SAFETY ANALYSIS AND SOLUTION OF RALLYSIM

HAMK
HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

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Rezwanul Islam

HAMK
HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

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Author	Rezwanul Islam	**Year** 2018
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Supervisor(s)	Jaakko Vasko	

ABSTRACT

This thesis is about the safety analysis and the possible safety solutions of rallysim. A rallysim is a simulator which helps its user to enjoy the driving of a rally car game at the comfort of one's home. To provide the feel of a rally car, it has various moving parts which can cause injuries to the user as well as the people around. In this thesis all the potential hazards with this simulator are identified and the possible protection against these hazards is suggested. An analysis was conducted in this project to make sure that the simulator meets all of the European Union standards and measurements.

Keywords rallysim, rally, simulator, safety, protection, measurement, European standards

Pages 29 pages

List of Abbreviations:

AI: Artificial Intelliegnce

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1 INTRODUCTION

Sim (simulated) racing is the collective term for computer software that attempts to accurately simulate auto racing, complete with real world variables such as fuel usage, damage, tire wear and grip; and suspension settings. To be competitive in sim racing, a driver must understand all aspects of car handling that make real world racing so difficult, such as threshold braking, how to maintain control of a car as the tires lose traction, and how properly to enter and exit a turn without sacrificing speed. It is this level of difficulty that distinguishes sim racing from arcade driving games where real-world variables are taken out of the equation and the principal objective is to create a sense of speed as opposed to a sense of realism. (Sim racing, 2018.)

In general, sim racing applications, such as “Rfactor”, “Grand prix legends”, “Race 07”, “F1 challenge '99-'02”, “Assetto corsa”, “Rfactor 2”, “Gtr 2” and “Iracing” are less popular than arcade-style games, mainly because much more skill and practice is required to master them. However, sims such as “Nascar racing 2003 season**”** and “Richard Burns rally” have achieved worldwide fame. Also, because of the demands on the computer system, race sims require faster computers to run effectively, as well as a somewhat costly steering wheel and pedals for the throttle and brakes. Most arcade-style driving games can be played with a simple joystick controller or even a mouse and keyboard. With the development of online racing capability, the ability to drive against human opponents as opposed to computer AI is the closest many will come to driving real cars on a real track. Even those who race in real-world competition use simulations for practice or for entertainment. With continued development of the physics engine software that forms the basis of these sims, as well as improved hardware (providing tactile feedback), the experience is becoming more realistic. (Sim racing, 2018.)

And these types of simulated games become more realistic when the game is played in a real simulated environment with the setup of a driver’s compartment instead of just a computer. These setups have all the driver’s controls created on a tiltable base which will give the gamer a real life feel to the game with the necessary vibrations and tilting. As participating in a real rally race is expensive, not everyone is able to participate. Due to the sim setup any rally enthusiast can have a taste of real rally driving.

A rallysim device has been designed and constructed. There are moving parts in the design, which form some gaps and can be hazardous for the user and also the people around. In this thesis all the possible mechanical safety hazards of the design are identified and compared with the

European Standards (SFS Standards) measurements. In accordance with the analysis, their possible solutions are found out.

2 RALLYSIM

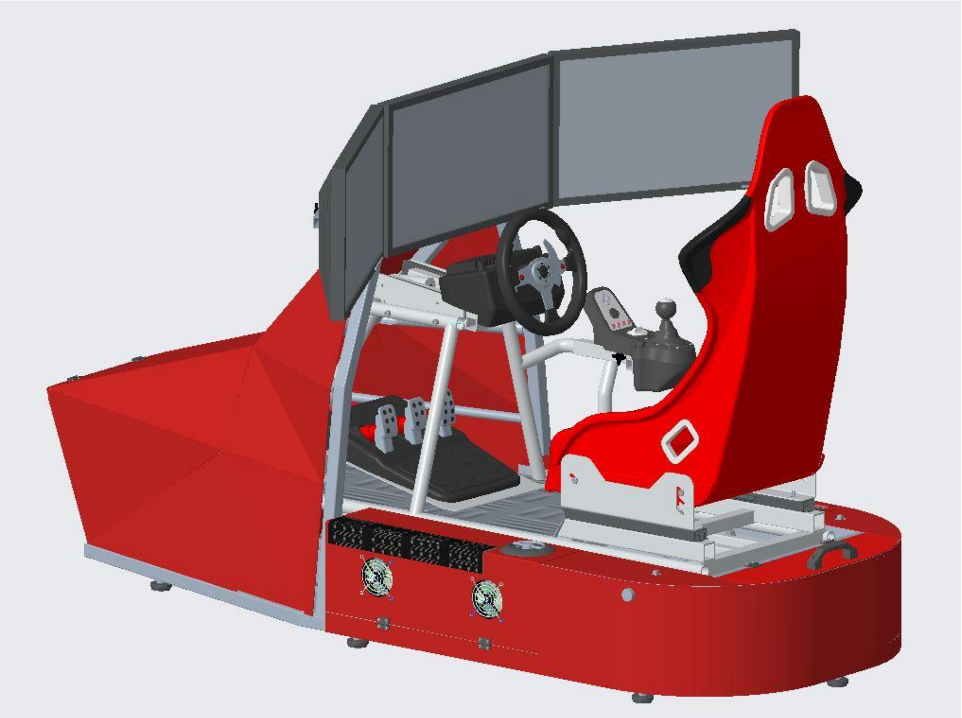


Figure 1. Rallysim

A rough design was made, which was working but had plenty of design and handling flaws. So in one thesis project Joachim Bonte has designed the whole concept and made a full scale 3D model of the design in Creo Parametric 3.0 supplying every single detail in it. The model is shown in Figure 1.

2.1 **Examining rallysim from all directions**

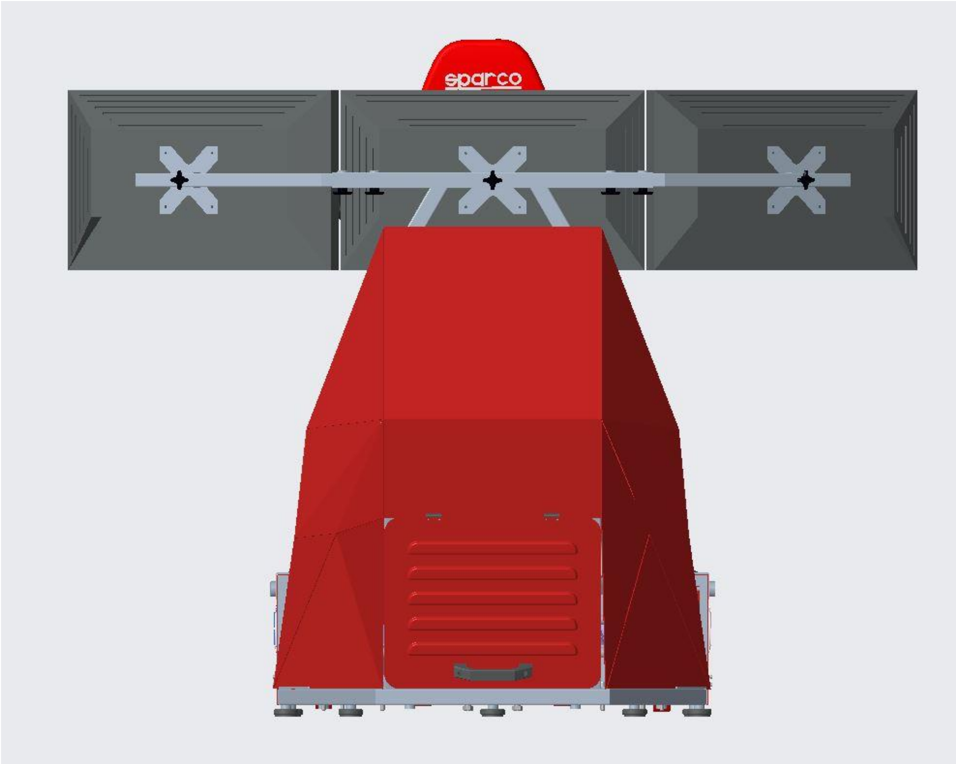


Figure 2. Front view of rallysim

Figure 2 gives the exact view from the front of rallysim. We can see the front cover of the model and also back sides of the screens. We can also see how the screens are held together.

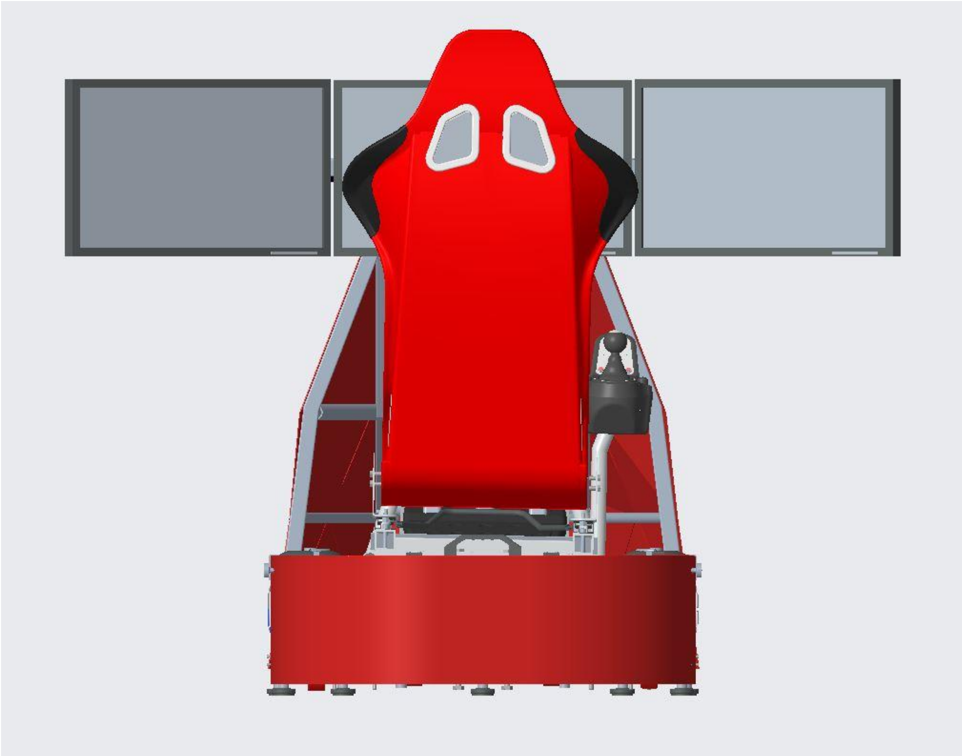


Figure 3. Back view of rallysim

Figure 3 gives the exact view from the back of rallysim. It shows how the seat is attached to the platform. We can also get some idea of the setup from this view.

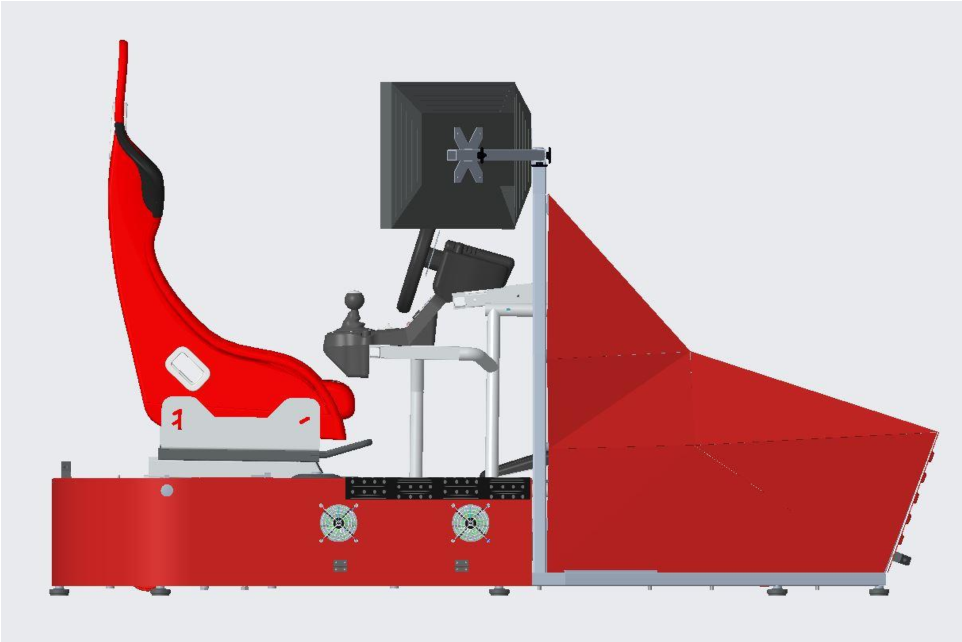


Figure 4. Right view of rallysim

Figure 4 gives the exact view from the right side of rallysim. From this view we can see the setup of driver's seat, steering, gear control. The ventilation attached on the sides are seen and the shape of front part is also understood. The small legs on which the model stands can also be seen.

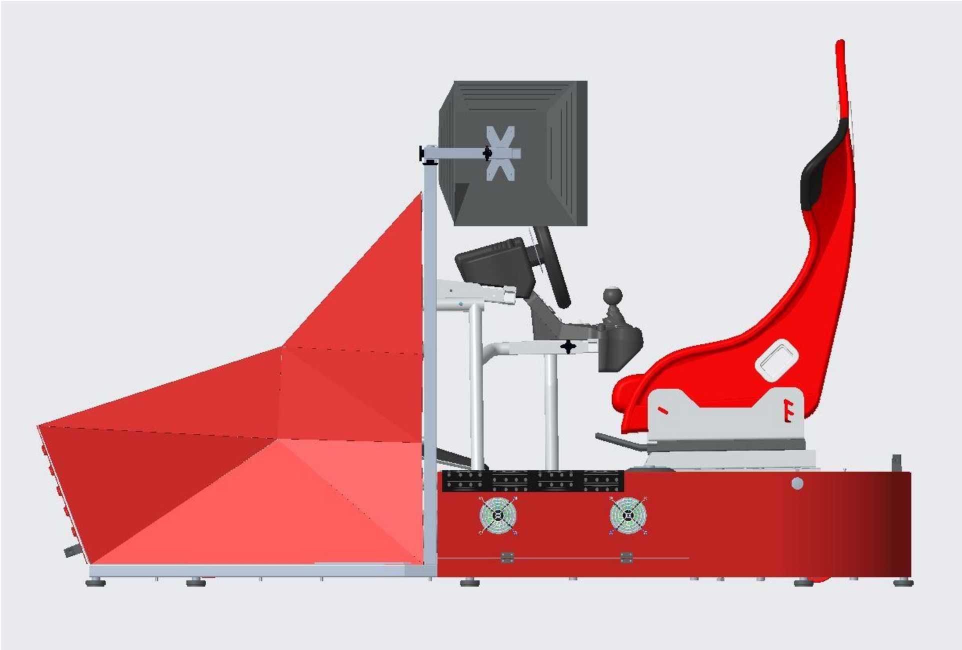


Figure 5. Left view of rallysim

Figure 5 gives the exact view from the left side of rallysim. From this view we can see the setup of driver's seat, steering, gear control. The ventilation attached on the sides are seen and the shape of front part is also understood. We can also have a better view of inside and see the frame on which steering and gear control are attached.

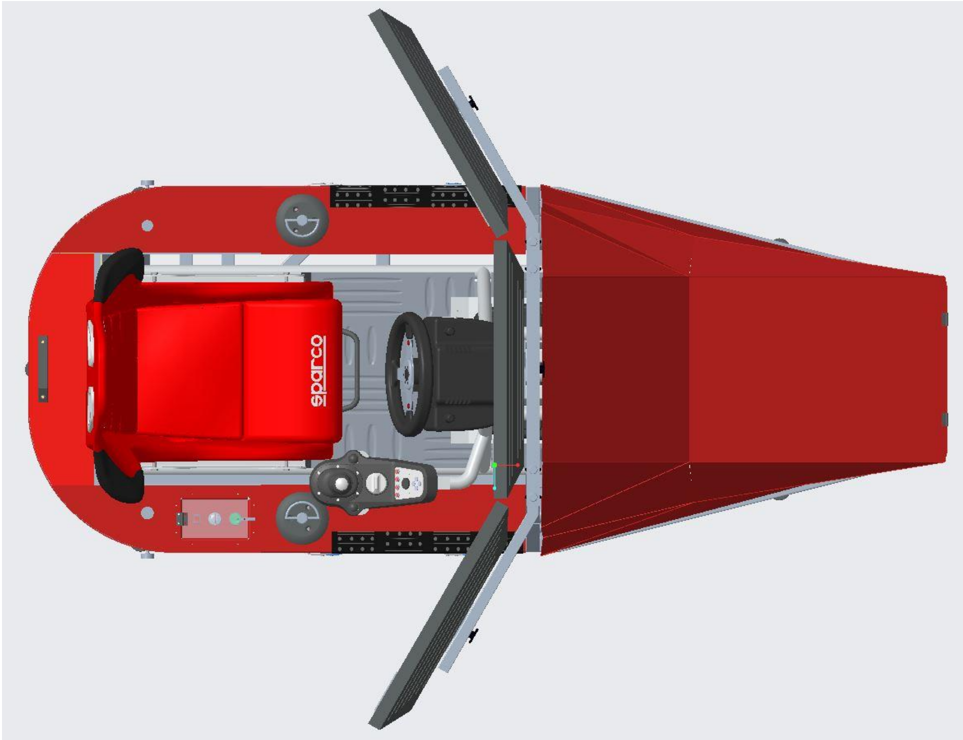


Figure 6. Top view of rallysim

Figure 6 gives the exact view from above the rallysim. From this view we can see the platform on which the driver's seat is set up. Also we can see how the screens are oriented to provide with a surrounding view to the user.

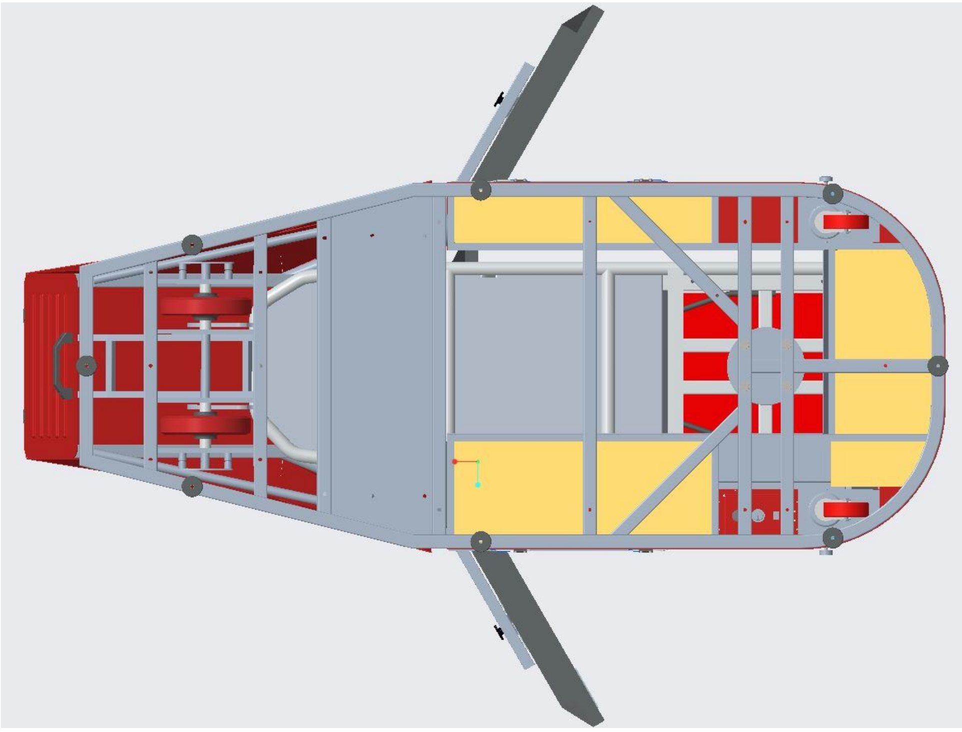


Figure 7. Bottom view of rallysim

Figure 7 gives the exact bottom view from below the rallysim. From this view we can see the frame on which the model is set up. Also we can see some small legs on which the model stands.

2.2 **Overall**

From the pictures we can see that the model has been made according to the driver's seat of a rally car. This means that the user will feel like sitting in an actual car with all the similar controls. The platform, on which the seat, steering and the gear control are attached is moveable and it will tilt at any direction according to the movement of respective car in the game. The whole outer frame and the screens are stationery. In the pictures we can see that the moving platform and the frame has some gap in three reachable directions. When the platform tilts mimicking the movements in the game, these gaps become smaller and bigger which can cause some safety hazard for the user as well as the people around. If there is children around, then those gaps can become more risky. Even if any object from the user's pocket such as a mobile phone or keys can fall through these gaps it will be very difficult to fetch them out.

3 POTENTIAL HAZARDS WITH RALLYSIM

In this chapter we will point out all the sections in the rallysim model which might be in some way hazardous to the user or people around.

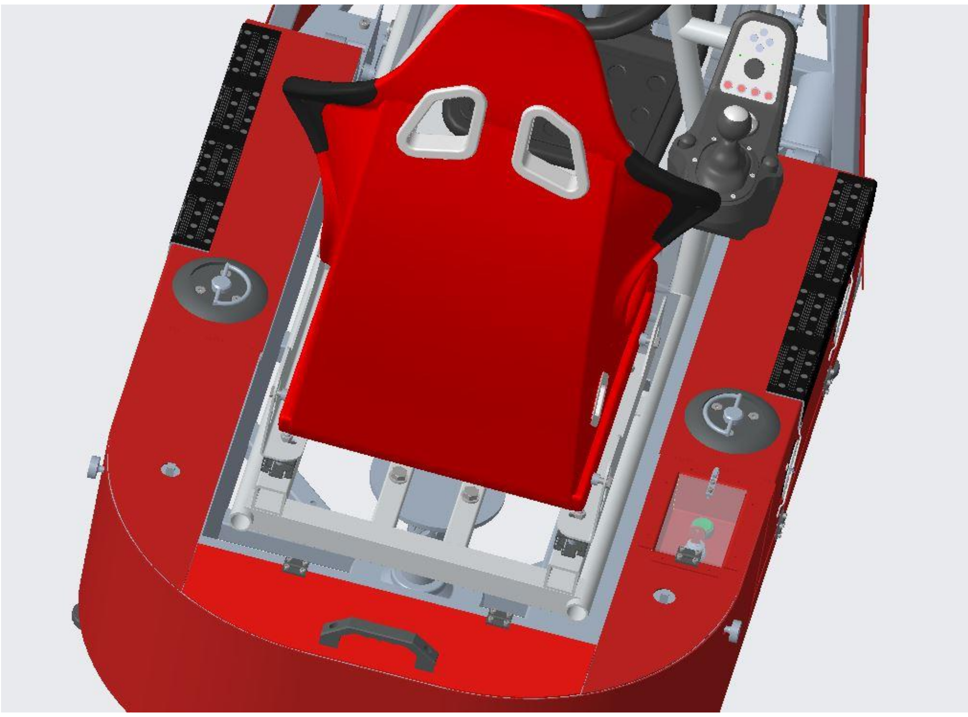


Figure 8. Closer view of rallysim

Figure 8 presents a closer view to the base of rallysim. From this figure we can clearly see that around the tilting platform there are gaps on three accessible sides: On the right, back, and left sides.

3.1 **Measurement of gaps**

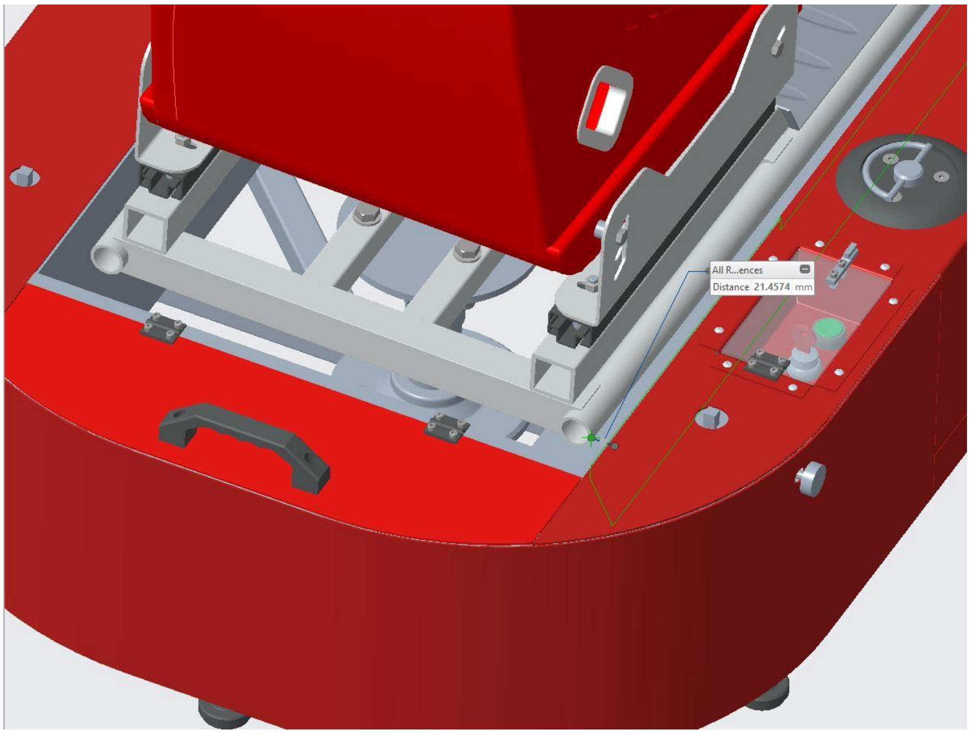


Figure 9. Right hand side gap

Figure 9 shows when the rallysim is in initial position, the gap at the right hand side between the platform and the frame is 21mm.

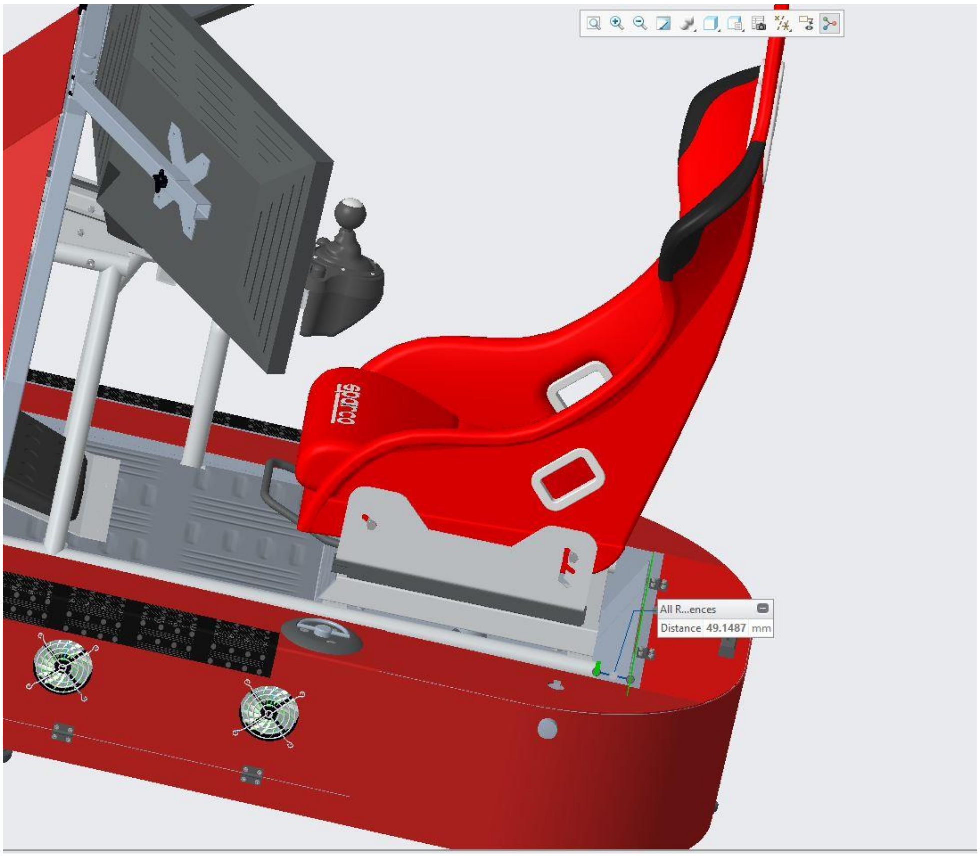


Figure 10. Back gap

Figure 10 shows when the rallysim is in initial position, the gap at the back side between the platform and the frame is 50mm.

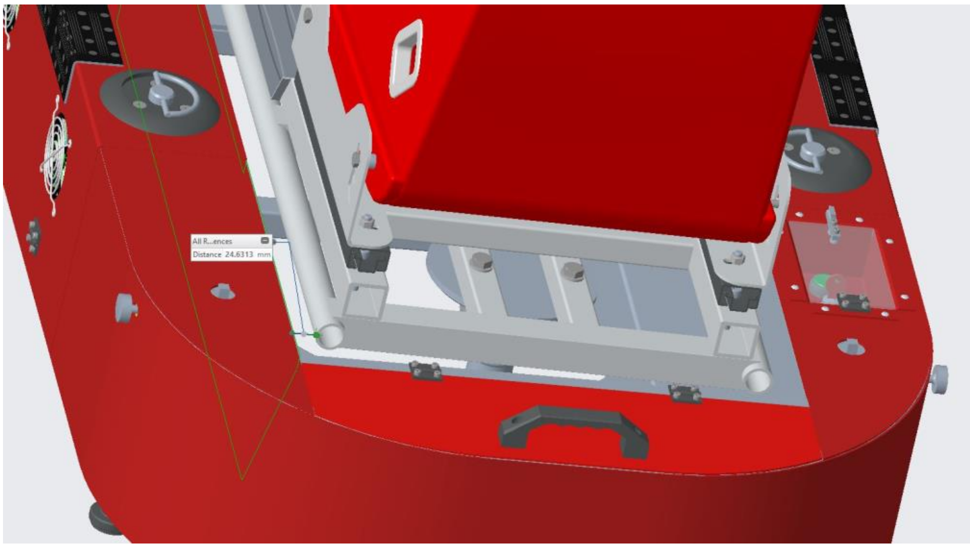


Figure 11. Left hand side gap

Figure 11 shows when the rallysim is in initial position, the gap at the left hand side between the platform and the frame is 25mm

4 ANALYZING GAPS WITH MOVEMENT OR TILTING

In this chapter we analyse the possible maximum increase or decrease of the gaps after the rallysim has been tilted

4.1 **Right side**

4.1.1 Right side of platform tilted upwards

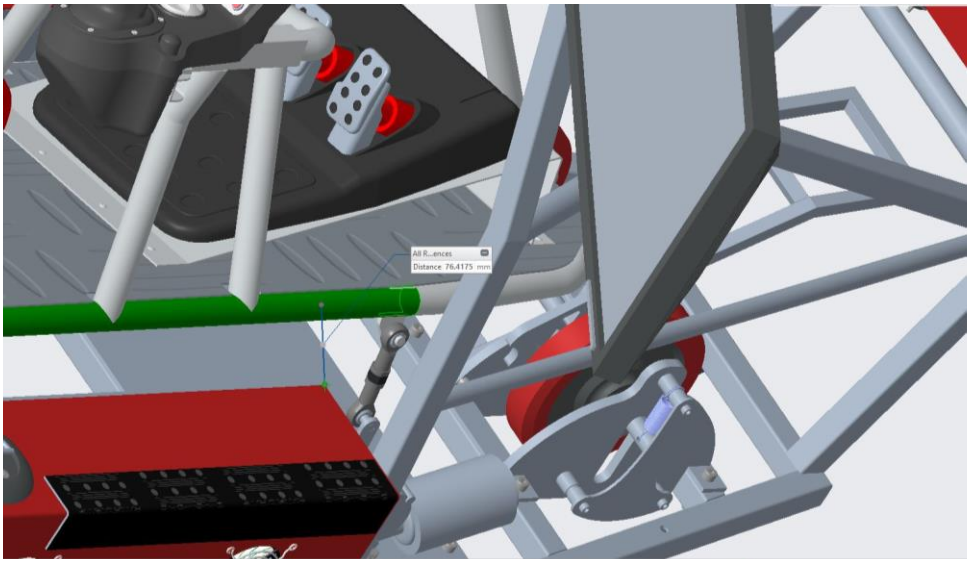


Figure 12. Front edge

Figure 12 shows front edge after right side of the platform is tilted upwards to the maximum possible height. The gap between the platform and the frame is measured.

The cylindrical pipe from whose centre the distance is measured, has an outer diameter of 15mm.

Therefore gap in front edge is (76-15) = 61mm

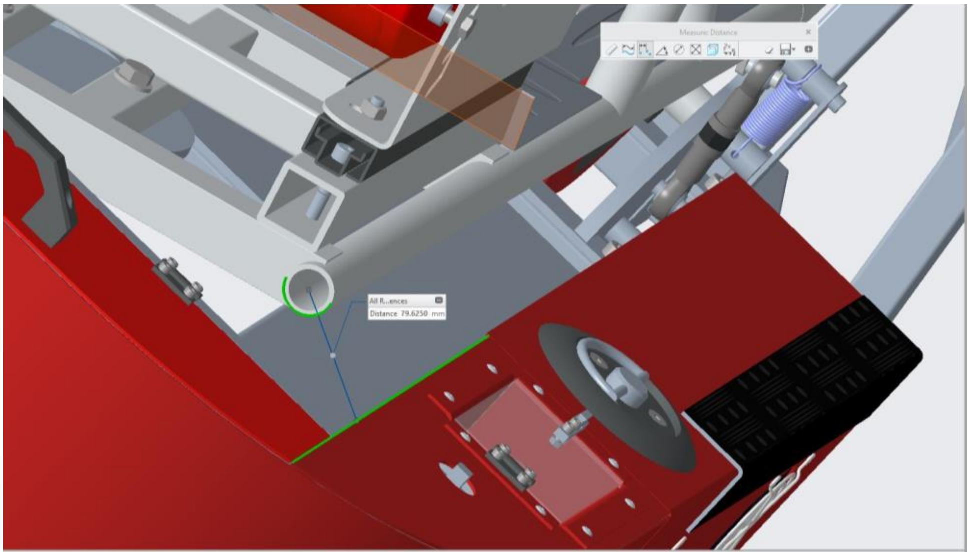


Figure 13. Back edge

Figure 13 shows back edge after right side of the platform is tilted upwards to the maximum possible height. The gap between the platform and the frame is measured.

The cylindrical pipe from whose centre the distance is measured, has an outer diameter of 15mm.

Therefore gap in the back edge is (80-15) = 65mm

4.2 **Left side**

4.2.1 Platform tilted upwards

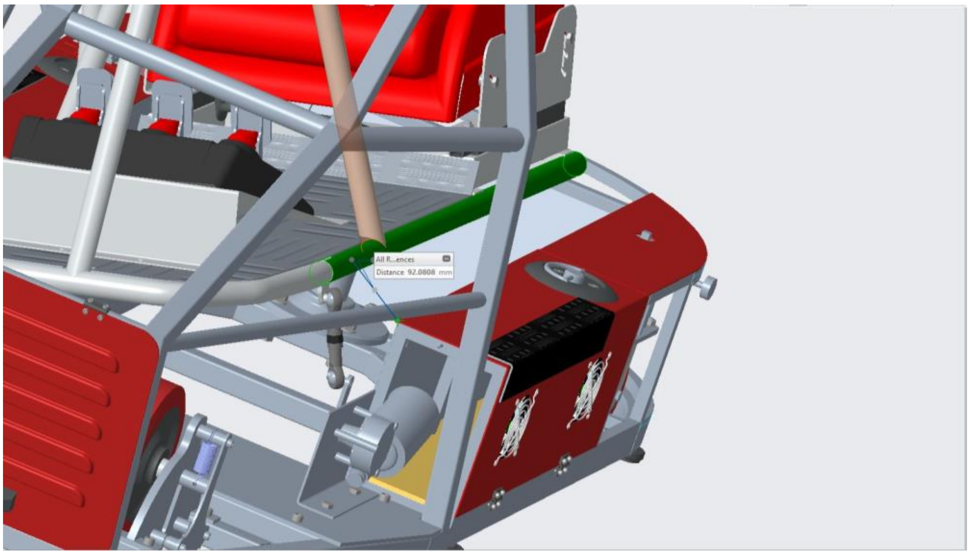


Figure 14. Front edge

Figure 14 shows front edge after left side of the platform is tilted upwards to the maximum possible height. The gap between the platform and the frame is measured.

The cylindrical pipe from whose centre the distance is measured, has an outer diameter of 15mm.

Therefore gap in front edge is (92-15) = 77mm

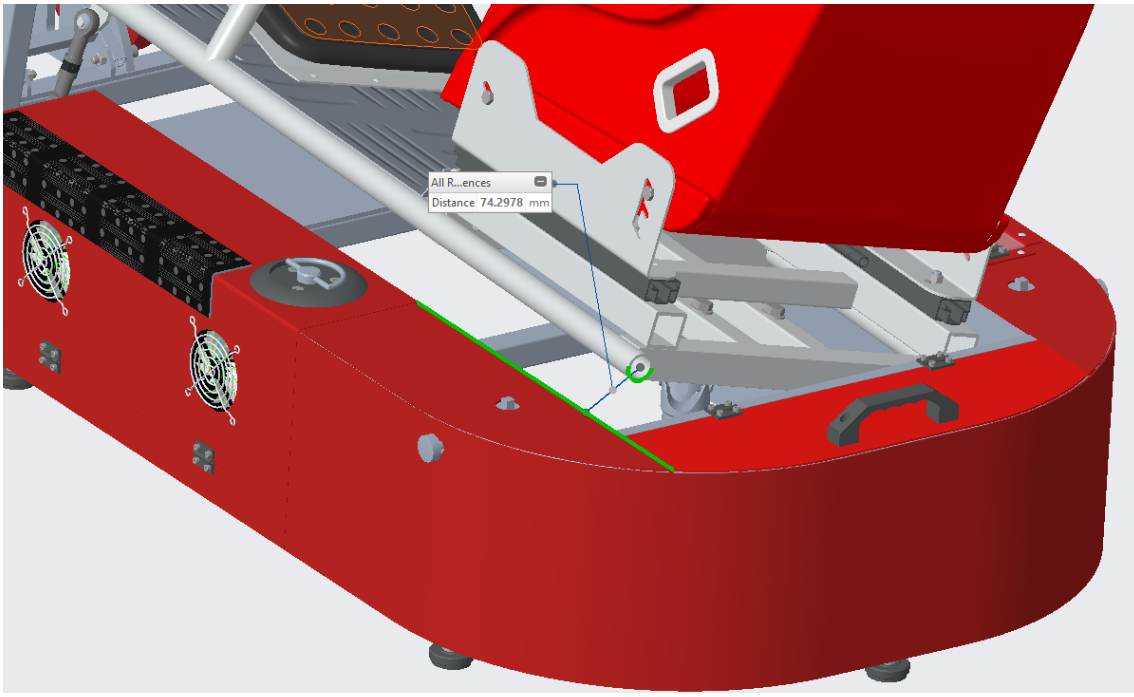


Figure 15. Back edge

Figure 15 shows back edge after left side of the platform is tilted upwards to the maximum possible height. The gap between the platform and the frame is measured.

The cylindrical pipe from whose centre the distance is measured, has an outer diameter of 15mm.

Therefore gap in the back edge is (74-15) = 59mm

4.3 **Back side**

4.3.1 Back of platform tilted upwards

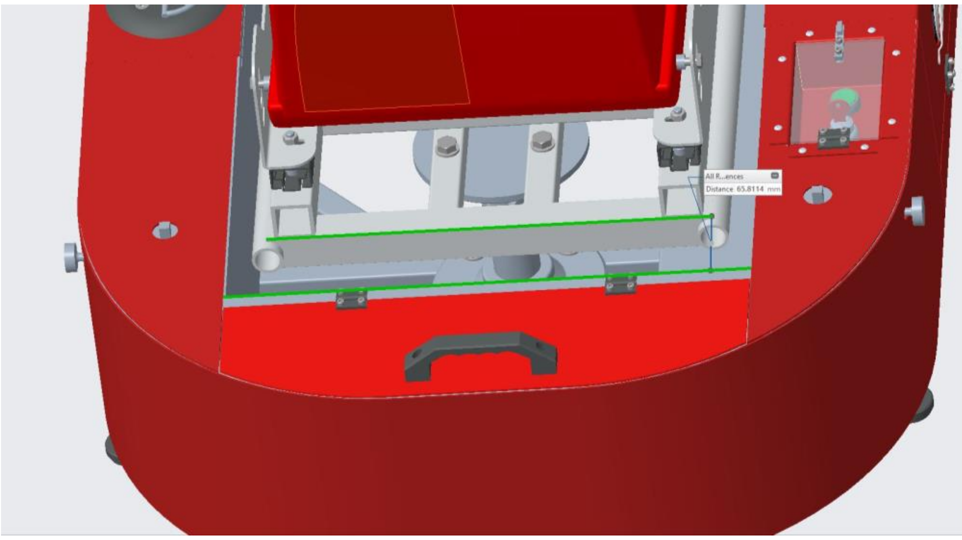


Figure 16. Back gap 1

On Figure 16 we can see that the back side of the platform is tilted upwards. From edge of the frame to edge of the platform, the gap is measured to be 66mm

4.3.2 Back of the platform tilted downwards

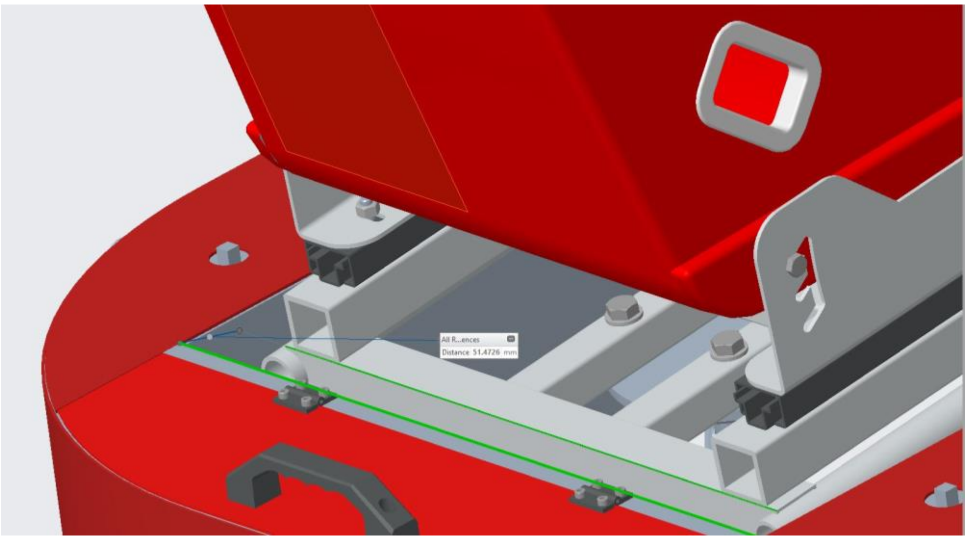


Figure 17. Back gap 2

On Figure 17 we can see that the back side of the platform is tilted downwards. From edge of the frame to edge of the platform, the gap is measured to be 51mm

5 SPECIFICATIONS OF RALLYSIM IN A NUTSHELL

5.1 Measurements

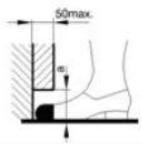
At the right side, during initial position the gap is 21mm. When tilted upwards, the front edge has a gap of 61mm and the back edge has a gap of 65mm. So after the right side is tilted upwards to maximum position, the gap is within 61mm to 65mm.

At the left side, during initial position the gap is 25mm. When tilted upwards, the front edge has a gap of 77mm and the back edge has a gap of 59mm. So after the left side is tilted upwards to maximum position, the gap is within 59mm to 77mm.

At the back side during initial position the gap is 50mm. When tilted upwards to maximum position, the gap is 66mm. And when it is tilted below to the minimum possible position, the gap is 51mm. Therefore the gap varies from 51mm to 66mm.

5.2 SFS standards

Table 1. minimum gaps to avoid crushing of parts of the human body (Dimensions in mm)

Part of body	Minimum gap a	Illustration
Body	500	
Head (least favourable position)	300	
Leg	180	
Foot	120	
Toes	50	
Arm	120	
Hand Wrist Fist	100	
Finger	25	

The Table 1 illustrates the minimum gaps needed to avoid crushing of certain parts of human body. These safety standards are set up by the European Committee for Standardization implemented in Finland by Finnish Standards Association SFS. (SFS EN 349:1993+A1:2008, 11)

6 ANALYZING SAFETY OF GAPS WITH SFS STANDARDS

There can be several cases in which the gaps can be hazardous. Fingers, hand, wrist and also foot can get into the gap. As this simulator is for home use, there can be children or minors who can place their hands or body parts on the gaps. Even some objects such as cell phones, keys, books or some other things can fall through those gaps. These fallen objects can be very difficult to fetch back and might also disrupt the functionality of the rallysim. Even there are chances of the objects getting damaged.
In this section we are going to compare the gaps with the SFS standards and determine whether these gaps comply with the SFS standards or not.

6.1 **Right side**

In this side the minimum gap at initial position is 21mm and when tilted upwards, it increases to 61mm to 65mm depending on positions.
Here we are considering the finger, hand, wrist and also foot.
The minimum gap for finger is 25mm, for hand and wrist is 100mm and for foot is 120mm.
So we can see that while in use, the simulator will be in constant movement, so there is high chance of getting the specified body parts crashed if gotten into.

6.2 **Left side**

In this side the minimum gap at initial position is 25mm and when tilted upwards, it increases to 59mm to 77mm depending on positions.
Here also we are considering the finger, hand, wrist and foot.
The minimum gap for finger is 25mm (which is alright for this side according to the standards), for hand and wrist is 100mm and for foot is 120mm.
So we can see that while in use, the simulator will be in constant movement, so there is high chance of getting the specified body parts crashed if gotten into

6.3 **Back side**

On the back side the minimum gap at the initial position is 50mm. When tilted upwards, it increases to 66mm and when tilted downwards it becomes 51mm.

Here also we have to consider the finger, hand, wrist and foot of some other person who might come near the simulator (it is highly unlikely that the user can reach the back side while sitting on it).

The minimum gap for a finger is 25mm (which is all right for this side according to the standards), for a hand and wrist it is 100mm and for a foot it is 120mm.

So we can see that while in use, the simulator will be in a constant movement, so there is high chance of getting the specified body parts crashed if they end up into a gap.

6.4 **Overall**

Overall we can say that the gaps are not completely safe. To increase the safety and avoid things getting into them, we have to cover the gaps with some kind of design which is flexible, strong enough not to let anything get into the gap and will not cause any hindrance to the movement of the platform.

7 FINDING SOLUTION

To find the best possible material and design for the covers we had to consider some factors and accordingly come out with the perfect solution.

7.1 Factors to be considered

Strength: The strength of the covers should be at least moderate so that nothing can squeeze through accidently. It should be able to withstand anything (for example a cell phone) falling on it and should be sturdy enough.

Durability: As one side of the cover is going to be attached to the moving platform and other side to the stationary frame, so there will be plenty of compression and expansion and to different extent at different sides. So it have to be durable enough to withstand such continuous compression and expansion.

Rigidity: The cover have to be rigid enough to withstand its shape no matter how much movement has occurred to it. If it is not rigid enough them the cover will squeeze itself into the gap which will be of no use.

Wear ability: The material by which the cover will be made of should not wear off easily. Due to extensive movement, there is high chance for the cover to wear off causing it to break and deform. So it should be made of material which will be wear resistant.

Noise: Noise is a big factor in this case. Unwanted noise due to movement can hamper the gaming experience as well as cause disturbance to the surroundings. So the cover design has to be in such way that no matter the direction of movement, it has to be as silent as possible.

Cleanliness: The cover should not catch much dirt and should be easy to clean up.

7.2 Possible options

In this part we are going to pick out all the possible options for the protection. Then we are going to analyse them one by one with all the requirements which will help us to come up with the best possible solution.

7.2.1 Flexible wooden cover

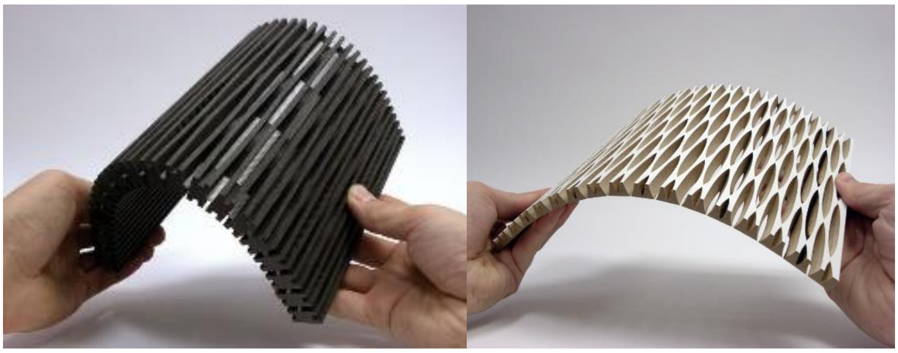


Figure 18. Dukta flexible wood

Wood is a low density low weight and moderately strong material. It is made into a flexible form known as dukta. Dukta flexible wood utilizes a type of incision process that makes wood and engineered wood flexible. Because of the incisions, the material gains textile-like properties and a wider range of applications, including partition walls, furniture and lamps. (Materia. 2016)

In Figure 18 we can see two designs of Dukta flexible wood. This flexible wood is lightweight and strong. But with excessive pressure it will break. This design is not suitable for too much compression and extension, as it may get deformed and break. Dirt and other materials can get into the gaps in this dukta flexible wood which will be difficult to clean. While flexing it may create some sound.

7.2.2 Leather cover

Figure 19. Leather

Leather is a durable and flexible material created by tanning animal rawhide and skin, mostly cattle hide. (Leather, 2018.)

Figure 19 shows a piece of leather. Leather is difficult to tear but very soft to bend. It has almost no rigidity. It is not stretchable so extra leather should be left bent in between while covering a moveable gap. Not a good option for preventing anything falling and crashing between the gaps.
It is easy to clean and has no noise.

7.2.3 Rubber/silicone sheet

Figure 20. Rubber sheets

Figure 21. silicone sheets

In Figure 20 and 21 we can see some rubber and silicone sheets. Rubber and silicone are soft, flexible and durable material. Thick rubber and silicone sheets can be used to cover the gaps. They have very low rigidity, which means they are soft and can bend itself into the moveable gaps. Its implementation is going to be same as leather. So not a good option for covering the moveable gaps in the rallysim. It also is easy to clean will have minimum noise in movements.

7.2.4 Flexible metal bellow cover

Figure 22. Flexible metal bellow covers

We all know that metals are strong and rigid. It is quite difficult to deform them. Figure 22 shows some flexible metal bellow covers. These flexible metal bellow covers are made up of aluminium which makes them quite light and strong. They are very durable and will not wear off easily on the movements. Will be easy to keep clean. It will be a good option for covering the moveable gaps in rallysim, but the main problem here is the noise. These metal covers will make a lot of noise during the movement which will cause disturbance to the user and also the surroundings. This is why it will not be a good option.

7.2.5 Flexible accordion type Bellow cover

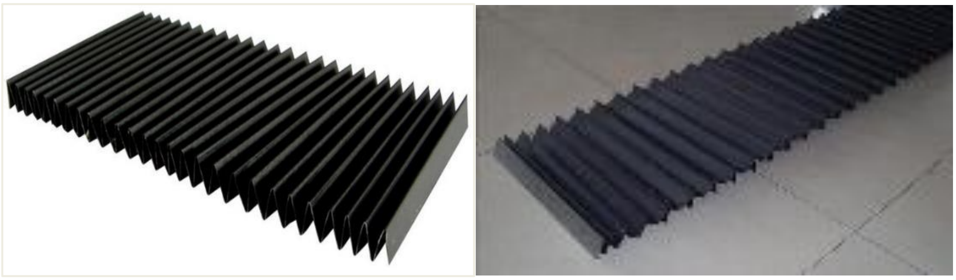


Figure 23. Flexible accordion type bellow covers

In picture 10 and Picture 11 above, we can see the accordion type bellow covers. These type of covers are quite popular in the industries. These covers are made of nylon cloth, pvc and plastics. Their shape gives them high amount of durability, flexibility and rigidity. These kind of covers are ideal for continuous compressions and extensions. They have very less wear ability and are strong enough to withstand light impacts. Very less chance of getting deformed and has minimum sound during movements. Also moderately easy to keep clean.
For these reasons it will be a good option for covering the moveable gaps of rallysim.

7.3 **Final solution**

In the chapter 7.2 we have discussed all the possible covering options by analysing their pros and cons and also their ability of fulfilling our requirements. From all the analysis we can clearly see that the option in chapter 7.2.5 which is “Flexible accordion type bellow cover” meets all our requirements. Thus I suggest that all of the moveable gaps of the rallysim should be covered with the “Flexible accordion type bellow cover” which will increase safety and will make the rallysim very convenient to use at home or any other places.

These type of covers are easily available online. For example we can buy them online from the website called “AliExpress” from “BF Machine tools Accessory Co., Ltd”. (AliExpress, BF Machine tools Accessory Co., Ltd, n.d..)
It is possible to order the covers with customized dimensions which can be determined by considering the compressed and extended length of the gaps.

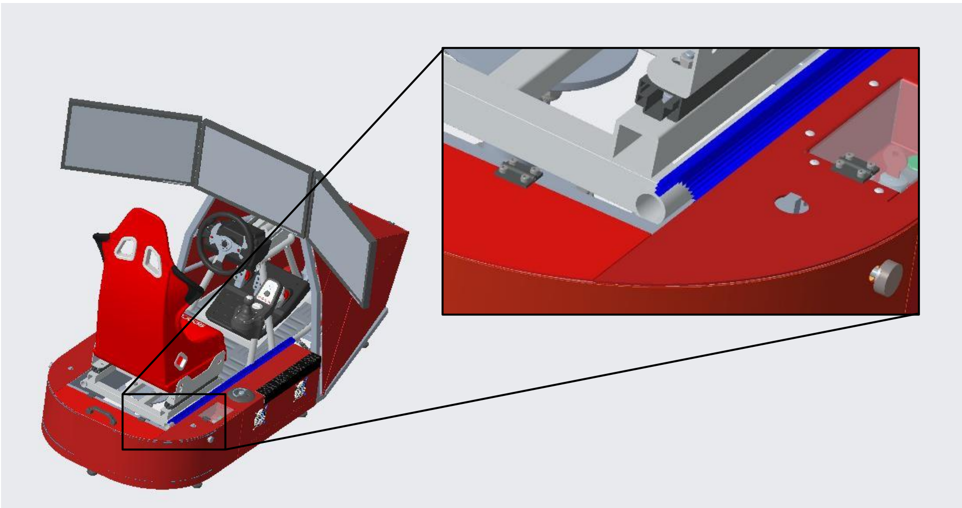


Figure 24. Rallysim with protection cover on the right side

Figure 24 shows the possible result after the protection cover has been added partially to the model.

8 CONCLUSION

Development of machines have made our day to day life very easy and enjoyable. For almost every machine we have to consider the safety aspects with highest of concerns. Or else instead of becoming our life easier and enjoyable it may become dangerous if no precautions are taken.

This rallysim is a beautiful example of how we can use machine for our leisure and hobby purposes. And from this thesis we can understand how safety can be a concern even in case of simulated computer gaming at home. This rallysim is a beautiful piece of equipment for a rally enthusiast or even a car enthusiast to fill a small room or a corner of a room into a racing zone.

In this thesis I inspected the model in Creo Parametric from all angles and tried to find out all the possible safety hazards which the model imposes to the user as well as to the people nearby. I have pointed out all the possible safety hazards and provided with detailed measurements and compared them with European Standards measurements. I was looking for ways how the safety in this model can be increased, and came up with some possible options. All the options were then analysed and the most suitable one was chosen.

By working on this thesis I have learnt a lot more about the mechanical safety and how to identify and overcome any possible hazard. I have also learnt more about the variety of materials which can be used as protective options. About the European Standards and how they can be used to assure safety in devices. I think all these knowledge can help me become more successful in my professional life and while working on any design I can identify and solve any safety issue without much difficulty.

REFERENCES

AliExpress, BF Machine tools Accessory Co., Ltd. https://www.aliexpress.com/item/H25mm-W330mm-L1000mm-Flat-Flexible-accordion-type-protective-bellow-covers-for-cnc/32782694129.html. Referenced 22.01.2018

Leather, 2018. https://en.wikipedia.org/wiki/Leather. Referenced 19.01.2018

Materia. 2016. Dukta Flexible Wood. https://materia.nl/material/dukta-flexible-wood/. Referenced 19.01.2018

SFS EN 349:1993+A1:2008 Safety of machinery. Minimum gaps to avoid crushing of parts of the human body. Part 4.2: Values. Helsinki: Finnish Standards Union. Referenced 17.01.2018
https://sales.sfs.fi/fi/index/tu otteet/SFS/CEN/ID2/3/194510.html.stx

Sim racing, 2018. https://en.wikipedia.org/wiki/Sim_racing. Referenced 15.01.2018