) Monitoring driving behavior and drivers' profiling

The Whole System



User Study

Type of Vehicles	Class of Vehicles	Owned by	Type of Drivers	Maintenance of Vehicle	Faith Level	Responsibility Level	Probability of Drowsiness	Possible Intervention
Four Wheeler Vehicles	Private Car	Owner	Owner of the car	Very Good	Very Good	Very Good	Very Less	Driver/Vehicle level
	Private Car	Owner	Employed Driver	Very Good	Good	Good	May be	Driver/Vehicle level
	Private Car	Owner	Hired Driver	Very Good	Satisfactory	Satisfactory	May be	Vehicle level
	Public - Taxi	Owner	Owner of the car	Satisfactory	Bad	Bad	High	Driver/Vehicle level
	Public - Taxi	Owner	Hired Driver	Satisfactory	Very Bad	Bad	Very High	Vehicle level
	Public - Ola, Uber	Owner	Owner of the car	Good	Good	Good	Less	Driver/Vehicle level
	Public - Ola, Uber	Owner	Hired Driver	Good	Satisfactory	Satisfactory	May be	Vehicle level
	Public - Rental	Private Organisation	Employed Driver	Good	Good	Good	Less	Driver/Vehicle level
	Public - Rental	Owner	Hired Driver	Satisfactory	Satisfactory	Satisfactory	May be	Vehicle level
Bus	Public - Rental	Owner	User	Satisfactory	Good	Good	Less	Driver/Vehicle level
	Public	Govt.(State TC)	Employed Driver	Bad	Bad	Bad	High	Vehicle level
	Public	Private TC	Hired Driver	Satisfactory	Very Bad	Very Bad	Very High	Vehicle level
Truck	Private	Private Organisation	Employed Driver	Satisfactory	Very Bad	Very Bad	Very High	Vehicle level
	HCV	Private Organisation	Employed Driver	Satisfactory	Very Bad	Very Bad	Very High	Vehicle level
	HCV	Govt. Organisation	Employed Driver	Bad	Bad	Bad	High	Vehicle level
	MCV/LCV	Owner	Hired Driver	Satisfactory	Bad	Bad	High	Vehicle level

Scale 1 (for first 3 factors)

Very Good	Good	Satisfactory	Bad	Very Bad
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Scale 2 (for drowsiness)

Very Less	Less	May be	High	Very High
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Explanation of the parameters

Maintenance of Vehicle	Faith Level	Responsibility Level	Probability of Drowsiness
It denotes to the level of maintenance for the respective vehicle by the owner/driver	It denotes to the level of faith on the driver from the perspective of passangers	It denotes to the level of faith on the driver from the perspective of passangers	It denotes to possibility of getting drowsy with respect to other issues

In critical situations **vehicle level intervention** is preferred

Design Brief

Design a **Drowsiness Prevention System** which will take care of Safety at the time of long driving focusing Drowsiness which is apparently not a deliberate reason for accidents but possible to avoid.

Focused group of users are Employed/Hired Drivers in Public vehicles – rented cars, bus and truck in long driving scenario.

And also it should go with Indian context and should cater maximum drivers to have mass implementation and secure maximum drivers.

Design Brief

Core benefits to the users

- (i) It will keep driver safe enough at the time driving – passengers too.
- (ii) It will change drivers' behavior of driving.

User and User Experience related issues

- (i) It should give a good driving experience at the monotonous situation and keep the driver awake and safe at the time of long driving especially at the night.

Ergonomics related issues

- (i) There should be no ergonomic problem which may disturb at the time of driving or deteriorate driving experience.

Manufacturing related issues

- (i) The built form must be very well enough durable to long last – robust design.

Integration related issues

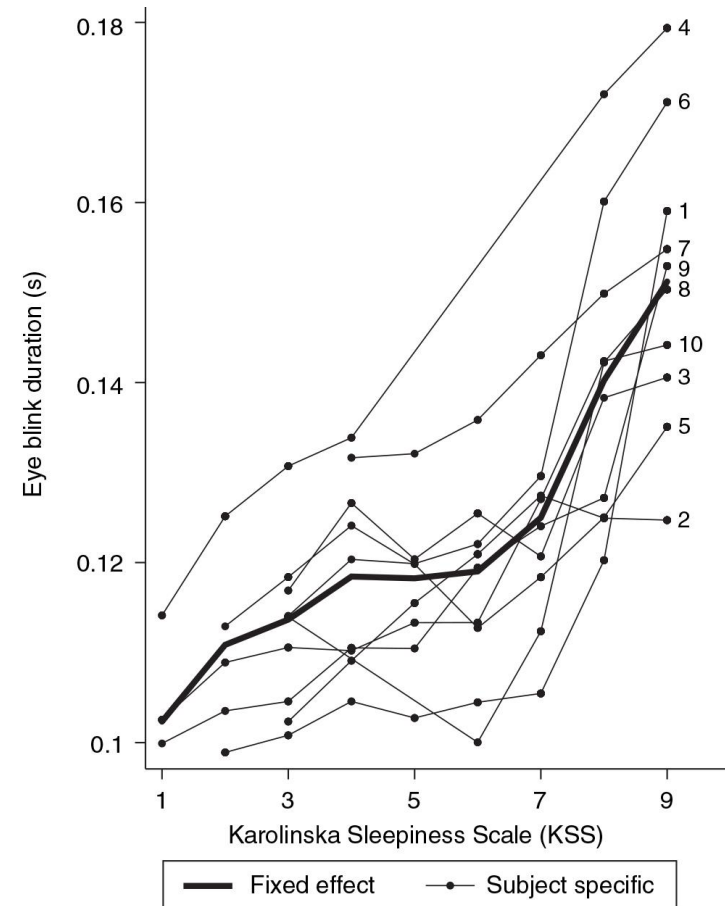
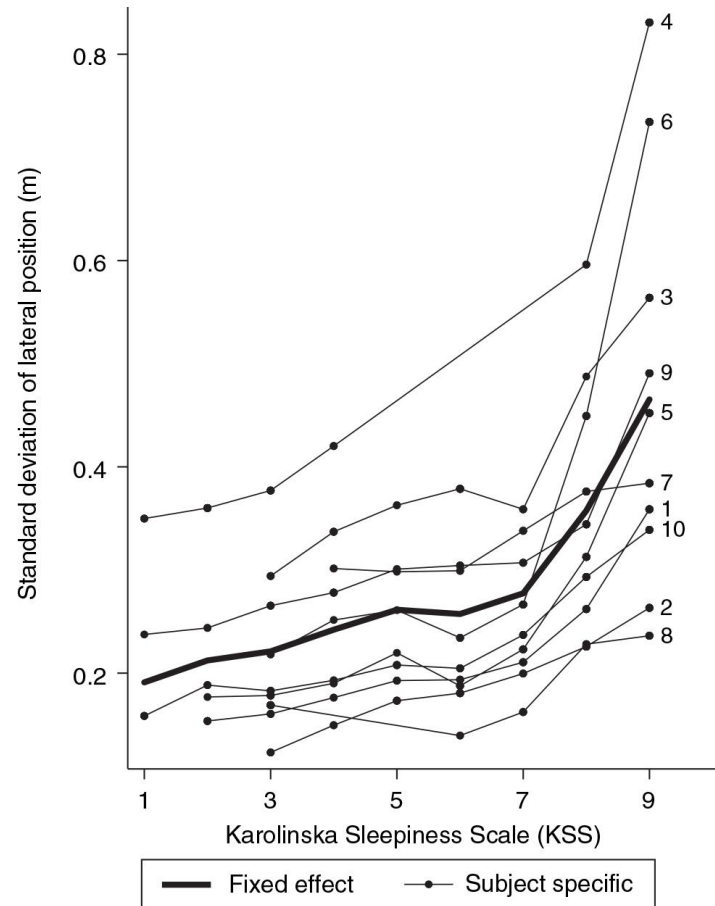
- (i) It can be well integrated to the vehicle system to give less cognitive load to the respective driver.

Comparison between different Driver state monitoring methods

Measures	Parameters	Advantages	Limitations
Subjective measures	Questionnaire	Subjective	Not possible in real time
	Deviation from the lane position		
Vehicle based measures	Loss of control over the steering wheel movements	Nonintrusive	Unreliable
Behavioral Measures	Yawning	Non-intrusive; Ease of use	Lighting condition Background
	Eye closure Eye blink		
	Head pose		
Physiological measures	Statistical & energy features derived from ECG EoG EEG	Reliable; Accurate	Intrusive

Non-intrusive methods are easy to implement in actual driving scenario

KSS vs. SLDP and Eyeblink



Non-intrusive methods are easy to implement in actual driving scenario

Existing Lane Departure System

OEM	System	Technology (Video Camera)	Trigger Speed	Driver Alert
Lexus	LDW	Mounted behind windscreen monitors vehicle position in relation to lane markings	-	Audio-visual Warning
After Market	SafeTRAC	do	-	Visual Lane Position Display
Mercedes	SPA	do	80 km/h (50 mile/h)	Vibrating Drivers' Seat
Nissan	LDW	do	72 km/h (45 mile/h)	Dashboard Display & Audible
Audi/VW	Lane Assist	do	65 km/h (41 mile/h)	Steering Wheel Vibration
BMW	LDW	do	70 km/h (44 mile/h)	Dashboard Display or Steering Wheel Vibration
GM	LDW	do	56km/h (35 mile/h)	Audible & Visual
Citroen	LDWS	do	80 km/h (50 mile/h)	Vibrating Drivers' Seat
Volvo	LDW	do	64 km/h (40 mile/h)	Audible

Existing Drowsiness Prevention System

System/Sensors/Parameters	Algorithm	Accuracy
EEG, ECG	Mean power frequency	-
Respiration Rate, Heart Rate, Heart Rate Variability	Power Spectrum	-
Cameras/Eyelid movement, Gaze movement, head movement and facial expression	Kalman filtering tracking	Yawn-82% PERCLOS-86% AECS-95%
IR Camera	Thresholding, Mean	-
Camera/Facial features of eyes, mouth and head	Fuzzy reasoning	Only focused on detection rate for facial tracking and face tracking rate
EEG	Principal Component Analysis (PCA)	Training - 92.6% Testing - 74.6%
ECG, EEG	Dynamic Bayesian network, first-order Hidden Markov Model	Drowsy (best) - 91% Active (best) - 91%
Eye movement, driving performance data	Support Vector Machines (SVMs)	Distraction detection (average) - 81.1%
Smartphone Display and Front Camera, ECG, PPG	Fuzzy Bayesian network	True Awake - 96% True Drowsy - 97%

Ways to keep the driver awake

Visual Stimuli

- Showing information within visibility
(with emergency sign & bright colour light)
- Increase ambient lighting around driver

Auditory Stimuli

- Music with beats
- Alarm/Beep Sound (with increasing intensity)
- Audible Instruction for some activity
- Conversation with Virtual Co-driver

Haptic Stimuli

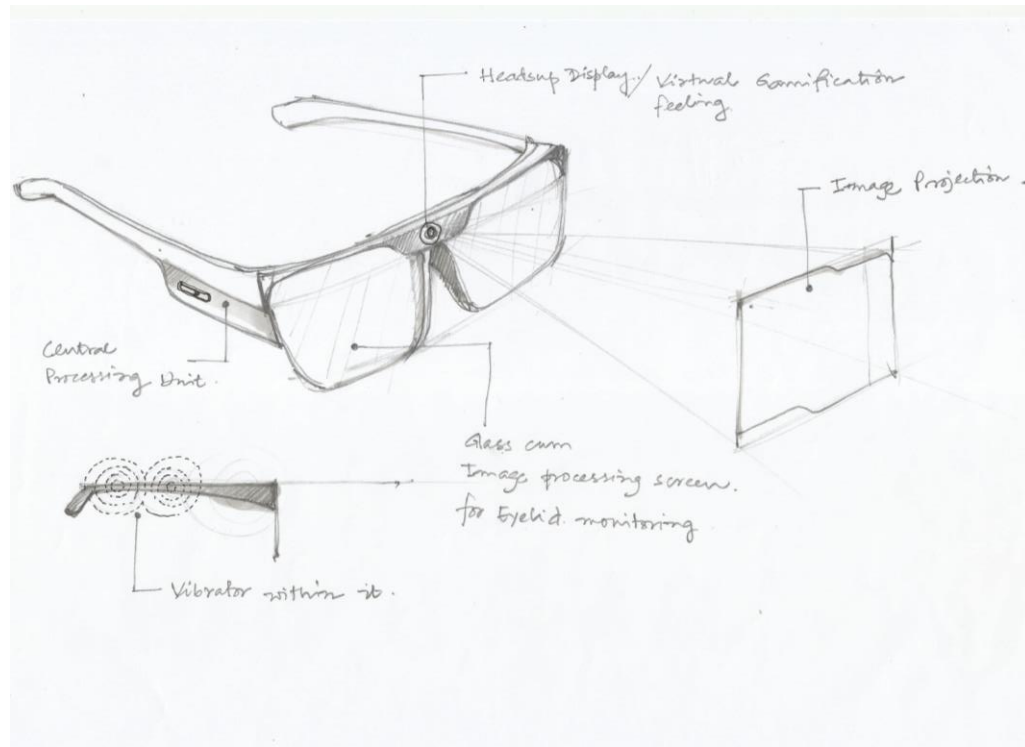
- Vibration in Steering Wheel/Seat
- Mild Electric Shock
- Hot/Cold Air Blow with olfactory stimuli
- Water Sprinkling

Existing Products



No holistic approaches and have usability problems to fit Indian Drivers

Ideations



Ideation I

This ideation is influenced from spectacles and google glass but there are few more facilities which is necessary to monitor driver state at the time of driving long journey.

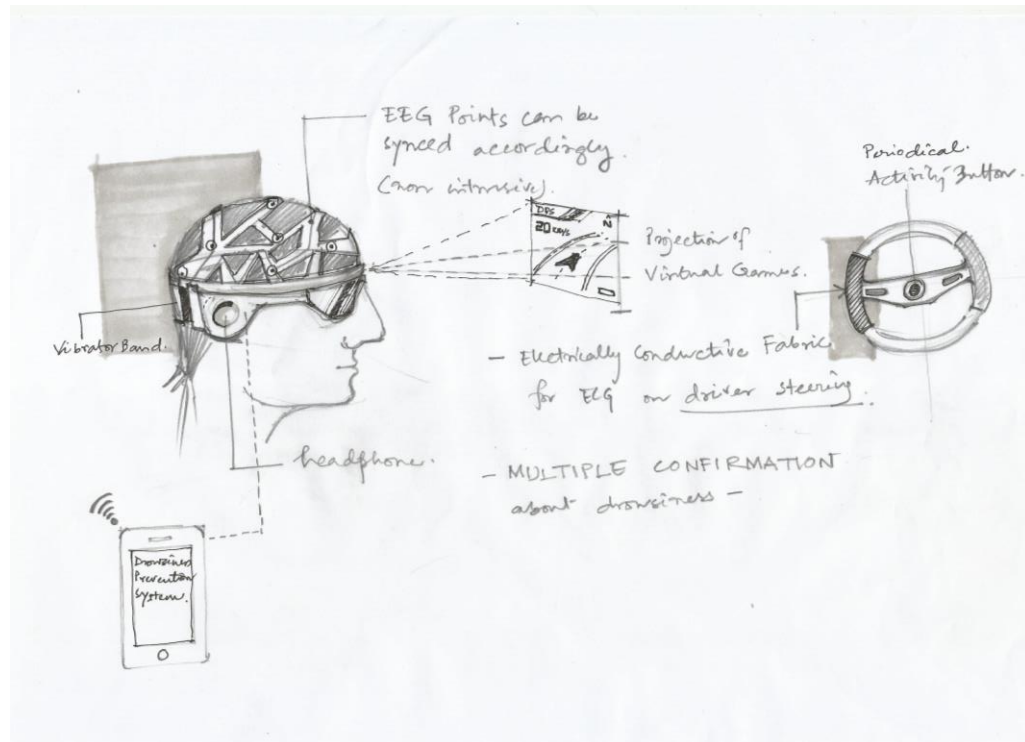
Pros:

- (i) A projection device will be placed at the spectacle frame between two eyes to project visual information on the wind shield
- (ii) vibration feedback can be provided through the temple of the spectacles

Cons:

- (i) There is no audio feedback

Ideations



Ideation II

This idea is influenced by the position of different points needed for EEG for a human. All the respective points can be joined and create a structure for a design of a head gear for the driver. Headphone and a vibrator band will be inbuilt to give respective feedback to the driver.

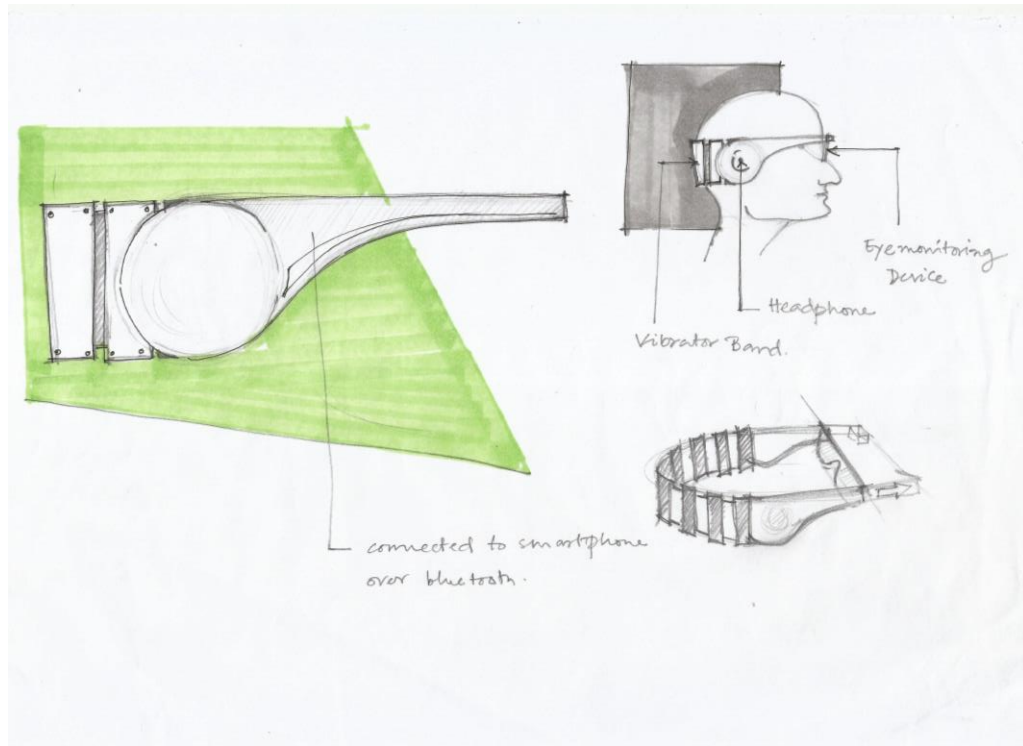
Pros:

- (i) Good looking shaped head gear
- (ii) Having all types of feedback system - audio, visual and haptic

Cons:

- (i) It will reduce comfortability of a driver and can't be worn over spectacles.

Ideations



Ideation III

Modification of Ideation 2, much more minimal, gives less cognitive load.

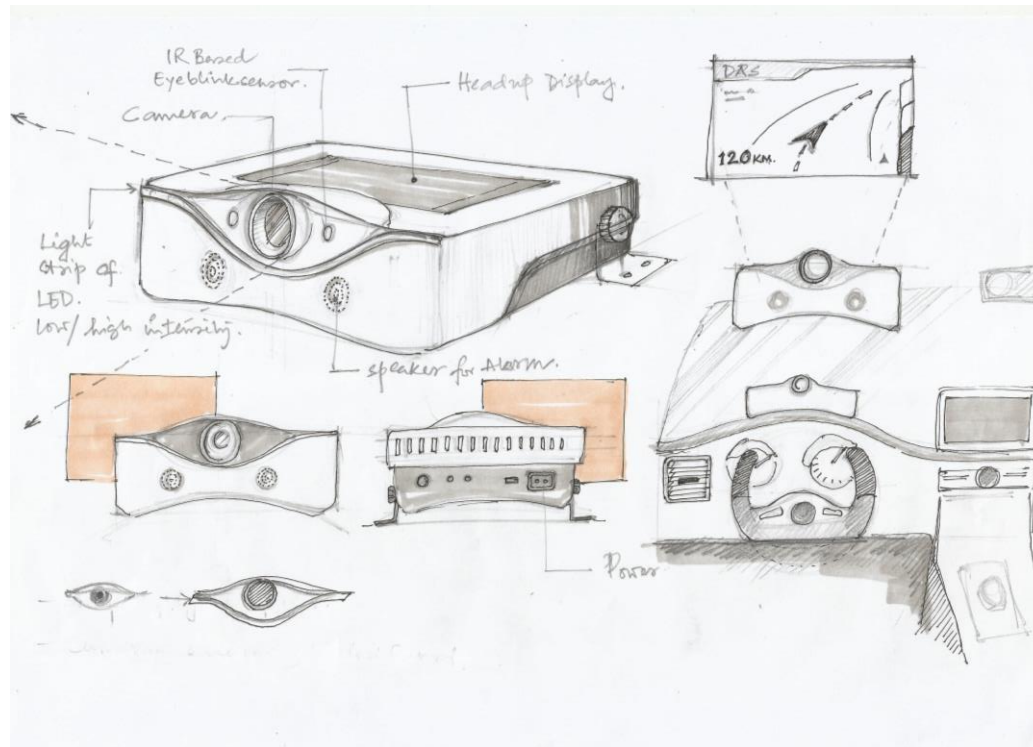
Pros:

- (i) Good looking shaped head gear
- (ii) Having all types of feedback system - audio, visual and haptic
- (iii) Glasses can be customizable according to different driver

Cons:

- (i) (i) It will reduce comfortability of a driver.

Ideations



Ideation I

It is a totally different approach, an independent device to monitor driver state very non-intrusively which can be positioned on the dashboard with respect to human ergonomics.

Pros:

- (i) Non-intrusive
- (ii) Can be implemented to any vehicle

Cons:

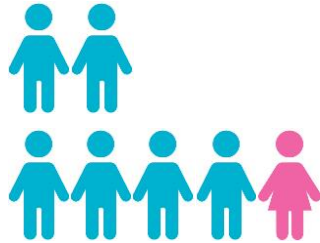
- (i) It might create blind spot on the viewing line of the driver.

User Study

8
Users

Germany: 2

India: 6



Persona II



Sex Male - Married

Age 35yrs.

Nos. of Family Members

3-5 people

Educational Qualification

Able to read English but not able to writing and speaking

Occupation

Hired or Employed Driver of Bus/Truck

Family Income per month

Around Rs. 10000 + facilities

Mobile User | Yes **Smartphone User** | Yes **Internet User** | Yes

Familiarity with Electronic Gadgets | No

Familiarity with Smart User Interface | Yes

Touch points

Driving Assistance is more preferred | It should not put too much cognitive load on the driver | It should not distract driver from driving | No fun is required with serious issues (music is accepted)

Users' Feedback

Findings after user feedback:

- (i) No wearable is preferred, even some of the driver spectacles also
- (ii) No disturbance is accepted at the time of driving
- (iii) There should not be any obstruction(blind spot) in viewing line & angle
- (iv) It should accommodate maximum percentile of driver from different socio-economic background
- (v) Safe driving assistance is more preferred rather than gamified experience
- (vi) Gamified Driving Experience is accepted only by young drivers who are also prone to drowsiness
- (vii) Alarm of increasing intensity is the basic solution. After that vehicle control should be interrupted.

Activity Analysis of Driver

1. Check fuel
2. Seat position adjustment
3. Seating height adjustment
4. Check visibility of car front edge
5. Adjust side view mirror
- 6. Adjust rear view mirror**
- 7. Wear seat belt**
8. Start the vehicle
9. Check surrounding
10. Start the journey



System Level Concept

System Level intervention for monitoring Drowsiness:

System components

1. Camera with night vision mode for Face Detection
 - Eye lid monitoring
 - Mouth monitoring
 - Head nod monitoring by nose movement
2. Alarm Sound with increasing intensity
3. Increasing Ambient Light
4. Steering Wheel Movement (SWM) monitoring
5. Integrated Heads-up Display (HUD)
6. Vibrator (in different location)

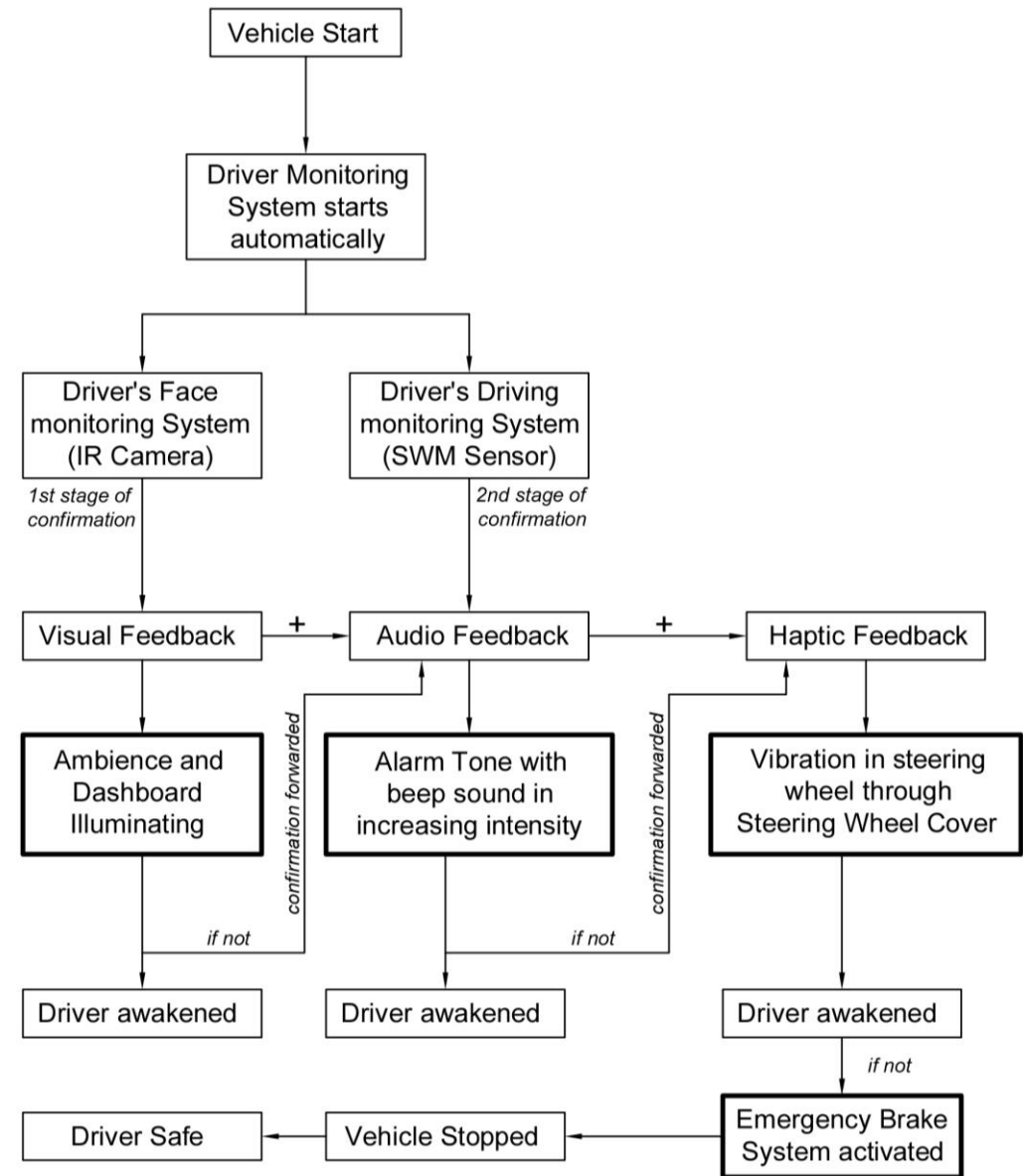
System Level Concept

Usability Issues

1. It should be non-intrusive
2. Less cognitive load on the drivers & smooth interaction with the system
3. It need not to be visible to the driver itself to give a feeling of smart system
4. Using existing features of the vehicle as much as possible
5. There should be minimum input from driver side to activate the system

System Level Concept

Flowchart for Feedback System



System Level Concept

Position of different components

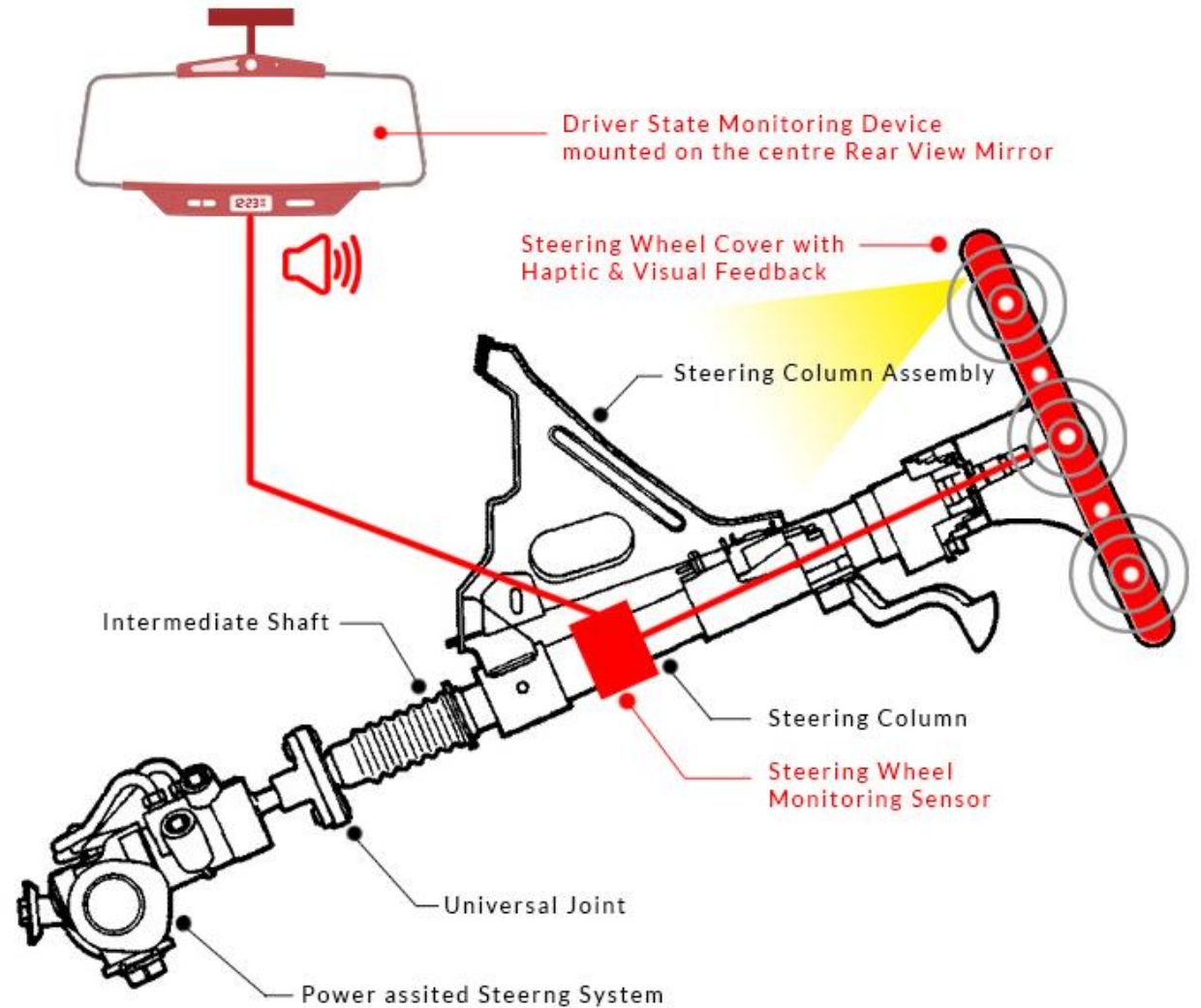
1. IR Camera with night vision mode
2. Alarm Sound with increasing intensity
3. Increasing Ambient Light
4. Steering Wheel Movement (SWM) monitoring
5. An Activity Button
6. Integrated Heads-up Display (HUD)/ Projection
7. Electricity carrying Fiber
8. Vibrator (in different location)
9. A Control Unit
10. Emergency Alert Screen



Final Concept

Position of different components

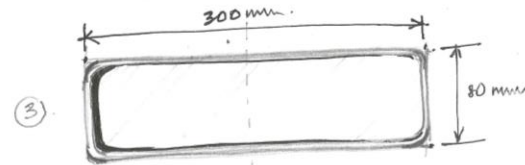
1. Driver state monitoring device mounted on the centre rear view mirror with audio feedback
2. Steering Wheel Monitoring Sensor attached with the steering column
3. Steering Wheel Cover with Haptic & Visual Feedback



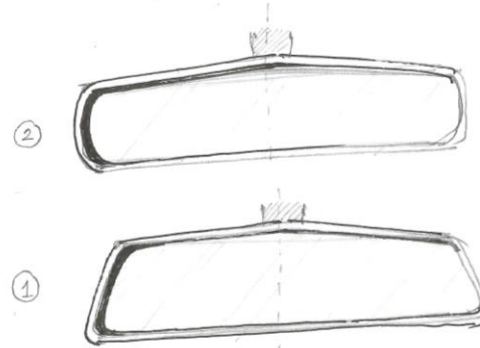
Ideation for Driver State Monitoring Device

General study on car mirror

Average size of the centre rear view mirror is 210mm x 75mm

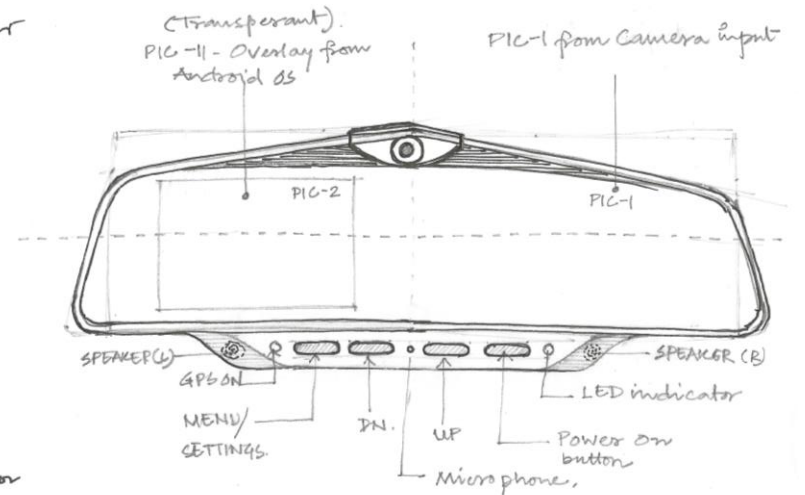


Standard Dimension of Rear View Mirror of Car.



Different shapes of Rear View Mirror (interior).

IR CAMERA MODULE

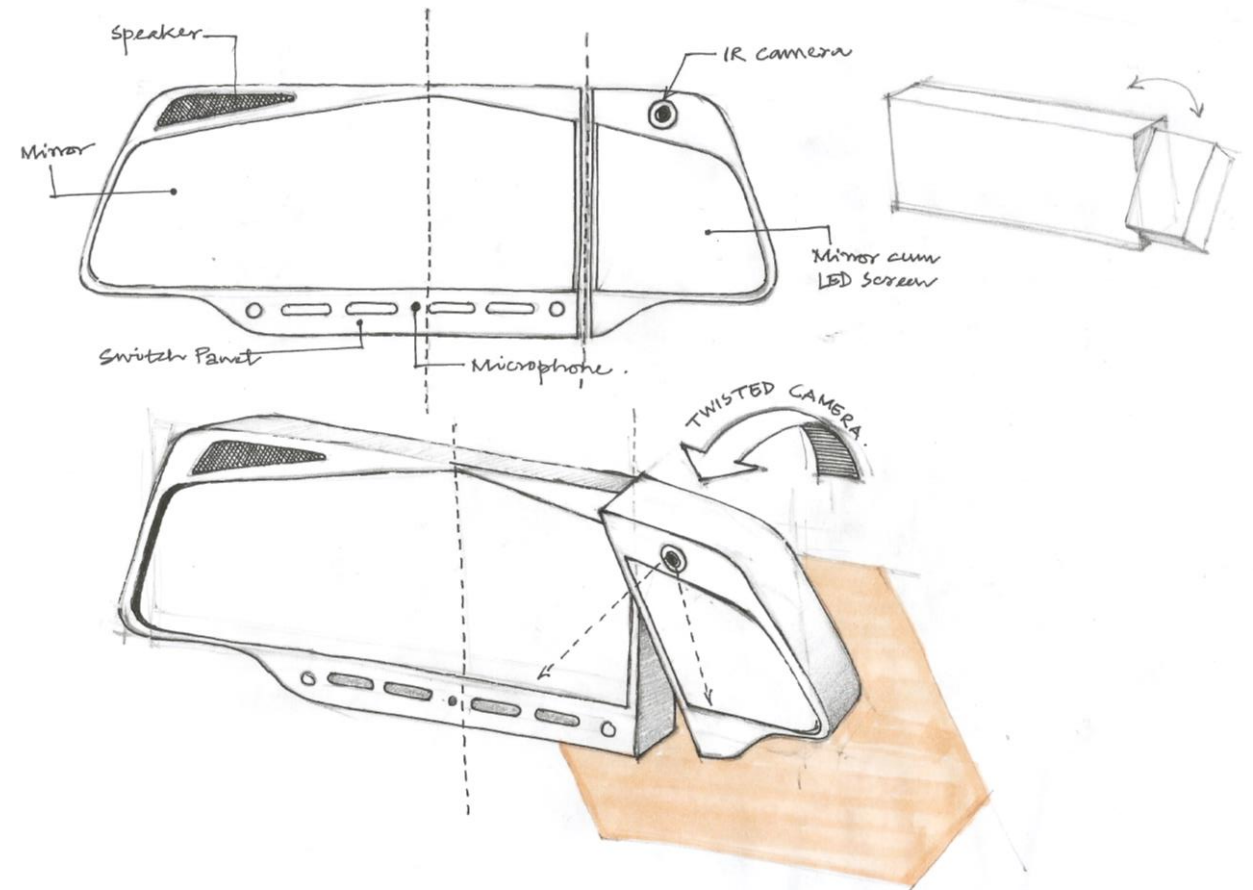


Ideation for Driver State Monitoring Device

Concept - I

This is a total concept of new centre rear view mirror which will replace the existing mirror.

It is based on twisting feature, which might accommodate more driver ergonomically. There will be the whole image processing unit behind the mirror, which includes IR Camera, Microphone, Speaker and a Control Panel. In the twisted part of mirror there can be some display system which will use PIP(Picture in picture) Technology.

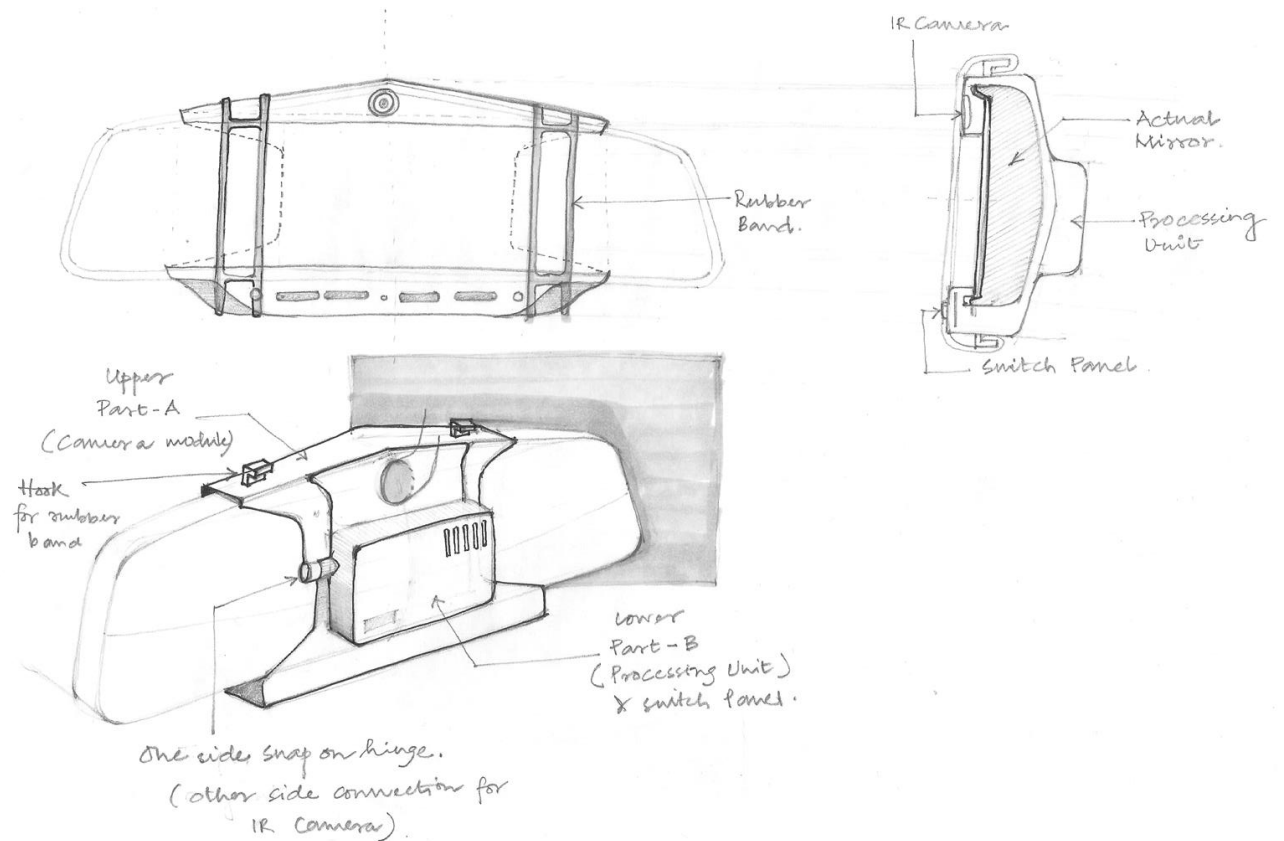


Ideation for Driver State Monitoring Device

Concept - II

This concept is about using the existing mirror but to use that Driver State Monitoring device as an add-on attachment which will be mounted over the existing centre rear view mirror.

As there is always a part for the fixing that mirror with the car, there can be two part of this device which will be attached through a snap on hinge and then mounted over the mirror and fixed with good looking rubber band which will not restrict the visibility.



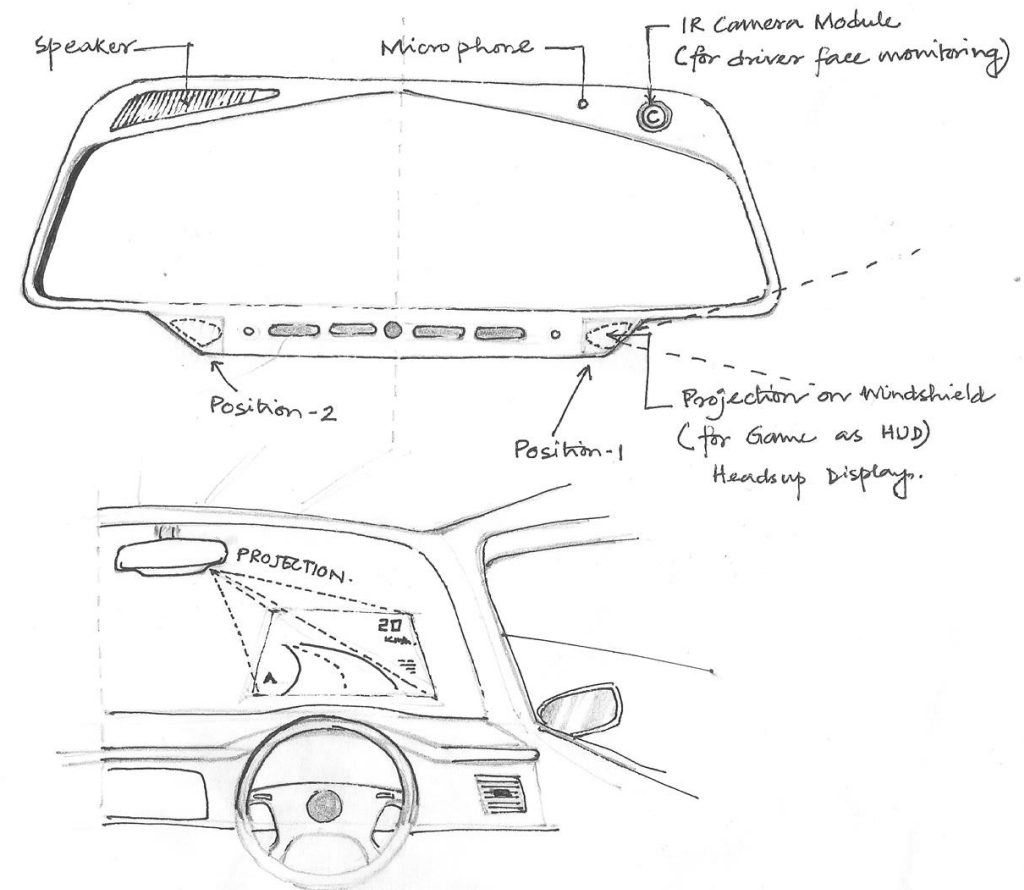
Ideation for Driver State Monitoring Device

Concept - III

It is an advanced special version of the concept - II product.

It can be also a new mirror or the mounting accessories.

Other than concept II, it will include a Projector, which will project visual informations on the windshield, preferred by young drivers who love gamified driving experience. Here camera module and speaker module is designed for Indian context(left hand traffic), which can be reversed for foreign countries(right hand traffic).



Existing Products Related to mounting on mirror

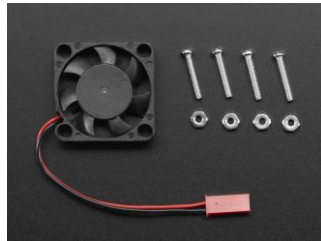
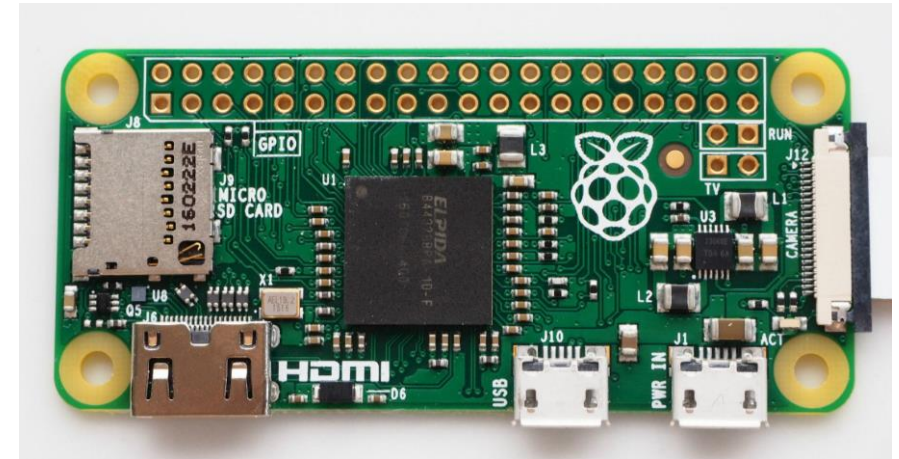


Mounting details of the existing products

Driver State Monitoring Device

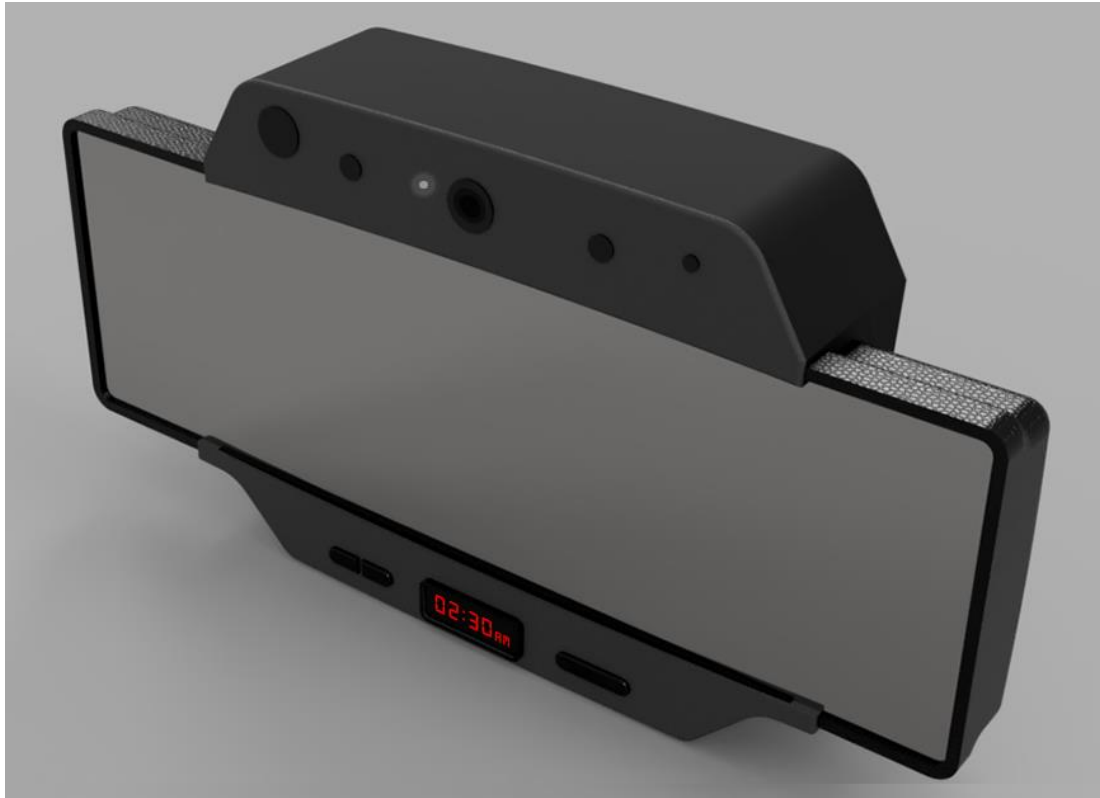
List of Hardware will be inside this device with dimension is:

- (i) **Raspberry Pi Zero** (65x30x5mm)
- (ii) **IR Camera Module** (25x20x9mm)
- (iii) **Piezo Buzzer Speaker** (33x13mm)
- (iv) **Microphone** (26x14mm)
- (v) **Cooling Fan** (30x30x10mm)
- (vi) **Digital Clock with battery** (38x22x14mm)
- (vi) **Control Panel**
- (vii) **Mini Projector Module** (optional)



Driver State Monitoring Device

3D View

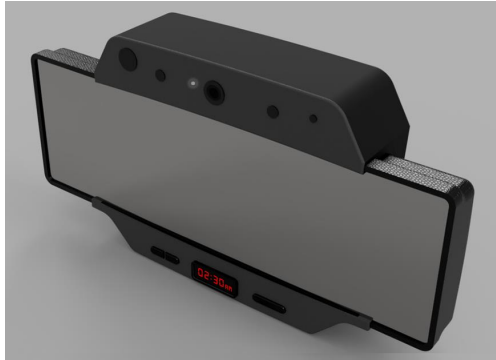


Front View



Rear View

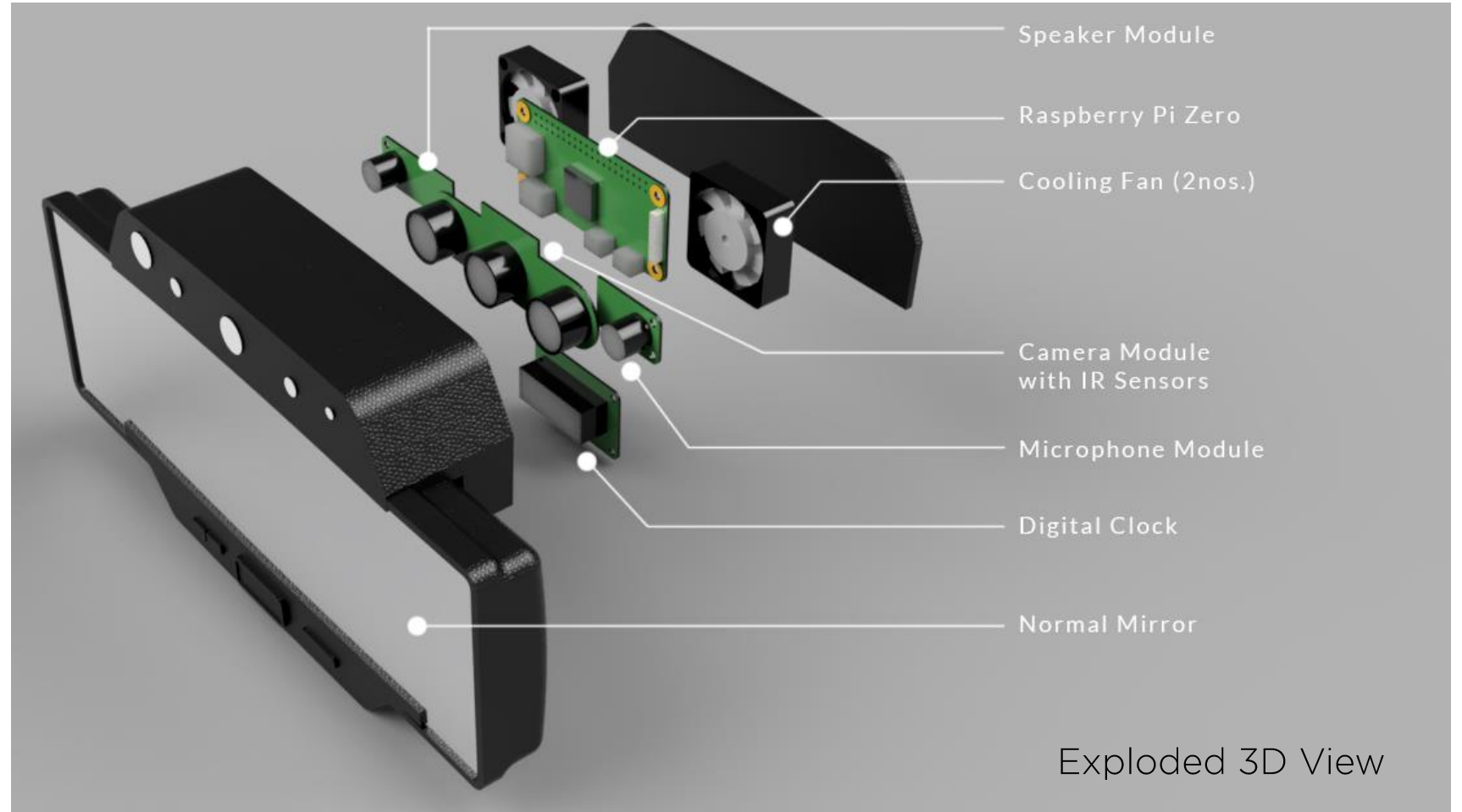
Driver State Monitoring Device



Front View



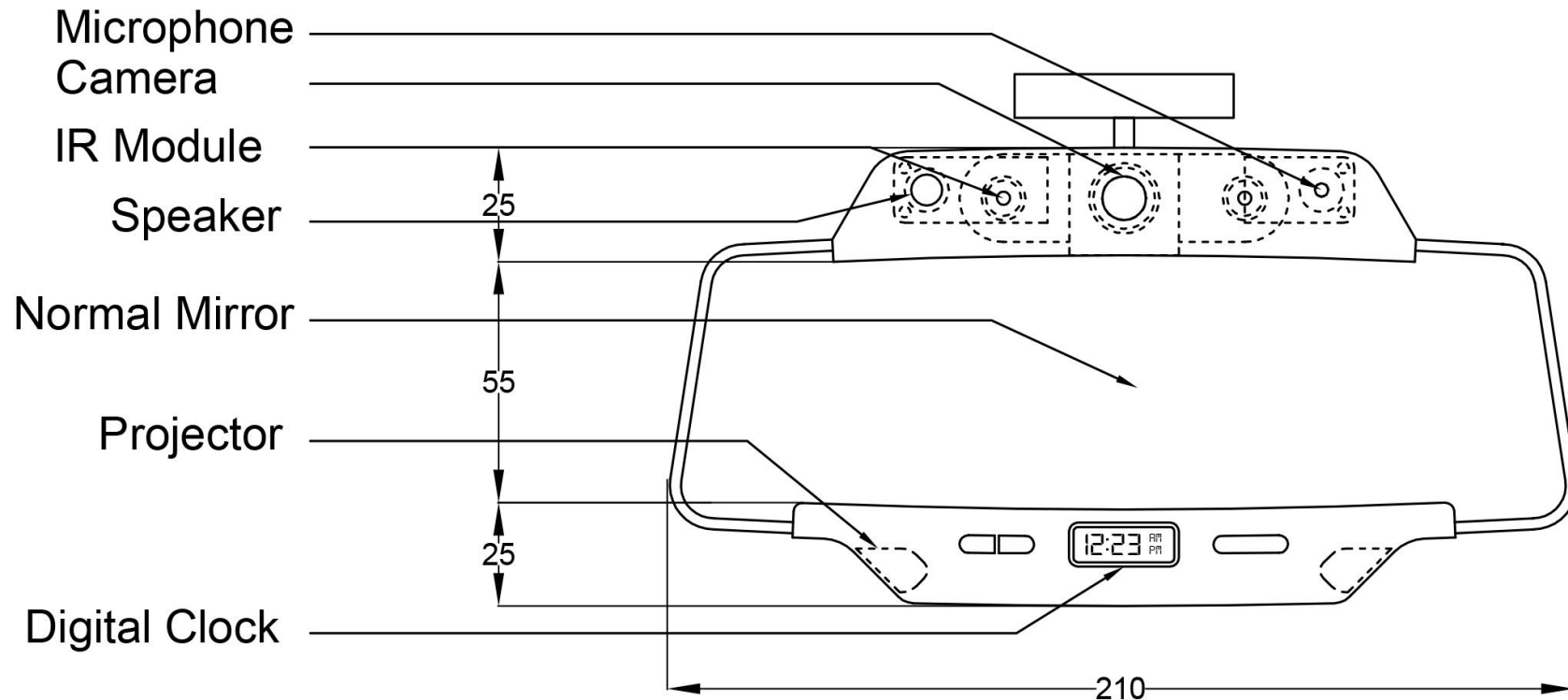
Rear View



Exploded 3D View

Driver State Monitoring Device

Detail Drawing

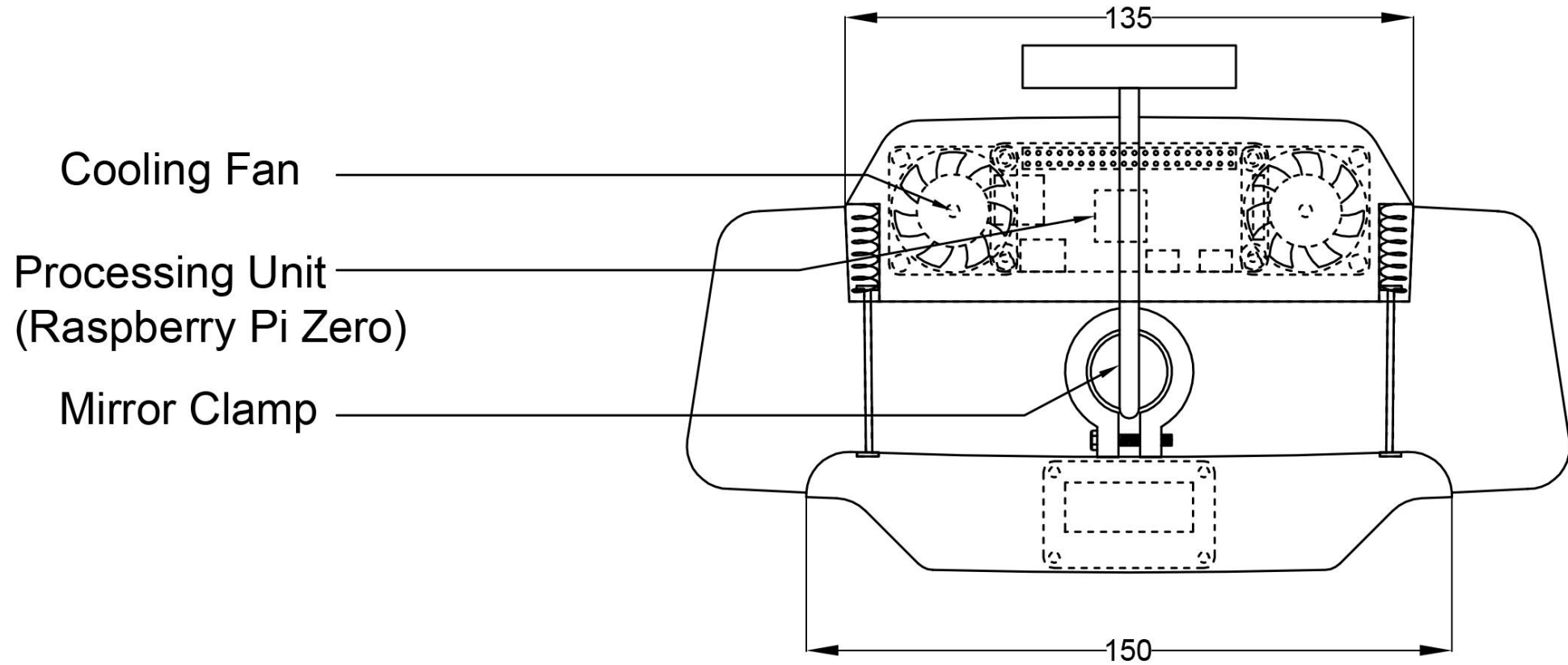


Front View

all the dimensions are in mm

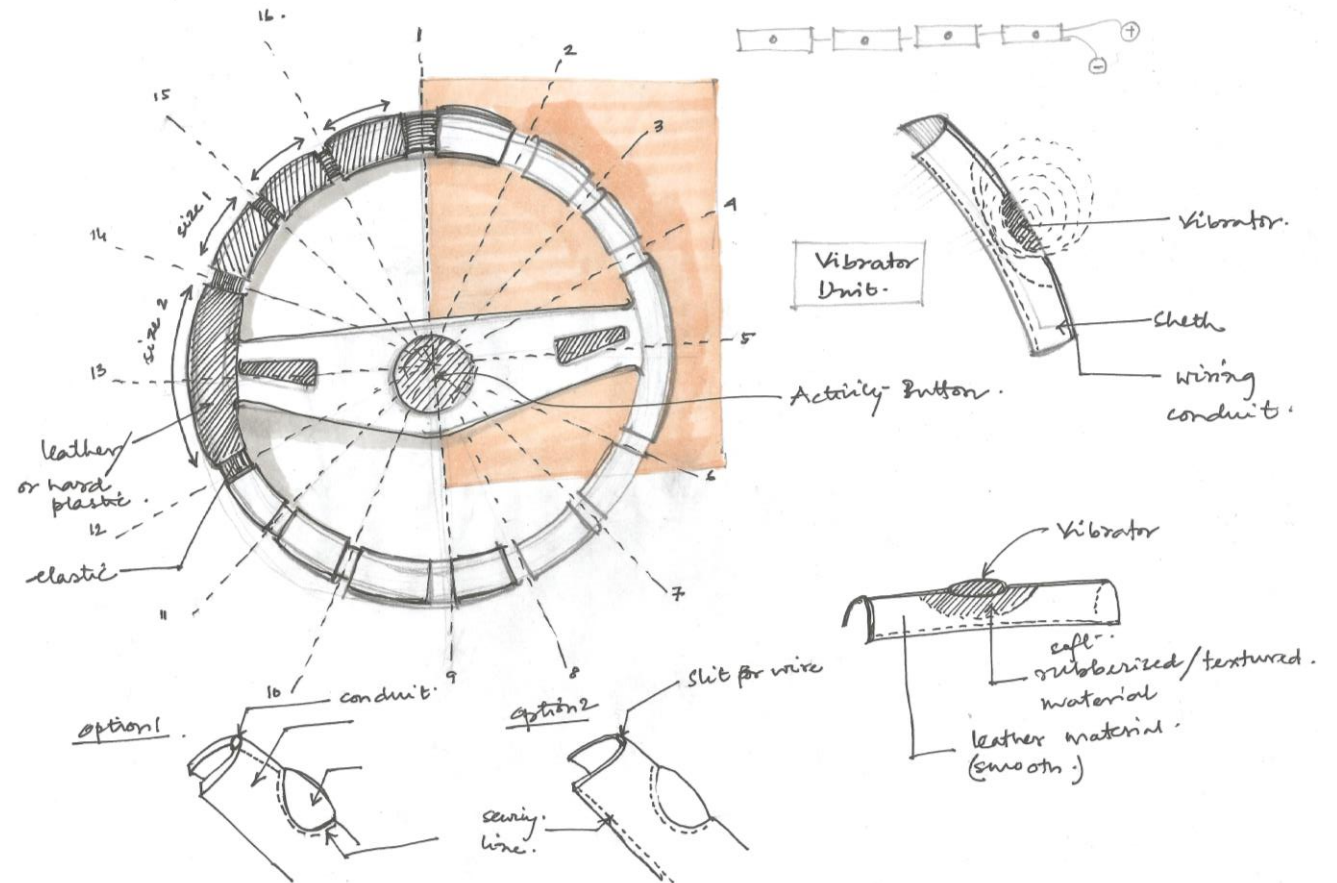
Driver State Monitoring Device

Detail Drawing



Rear View

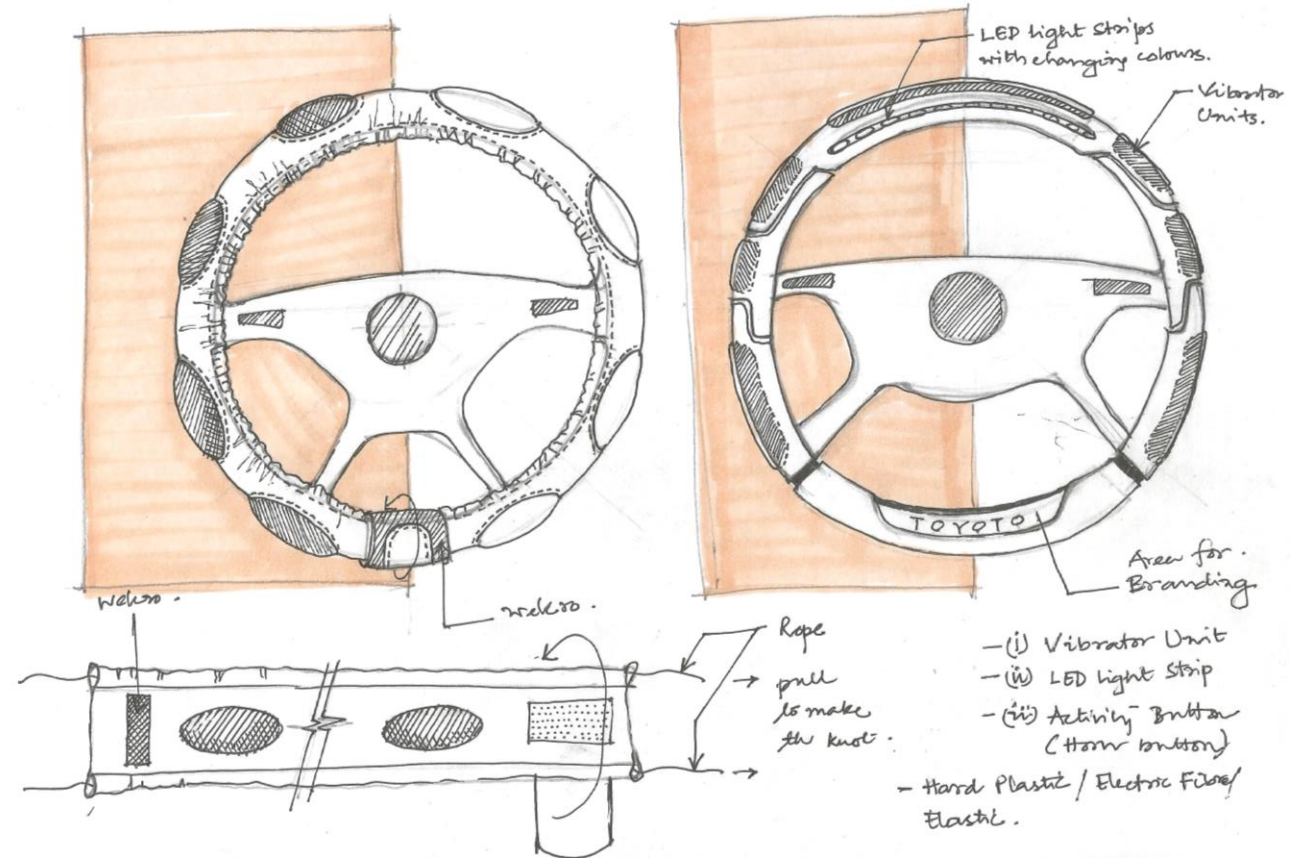
all the dimensions are in mm



Ideation for Feedback System to keep driver awake

Ideation 2

The cover with the vibration units will be in a roll and can be used by cutting and stitching according to diameter of the steering wheel.

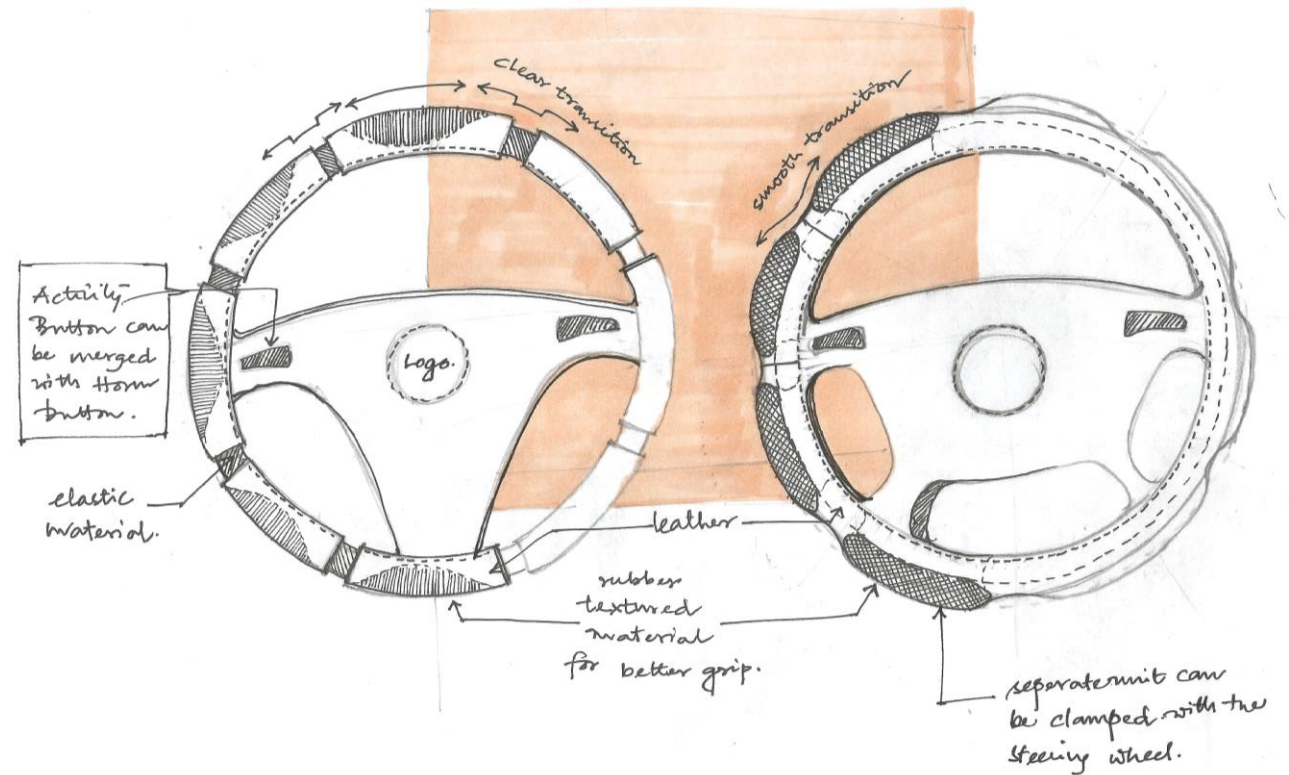


Ideation for Feedback System to keep driver awake

Ideation 3

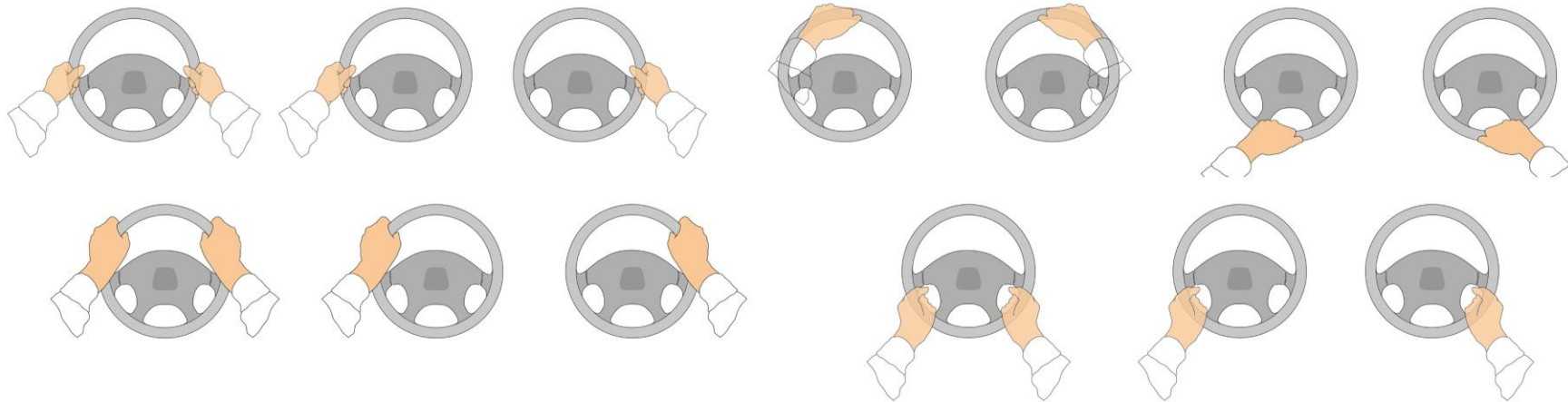
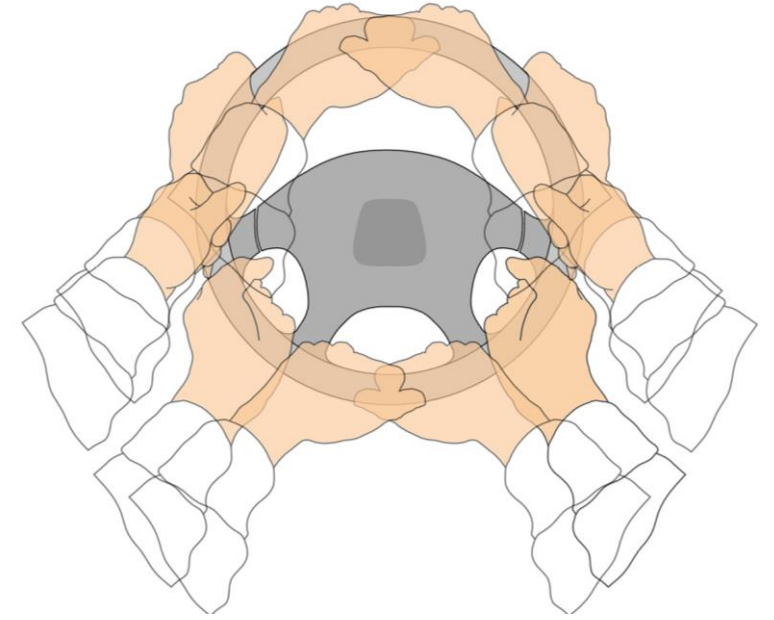
Vibration motors can be placed inside the steering wheel cover of existing design and will be sold as accessories.

This idea is selected from the point of implementation aspect.



Study of Different driving style

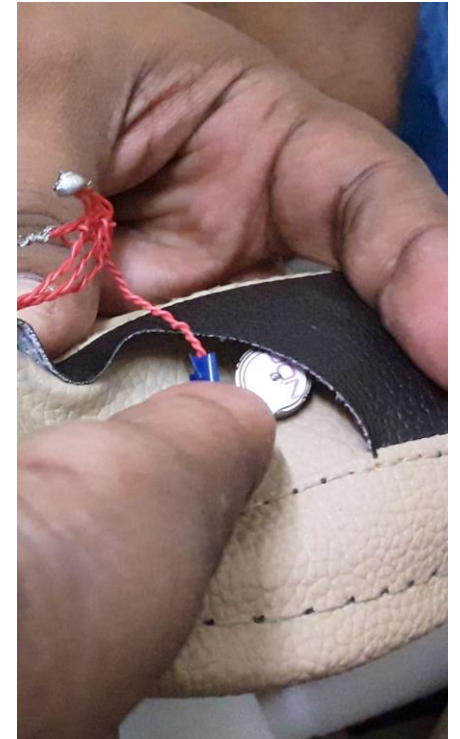
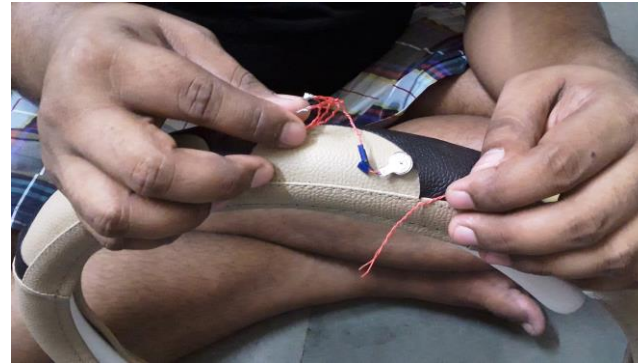
Different drivers and even single driver are used to driving in different style in different time. So to give maximum probability to keep the driver awake, it is found that vibrator units should be distributed through out the whole perimeter of the steering wheel cover.



Different driving posture collected from user study

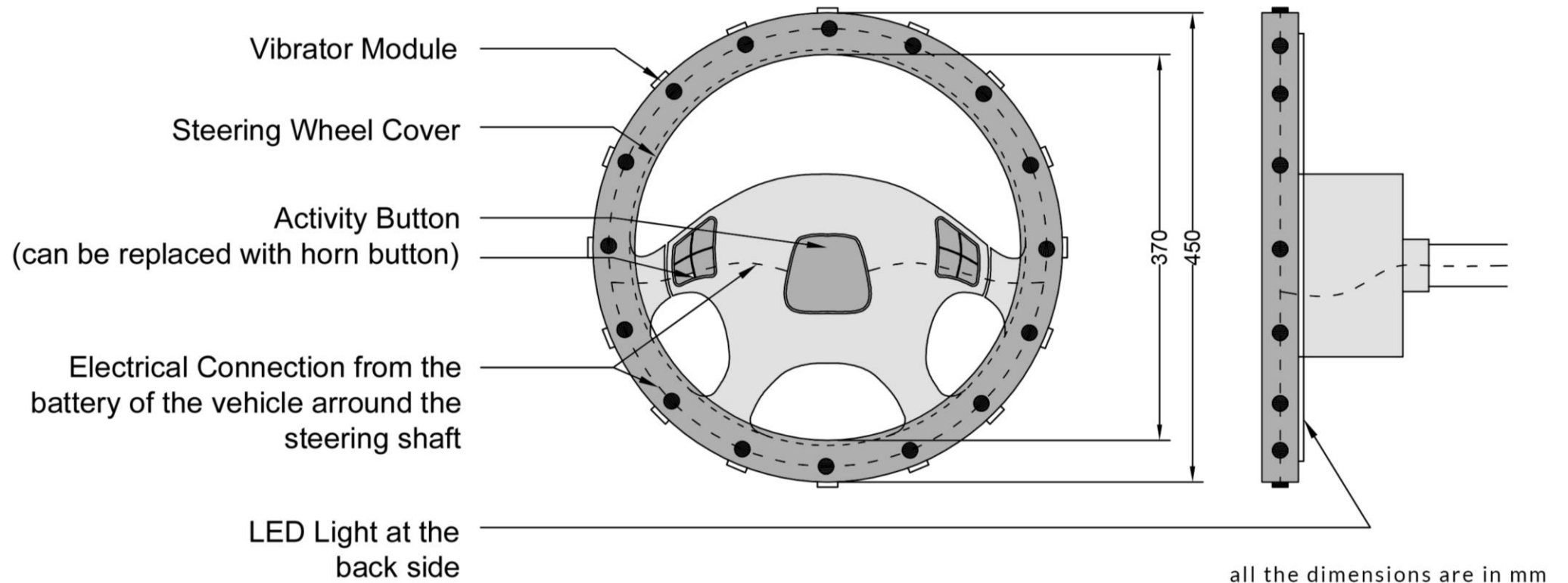
Feedback System to keep driver awake

Prototype



Feedback System to keep driver awake

Detail Drawing



Enclosure for SWM Sensor

Hardware will be inside this enclosure:

(i) **Steering Wheel Monitor Sensor**

To monitor nos. of micro-corrections which reduce at the time of drowsiness

This enclosure will be attached with the shaft of the steering wheel behind the dashboard. So it will not be visible but a important component for confirmation of the drivers' drowsiness.



Different Driving Scenario

Basic concept is generated on the car scenario, whether the other focused group is bus and truck drivers who drive on the highway for a long time at the night time.

Almost all the type of vehicle generally has centre pillar in the front, where wiper is installed. So in the same place we can place this Driver State Monitoring Device or near Pillar A



Further Scope in this Project

1. This concept must be validated by other parameters and actual driving scenario or in the driving simulator
2. There can be different monitoring system (like Heart Beat rate etc.) and respective feedback system in other location (like Seat belt, Seat etc.) can be tested.
3. There can be pattern in the vibration to differentiate from actual vibration of the vehicle at the time of driving.
4. Proper design of dashboard to keep monitoring devices.
5. Exploration is some other different feedback system (like giving feedback by ringing the drivers' smartphone etc.)
6. A way to implement mandatory and legally to keep drivers' driving history.



Thank you!