2019

M. Des Industrial Design Project 2

Motorcycle Helmet redesign

For Ventilation

Guide. Prof. B. K. Chakravarthy
By. Abhishek Jaiswal 186130006

IDC School of Design
अभिकल्प विद्यालय

Acknowledgment

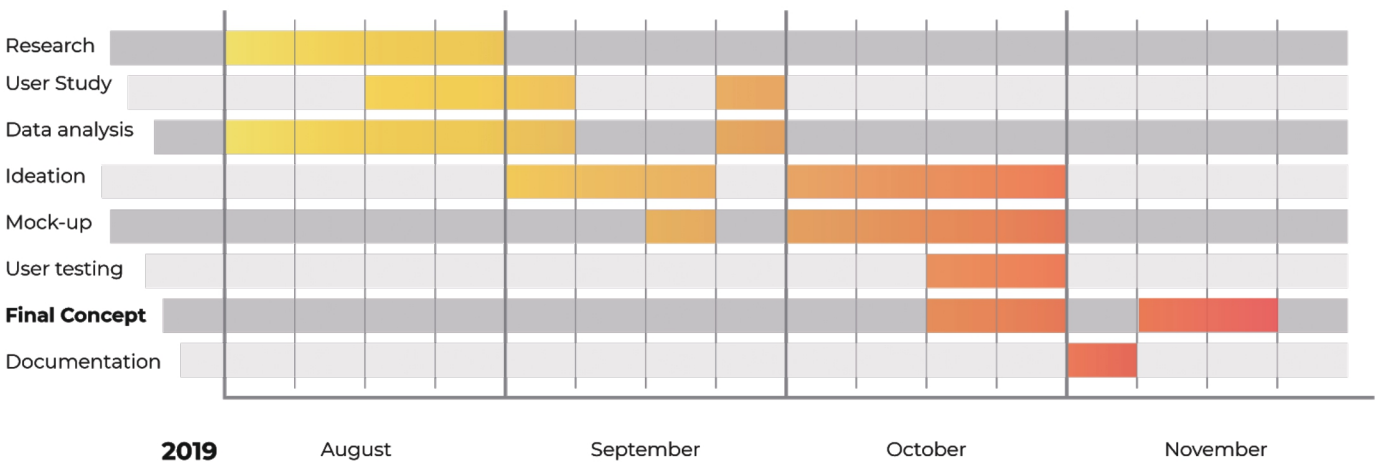
I would foremost like to express my heartfelt gratitude to Prof. B. K. Chakravarthy, my project guide for his support, mentorship and guidance throughout the project. He motivated me to look at the project from a wider perspective at every stage. His pragmatic inputs at each stage were invaluable for the progress and decision.

I would like to thank my classmates and people at IDC for supporting me throughout the project and providing me feedback at every stage.

Abhishek Jaiswal

Project Time-line

Each block given in chart represents a week of that respective month.



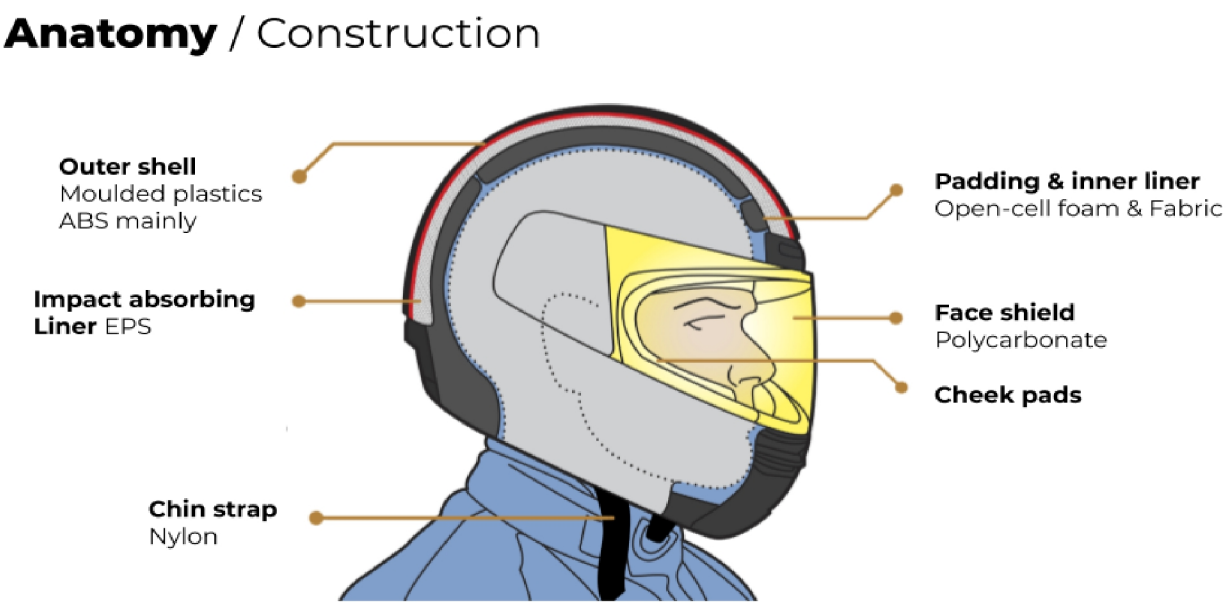
Content

Data collection

Initial study of user, market and guidelines for standards by Bureau of Indian standards to support my design interventions.

Motorcycle Helmet

Below, key parts and components of motorcycle helmet are represented, this is the most basic set of components essential for full



Components and their function

Various components in motorcycle helmet serves various functions and acts as a layer of protection during impact. Following list of components along with there function is given below.

- **Outer shell:** Its primary function is to protect your head in the event of impact or abrasion and to prevent penetration from outside objects, such as rocks, insects, etc.

- **Impact Absorbing layer EPS:** Primary function of the liner is to absorb shock and displace energy during an impact. The outer shell keeps foreign objects from penetrating the helmet, while the inner layer keeps the energy of the impact from transmitting to your head.

- **Inner padding:** The padded comfort layer is the area that your head rests against while you're wearing the helmet. Designed to wick away sweat and keep you cool while riding. It is usually removable for cleaning purposes, and is interchangeable to accommodate different head shapes. Check with your helmet manufacturer to see if they offer different comfort liner shapes to best fit your head shape.

- **Face shield/visor:** The face shield or visor is a safety feature meant to keep bugs, debris, and everything else out of your helmet. They're usually designed to be removable for cleaning purposes or to swap out for another shield/ visor.

- **Cheek pads:** They are removable for cleaning and are customizable to accommodate different head shapes. They are an added comfort feature similar to the padded comfort liner, intended to provide extra protection to your face and to help keep the helmet in place on your head.

- **Retention system:** It's made from a woven material and fastened with two d-rings to stay secured. When properly secured. The strap is usually partially covered a similar cloth as the comfort liner to wick away sweat and for comfort, as it rests against your skin.

Rational of project

- Casualty of 1,47,913 people to road crashes in 2017, of which 48,764 were on two-wheelers. Roughly 130 deaths every day.
- Uttar Pradesh (17,666), Tamil Nadu (15,642), Maharashtra (13,212), Karnataka (10,856) and Rajasthan (10,510). Number of road casualties.
- India, with estimated 37 million motorcycles/mopeds, home to the largest number of motorized two wheelers in the world.
- India has the worst road safety standards in the world, WHO.
- Proper use of Helmet reduces chances of fatal injury by 40%, But if not used properly it may increase the chances as well.
- Not wearing helmet will attract a fine of 1,000 and lead to suspension of license for three months. Motor vehicle Act, Sep 1

Insights from data collection

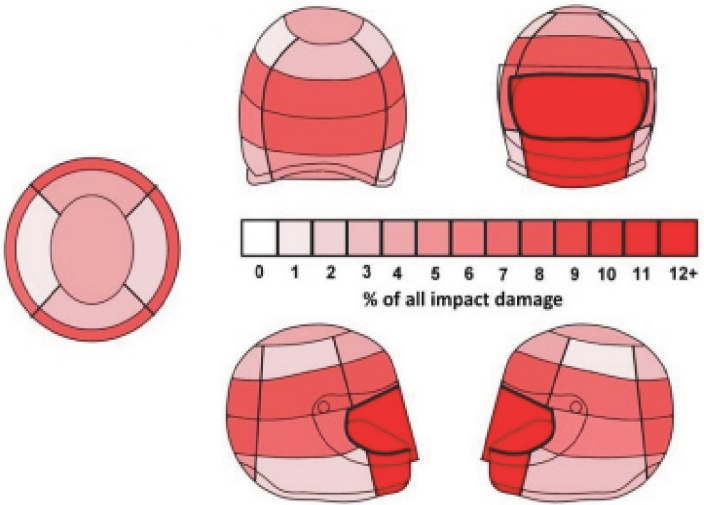
I would foremost like to express my heartfelt gratitude to Prof. B. K. Chakravarthy, my project guide for his support, mentorship and guidance throughout the project.

- **Discomfort**, lack of good ventilation causes discomfort in long distance commutes especially in summers.
- **Storage and management**, is huge issue especially for motorcycles with no storages.
- **Reduced senses**, Inability to hear or look side vise creates trouble during riding.
- **Hygiene**, lack of ease of wash ability.
- Fit, Helmet losing its fitting with time due to moisture ingression in inner foam lining.
- **Fogging of visor.**
- Water ingress, through vents.
- **Aesthetics**, as most of them are similar in looks which is not appealing to most part of population.

Test for structural intigrity of Helmet

To ensure that final outcome can withstand desired stresses a suitable position for vents has to be determined which does not affect overall integrity of helmet. Table given below is taken into account to resolve this issue.

This test on set of helmets determines strong and weak areas in outer shell when introduced to impact at multiple points.



Location on helmet	Frequency of cases	Percentage of cases
Chin bar	34	63.0 (of full-face type helmets)
Visor/Facial	39	65.0 (of visor equipped helmets)
Frontal	19	29.2
Any frontal impact damage	51	78.5
Left	30	46.2
Right	32	49.2
Rear	40	61.5
Crown	8	12.3
Total helmets with recorded damage location	65	100.0

Standards / Guidelines

BIS 2019 / IS-4151

- **Helmet weight reduced to 1.2 kg from 1.5 kg, BIS 2019.**
- Temperature in the shell should not rise inordinately.
- To prevent this ventilation holes may be provided to increase comfort for the rider. IS-4151.
- Ventilation holes and opening should not affect the structural integrity of outer shell.
- Helmet shall not dangerously affect user's ability to hear .
- All the projections inside and outside of the shell and other parts of helmet should be in limit of 2 mm and should be tested for surface friction and shear assessment.

Objective

Redesigning motorcycle helmet for ventilation to increase user comfort.

Design Brief

- Vents design to provide **good air circulation at minimum speed of 20 km/hr.** (retractable)
- **Contemporary aesthetics.** As per the current style trends
- Removable and washable inner lining for **User hygiene**.
- Working under **design specifications by BIS** to fall in line with current market.

Initial Ideation

Ideation for working principle.

Initial ideation stage started with exploring multiple working principles for new helmet design in order to induce primary function of elevated comfort and air ventilation/moisture displacement.
Many phenomenons are taken into account to provide desired functions. All those phenomenons are listed below:

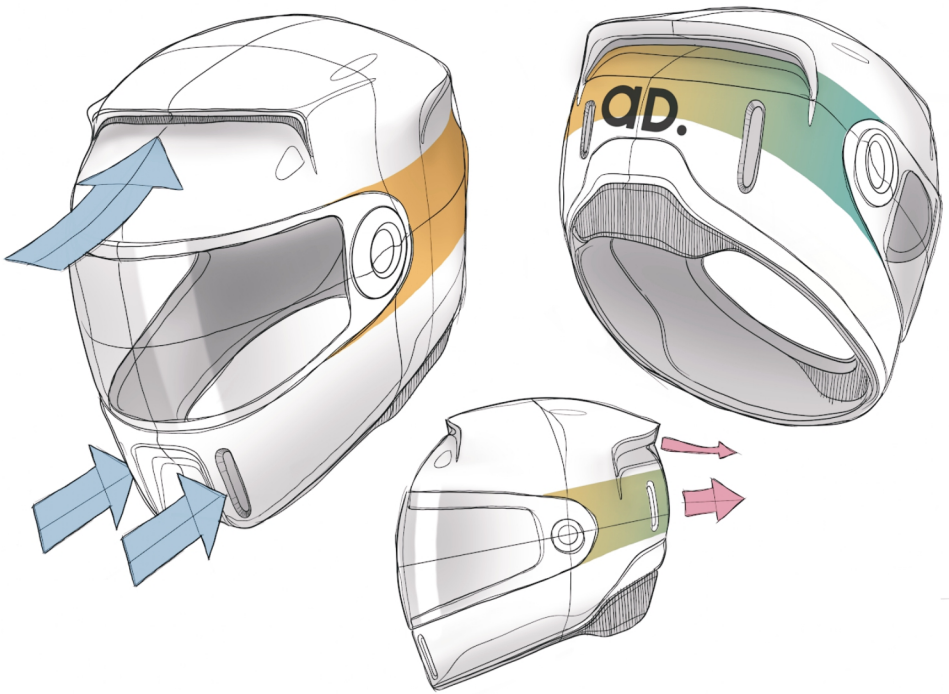
- **Moisture wicking** used in Sports wear fabric.
- **Capillary action** to displace moisture due to various physical and material properties of fabric.
- **Venturi action** which provides cooling of fluid due to forced passage through tighter space.
- **Water cooled inner lining** which can also provide increased protection against shock.

Principle 01

Forced Air Flow.

Venturi action into play, can increase velocity of fluid (air) and can also generate pressure differential to displace higher density fluid (moisture). Present into that closed envelope.

Venturi effect can provides better forced air flow through vents and it can also take away generated moisture while doing so.

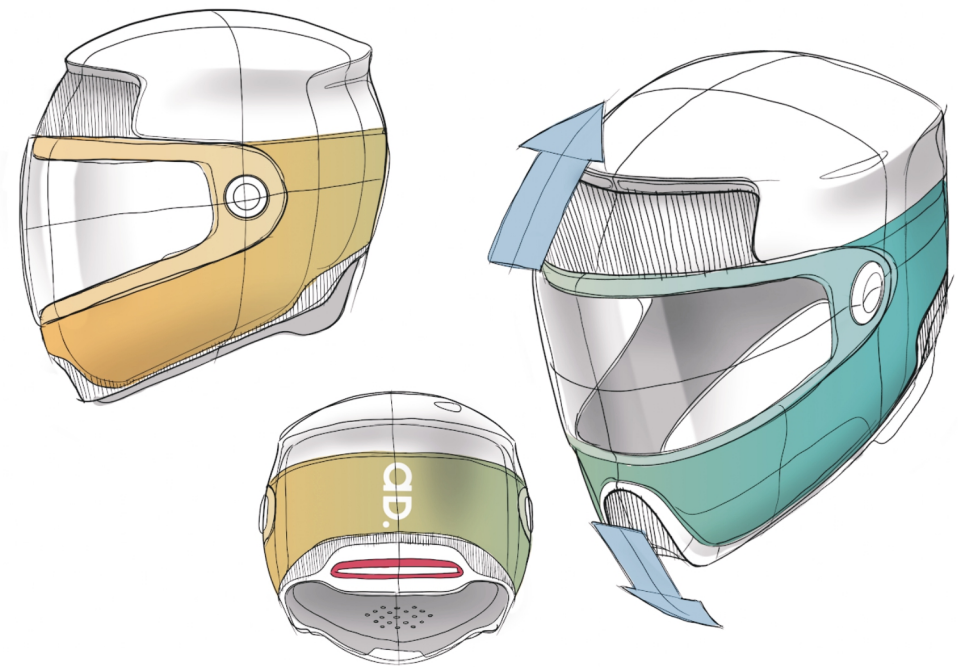


Principle 02

Moisture Wicking.

Inspired from active / sportswear fabric which directly evaporates the moisture int environment.

Combined effect of capillary action and moisture wicking, An exposed fabric lining can act as a fin to evaporate moisture through flowing air stream.



Final working principle

Air ventilation over other methods

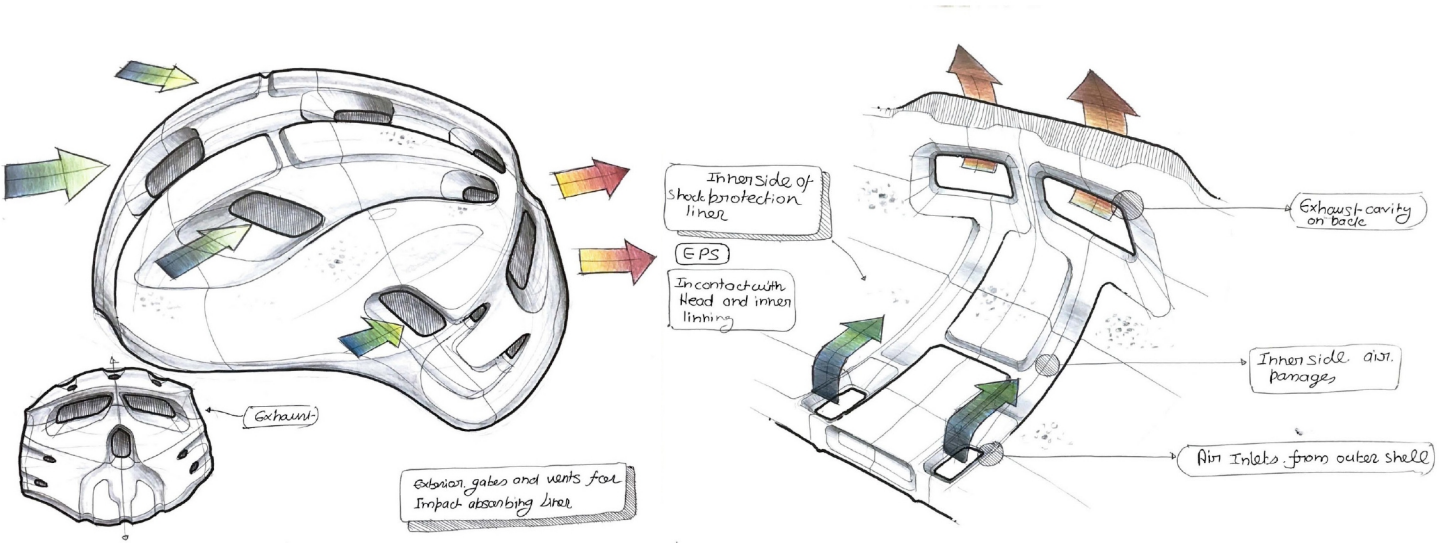
Exploring various methods like water cooled and electronic based helmet to overcome problem of sweat and heat inside helmet. Air ventilation can be said as most effective method as is it utilizes air around the helmet and does not require any special hardware to work.

Cooling by ventilation in helmet causes no increase in weight and cost of the helmet as both of these factors has to be maintained as less as possible in order to make this design reachable for masses.

Key Component

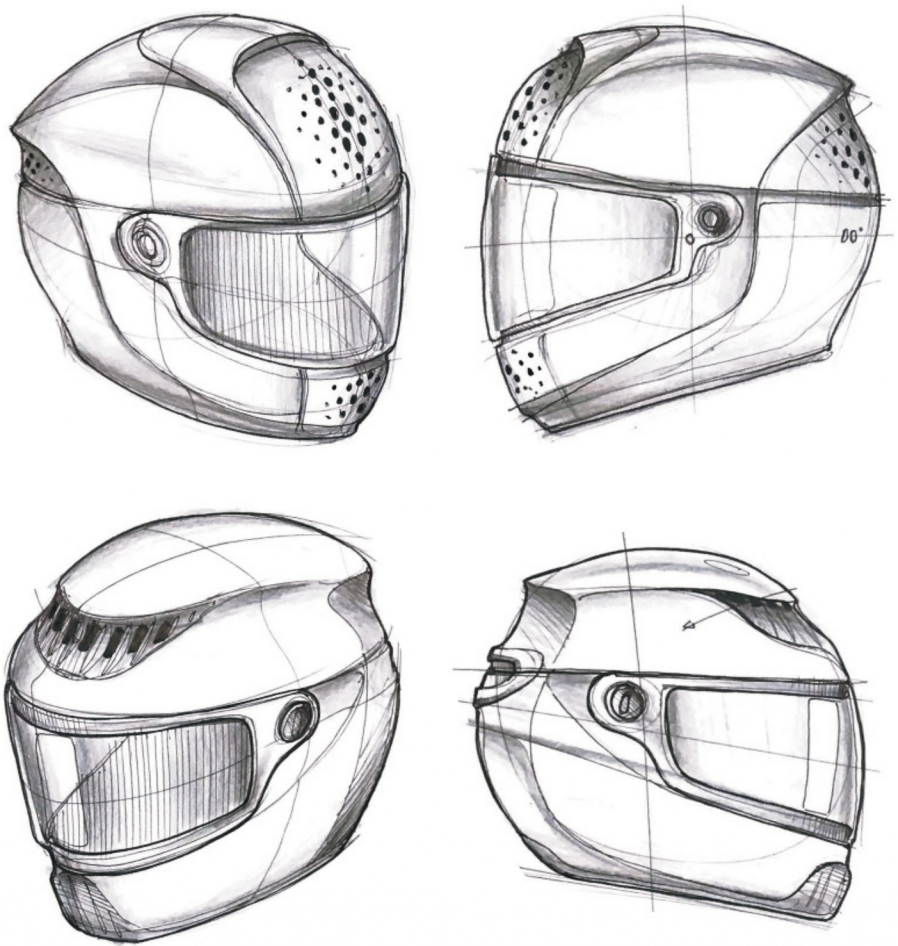
Impact absorbing layer (EPS) & Ventilation map.

Acting as prime component in ventilation as inner EPS layer of helmet is placed between outer shell and fabric lining. It acts as hub and pathway to collect and circulate air from outer shell to head.



Ideation

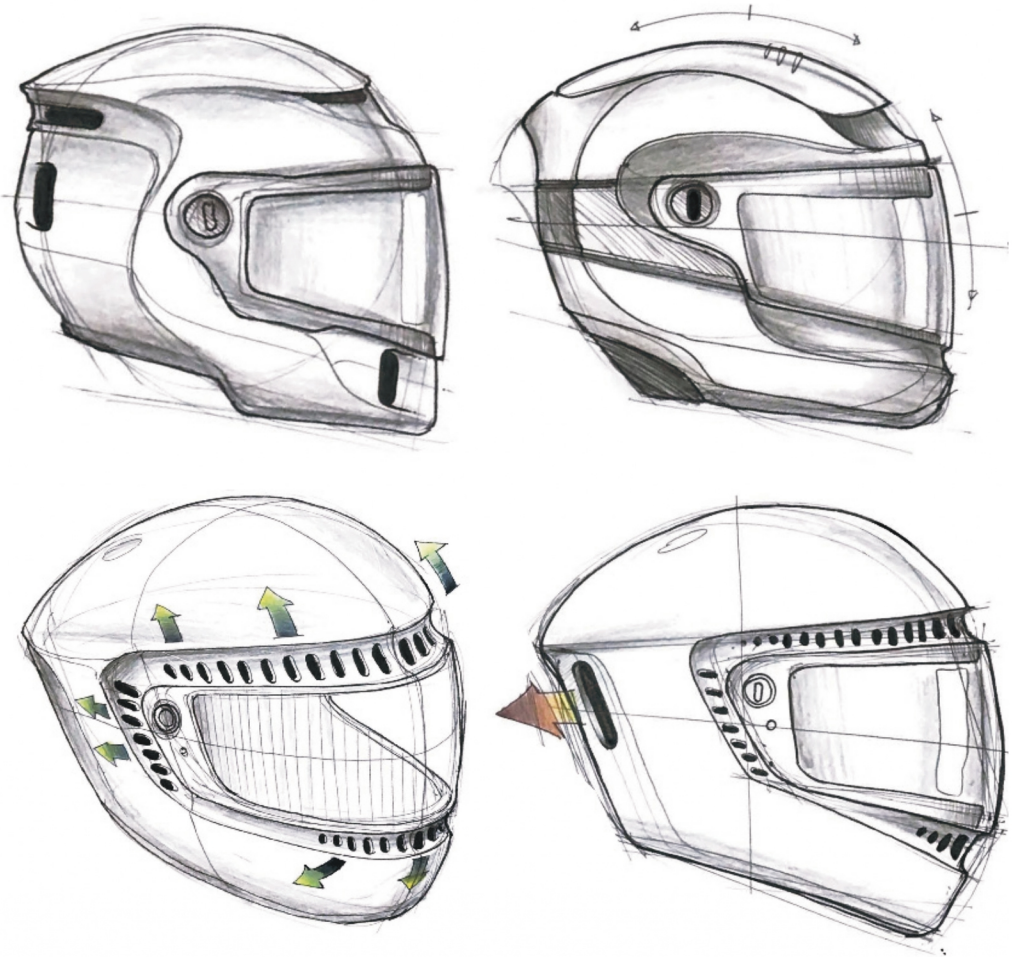
Exploring various ways and designs for air ventilation in Motorcycle helmet.



Ideation for vents design.

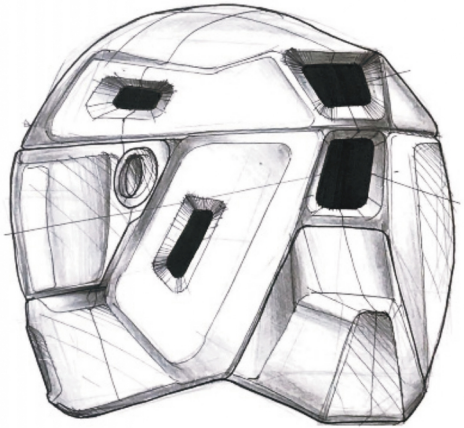
Exploring various vents design for air ventilation design, exploring various form factors and functions of these designs.

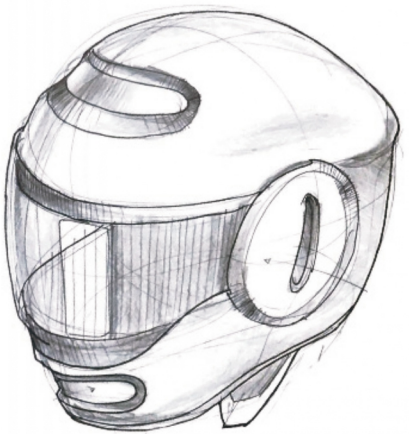
- Inspired from sieve, first design has pattern of tiny holes at inlet and outlet of air.
- Dynamic form and contoured vent layout in second ideation is form exploration based on core function of helmet itself which is air circulation.



- Another iteration for form exploration based on air flow function showcasing dynamic and contoured shape of helmet.

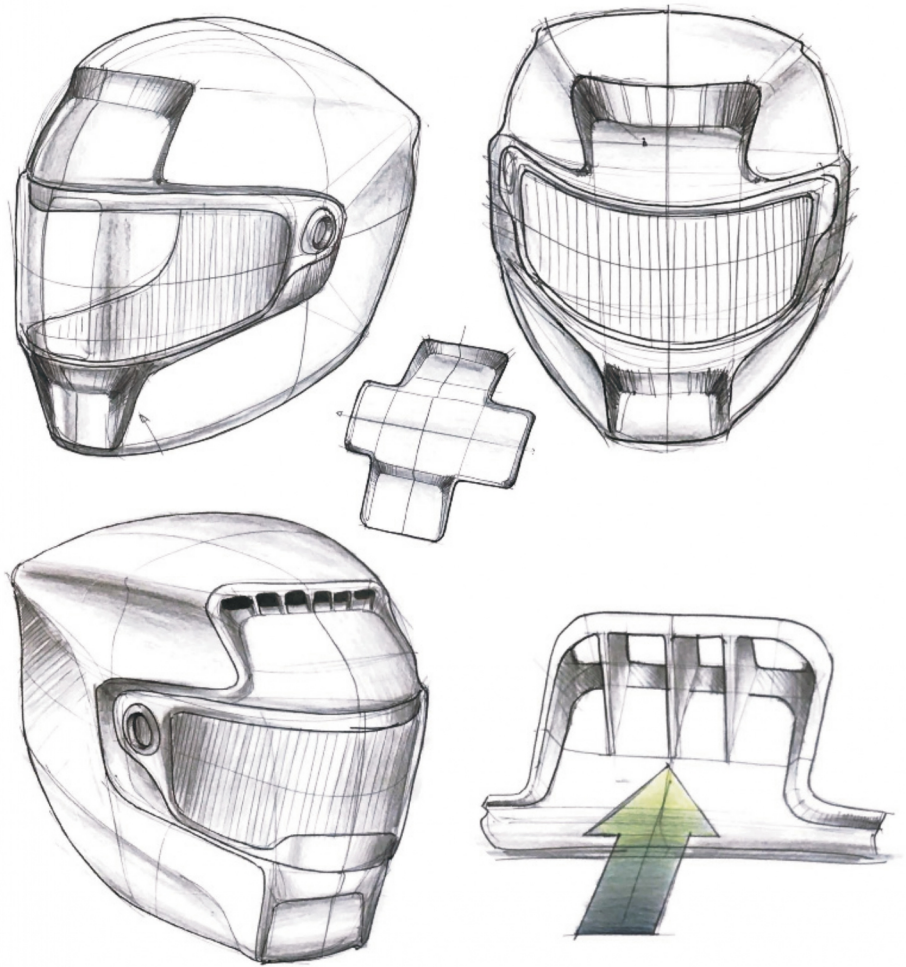
- Second concept presented here is inspired by traditional bridal makeup above eyes, which inspired for array of vent surrounding the visor area of helmet.





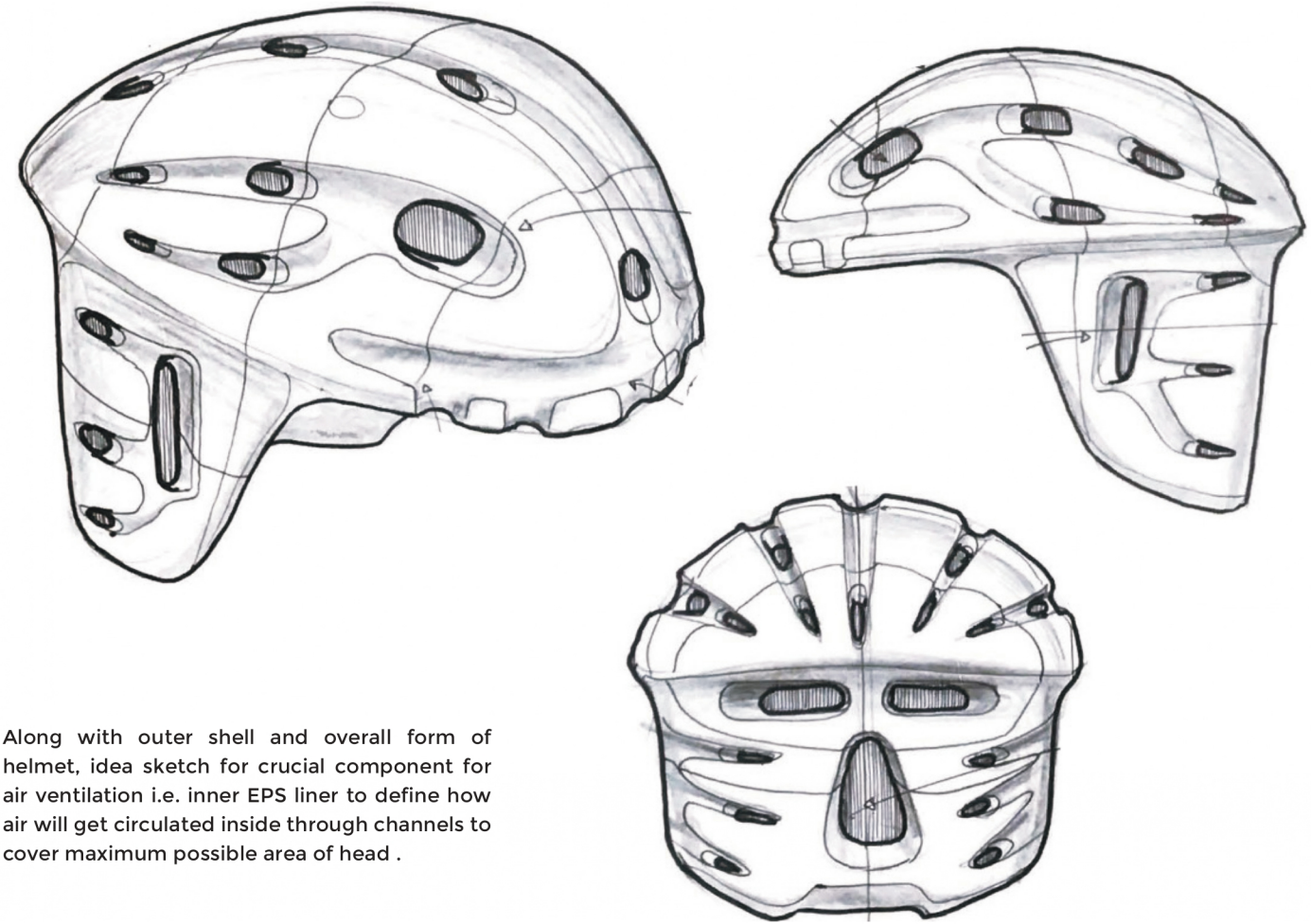
- First set of sketch is another exploration based on alien like form with numbers of vent opening at major air striking regions.

- Second set is application of shut wall in vents which will allow only air to enter the helmet cavity other environmental elements will be discarded due to tight cross-section of vents.

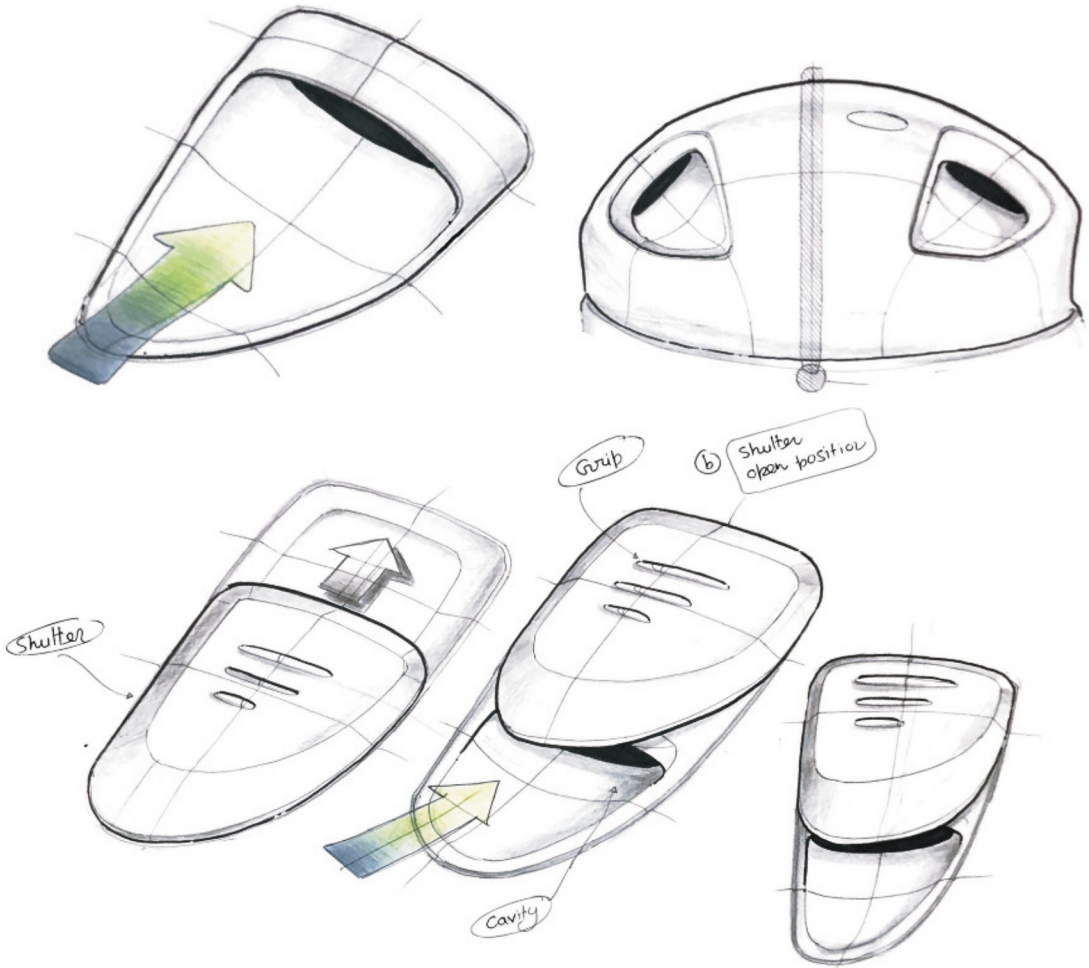


- Another set of sketch derived from simplicity and uniformity with faceted design. Form derived from principle of air capturing this set of sketch can be said as best suitable for air ventilation.

- Second set of sketch is air vents design inspired from front radiator grill in automobiles along with section view sketch of it.

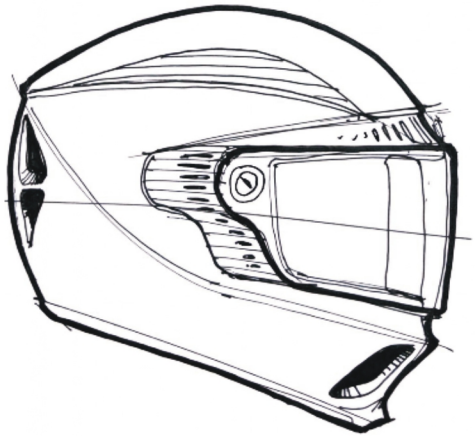


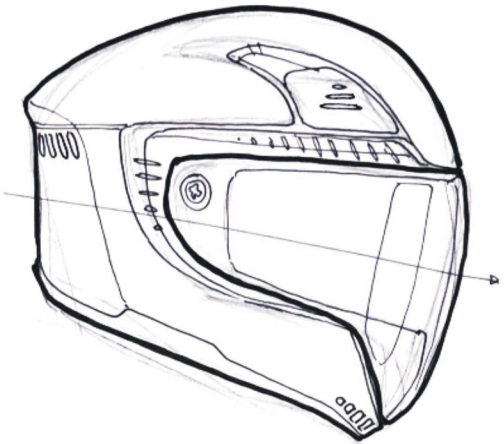
- Along with outer shell and overall form of helmet, idea sketch for crucial component for air ventilation i.e. inner EPS liner to define how air will get circulated inside through channels to cover maximum possible area of head .

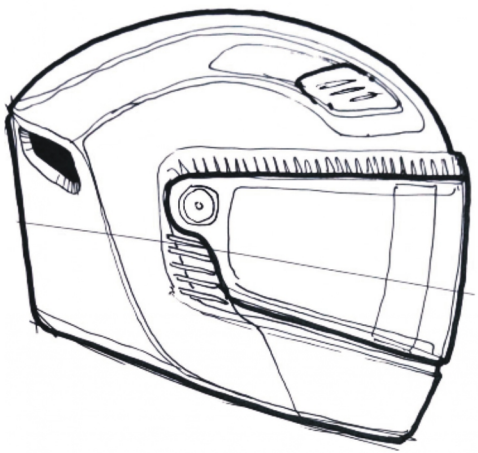


- Detailed sketch for inlet vent design on outer shell, overall form of it, its position and number on shell along with closure for this vent system showcased in lower set of sketches, also showcasing its movement for vent to keep closed or to function.

- Some miscellaneous early detail sketches for various components and their contact points. Along with their positions and shape on the outer shell.



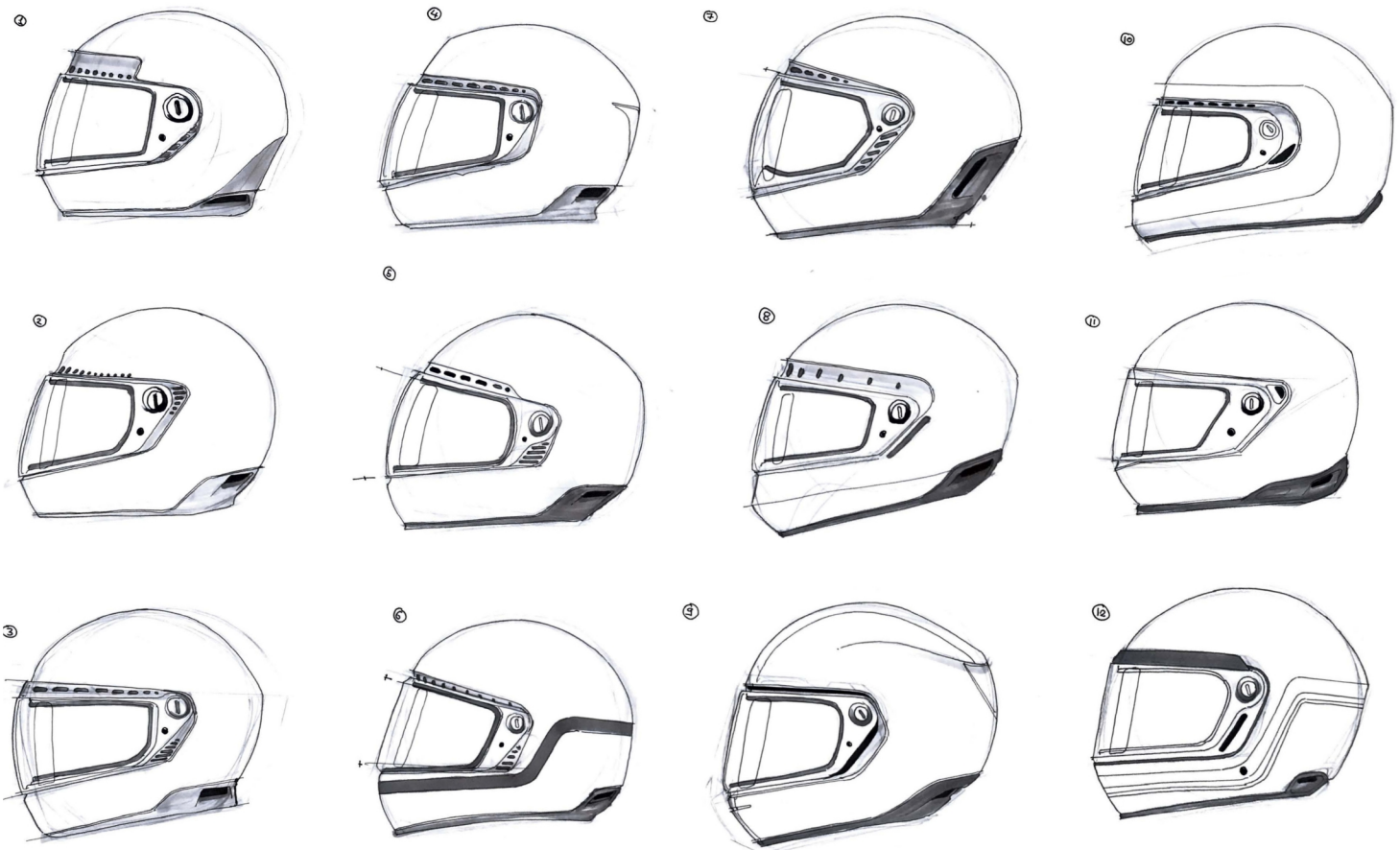




Schematics for eyebrow vents.

Schematic ideation for eyebrows vent design combined with various other features, explorations for placements and overall form for final proposed design.

- Playing with form lines and component boundaries to achieve visual harmony.


1
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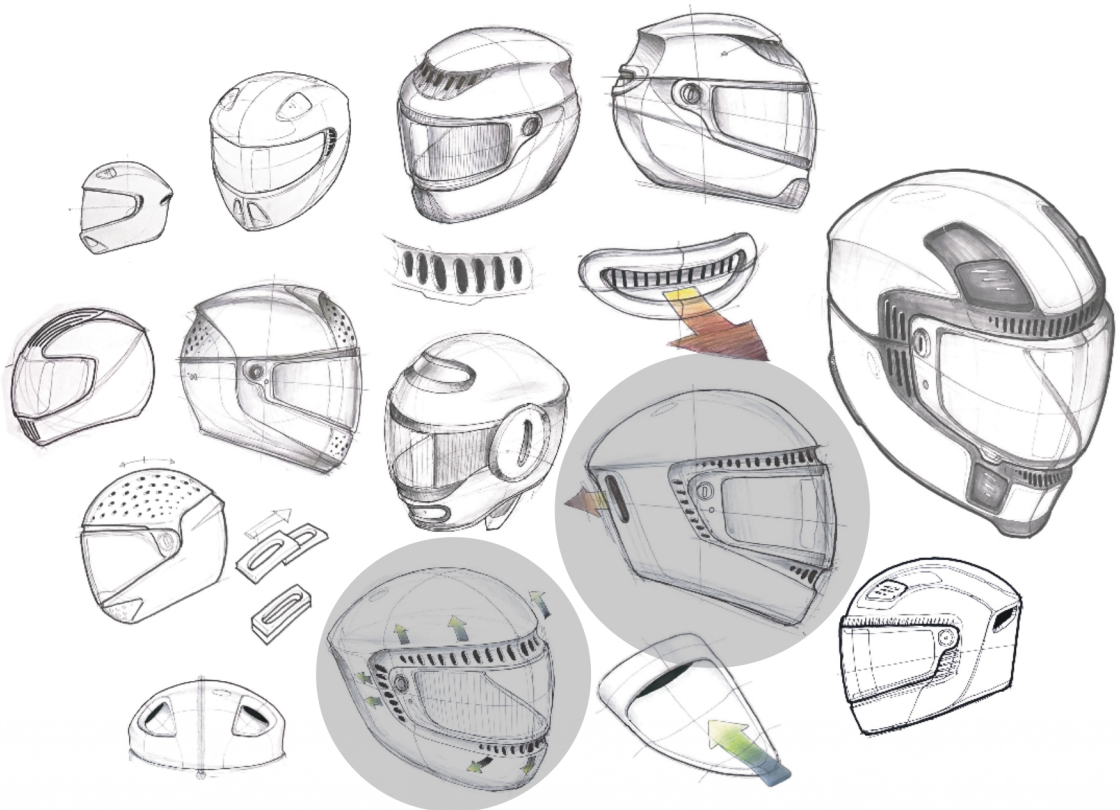
Affinity cluster and concept generation

Combining various sketches which falls under affinity towards three different factors i.e. ease, closure and predominant semantics for air flow to develop concepts.

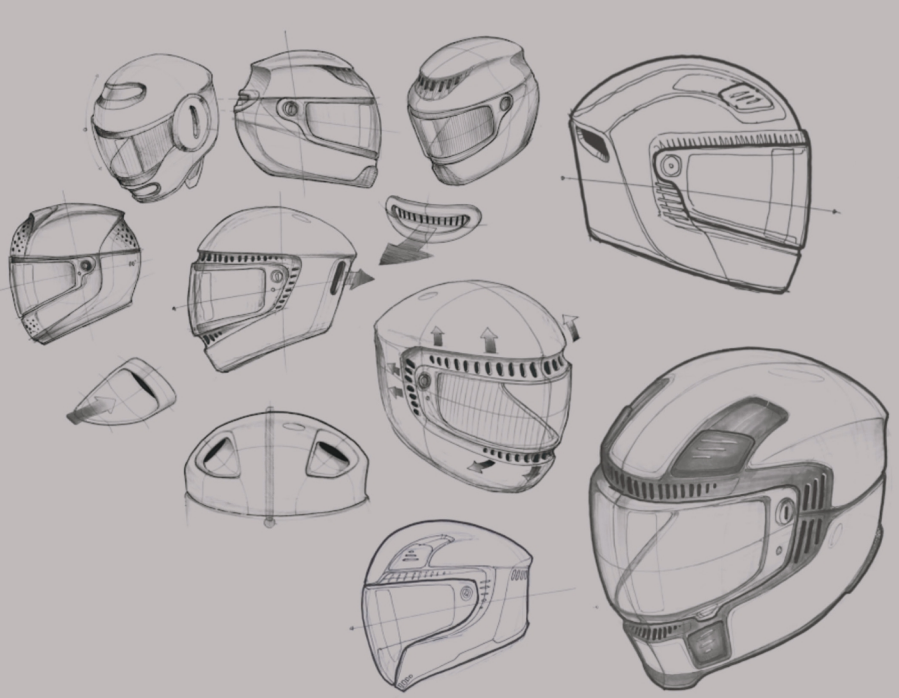
Affinity cluster for ease of airflow.



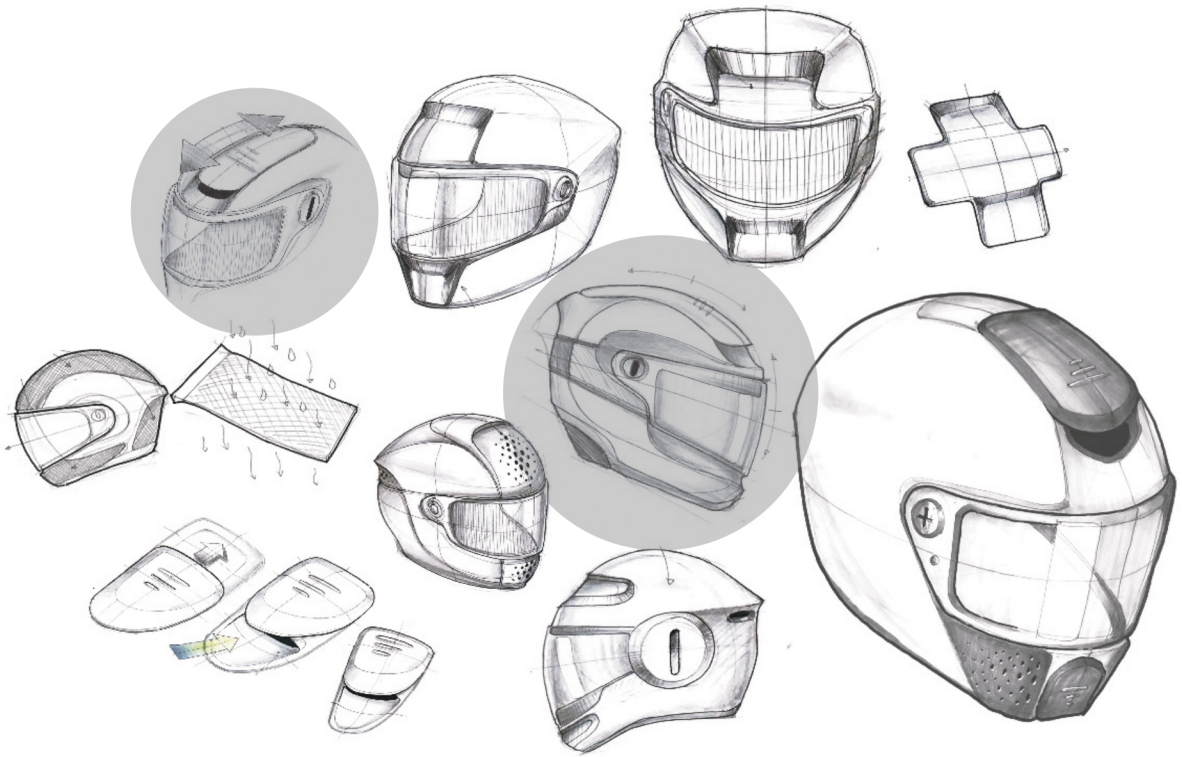
Concept 1

Concept for ease of Air flow

Ideation based on ease of airflow clustered together and combined into one single concept.



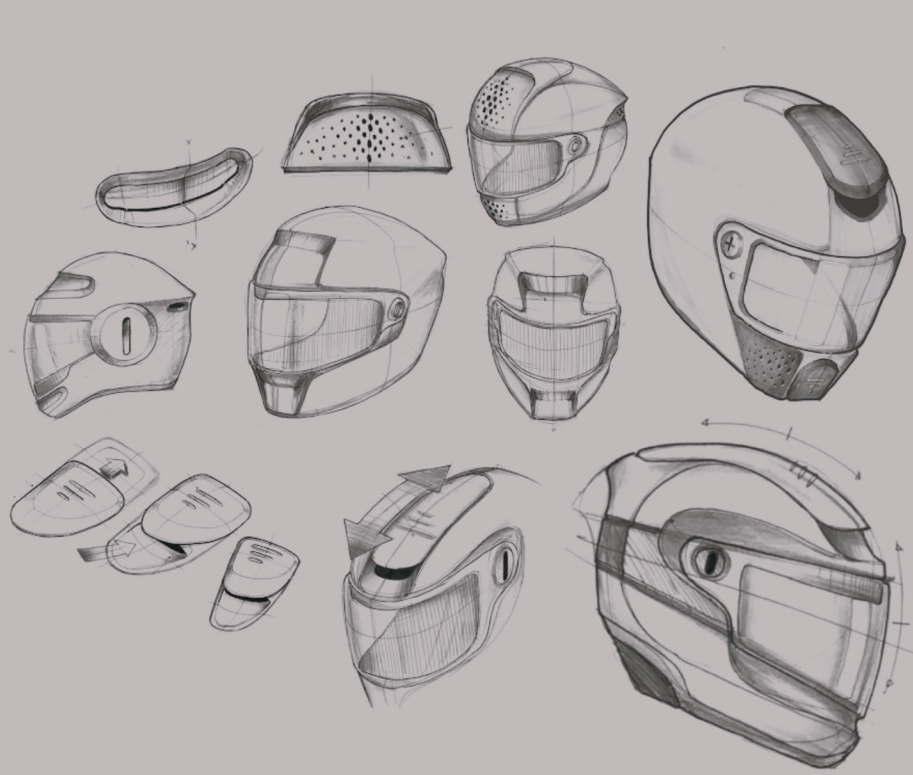
Affinity for cluster closure of airflow.



Concept 2

Concept for closure of Air flow

Ideation based on ease of airflow clustered together and combined into one single concept.

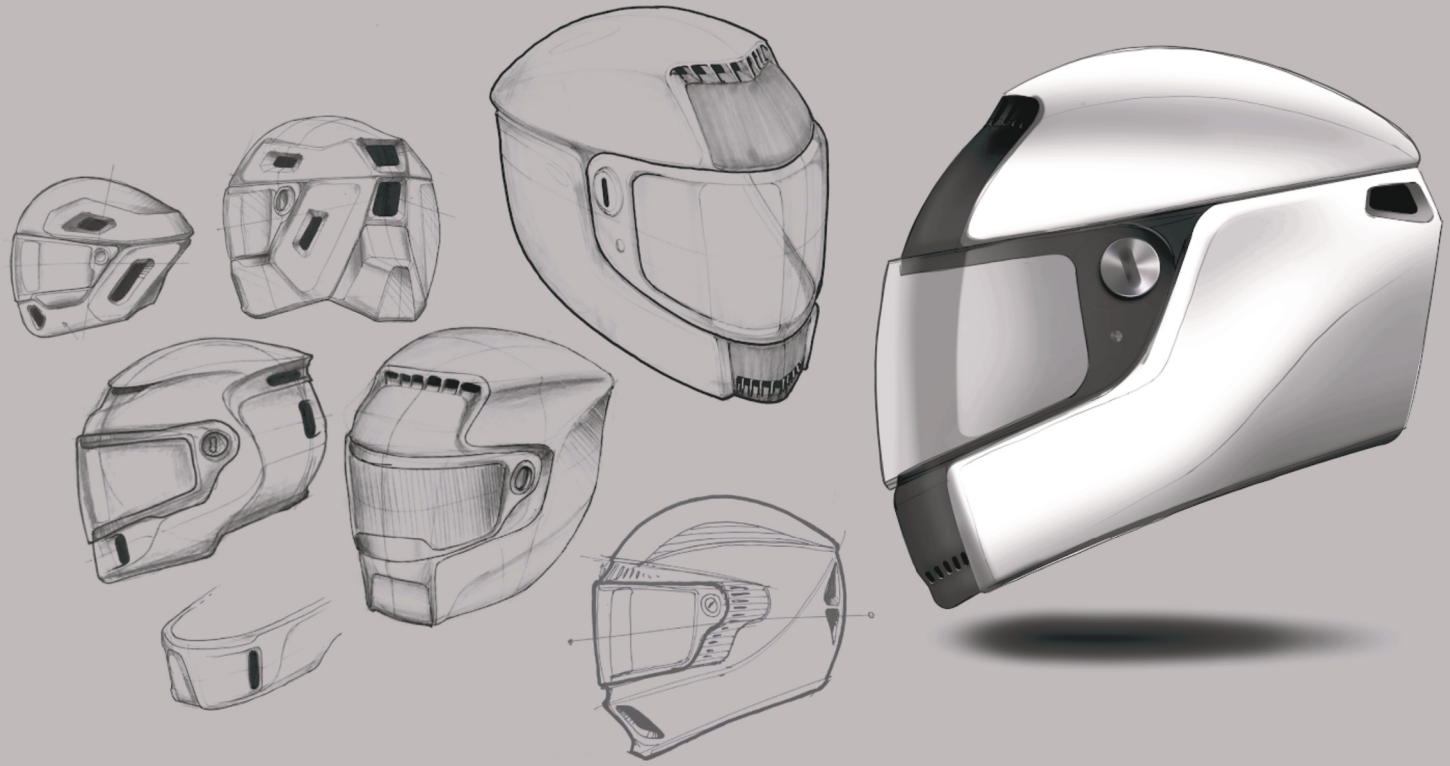


Affinity for cluster Semantics of airflow.

Concept 3

Concept for Semantics of Air flow

Ideation based on ease of airflow clustered together and combined into one single concept.



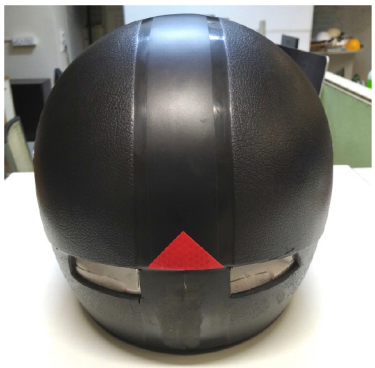
Concept Testing

Initial study of user, market and guide for standards by Bureau of Indian standards.

Rig Models

Concept 01 details
(Overhead vents with shutter)

- Overhead vents with shutter X 2
- 60 x 30 mm opening.
- EPS layer thickness 25 mm.
- 6 mm internal and external slot on EPS layer.
- Outer shell thickness 5 mm.
- Rear Air outlet slot X 2
- 50 x 30 x 40 x 25 mm opening.
- Metal mesh at all opening.



Concept 02 details
(Eyebrow-side vents)

- Overhead vents holes X 13
- 7 mm diameter opening.
- Side vent slot X 2
- 50 x 7 mm opening
- EPS layer thickness 30 mm.
- 6 mm internal slot on EPS layer.
- Outer shell thickness 5 mm.
- Rear Air outlet slot X 2
- 60 x 25 x 55 x 15 mm opening.
- Metal mesh at all opening.

Test 01

Objective

To test two different helmet designs working on two different air vent types and to find out which works better among these.

Test Setup

3 different helmet (2 concept rigs and 1 regular generic helmet) have to be used while driving through similar path on similar vehicle on 3 different speeds by 5 different users. At the end of each ride user has to grade each concept based on comfort experienced during rides from A-very good to F-very poor.

Test area and conditions

Day 1 Mumbai, October 24, Afternoon-Evening, Cloudy, Moderate climate.

Day 2 Mumbai, October 26, Morning-Afternoon, Clear sky, Hot Climate.

Test Data

- **Mean of ratings from 5 users for each step has been mentioned in table given below.**

	Concept 1 Overhead vents with shutter	**Concept 2** Eyebrows vents
Vehicle speed		
Low (10-20 km/hr)	D	B
Medium (30- 45 km/hr)	B	A
High (Above 45 km/hr)	A	A

Data Table 01: Test data for concept performance

Observations

During high speed commutes both concepts provided very good ventilation while concept 2 is very effective right from the starting of rides as it provides better ventilation even at lower speed than concept 1.

User Feedback

Concept 1

- Ventilation is really dominant in front area where air is entering inside helmet after that its effect is getting voided.
- Overall ventilation is weaker in comparison to concept 2.

Concept 2

- Effective in both front and back of head and sideways also.
- Due to presence of entry points for air on each side of helmet, ambiance noise is more but noise disturbance due to air is also there (permanent wheezing sound).
- Works even at slow speed, ventilation is nominal but comforting.
- Some air is falling directly on visor which is also not letting fog accumulated on visor even during heavy breathing.
- There is no shutter for vents to control air flow.

Test 02

Objective

To test which feature among all in concept 2 is contributing how much to the total user comfort and till what extent they can be optimized.

Test Setup

Test 2A: Test for overhead eyebrow vents, User has to make 8 rides through which increasing number of over heads vent holes will be sealed from 15 to 0 in count. At the end of each ride user has to grade each ride based on comfort experienced during it from A-very good to F-very poor

Test 2B: Test for Side vents, User has to make 2 rides during which side vents either be closed or opened. At the end of each ride user has to grade each ride based on comfort experienced during it from A-very good to F-very poor

Test 2C: Test for rear air outlet slots, User has to make 4 rides through which increasing size of rear air outlet slots will be opened from 10mm to 40mm, whereas length of slot is kept similar through all. At the end of each ride user has to grade each ride based on comfort experienced during it from A-very good to F-very poor

Test area and conditions

Mumbai, October 26, Afternoon-evening, Clear sky, Hot Climate

Test Data

- **Mean of ratings from 5 users for each step has been mentioned in table given below.**

Active Overhead vent holes	Ventilation effect and comfort
0	E
3	E
5	D
7	B
9	A
11	-
13	-

Data Table 02: Data table for overhead vents performance

Active Side vents	Ventilation effect and comfort
0	D
2	A

Data Table 03: Data table for side vents performance

Opening size for Rear exhaust slot at wide side	Ventilation effect and comfort
0 mm	C
10 mm	A
15 mm	-
20 mm	-
25 mm	-

Data Table 04: Data table for rear outlet slots

Observations

- Ventilation effect increased with number of overhead vent holes but it reached its peak at middle of test at 9 number of holes after which there was no change in performance of vents even when vent hole count was raised to 15 in total.
- Side vents are adding to overall performance and air circulation are inside the helmet without which overall performance of concept 2 drops drastically.
- Rear exhaust can be made 10 mm wide only as it has no effect over ventilation performance of concept 2.

Component details

Parts and Components detail for final proposed design. These are early detail sketches for final design which may vary in with time.

Concept details

A form to be compatible with both regular and sporty user out there.

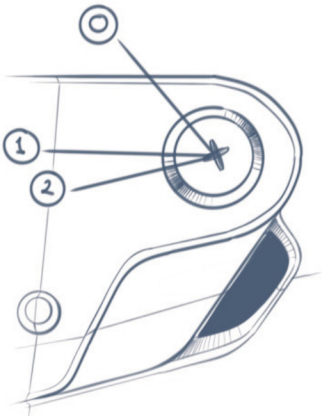
Main feature for this concept is visor being only mode of interaction to reach different modes in helmet i.e. ventilation mode n isolation mode.

3 different positions and their working is present below

Position 0. Fully opened or raised up position for visor

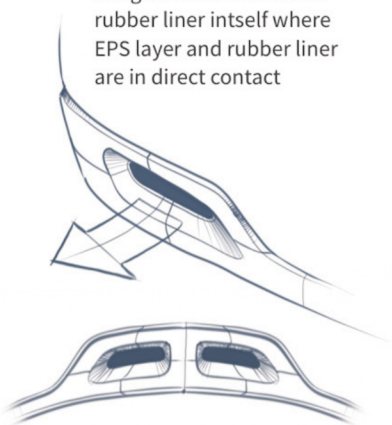
Position 1. Rubber strip on top of visor covers the over head vent holes completely, where as it is in contact with chin guard at this position as well.

Position 2. One click down and over head vents are exposed to take air in and provide ventilation.



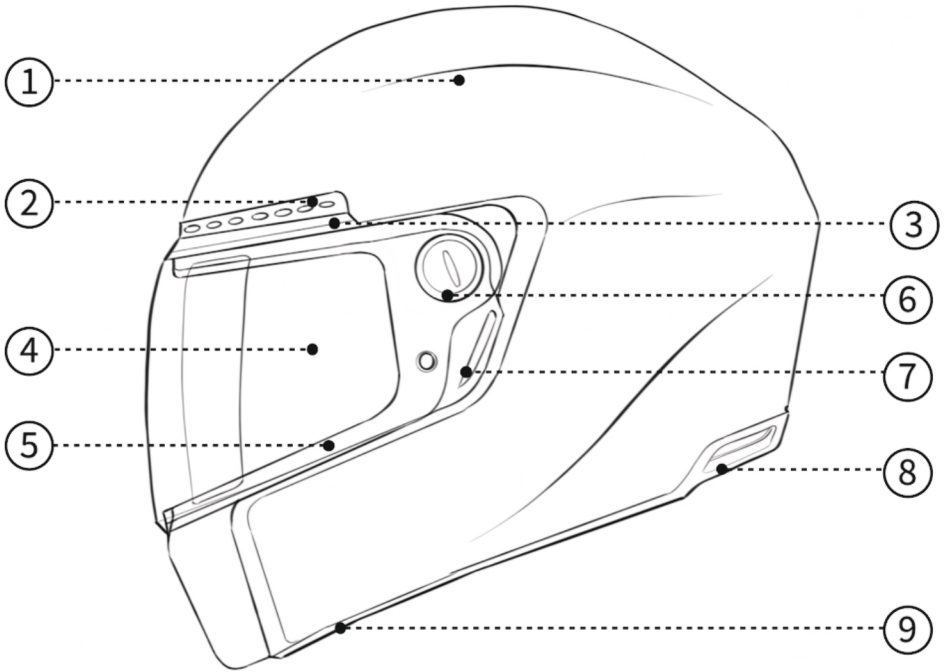
Helmet rendered above is in position 2 i.e. ventilation mode.

Rear air cutouts are integrated inside bottom rubber liner intself where EPS layer and rubber liner are in direct contact



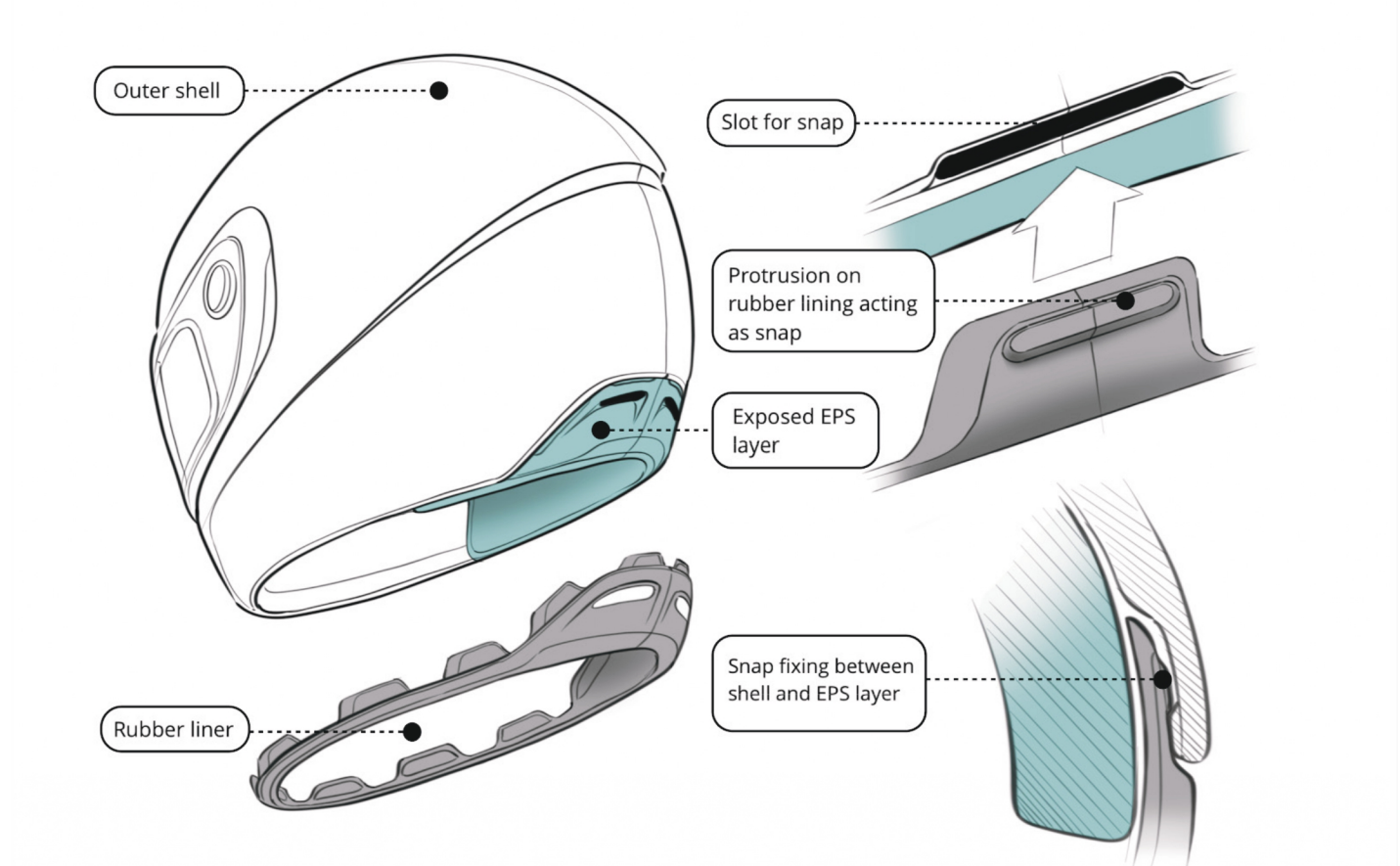
List of components

1. Outer shell
2. Over head vents
3. Rubber strip
4. Visor
5. Face rubber liner A
6. Hub screw
7. Side air vents
8. Back air vents
9. Bottom Rubber liner B



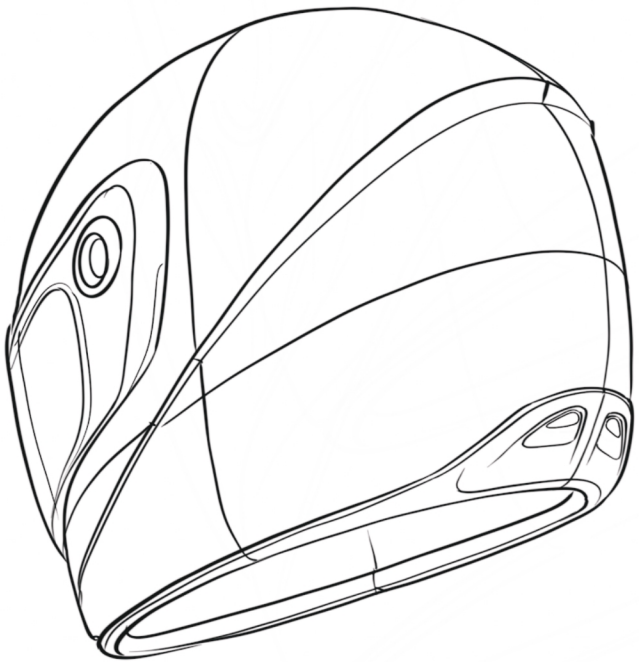
Rubber liner for base (rear exhaust vents)

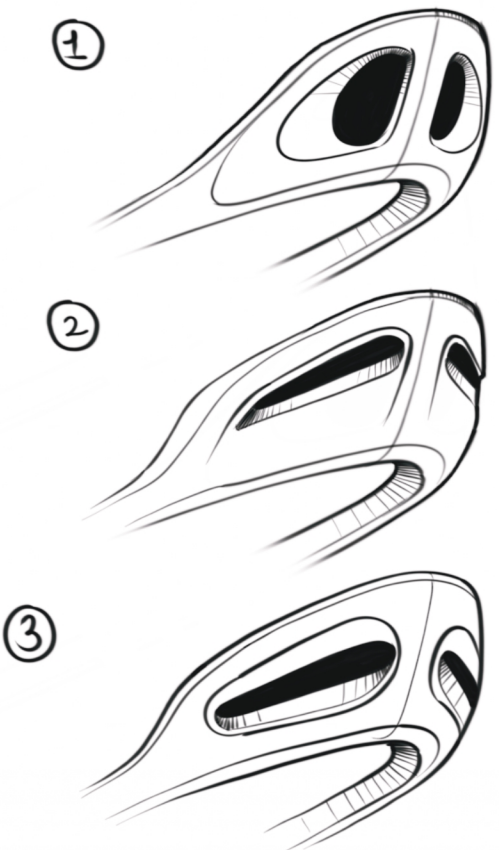
Detail for contact point between outer shell, exposed Inner layer and rubber liner along with fitting detail of it on edge of outer shell.



Form details for rear exhaust vents

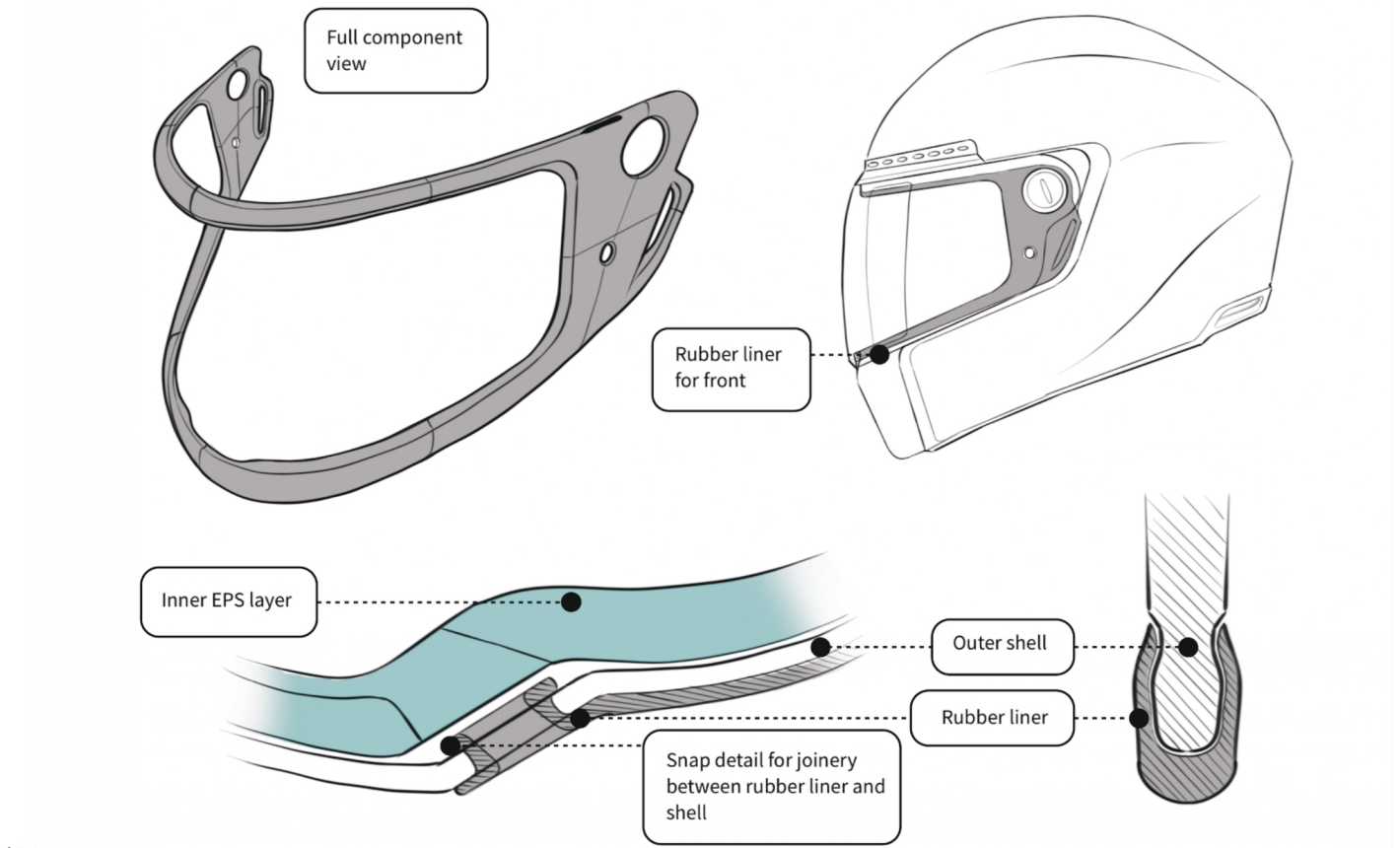
Making it an design element in helmet, exploration for form of exhaust vents is done for it to match the over all design language of helmet.





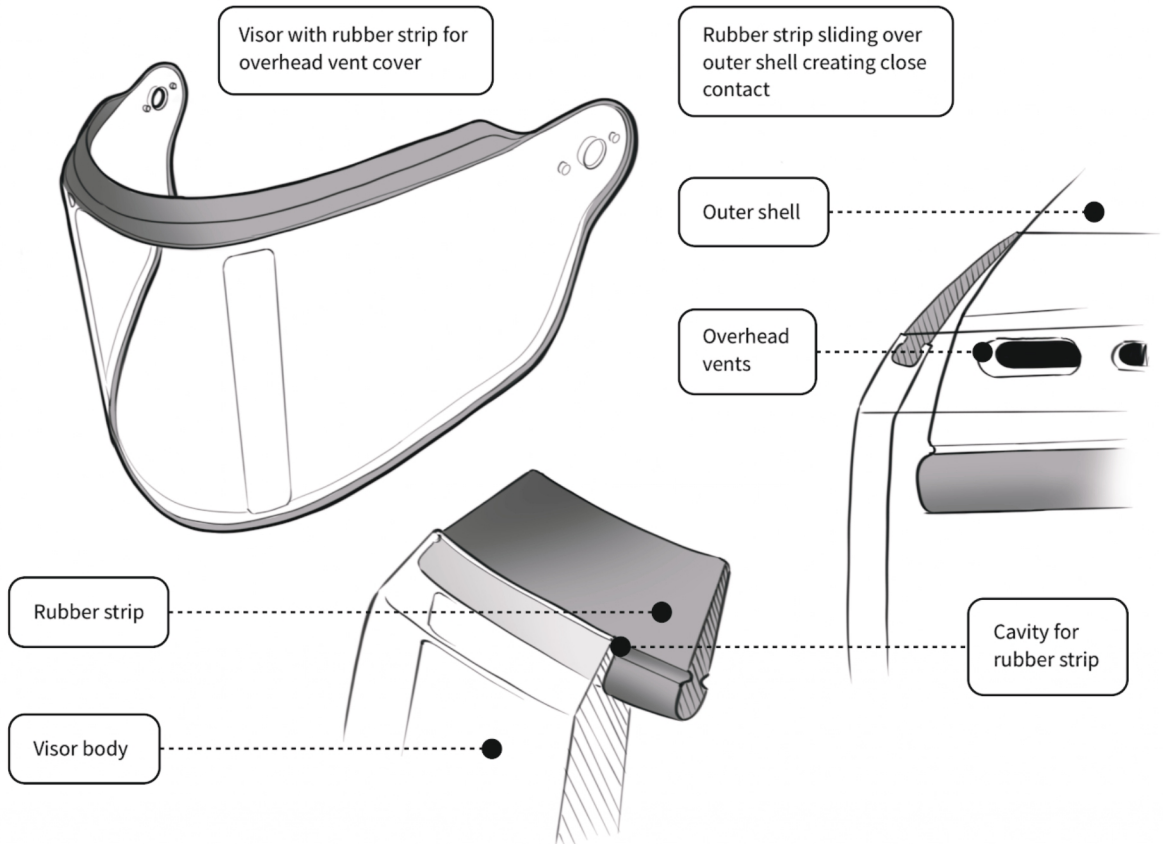
Detail for front rubber liner

As there is an opening for side vents on both half of the helmet, front rubber liner is formed around it to cover it completely along with snap detail for it to lock inside vent holes.



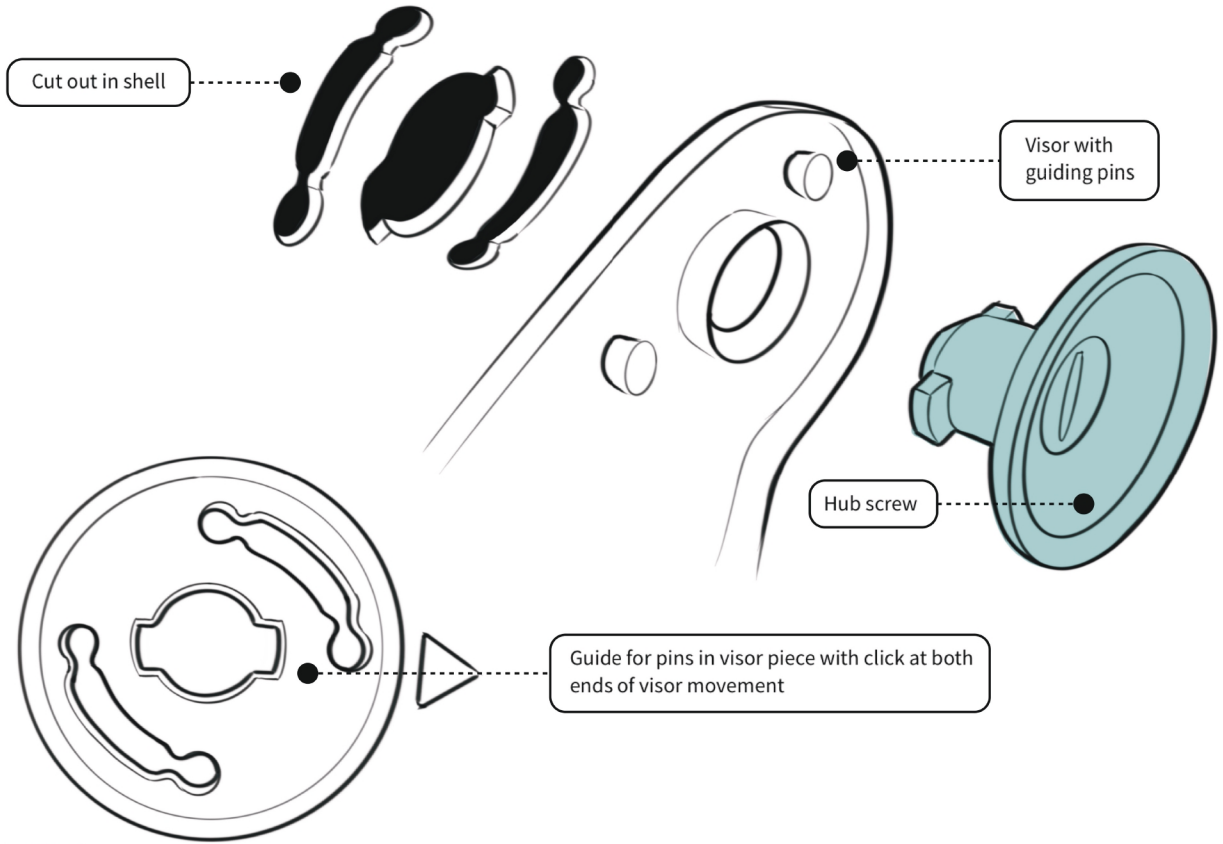
Detail for visor and eyebrow vent cover

Fusing vent cover in visor only helps in unified design for user interaction with helmet as it makes visor only point of interaction to hide or open overhead vents.



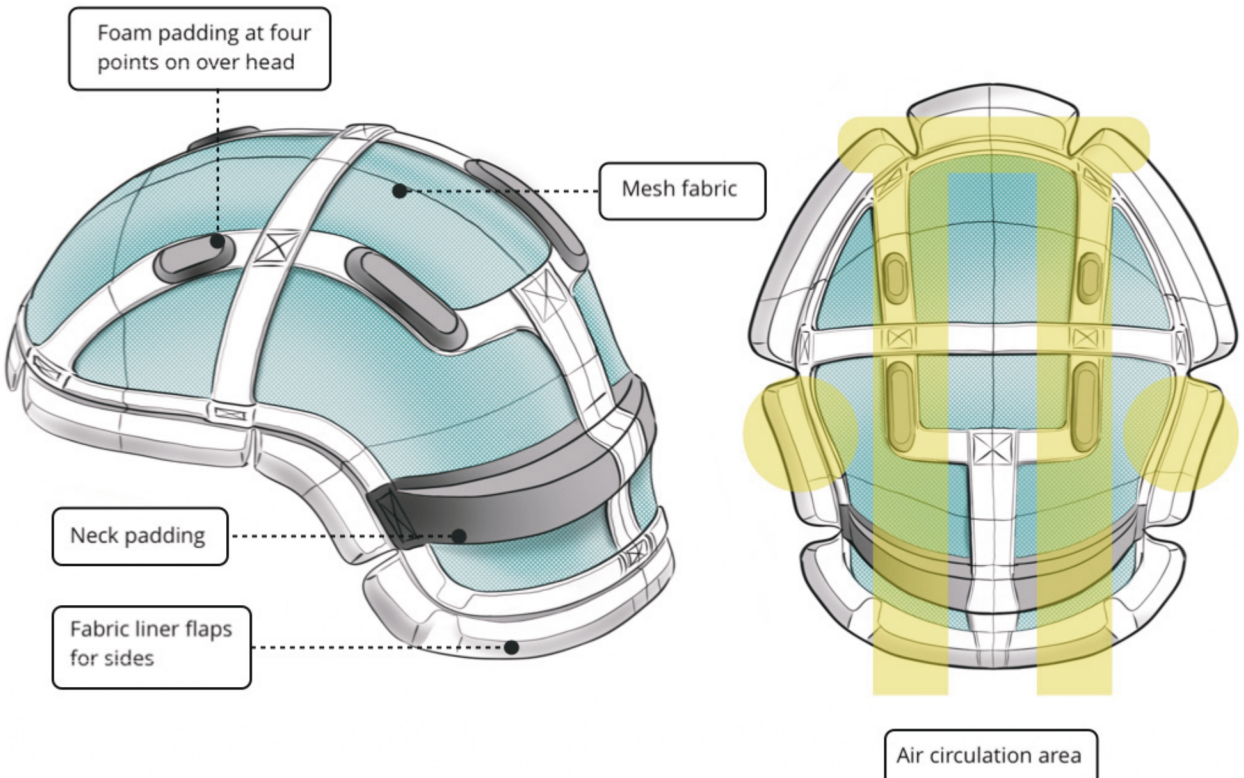
Detail for visor/shell contact point, Hub

Three stop detail for visor in visor hub to provide all three modes of helmet i.e. Open visor, closed visor-closed eyebrow vents, closed visor-open eyebrow vents.



Detail for Inner fabric liner/padding

Being second most important component for ventilation helmet inner fabric liner if not designed properly can reduce air circulation or air contact with head drastically.

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