ANTI-MOTION SICKNESS BOOSTER SEAT

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Executive Summary

Discover

In the first phase of the project, I explored the causes of distractions in a car identify the friction points drivers in general face. This research opened doors into studying children as a cause of distraction. Following that, I did some user testing as well as interviews with parents to find out more about this problem.

Define

Then, I started going deep into the reasons behind children being a source of distraction. I studied the causes of motion sickness in children and how its symptoms is the main cause of them being a distractive element for the driver.

Develop

Following that, I started exploring the possible solutions that could solve the motion sickness problem amongst children and the different mechanisms and materials that could dampen the frequencies that cause this issue.

Deliver

Finally, after deciding on the final prototype, human factors were studied to account for the whole age range of the user group. Then, renders and models were produced to visualize the product.

Research *Primary*

The first design proposition was to find ways for drivers to minimize distractions in the car and to access its functions while staying focused on the road. The initial step was to find the most distractive elements inside the vehicle.
In short, almost all studies had the same conclusion, entering navigation details, texting and using the centre screen and console controls are mainly the main distractive actions where it increases the chances of accidents by many folds. However, one study included children inside the car as a potential cause of distraction and it was deduced by the end of the study that children are a major cause for driver on-road focus disturbance.

As it was a very interesting piece of information, it was decided to dive deeper into it since it unfolded a lot of potential unsolved issues. Another study concluded that ''The most frequent types of distracting activities that drivers engaged in included: touching their head or their face (35%), interacting with child passengers in the rear seat (12%), and engaging with the front seat passenger (9%).'' (Koppel, Charlton, Kopinathan and Taranto, 2011)

> “Our results showed that drivers with child passengers were more often assessed as inattentive compared to drivers without child passengers, which indicates that children in the vehicle represents a potential source of distraction.”(Bullas, 2005)

Driver Behaviour with children in the car:

While ideally a recorded personal investigation on how drivers interact with children inside the car would have worked best, it was not possible due to due moral and legal reasons as well as safety concerns since Covid restrictions were in action during the time of this project. The images below are obtained from a scientific journal on children as potential distraction. (Bullas, 2005) *

Driver attempting to turn on DVD player.

Driver passing drink to child rear seat passenger.

Driver turning to talk to child in rear seat.

As seen in the pictures above, there could be many reasons for driver distraction with children inside the car. Therefore, and obviously, the main reason for driver inattentiveness in a car with children is because children’s constant need for attention. And one of the main reasons is because children are more prone to get car sick and thus need an adult attention. In fact, studies show that while car sickness can occur in babies, it is most common between the ages of 4 and 12, with most severe symptoms between 6 and 8 years old. (Huppert, Grill and Brandt, 2019)
Therefore children car sickness and needs is noted as a friction point of potential friction point.

Research *Secondary*

User Testing

Since children up to 12 years old (or under 135 cm) should be using booster seats, it was decided to investigate the seat itself to see if there is any areas that needs to be improved. A small experiment where few people were asked to enter the booster seat inside the car and latch it.
This experiment showed that just getting the seat in was not of an issue.
It is important to note that this experiment did not take into account the fact that a real life scenario includes a child and possibly bags that would make the process of getting the seat in more difficult and thus by doing so it could have unveiled more areas of possible problems.

However, latching the seat was of a problem and took allow of time. And therefore it was noted as a friction point.

Interview:

To get further insight on children behaviour inside the car. Two phone interviews were conducted with parents who have children aged 7 and 10. The following questions were asked:
-Do you feel that it is time consuming to place and latch the booster seat?
-Would you prefer to have the booster seat integrated inside the car?
-Does your child get carsick very often?
-Do you give your child any type of gadget or device to keep them occupied?
If yes, do you feel your child sits in a wrong posture(back bent and head leaning forward), specially when using a phone/tablet?
In short, the answers these questions concluded the following:
-Getting an integrated booster seats is preferable since it saves time
-Car sickness was a common issue with one of the interviewee's child, but both noted that it is a common problem within children.
-Children are usually given a tablet/phone to keep them occupied during car rides.
-One of the interviewees noted that her child constantly bend forward when using his iPad where she is concerned about his posture.

The child posture is also noted as a friction point.

Research findings/ Friction Points

Car Sickness

Latching the seat

Child posture while using screens

Problem Statement

The problem that is decided to be worked on is enhancing comfort for children so they would be less of a distraction for the driver. The main purpose of this product is to enhance the car ride experience for children so they are less prone to get carsick.

Motion sickness is a sensation of wooziness. It usually occurs when you're traveling by car, boat, plane, or train. Your body's sensory organs send mixed messages to your brain, causing dizziness, light-headedness, or nausea. (Heitz, 2021) This confusion and contradictions in signals, if eliminated, can almost eliminate motion sickness.

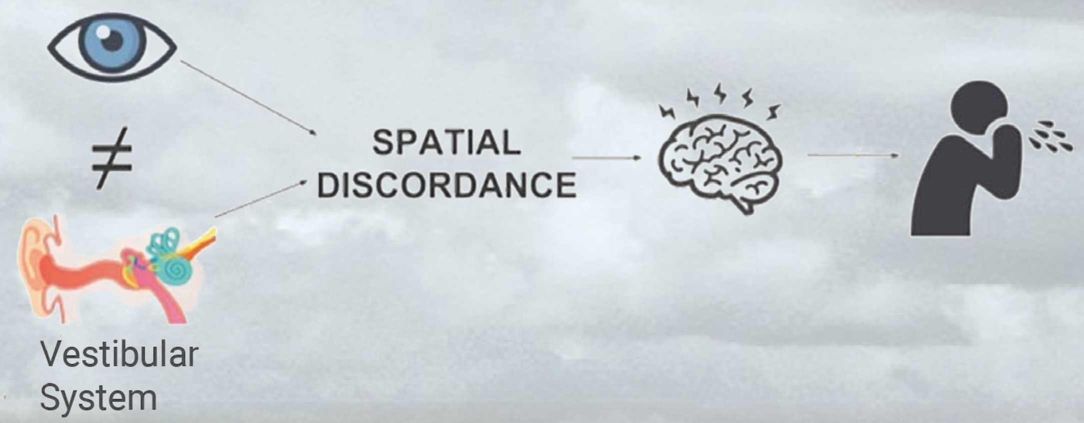
The main input signals to a person in a car, and a child in our case, are mechanical vibrations, noise, and visuals.

It would be ideal to isolate all these sensory inputs for the most optimal solution; however, this project is going to focus only on mechanical vibrations.

Thus, the main product requirement is :

-Minimize the experience of mechanical vibration frequencies that cause motion sickness

So when the child is using a screen or reading, their sensory input would be coherent.



Secondary Requirements include:

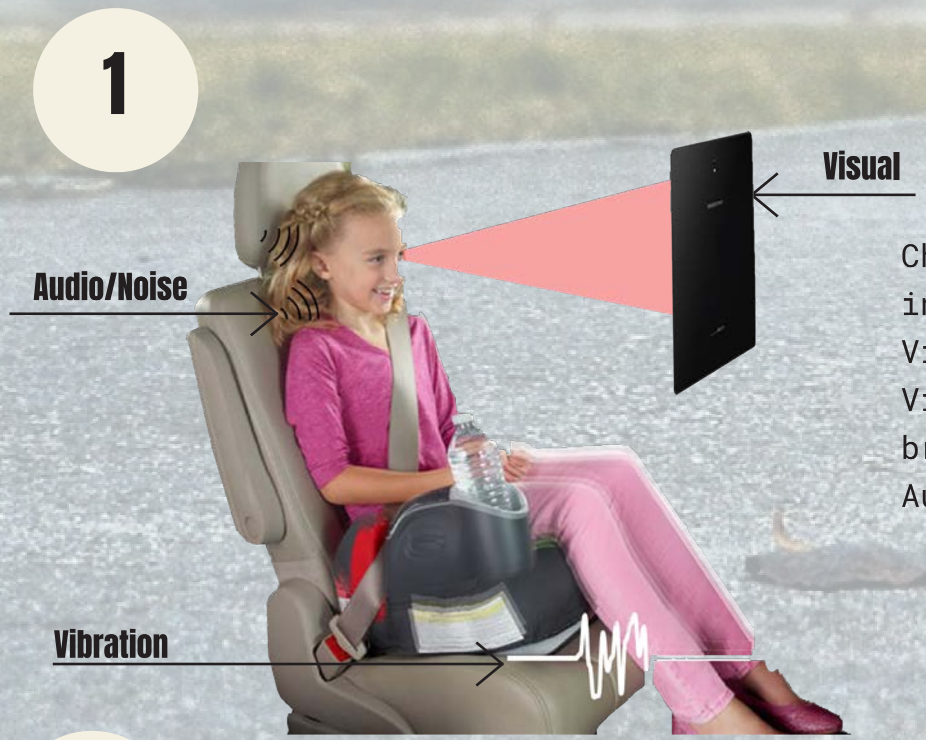
-Easy to clean

-Highly reliable

-Easy to install

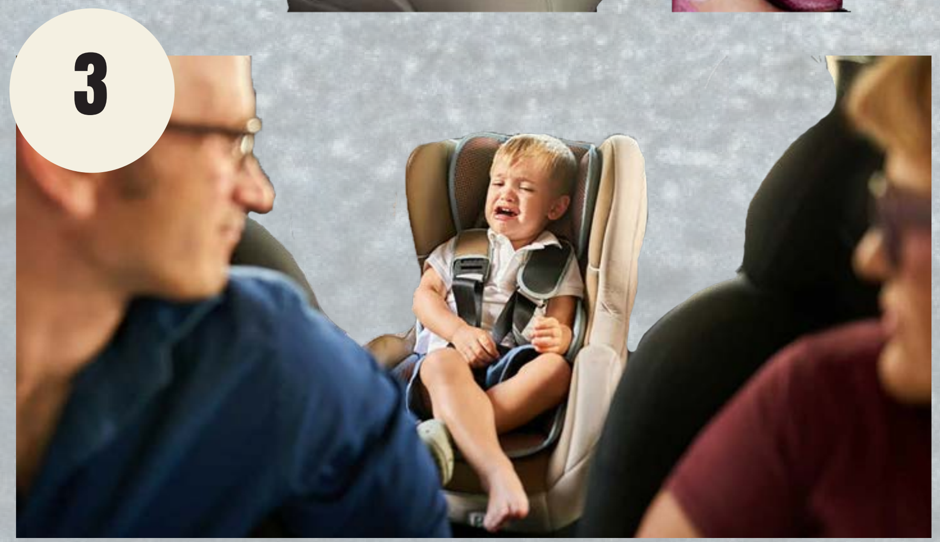
-Safe to be used around children(no sharp edges)

Story Board



Child receives conflicting input
Visual(Screen, book etc..)
Vibration(Mechanical vibration)
Auditory(Road noise)

Due to these conflicting inputs, the child gets car-sick.



Symptoms of motion sickness develop and parents/driver looks towards the child to take car of them.

Chances of accidents increase because of the parent's distraction with the child.

User Analysis

There are many variables that can be controlled to solve the motion sickness. Mainly mechanical vibrations and sound. To be able to do deep investigation and research, it was decided to try and tackle only the mechanical vibrations problem. However, ideally solving both of them is much likely to improve the ride experience more.

Prevalence

Percentage of children who experience motion sickness in these modes:

Car: **49.2%**

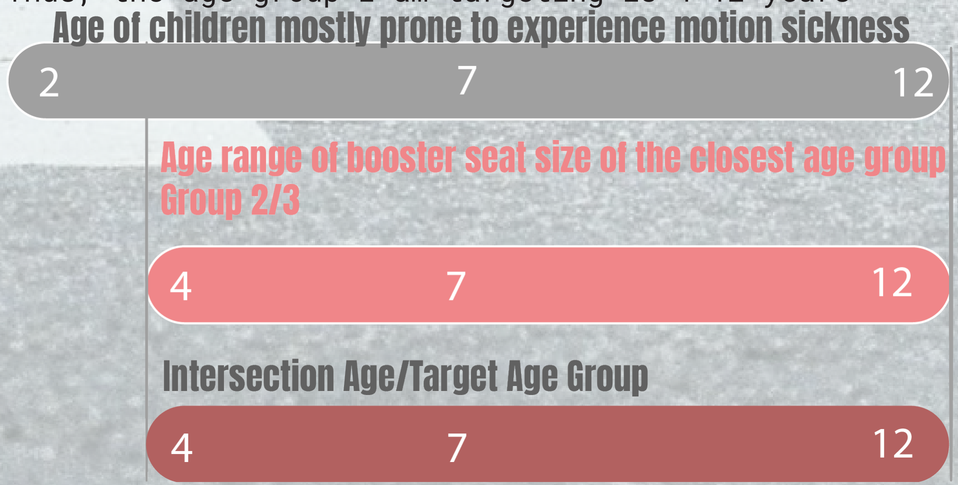
Bus: **43.2%**

Age Group

According to research, children who are most prone to get car sick are aged between 2-12. And car booster seat of Group 2/3 is for the age group of 4-12.

Therefore, it was sensible for the age group to be the intersection of both age ranges.

Thus, the age group I am targeting is 4-12 years



WHO: Children using booster seats aged between 4-12

WHEN: During car journeys specially long trips (road trips, getting grocery, parents driving children to school..)

WHAT : A method that reduces amplitudes of frequency vibrations that causes motion sickness

WHY: To make children less prone to be car sick and ultimately making the driver less distracted

WHERE: Inside cars

Frequency Inducing Motion Sickness

The vertical frequency range that is most car sickness inducing is 0.8-2 Hz. Therefore, my product is aimed to minimize the amplitude of the frequency at this frequency range in particular.

Market Analysis

The only source of information about number of car seats sold is Sky News where an article states that 2.1 million car child seats are sold in the UK each year. Scaling that globally, while being very conservative:

50 million

booster seats are sold yearly globaly. And since 2/3 of the total age range of the whole market it will be assumed that 30 to 35 million car seat car children's seats are sold each year.

This big market, with high percentage of children experiencing motion sickness in cars is enough justification for finding a solution to this problem. (Global Baby Car Seat Market Size | Industry Report, 2025, 2019)

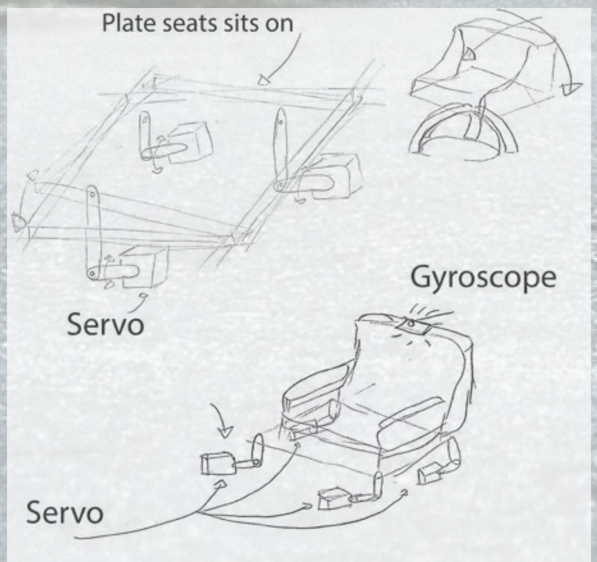
Ideation

Following research done on possible solutions to damp vibrations. Many possibilities were open for investigation.

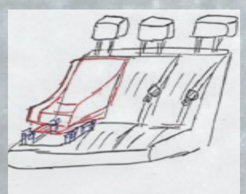
Active Body Control

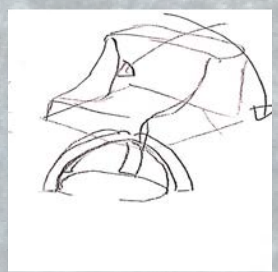
First of all, there is the full body active control system. That uses sensors to read tilt and vibration conditions then servo motors are used to adjust the seat, keeping it horizontal with minimal vibration. However, this method was disregarded since it is very complex and error in the sensor reading could major instability and thus harm for children. It would be a complex system that is difficult to clean and maintain (violating one of the minor requirements).

Seat sits on a plate that keeps it horizantal



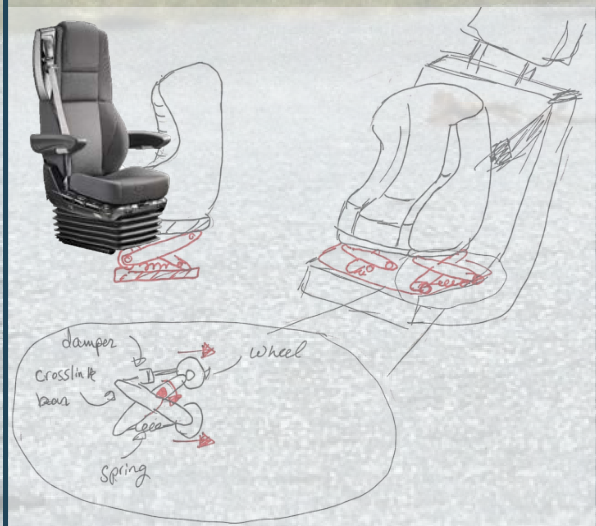
Gyroscope reads tilt, and adjusts servos.





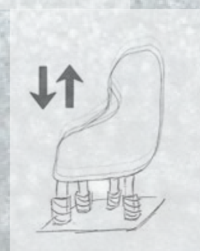
Spring/Damper Mechanism

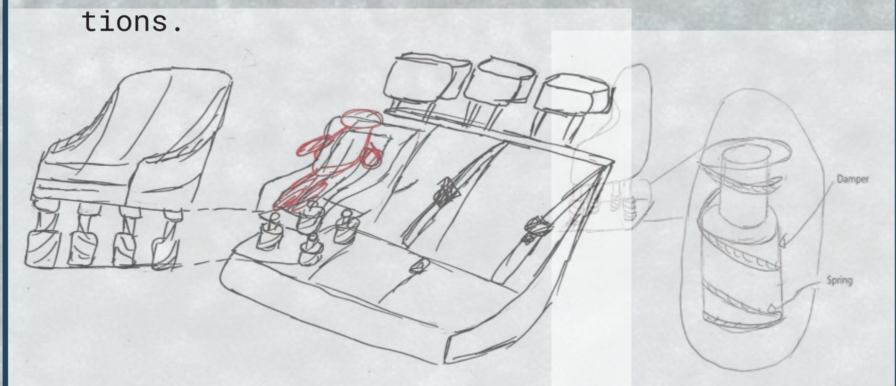
Then two spring damper mechanisms were regraded. This system is way less complex and is passive. The first, is a normal spring damper. The other is one similar to the one's found in truck seat that has proven effectiveness(the one's used in truck is a semi-active system). However, since cars and road conditions are hugely variable, it is very difficult to find a suitable spring and a damper (as a passive system) that would be work everywhere so and using a semi-active one adds a lot of complexity this method is also disregarded.



Similar to truck seats, the vertical vibrations cause the wheels to slide horizontally while being resisted by the spring/damper.

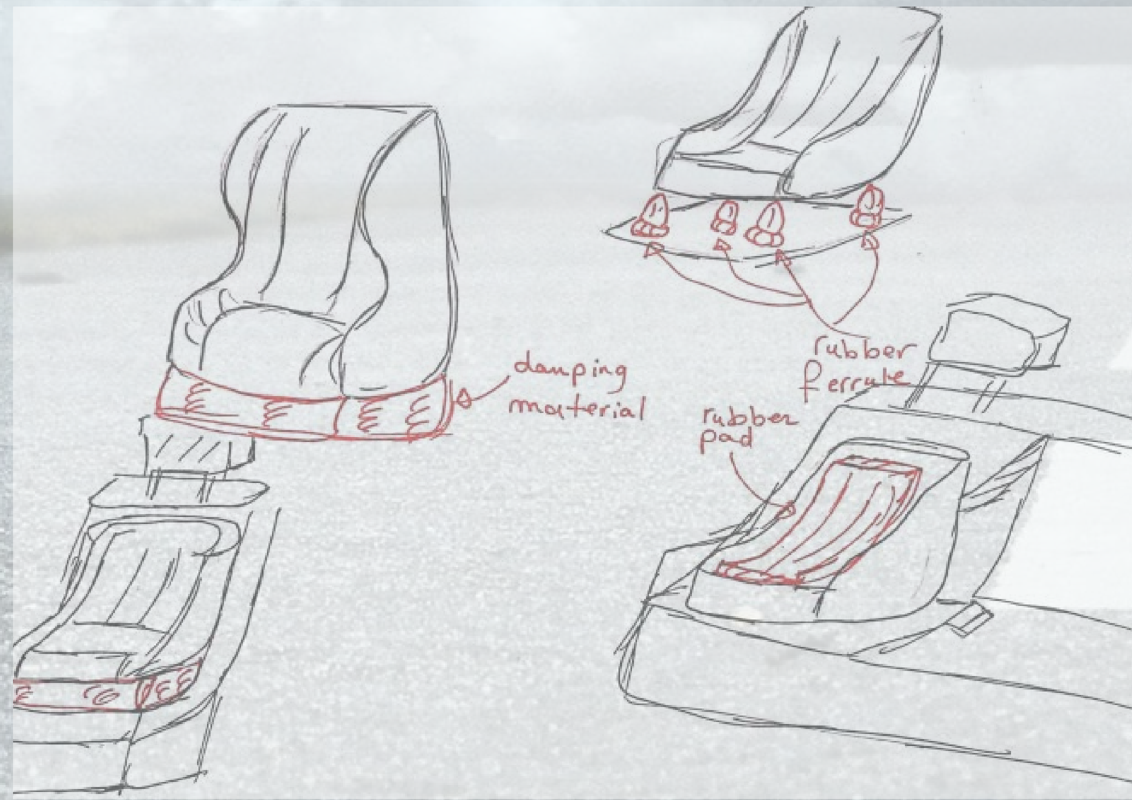
A regular spring damper system is less complex but also difficult to predict in variable road conditions.

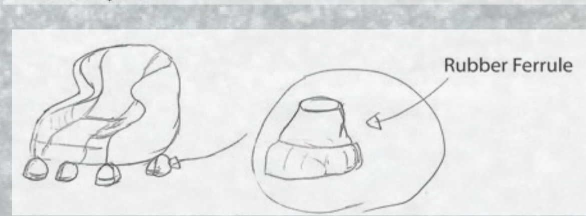




Damping Materials

There is also the possibility of using materials to damp the vibrations. This method is the least expensive and the most reliable. Therefore it is decided to go with this option and look further into its application.





Using Damping Materials under the seat is an option, it adds an extra layer of cushioning.

Prototype Generation

After on the of use damping materials, several concepts were iterated to reach to final concept.

First thought was using a damping material under the seat. In this way, it would absorb the vibrations before reaching the seat itself. One idea was using a pad make the seat stand on, the other was using rubber stands (rubber ferrules).
However, it was not moved forward with because different seat brands have different geometry. So, it would be difficult to create a size fits all

Then, the idea of using the material on top of the seat. However, two issues emerged.
One, this method would also not fit all seat since the position and the geometry of the seatbelt openings is different in each car.
Two, it uses a lot more material than is needed. Were there now there is foam even in places the body is not in contact with.
So, further iterations is needed.

A method of using strips to minimize material usage is iterated. In this way these material strips would fit all seats as well. However, it does not provide enough contact surface in this form.

Following the previous iteration, an idea of using material only in place the body is in contact with the seat is prototyped. Back pads, butt and leg rests are mainly where the body weight is pushed on.
The problem with idea is it is made of many parts which can be improved to enhance user experience.

Further thought was put into the next iteration and the conclusion was that the main source of vibration is the bottom part of the seat. So, the back part was removed. Also, the bottom part is supported on its sides to enhance comfort.

The last iteration was a cushion that is anatomical making it more comfortable. There are three layers each is dedicated for an age group. In this way, depending on the age of the child a layer would be chosen.

Final Concept Summary

This added cushion is a part of the seat itself where it is used by the biggest size group of this seat (till 12 years or 135 cm).

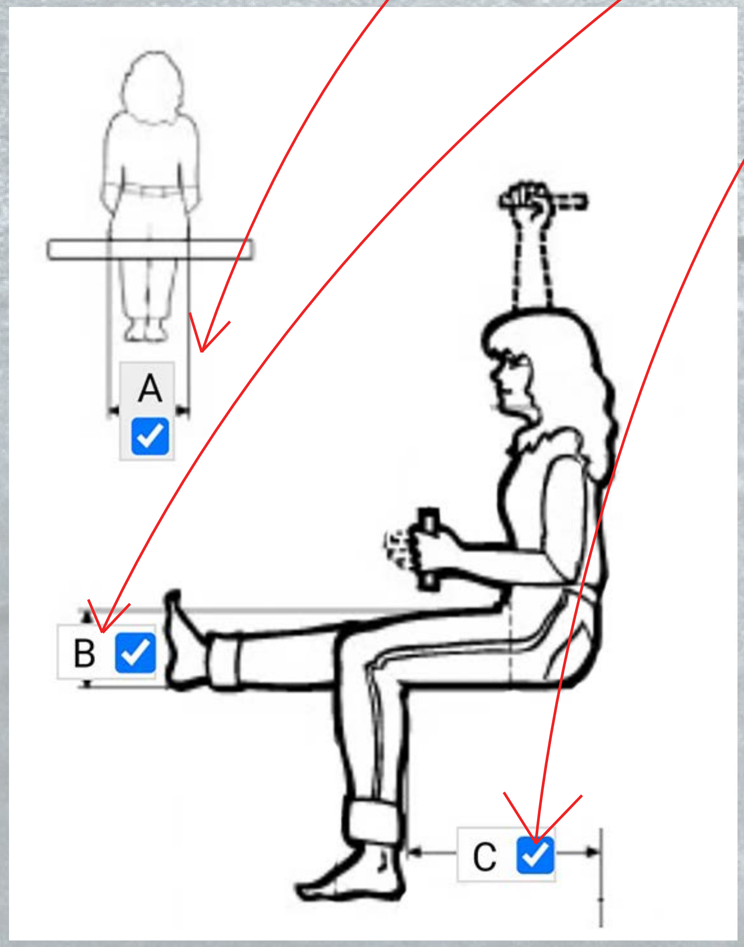
The base is fixed. The upper 2 layers are removable.
So, for example, if the child fits the size group 1 then the child uses layers 1 and 2. If the child fits size group 2 then the first layer is removed and the child sits on layer 2 that sits on the base.

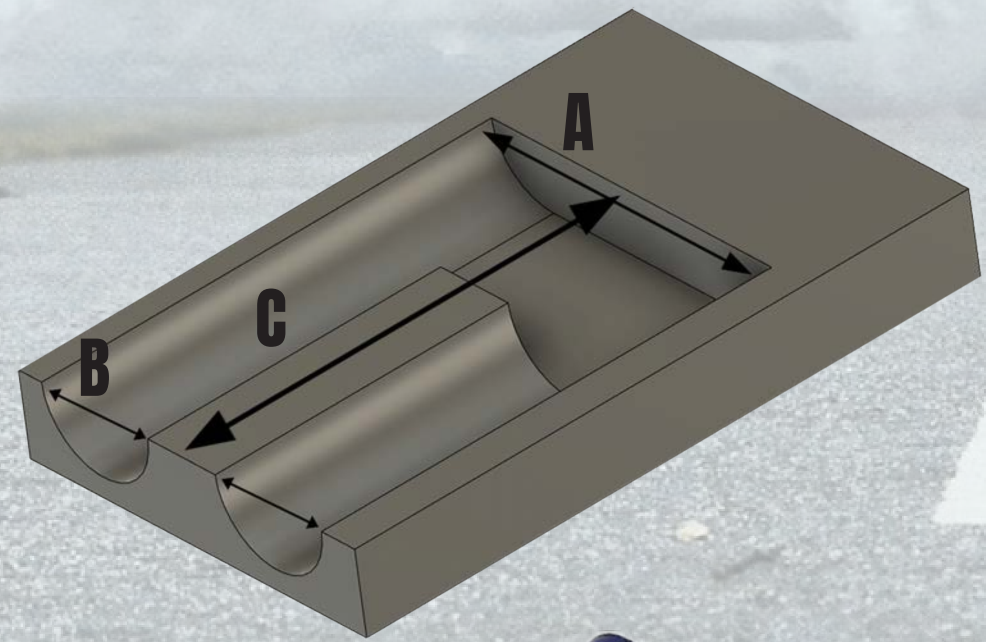
Therefore, this product is a part of the booster seat itself(Group 2/3). Would would solve the problem of its fitments in all cars.

Human Factors

The dimensions taken are the 50th percentile . This percentile is taken since it is bounded by the booster seat dimensions which is designed to the 50th percentile.

Age	Hipbreadth A	Thigh Width B	Buttock Depth C
4	215	81	289
5	223	85	318
6	231	90	337
7	243	96	359
8	250	99	374
9	261	104	399
10	277	112	420
11	286	115	434
12	295	117	452
Range	80	36	163





The main seating dimensions are the three shown in the figure to the right and quantified in the table above.
The final concept in the previous section proposed using different layers for different size groups. And assuming there is going to be three layers in total, the size range for each dimension was divided by three. Therefore, the three different colours of highlighted areas in the table above represent the three groups which happened to divide the age range equally by three as well. Since the size ranges are somewhat narrow in range, each layer was designed to fit the biggest size of each age range.
The figure to the right represent the placement for each body dimension on a seat cushion and is made for the first size group(similar pattern would follow for the other groups)

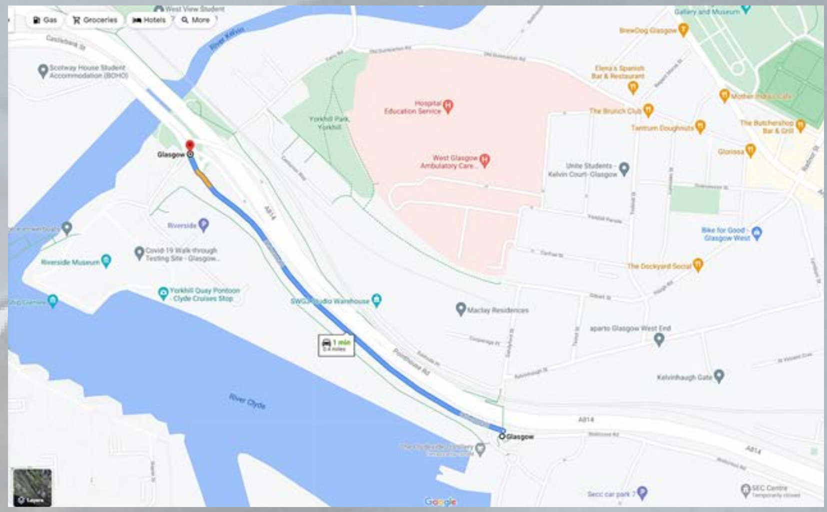
Testing & Results

Research into materials concluded that Rubber, Polyvinyl Chloride (PVC) and Polyurethane are three best performing materials in damping vibrations. And to be able to compare their performance, an experiment to find how well each material is in dampening the vibrations. And to do that, an accelerometer was used that measures the acceleration value with time, producing quantitative data to do comprehensible analysis.

The experimental setup is as follows:

1) A child booster seat was fitted inside a car
2) A material sample was placed on the seat
3) An accelerometer, measuring vertical acceleration vs time, was placed on the seat on top of the material
4) A weighted bag to simulate a child's mass was placed on the booster seat on top of the sensor

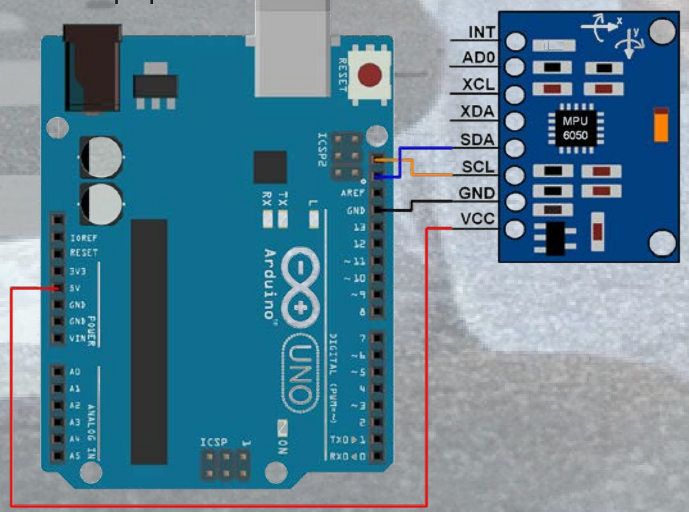
In this way, the sensor would simulate what is sensed by the child.



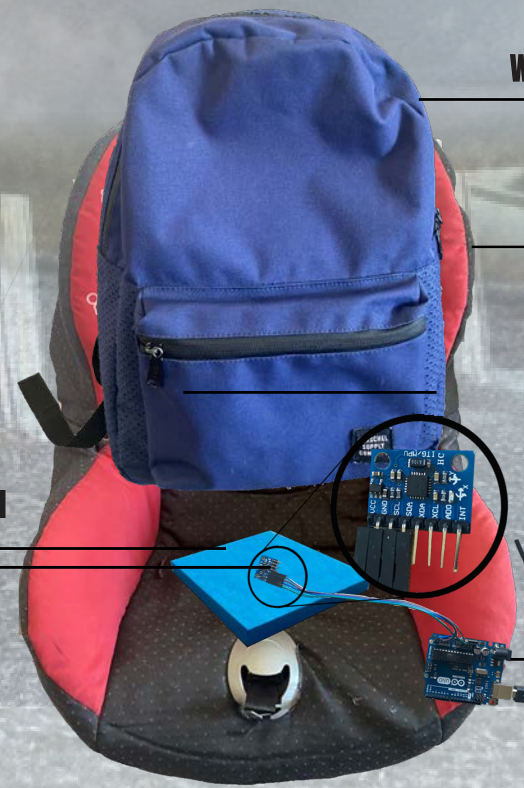
Four runs were recorded. The first was a control experiment, to measure the vibrations with no dampening material. It goes as the setup explained above excluding step 2.

The three following runs are with the three different materials mentioned earlier, interchanging the material between runs in step 2.

To control the experiment, the same road(shown in the figure) was travelled at the same speed(35 mph). The same start and stop points were started and finished with.

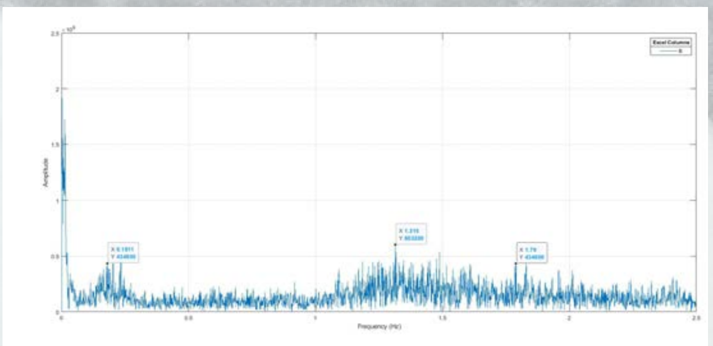


MPU-6050 accelerometer was connected to an Arduino UNO as shown in the figure below.

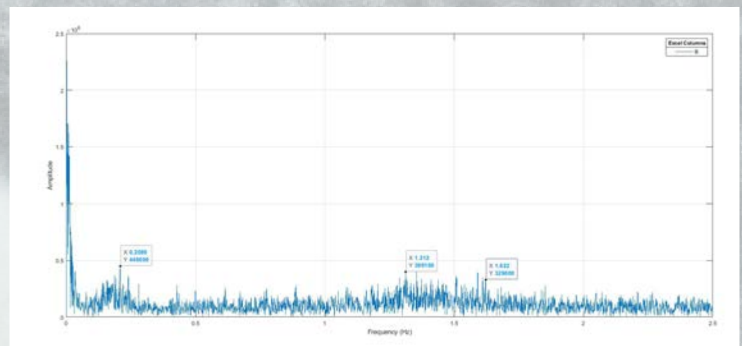


Results

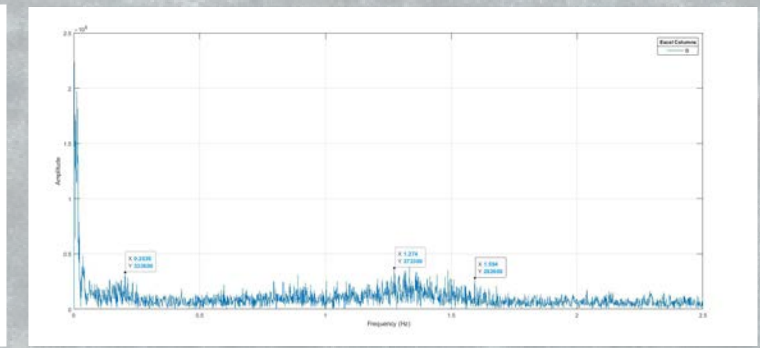
Control



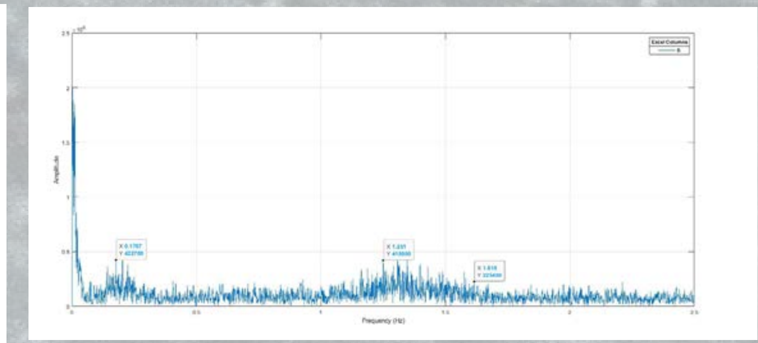
Rubber



PVC



Foam



Result Analysis

The analysis of the results concluded that under these conditions, PVC is the material that performed best and by quite a margin. It is important to note that many factors have an effect over the result, like the type of car, road condition, speed, weight that simulated the mass of the child(because that could vary a lot), thickness of the material etc... However, this experiment is intended to show results under basic condition and to demenontrate my abilities in performing competant experiments and do comprehensive analysis to the results.

User Journey

The user first selects the suitable layer depending on what size group the child belongs to.

The child is secured on the booster like other seat.

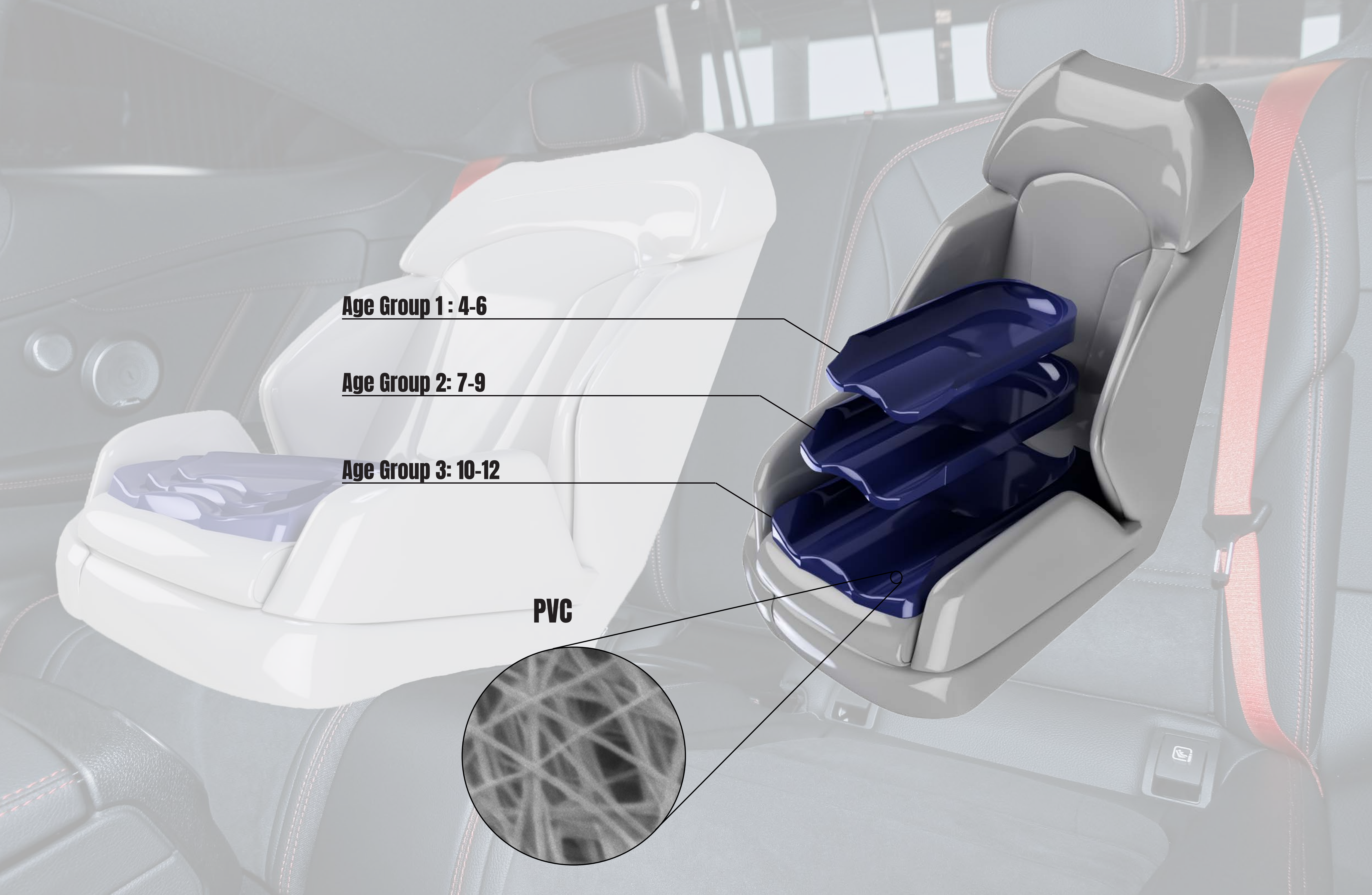
Without this product, the child is more likely to be car sick, experiencing motion sickness and feeling uncomfortable.

Without this product, because the child is more likely to develop symptoms of motion sickness, the driver is more likely to more distracted.

With this product, the child feels more comfortable and is less prone to develop symptoms of motion sickness

However, now that the child is more comfortable, the driver can be more focused on driving.

Embodiment



Working on this project was very interesting and challenging(in some places) overall. It was a learning curve were I felt that my skills in applying the design process with all its steps in details was quite sharpened. Looking back to my introduction project, then the human factors one, I have a feeling of content with regards to the progress that I have made. I believe projects like these were I am doing work freely with no bounds to customer requirments, budgets, etc.. are a great oppurtunity to find were I enjoyed working the most, what areas I am skilled at and where do I have work more on myself.

Future Conciderations:

There are alot of areas that I would have tackled if I had more time and accessibilty to respuces

1- I would study more sustainable materials. PVC, the material I chose, is quite a pollutant one in terms of manufacturing.

2- I would do wider material testing, on different roads, speeds and vehicle types. I am quite curious to see if any of these materials would be better if the conditions are changed.

3- I would manfacture a sample of the prototype from the material chosen and do testing.

4- I would try to cancel road noise to enhance comfort and isolate the child further specially when using a screenor a book. I actually bought a noise sensor but didnt do any testing because of the shortage of time.

5- I would concider methods to keep the layers of the product together(to avoid sliding). I did get an analoge scale to measure how much velcro could hold. But but to check the maximum g force experienced in a car and to check if it fits the dafety standards would take time.

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