Team T.I.M Downhill Racer Project: Final Report

By Tom Taylor

Acknowledgements

I would like to give a special mention to the team members, Isaac, and Mahmoud for their help, and a special thank you to Vince for his guidance and support throughout the project.

I would like to thank Jack with his help in procuring parts for the project.

I would also like to thank the subject matter experts that answered our questions.

Executive Summary

The following report investigates in detail the work done by myself and Team T.I.M to design and produce a downhill racer. I will be covering eight subject areas, explaining, and evaluating my work in each one. This document is designed to provide insight into the workflow of our project, as well as what work could have been done differently.

Included in the report are the following main topics:

1. Project Introduction (P5)
2. Project Specification (P7)
3. Project Planning (P9)
4. Subsystem Designs (P13)
5. Implementation (P18)
6. Testing (P24)
7. Subsystem Delivery (P27)
8. Project Conclusion (P28)

A key finding of the report is that the structuring of the project is essential to moving it forward smoothly and efficiently. The documents that have been produced as a result of project structuring have been very beneficial for organisation and tracking of each member's subsystem. This report looks in detail at how a number of these methods have been used and have been useful tools.

Another finding is that collaboration was vitally important throughout the project. It has made it far easier to ensure our designs are appropriate and compatible with other subsystems and that we are all happy with the direction the designs are taking. Using programs such as Microsoft teams for document sharing and holding regular team meetings has proven to be the most effective way for us to collaborate and move forward as a team in a focused and synchronised way.

This report discusses the use of CAD models compared to traditional drawings. During the later stages of this project we used Solidworks to a large extent, saving the complication of trying to collaborate remotely and generally saving us time and effort. We also discovered that the use of Solidworks allows us to better demonstrate our work with the use of simulation and evaluation.

Lastly, evaluation and justification of our work has proven to be an important step in the project. Evaluation can be used to find mistakes or important considerations that we may have missed, and justification can be used to validate our choices and explain the design decisions that were made in the process. Evaluation and justification have been utilised successfully during the chassis design process for instance in the evaluation section of this report where we compared against the customer brief, PDS, safety and budget of the project.

Overall, I have learned a huge amount about the processes involved with a professional project, this document is a guide to those methods, showing how I utilized them to produce something easily understandable and repeatable.

Contents

1.0 – Project Introduction

The downhill racer project undertaken by Team T.I.M has been set up to test our ability to specify, design, organize, plan, implement and present our work using professional methods. This is highly important in the engineering workplace and has been a huge help for us in understanding these methods.

Team T.I.M has split the workload into three main subsystems; chassis, wheels, and steering. This has been done because it allows us to divide up the problem (the overall racer) into smaller tasks, giving a better end result.

This section will explore the important factors we considered before getting started with the project.

1.1 – Aims and Objectives

Aims and objectives have been an important component of the project throughout. They provide the basic framework for all work carried out as they define in the simplest way what has to happen. The aims of the project provide the overall direction and the objectives provide the technical requirement of the aims. Appendix 10.7 shows the client requirements document, where as a team we figured out exactly what has been asked of us. In that document we laid out the following aims and objectives:

The overall aims for the chassis subsystem as stated on the client brief are:

1. **To produce a chassis for the downhill racer project, including the design manufacture and testing of the vehicle.**
2. **To complete the secondary sub-systems required for the vehicle to function properly.**

These aims are broad and difficult to achieve on their own. For this reason, these aims have been broken down into shorter-term objectives, which are as follows:

1. **Utilise the formal project management techniques to plan and produce a chassis subsystem.**
2. **Follow the Gantt chart, to ensure tasks are being completed on time.**
3. **Update the logbook periodically.**

In page 7 of the interim project report, I gave my reasoning for the short-term objectives;

"My reasoning behind the choice of these short-term objectives is that it is vitally important that all project members keep records and schedules of what they are doing, for a variety of reasons: team members must avoid repeating themselves, missing out important steps, or simply losing track of what they are doing. It is also vitally important so that in the future anyone can look back at the project documents and understand what process took place and how the project was carried out. Using this methodology allows us to organise the technical information required in the project and to keep it accessible to all engineers or project members who may be reading it. The overall aims are largely self-explanatory, and are essentially designed to ensure that the project is completed to a good standard." -

Overall, I can say that these aims, and objectives have largely been met. We have utilised the formal project management techniques throughout the project which has made it far easier to organize and prioritize the tasks at hand. We have used Gantt charts (see appendix 10.4 – 10.6) to a large extent, allowing us to precisely map out and plan our limited time available to work on the project, as well as logbooks to record our workflows and provide a permanent record of the successes and fallbacks of the project (see appendix 10.1, 10.3).

1.2 – Project Members and Their Roles

The next factor that we needed to consider was the roles of the team members and the allocation of subsystems. We discussed this in the first team meeting on the 18th of September (see appendix 10.1) and decided on the following structure:

- Our team roles are as follows:
  - Tom covers the chassis and the roll cage and is group manager.
  - Mahmoud covers the steering and seating.
  - Isaac covers bodywork braking and wheels.

From that we refined the role of each person to:

- Tom does the chassis and is group leader.
- Mahmoud does the steering.
- Isaac does the wheels.

This was a vitally important step because once it was done it gave everyone a sense of direction in their project and gave them something to consider.

In my role as group leader, I had additional responsibilities to maintain the direction of the project and facilitate meetings and discussions between all three of us. This ended up being very important since it prevented us from forgetting the other subsystems and how they will all work together; without this they would run the risk of not being compatible. At this point I set up the teams page for the project, providing a go-to location for project documents and conversation, which helped to keep the project as a whole organized.

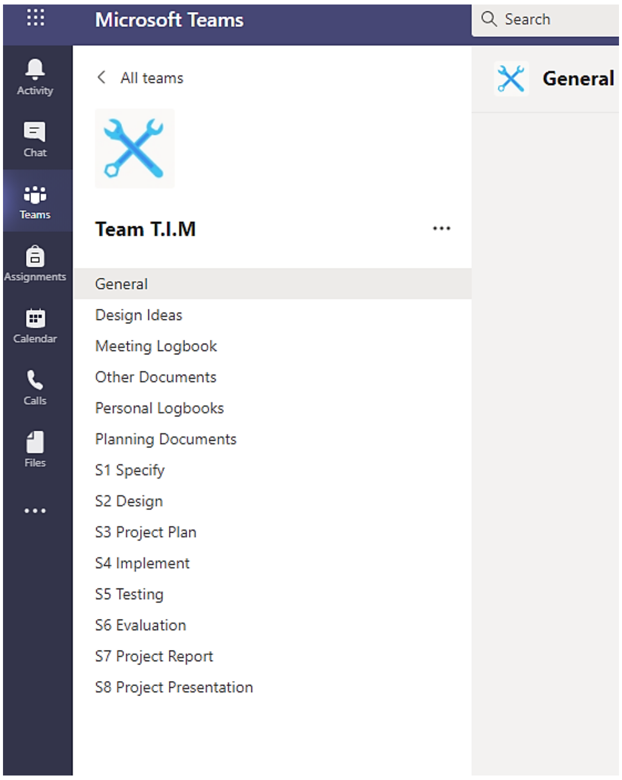


Fig 1A – The Team T.I.M teams page.

2.0 – Project Specification

Now that the introduction and initial setting up of the project is complete, we can move on to the specification of the product. This was important because it is the point where you develop the aims and objectives, the customer brief, requirements, and feasibility study, and produce a PDS that you can work to.

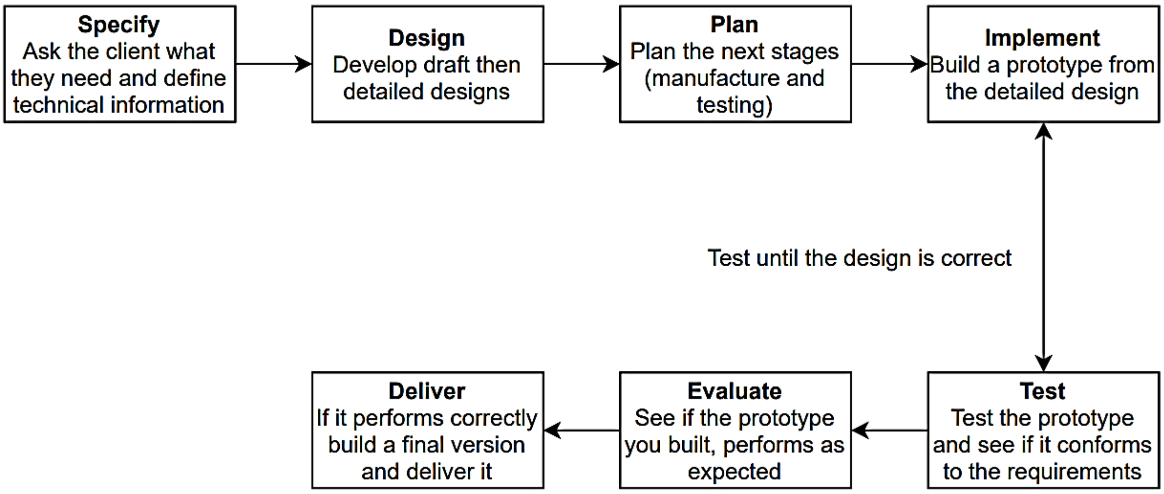


Fig 2A – The design process.

Figure 2A is a diagram showing the general design process for an engineering project. We are now in the specify stage of the project where we need to understand how we are going to map out the project and get to understand the phases of design we need to go through to get a good end-product.

2.1 – Customer Design Brief

The first step to specifying the project is to obtain the brief, this is the most basic and general requirements for the project and are usually provided in non-technical language. For this project it was provided by both Vince (the project tutor) and Richard's Castle (the race venue). Vince's requirements were simple: set up a project to design, plan, and build a functional downhill racer. Richards Castle's requirements were more complicated since they included technical requirements put in place to improve safety (see appendix 10.16).

2.2 – Client Requirements

Once the requirements set out in the brief had been consolidated, we were ready to produce the client requirements (see appendix 10.7). The way that I produced this document makes it a sort of mini-PDS, it contains the same fields as the PDS however the requirements are still fairly broad and non-technical. Producing a document like this is very helpful at this stage because it allows us to:

1. Gather all of the customer's requirements and lay them out in an easily understandable and referenceable format.
2. Ask the customer to review the document so they can verify that all the important criteria have been met.
3. Use the document to produce a full technical PDS (see appendix 10.8).

All of this contributes to the organization of the project as a whole. Because keeping things understandable and observable is a crucial part of any project.

2.3 – Feasibility Study

This document allows us, as engineers to decide what is realistically possible in the project. Creating this document can save a lot of time in the design phase of the project because it prevents a designer from spending time to implement something that can't fulfil the criteria. The feasibility study can also be used to figure out the scope of the project, for example, we can use it to decide if the project timeframe and resources are workable, or whether they need to be changed.

In the document shown in appendix 10.9 we can see that the materials, manufacturing, tooling, and space have been evaluated. The material selection was especially helpful at this point because it gave me an idea of the material cost, size, and shape, and what kind of manufacturing techniques I might need to use.

2.4 – Project Design Specification (PDS)

The last thing to do when specifying the project is to create the full technical PDS. This document contains all the important factors that must be considered before starting the design process and gives the engineers an opportunity to visualise the finished product. Appendix 10.8 shows the PDS for the chassis subsystem. It shows that many different requirements have been considered, such as weight, size, and manufacturability.

This information will directly influence the design process and everything after, so it is important to get it right first time. And because this is an evolution of the clients initial PDS, care must be taken to ensure it does not stray away from the original plans. Figure 2B shows a part of the technical product design specification, demonstrating the kinds of data that are considered in the document. The full document can be viewed at appendix 10.8.

1.0 Functionality (what the product should do)
1.1 Must not fall apart during service
1.2 Must be capable of driving
1.3 Must be manourverable
2.0 Environmental Conditions
2.1 Must be capable of withstanding rain for an hour
2.2 Must be capable of withstanding temperatures down to freezing
2.3 Must be capable of not coroding over time while covered
3.0 Size
3.1 Length must not exceed 2500mm
3.2 Width must not exceed 1500mm
3.3 Height must not exceed 1.5m
4.0 Weight
4.1 The chassis must not exceed 80kg

Fig 2B – Part of the technical PDS

3.0 – Project Planning

Project planning is important when running a project with multiple members and multiple sub-systems. This is because without proper planning, tasks may be repeated unnecessarily or skipped accidentally, always taking more time and money to resolve. With appropriate planning, individual engineers can easily understand where they are, and where they need to be, as well as where others and the whole team are.

3.1 – File Management

File management has been key to keeping the project organized and understandable to outside sources. We have all utilized tools such as Microsoft Teams to great effect, allowing all of the project members instant and collaborative access to project files wherever they are. Our method for organizing the sections of the project have also been reflected, channels named after each project phase have been created, each housing the appropriate documents created for that stage.

A big advantage with storing all of the project documents in the cloud instead of with physical copies is that the data is far more secure. This could be advantageous for companies undertaking projects who want to ensure the safety of their documents, and who want to implement access control for their documents. Although our team doesn't need access control or security, it is still nice for our project's files to be stored safely with backups.

Physical documents have also been used to some extent, usually in the form of project drawings and sketches, although we have digitised these and uploaded them to teams to make them easier to access. Figure 3A is an example of a drawing that has been digitised.

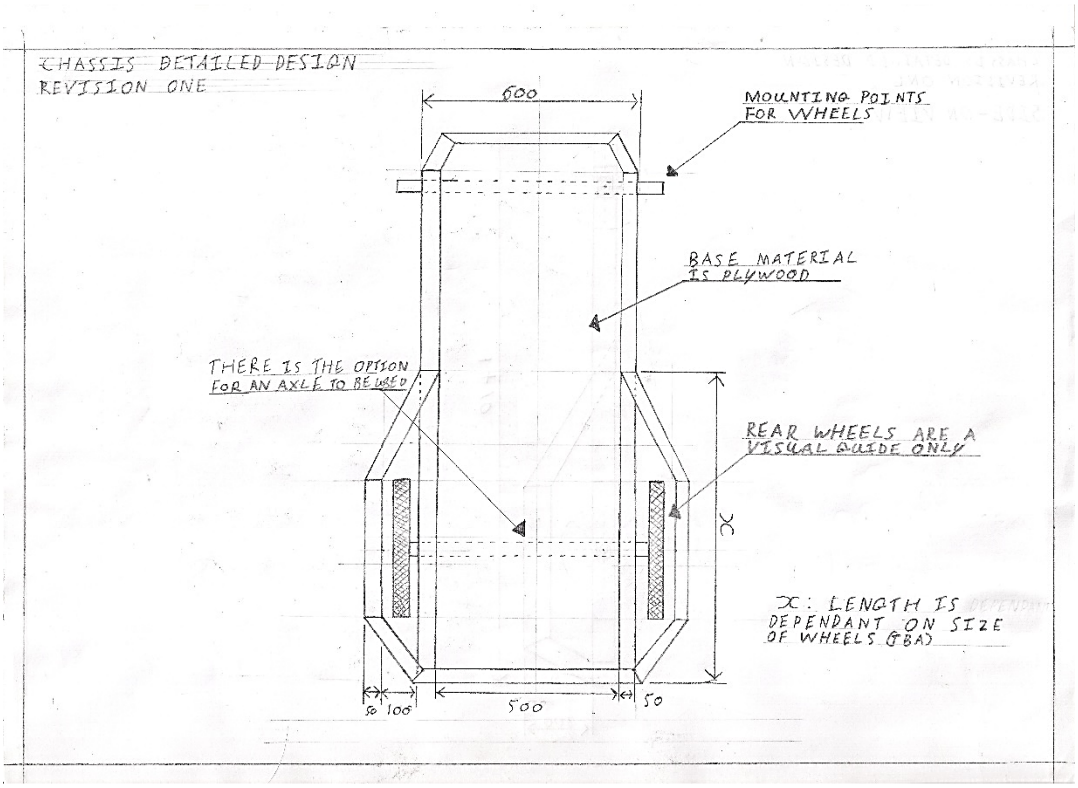
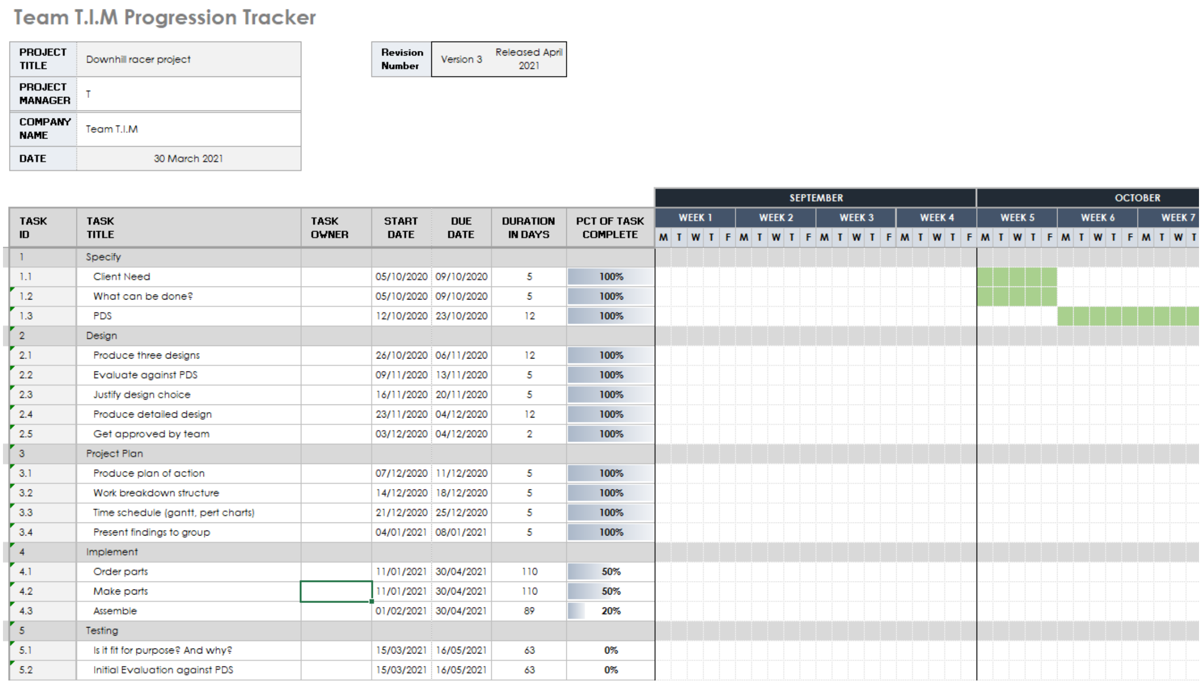


Fig 3A – Example of a digitised drawing.

3.2 – Time Management

Like other planning methods, time management is essential for keeping things on track. Without time management, engineers run a high risk of running out of time or working inefficiently. In order to provide time management in our project, we have used detailed Gantt charts (see appendix 10.4 – 10.6), in figure 3B below you can see part of the Gantt chart used for the chassis subsystem, for simplicity the chart has been split into the phases and tasks of our project, providing us with a very detailed view of where we are and need to be.



Team T.I.M Progression Tracker

PROJECT TITLE	Downhill racer project
PROJECT MANAGER	T
COMPANY NAME	Team T.I.M
DATE	30 March 2021

Revision Number	Version 3	Released April 2021

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Specify					
1.1	Client Need		05/10/2020	09/10/2020	5	100%
1.2	What can be done?		05/10/2020	09/10/2020	5	100%
1.3	PDS		12/10/2020	23/10/2020	12	100%
2	Design					
2.1	Produce three designs		26/10/2020	06/11/2020	12	100%
2.2	Evaluate against PDS		09/11/2020	13/11/2020	5	100%
2.3	Justify design choice		16/11/2020	20/11/2020	5	100%
2.4	Produce detailed design		23/11/2020	04/12/2020	12	100%
2.5	Get approved by team		03/12/2020	04/12/2020	2	100%
3	Project Plan					
3.1	Produce plan of action		07/12/2020	11/12/2020	5	100%
3.2	Work breakdown structure		14/12/2020	18/12/2020	5	100%
3.3	Time schedule (gantt, pert charts)		21/12/2020	25/12/2020	5	100%
3.4	Present findings to group		04/01/2021	08/01/2021	5	100%
4	Implement					
4.1	Order parts		11/01/2021	30/04/2021	110	50%
4.2	Make parts		11/01/2021	30/04/2021	110	50%
4.3	Assemble		01/02/2021	30/04/2021	89	20%
5	Testing					
5.1	Is it fit for purpose? And why?		15/03/2021	16/05/2021	63	0%
5.2	Initial Evaluation against PDS		15/03/2021	16/05/2021	63	0%

Fig 3B – Part of a Gantt chart used throughout the project.

Using this type of chart can be advantageous because of its visual nature, instead of writing down dates and making a list, we can instead see an actual line and slope showing us how hard and how long we need to work on each task. This is then backed up by dates and durations to make it easier to reference.

This method of time keeping is also useful when looking back at the project. This is because every time the Gantt chart was reissued and modified it tells us a lot about the state of the project and the accuracy of the original Gantt chart. In out project we had to reissue the Gantt chart twice largely because of the issues and delays brought about by the covid restrictions.

3.3 – Logbook

The project and meetings logbooks have been a very useful tool during the project, they have allowed me and the rest of the team to reference our previous work and decisions, and has provided a diary of events which can be looked back at when the project has been completed. This would be useful when writing a report like this one or before starting a new project, so that I can look back at them and see what improvements could have been made.

In appendix 10.3 you can see my personal logbook, I have been updating this document whenever something significant has happened, and I have generally tried to update it every week as well. It is interesting to read through because it shows how we all had to adapt to the issue of coronavirus. The meetings logbook provides a similar but slightly different perspective on the project, focusing on the group interactions. Appendix 10.1 shows this document in detail.

Team T.I.M Logbook – Tom Taylor

Friday 18th September 2020:

- We have held our first group meeting earlier today and have decided many details including: our roles, how the project will be laid out, and the priorities for assembling the vehicle. (all these details are available in the first entry in the meetings logbook.
- I made the teams page for the project to make sure all the documents and ideas are kept together, and we have all decided to store everything on there instead of on our own devices.
- No work has been allocated yet.

Friday 25th September 2020:

- We have gone through a PowerPoint as a class which details the separate stages for the project and the base requirements for the project. The PowerPoint can be found in the team T.I.M teams page or the engineering L3 teams page.
- I've seen some ideas for the chassis design. Which can be found on the team T.I.M page.
- I will schedule my own work up until around July and make a Gantt chart to stay on top of it (this will be based on the document provided by Vince)

Friday 2nd October 2020:

- I have now produced a Gantt chart on excel to log my progress and to keep track of what needs to be done. I've uploaded it to teams so Mahmoud and Isaac can use it and adapt it if they want.
- The Gantt chart shows me that we will be expecting to finish around halfway through may with the opportunity to overrun by a couple of weeks.
- The client requirements have been done now, and I will likely start work on the PDS document in the next week.
- Me and Isaac have decided to change tasks, I am now doing the bodywork as well as the other sub-systems I'm currently doing.

Figure 3C – Part of my personal logbook.

Figure 3C shows part of my personal logbook. We can see that it has been laid out logically in the shape of a list, with each heading being the date the entry was written, making it easy to reference.

3.4 – Procedure Documents

Procedure documents have also had a helpful role in this project. The purpose of these documents is to lay out the steps required to meet an end goal, making it far easier to achieve overall. A good example of one of the procedure documents used in the production of the chassis, is the work breakdown structure or WBS document (see appendix 10.13). This was advantageous to use because it provided me with a clear visual chain, showing which tasks relied on others giving me a better idea of my progress. Documents like this go hand in hand with the Gantt chart (see appendix 10.6) in breaking the project down into manageable chunks that can be tackled in an organized way. Using something like a work breakdown structure, also allows someone completely unfamiliar with your project to move in and at least get a primary understanding of what you are working on. Figure 3D shows my work breakdown structure for the chassis.

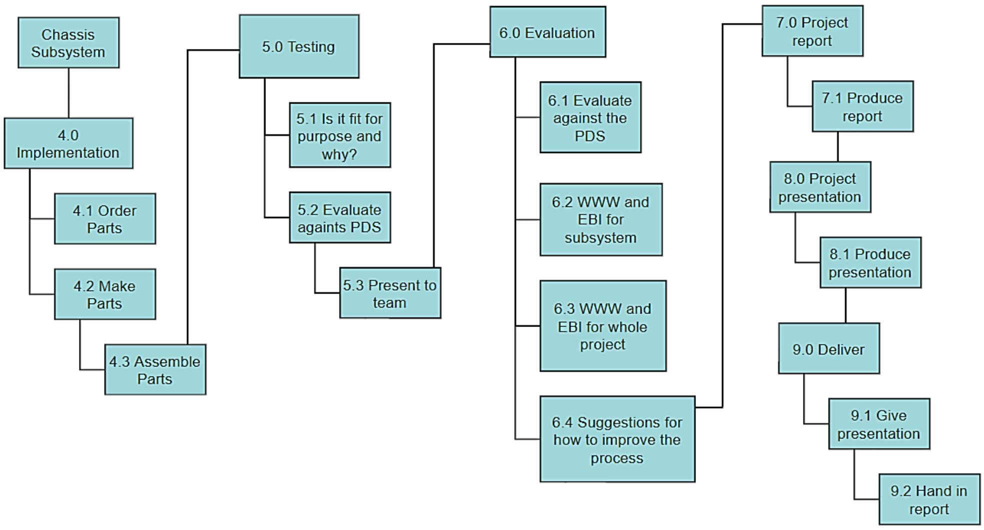


Fig 3D – Work Breakdown Structure for the chassis subsystem.

Another document that proved to be handy was the plan of action. I produced one of these back in December and although it was a simple document, it was able to improve my understanding of where I was in the project and what I needed to do next. This document also provided me with a diary like record of what the team was doing at that point, much like the logbook (see appendix 10.3). Figure 3E shows part of my plan of action.

Current progress:

- The draft and final designs of the chassis have been completed.
- The feasibility study is complete and can be amended if needed.
- Client need / requirements and PDS are complete.
- Evaluation and justification against PDS are complete.

Next steps:

- The team can be shown the results of my work in a meeting and we can agree on the precise course of action we will take.
- In general, the next steps are to research material prices and calculate how much material is needed to proceed with manufacture.
- Required components will need to be worked into the budget of £200 and this needs to be agreed unanimously with the team.
- Planning documents (Gantt chart, pert chart, and work breakdown structure) will be produced to lay out exactly what has to happen to achieve the end product on time.
- Testing and evaluation must come next to ensure the product is correct and fulfils the original customer requirements.

Am I on track:

- Currently yes, I have completed the documents up to this point and will be completing the Gantt chart and work breakdown structure afterwards in line with the main project Gantt chart.

Is the team on track overall:

- Overall, we are slightly behind schedule however we are working hard to catch up again.

Fig 3E – Part of the plan of action for the chassis subsystem.

4.0 – Subsystem Designs

Now that the specification and the planning of the project had been laid out, we could start to design the subsystem. I found this to be the most interesting part of the project because it gave me the opportunity to be creative and try several different approaches before finding the right one. Referring back to the diagram fig 4A showing the phases of the project; we can see that the project is now on the second box. In this section the initial, draft final, and final designs will be produced, and in the case of our project, a Solidworks model will be created.

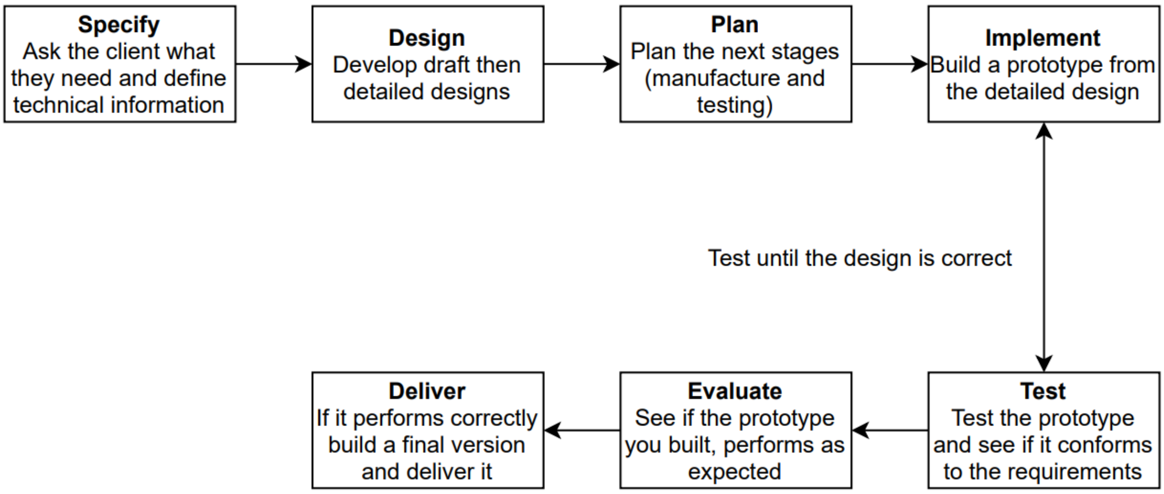


Fig 4A – The design process.

4.1 – Initial Designs and Concepts

It all starts with initial concepts, this is the most creative and experimental of the designs, where research from the internet, books, and especially real-life examples can be recorded and made into an interesting draft. To make sure we have a decent amount of variety, this is repeated until we have at least three different designs.

One regret that I have with the initial designs of the chassis is that they are not especially creative. They all meet the clients' requirements which is essential, but they didn't provide anything really unique or novel. I think that if we had access to more equipment for manufacture, I may have made some more interesting designs.

The chassis design evaluation document (appendix 10.11) shows the three draft designs. Design one (fig 4B) is a simple design which hits all the right criteria with the least waste. The design is not very aesthetically pleasing, but it is effective and easily adaptable.

Design two (fig 4C) is the middle of the road design, with wheel guards at the back and an angled front. One downside of this design was that the front wheels were quite exposed. However, this design does meet all criteria while improving on the aesthetics of the first design.

design three (fig 4D) is the most elaborate, featuring wheels guards for both the front and back wheels, because of this it is the most angular design of the three.

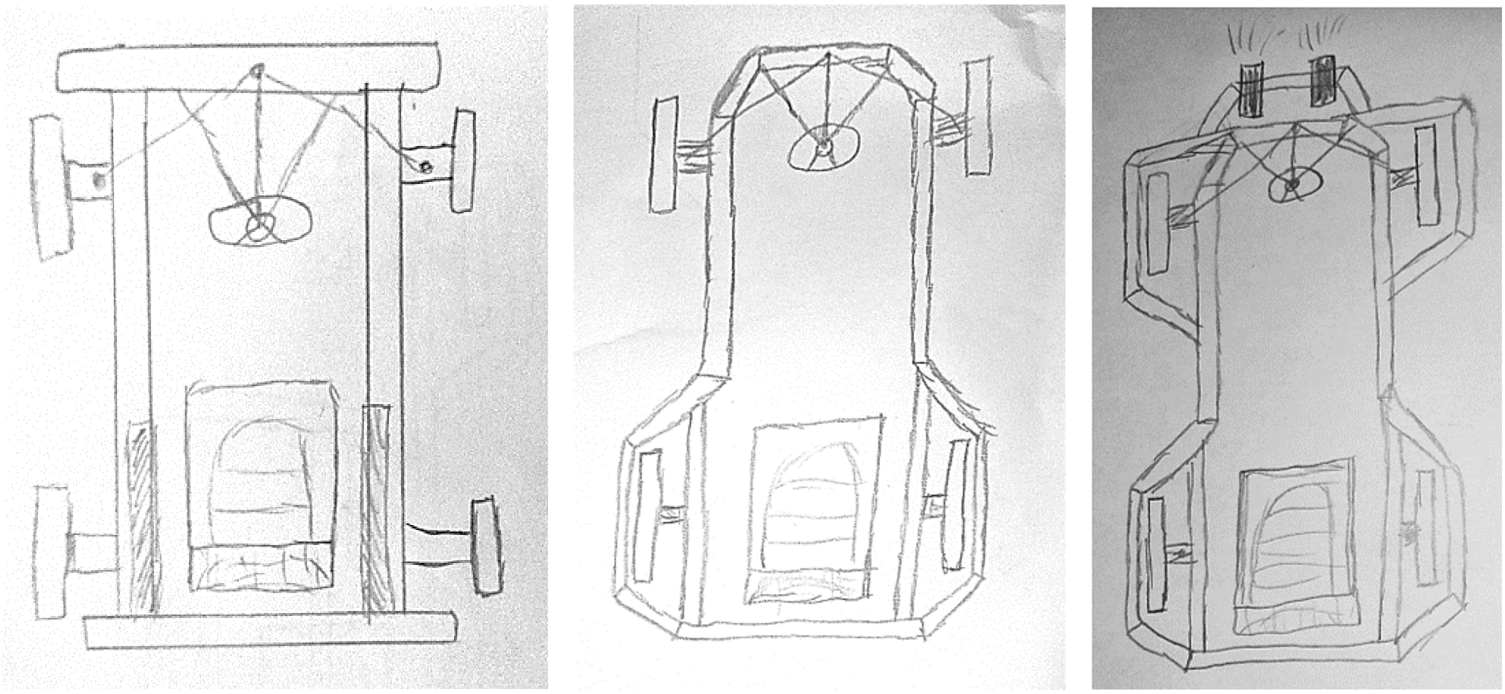


Fig 4B, C, and D, respectively. The draft designs for the chassis subsystem.

4.2 – Down Selection

In appendix 10.11 you can see the three initial concepts I put forward to be evaluated. The method of down selection I have used is called a comparison matrix. This is a relatively simple method of ranking each design in a number of different factors, allowing me to add up and evaluate the strong and weak points for each design. Graphs can also be produced which can be useful for identifying designs that have very strong or weak points as well as gaining a better overall view.

In my down selection I decided that design two (fig 4C) was the most valuable design overall, this was largely because it was a good balance between design one (fig 4B) and design three (fig 4D). Design two was also a leader in handling, aesthetics, and aerodynamics.

Design one was advantageous in that it was cheaper, easier, and lighter than other designs however it was lacking in other factors such as safety, aesthetics, and modularity.

Likewise, design three was good for safety and modularity, but it still scored lower in cost, manufacturability, and weight.

4.3 – First Detailed Designs

The next step after the down selection is to work on the winning design. My design ended up going through several redesigns, largely due to changes in material and tooling availability. The frame of the chassis is made from mild steel, which was the second favourite option listed in the feasibility study. This is because aluminium proved to be too expensive and difficult to work with considering the tools available. The form of the metal is box section, due to its high bending strength, relative low cost, and the fact it is easy to work with in manufacture.

Fig 4E – A view of the mild steel used in the chassis.

The next iteration of the design after the draft designs can be seen in appendix 10.14, I produced two orthographic drawings and one isometric drawing to give an overview of the design. The isometric drawing is show below in fig 4F.

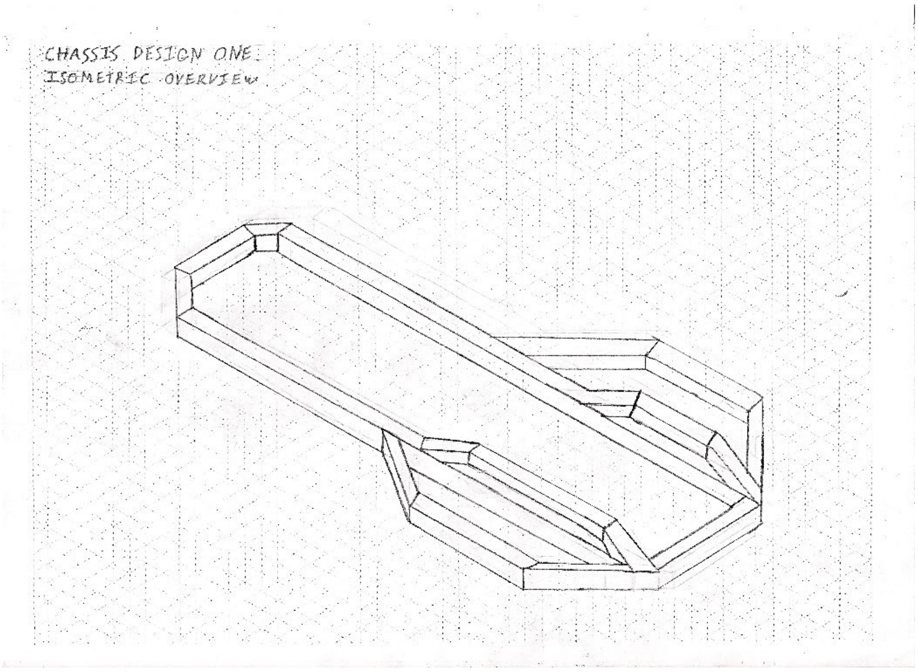


Fig 4F – The first final design isometric drawing.

4.4 – Coronavirus Restrictions

Around about the time that the first final design was produced, the country went back into a Covid lockdown. This had a strong impact on our project because we were relying heavily on being able to convene and discuss in person using the Friday lessons as a regular time for conference. Although we were able to keep going, we did find it difficult to switch entirely to Teams, and as a result we all fell behind schedule during that period.

In the meetings logbook for 15th January 2020 (see appendix 10.1), you can see that things got quite difficult for the project:

"Unfortunately, due to the heavy covid restrictions it is looking unlikely we can assemble or even source the parts due to funding no longer being available." … "Furthermore, Richard's castle has cancelled the race event so we cannot compete in any competitions. "

This had a big impact at the time because it meant that we were very unlikely to be able to actually produce anything, which was a shame as we were all really looking forward to the build phase.

4.5 – Detailed Redesigns and Adaptations

For a while, our project slowed right down: we were focusing on getting caught up in terms of designs and evaluations first before we moved on.

However, once the covid restrictions were lifted and colleges were allowed to reopen in March, our project quickly returned back to life. Halfway through March I began working on a solidworks model (see appendix 10.17) including all of the necessary subsystems.

For my chassis subsystem, I decided that because of the delay and change in what materials were available to us, I would pursue a design closer to concept design 1. This would be easier and faster to manufacture which was now a priority. In fig 4G below, you can see that the final design is fairly close to design 1 and has provided enough modularity for the other subsystems.

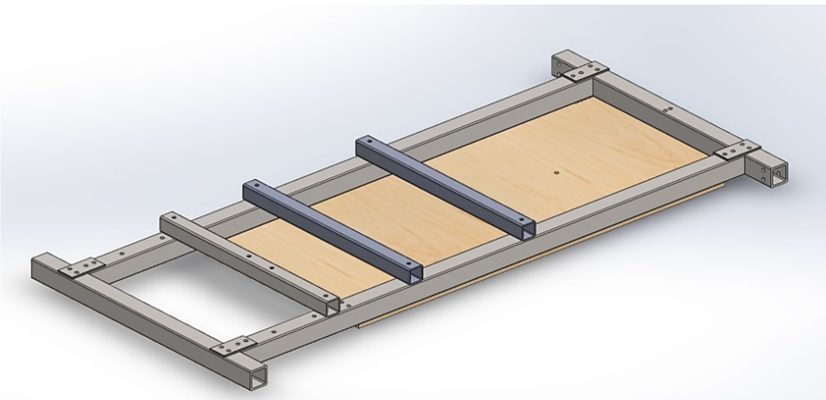


Fig 4G – The final design for the chassis after the change in direction.

Another important factor that changed my design was getting access to a gasless MIG welder. This would allow me to avoid having to drill holes and use large and expensive nuts and bolts. For the chassis it was a game changer because I was now able to get rid of any brackets that would have been needed, which reduced the material we needed. These brackets can actually still be seen on the solidworks model, but they are effectively ignored when manufacturing the chassis.

4.6 – Solidworks CAD Model

The final design was completed on the CAD package solidworks. This allowed me a lot more flexibility in collaborating with the other team members, we could work on our subsystems as CAD models then connect them together as an assembly, allowing us to identify any parts that don't fit or could be designed in a more efficient way. This also helped as we could share the files over the internet instead of having to exchange them in person.

When developing the CAD model, I spent an extra few minutes drawing in the other subsystems required to convert the vehicle from a downhill racer to a go kart. This included the engine and centrifugal clutch, which were both standard components imported from the internet.

Appendix 10.17 shows detailed photos of the solidworks CAD model, including the chassis on its own, other relevant subsystems, and all of the subsystems together.

The main reason for producing these CAD models was Covid: During the month of March, we all needed to progress our plans for our subsystems, but we couldn't get any meaningful progression from producing paper drawings since these had already been produced and they do not offer any kind of error correction or evaluation that CAD can produce. As a result, the CAD models gave us increased insight and perspective for the product we were producing, which proved to be extremely helpful in discovering small issues with how the subsystems interface with each other. The use of solidworks also allows us to produce engineering drawings for production. This would be vital for future engineers to come in and understand how to manufacture and reproduce components and assemblies in the kart.

In fig 4G we can see the steering subsystem, this was simulated using mates and limits to verify if the dimensions of components are correct for steering. This was a huge help for this subsystem because it allowed us to determine correct proportions before we had to manufacture anything.

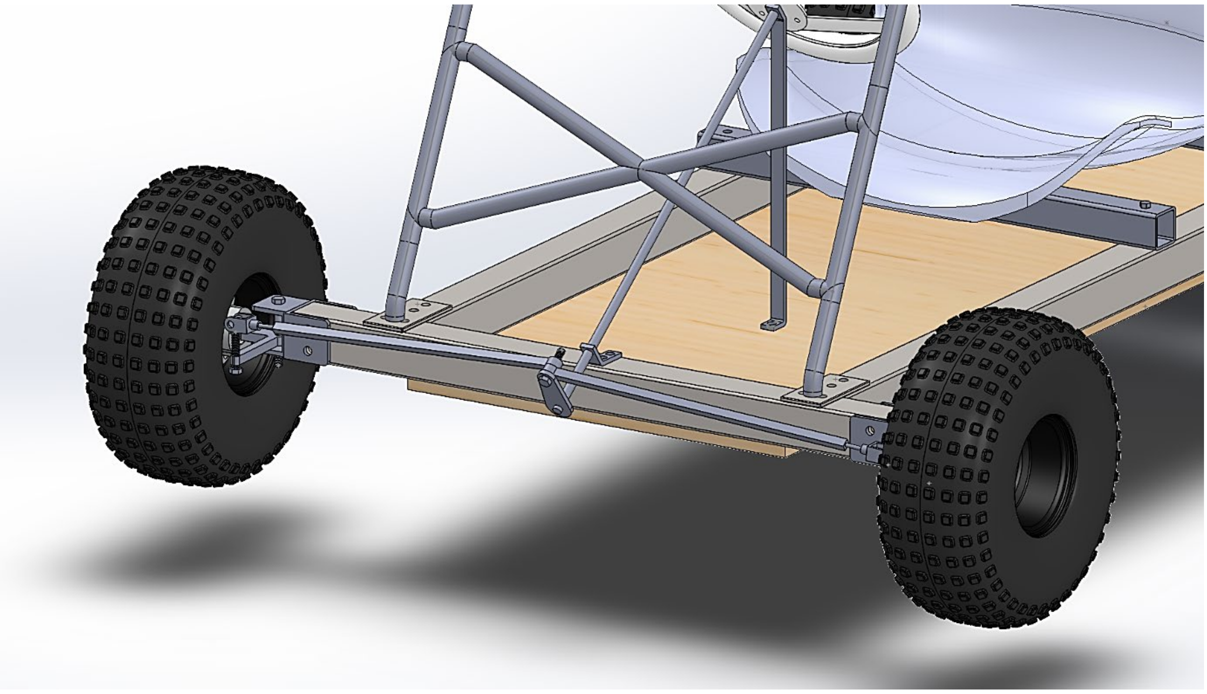


Fig 4G – Image showing the steering subsystem.

5.0 – Implementation

Once Covid had subsided and we were allowed to go back to college in person, we quickly ramped up the project again and continued our work to produce the subsystems. The Solidworks model was complete by this point and some of the chassis had been constructed.

5.1 – Subsystem Manufacture

The manufacture of the chassis unfortunately stated much later than it should have done, meaning we had to rush a bit to get it up to scratch. This change in schedule was also reflected in our reissued Gantt charts, which can be seen in appendix 10.4 – 10.6. With the addition of the gasless MIG welder I was able to build the base of the chassis fairly quickly. Originally the four lengths of box section which make the frame were to be connected with 50x100mm mild steel plates, nuts, and bolts, this would not have been ideal since it would have taken longer to produce the holes, and expensive fittings would have been necessary.

For the rest of this section, I will be looking at the various processes that were utilised while making the chassis starting with welding:

<u>Welding:</u>

The process used was gasless (flux core) MIG welding. This process ended up being ideal for my needs on this project because it is quick, fairly cheap and produces strong welds. A problem with this process, however, is that the lack of a shielding gas produces slag on the weld which must be removed once the weld is finished. Another issue is that it produces a high amount of spatter, however this is only a cosmetic issue and can be fixed by grinding off the spatter afterwards.

The image below shows the machine used to produce the welds, it was challenging to use because it did not allow for the voltage to be adjusted and the minimum feed speed was too fast.

Fig 5A – Image showing the welder used in the chassis production.

The welds produced with this method came out very well, and with minimal defects and spatter. Fig 5B shows a couple of straight welds produced to connect one of the side lengths of box section to the front box section.

Fig 5B – An image showing a continuous weld between two lengths of box section.

Another example of these welds was on the kingpins for the front wheel stub axles, being able to weld these saved my bacon as I would have needed to fabricate a bracket to attach these to the frame otherwise. The kingpins are attached to the ends of the front box section on the chassis, this provides a strong connection to the chassis for the stub axles and therefore front wheels. Fig 5C shows the kingpins welded to the chassis. Fig 5D shows the location of the kingpins.

Fig 5C – An image showing the kingpins welded to the chassis box section.

Fig 5D – Image showing the location of the kingpins.

<u>Grinding</u>

Grinding was the second process that was used heavily in this subsystem, it allowed me to prepare the metal for welding by removing oxidation, oil remnants and any other impurities. It also gave me the option of re-attempting a weld if it went wrong. In the image below you can see a patch of material that has been linished to remove the spatter from a nearby weld and to smooth out a weld between two sections of metal. This improves the aesthetics of the component but also prepares it for future painting to further improve the aesthetics.

Fig 5E – A patch of material that has been linished.

<u>Drilling</u>

A pilar drill was used to produce holes in the frame and brackets, however this plan was abandoned when the welder became available. Drilling was also used to produce the holes in the long sections of the chassis in order to screw the wooden floorboard to the chassis.

Fig 5F – Image showing the pillar drill used to make the brackets.

Being able to use this machine instead of having to use a hand drill made it a lot easier to carry out the process because of the pillar drill's ability to apply a large pressure on the drill bit without transferring it to the user.

5.2 – Evaluation

Overall, I can say that the implementation phase has been successful so far. The process used and the tooling available have meant that I have been able to produce my subsystem to a point of usability and conformance to the client requirements. This phase would have been even better if the welder were available from the start as I did lose some valuable time drilling holes in the brackets and frame that I did not need in the end.

Something that I discovered in the production of the chassis was that the box section used to produce it was way thicker than it needed to be at around 5mm thick. Because of this it adds a large amount of excess weight, decreasing the manoeuvrability of the vehicle. This cannot be attributed to the design however, as these box section lengths were obtained a few years ago for a different purpose and were used on this instead.

5.3 – Team delivery

Although the implementation phase has been successful, the chassis subsystem has not been delivered to the team or the customer as of yet. This is because of the delays in manufacturing and the knock-on effects of Covid. The subframe of the chassis has been constructed however some parts of the welding have not been completed. In this case I can learn from the mistake and next time adjust the schedule to better prepare for delays and issues that could come up. This has shown me that when dealing with projects that span many months, completely unforeseen and disruptive events can occur and require a great deal of flexibility, adaptability and teamwork.

6.0 – Testing

In this section I will be evaluating the design of the chassis subsystem against a number of different design factors. These include the customer brief, technical PDS, safety requirements, and budget requirements.

6.1 – Evaluation Against the Customer Brief

The original customer brief featured a number of important factors that needed to be considered. In the table below I will be looking at these factors and evaluating the similarity with the end product.

Factor	**Description**	**Pass or Fail**
Functionality	The chassis can drive down Richard's castle without breaking.	Pass
Environmental Conditions	The chassis is effectively weather-proof, although it would rust after some days exposed to bad weather or excessive moisture.	Pass
Size	The chassis is within size limits.	Pass
Weight	I would consider it heavier than it should be but still within limits.	Pass
Aesthetics	The chassis does look OK although further work such as painting should be used to cover messy looking sections.	Pass
Ergonomics	The chassis is easy to use.	Pass
Reliability	The chassis is unlikely to fail.	Pass
Maintainability	This chassis can be maintained easily because of the use of mild steel.	Pass
Manufacturability	Easy to manufacture because of the material used and the ability to weld.	Pass
Recyclability	This chassis is currently only constructed from recyclable materials.	Pass
Compatibility	The chassis is compatible with other subsystems.	Pass
Efficiency	Because of the extra width of the box section this design is not efficient, it is much heavier and stronger than it needed to be.	Fail
Cost	The cost of the chassis was not too high as the majority of that material was already obtained. The remaining material was worth approximately £120.	Pass
Compliance	The chassis does not fully comply with the rules and regulations, this is because it does not currently have a roll cage. This however could be considered a different subsystem.	Fail
Disposal	The chassis will be converted to a go kart afterwards.	Pass

6.2 – Evaluation Against the PDS

Evaluation is needed to ensure that the manufactured product is able to fulfil the PDS generated in the design phase. I will be taking a brief look at the specific requirements of the PDS and giving an opinion on whether it has been achieved or not.

After evaluating the results, I am happy that the chassis has passed and is suitable for the project. It passed in most fields and did not pass in some fields that do not affect the original customer requirements. Most of these failures seem to be because of the issues and delays caused by Covid in the project.

The following fields did not pass:

5.1 The chassis does not have to be aesthetically pleasing however it would be great if it was.	Did not pass as I ended up using the more boring design, this was due to delays from covid, this does not affect the customer requirements.
5.2 Welding joints need to be covered up.	This was not necessary and was more of a bonus to make it look nicer, it will not affect anything other than aesthetics.
7.2 The chassis must be designed to fail in a safe way.	This partially passed, it has been designed in a way that will not be dangerous, however specific techniques have not been used to make it safer. Overall, it is still safe to drive.
7.3 The chassis must have a lifespan of at least a year without being maintained.	This has not been tested so hasn't passed. It is very likely to pass however.
10.1 The chassis can be made from components such as old bike frames and other sources of scrap metal.	This was not true as the chassis was constructed from new materials only. This does not affect the customer requirements.
12.1 The design will not be over-engineered.	It is over-engineered but again this doesn't affect the customer requirements.

6.3 – Safety Testing

Limited safety testing has been completed on the chassis subsystem which is represented in the table below. **However, it should be noted that the racer needs further safety testing before it could be signed off and used in the Richard's Castle race.**

Factor	Description	Pass or Fail
Design Safety	The chassis is now based on concept design one which is inherently slightly less safe than design two. Because of the lack of wheel guards. The design, however, is still safe enough.	Pass
Operator Safety	Excluding the roll cage, which is a separate subsystem, the chassis itself still falls short of providing full operator safety. This is due to the lack of operator restraints or impact absorption on the front of the chassis. Therefore, in a crash the operator may be seriously injured. This can be remedied with further work to install some kind of bumper on the front and seat belts for the operator.	Fail
Safety of pedestrians.	The chassis provides no protection to pedestrians.	Fail

6.4 – Budget Requirements

The materials required to manufacture the chassis cost approximately £120, this was excluding the box-section which we already had access to before the project started. However, if this material were also included it would have pushed to cost nearer to £190.

6.5 – Evaluation of Evaluations

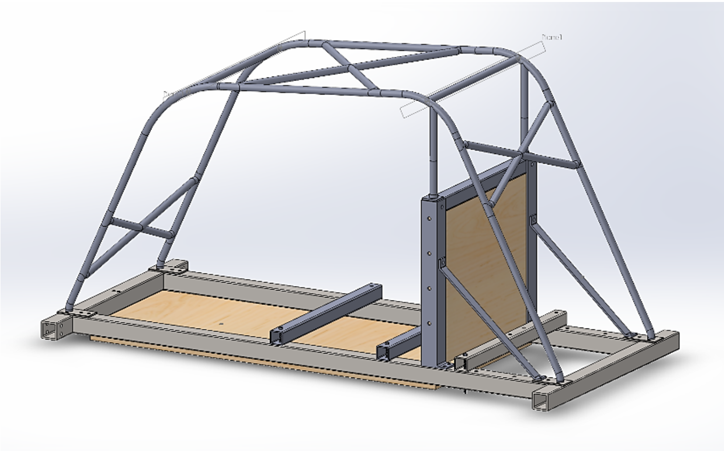
Evaluation	Impact on the project
Customer Brief	The results of this evaluation reveal that everything passes except for two factors. The efficiency and compliance of the chassis. The efficiency of the chassis is not an essential factor and therefore will not affect the usability of the vehicle, however the lack of a roll cage and therefore lack of compliance to Richard's castle regulations, makes it unable to fulfil the customer requirements. For it to fulfil the requirements, a roll cage must be constructed.
Technical PDS	The evaluation of the technical PDS shows that the chassis does not pass on a number of factors, however none of these restricted the usability of the chassis. *The reason that the safety concerns did not come up in the technical PDS was because it is only considering the chassis itself and not the roll cage which is a separate subsystem.*
Safety	The safety evaluation has thrown up some issues with the chassis. The concerns are about the safety of the operator and pedestrians. The safety of the operator can be enhanced with the use of seat belts, a roll cage and most importantly, an appropriate helmet. The safety of pedestrians can be improved by using plastic panelling to soften an impact somewhat. Although this is a concern it is not a requirement in any brief.
Budget Requirements	The cost of the chassis materials is within the budget requirements therefore it is not of concern.

7.0 – Subsystem Delivery

In this section I will be taking a brief look at the delivery of the chassis subsystem to my team and the clients.

7.1 – Delivering the Subsystem to the Team and Clients

The chassis has not been fully completed therefore I have delivered it to the team in its current state. The chassis is usable and drivable, however there is no structure to support a seat, steering column, or rear compartment separator.



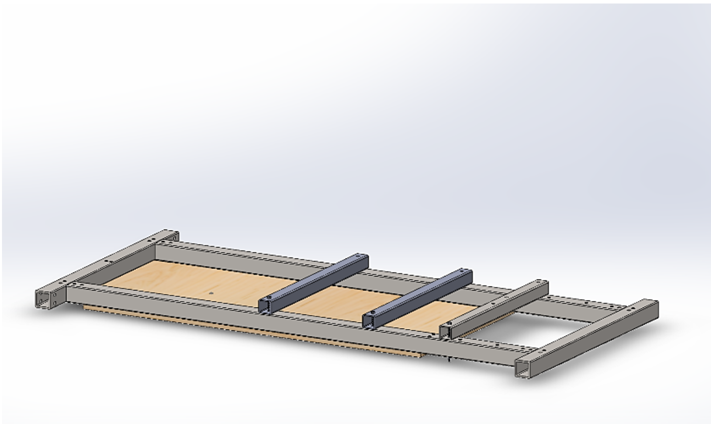


Fig 7A and 7B – Showing what should be constructed and what actually has been constructed.

Fig 7A above shows what the chassis would ideally look like at this stage, however due to the delays and issues, it currently looks like fig 7B on the right. This is still usable but is missing some important features.

As we have reached the end of the project, and effectively none of the subsystems are completed, and Richard's Castle is not proceeding with the race this year, the go kart itself will not be delivered to the client. The report, presentation and plans will be delivered.

8.0 – Project Conclusion

At the end of the project, we can evaluate all of the successes, failures, surprises, and knowledge gained over the past few months.

8.1 – Project Evaluation

Over the course of this project, we have learnt a huge amount about the importance and relevance of documents to support project plans and drawings. This has shown how you cannot just draw up a plan from the get-go and manufacture it the next day, instead it is better and far more professional to produce documents explaining and evaluating the designs, making it easier for future engineers to look back and understand the scope of the project, and the events that took place.

Overall it has been fun to learn about the processes and methods used in a professional project and to see how it would work on a much bigger project.

8.2 – What Went Well

- I was especially happy with the quality of the CAD model produced on Solidworks; I am glad that we now have that to show to people in future as it shows so much about the project.
- The use of Gantt charts and planning documents really helped us keep track of our progress throughout the project. It was really useful to have a graphical reference to look at whenever needed.
- Being able to use teams saved us so much time and confusion, especially during Coronavirus. If it weren't for Teams being available, we would have really struggled to get anything done during the lockdowns and likely wouldn't have the CAD model.
- The addition of the welder allowed us to manufacture the kart of much faster and to a much better standard than otherwise. This was an unexpected addition, but a welcome one!

8.3 – Even Better If

- The main issue that I would have liked to resolve was that I did not deliver the kart to the customer. This was regrettable and would have been avoided if not for Covid. I would maintain that it hit the project at a bad time (just before the procurement phase), but I could have prepared for it better than I did, with more communication over Teams, more team meetings, and more drive to get things moving.
- Because of the delays and issues, we had to rework the schedule of the project three times.
- In our logbooks there are quite a few gaps, although those days likely didn't have anything of note happening, it was still important to ensure there was a continuous record.
- Our procurement of parts was late, therefore we had very little time to manufacture before we had to focus instead on the last assignments for college.
- The design of the chassis changed dramatically after the first final design had been issued, this isn't necessarily a problem, but it would have simplified things if it was a draft that changed.

9.0 – References

10.0 – Appendices

This section contains all of the relevant project documents, that have been referred to in previous sections. The table below is a guide to these documents.

10.1 – Meetings Logbook

Team T.I.M Meetings Logbook

This logbook holds a record of the communications between the project members.

Friday 18th September 2020:

- First team meeting where we decide our roles and which sub-systems, we are responsible for.
- We have decided **we will have four phases of the project**, individual research (including basic designs and materials that can be used) phase two is the collaborative part where we will compare information and create a basic then more detailed design for the racer, the third phase will be construction and assembly which will be a mix between individual and group work whenever necessary. And the last phase will be getting all of the documents in order and getting the presentations made.
- Our team roles are as follows:
    - Tom covers the chassis and the roll cage and is group manager.
    - Mahmoud covers the steering and seating.
    - Isaac covers bodywork braking and wheels.
- We have agreed not to use suspension because it is not a requirement for this vehicle, and it would be complicated to implement.
- We have decided the assembly priorities, and they are as follows:
    - 1st Chassis / roll cage
    - 2nd Seats
    - 3rd Steering
    - 4th wheels
    - 5th braking
    - 6th bodywork

Friday 25th September 2020:

- We've gone through a PowerPoint as a class detailing the headings of the project and where we need to go from here. We have decided to change the structure of the project to match what was listed in the PowerPoint. This is because it is a more realistic structure, and it is more detailed than our layout. The structure is as follows:
    - Specify
    - Design
    - Plan project
    - Implement
    - Testing
    - Project Evaluation
    - Final Report
    - Final Presentation
- More details are available in the presentation provided by Vince located in the engineering L3 teams page and the team T.I.M page.

Friday 2nd October 2020:

- We have completed the client requirements document and will soon be working on the feasibility study for the design and will be working on the PDS after that.
- Tom is now doing the bodywork as well, so Isaac now does the wheels and braking, and Tom does the chassis bodywork roll cage.

Friday 9th October 2020:

- We will need to come up with some questions for SME's coming in next week.

Friday 16th October 2020:

- We have asked some questions to the SME's and have recorded the notes in a document in teams – S1
- We have been getting ready to produce the outlined designs for our subsystems and have been researching and planning out how we will do it.

Friday 6th November 2020:

- We have been working on our outlined designs for our relevant subsystems and have produced documents detailing the advantages and disadvantages of the designs and our choices for detailed designs.

Friday 13th November 2020:

- We have been working on ensuring we have our documents up to date, we have discussed possible wheel types and will be moving on to our design evaluation.

Friday 20th November 2020:

- We have looked at Mahmoud's designs for the steering system and have begun to see if it would work properly.

Friday 27th November 2020:

- We have decided to go ahead with Mahmoud's designs and are getting the designs for the other subsystems ready.

Friday 4th December 2020:

- Work is continuing on the detailed designs; Mahmoud is verifying the work he has done up to the third milestone and Tom and Isaac are approaching the third milestone.

Friday 8th January 2021:

- We have had a group meeting on teams to discuss what levels we are all at. We are running behind schedule and are currently around the 2.5 point when we should be at 4. Section 3 consists of small tasks so we can get up to speed quickly, which we are now doing.
- Due to coronavirus, we are going to reissue our planning documents to better reflect the situation, this means an updated Gantt chart and / or pert chart.

- Procurement is an issue now that we can't access college easily, so we will be listening for information on that front and in the meantime, we will be finding the parts that need to be procured and calculate the budget.
- We have now made a list of items that are available to us right now, this includes materials and tools, so we know what we don't need to procure.

Friday 15th January 2021:

- We held another team meeting and discussed the issues around covid, we are working towards reissuing project plans and have already issued a new Gantt chart.
- Other documents will be reissued as needed.
- Unfortunately, due to the heavy covid restrictions it is looking unlikely we can assemble or even source the parts due to funding no longer being available.
- Furthermore, Richards castle has cancelled the race event so we cannot compete in any competitions.
- We will still research and plan as if the budget were still available just in case the situation changes at the last minute.

Friday 29th January 2021:

- In a review of circumstances, the government has announced that schools and colleges will not be returning to in-person learning until early March at the latest, thus impacting the project.

Friday 26th February 2021:

- We have held a team meeting to discuss the overall progress of the project.
- After the news from Vince that we will be returning to college on the 8th of march, we can now look again at trying to put in a purchase order for parts.
- We will now be looking into setting out plans for the assembly of the project.

Friday 12th March 2021:

- We have held a team meeting and have discussed the issue of covid and the disruption to our project.
- We are discussing the possibility of altering the scope of our project so we are still able to produce a system.
- We are now likely to produce a scaled-down version of our original system, possibly amalgamating it into an RC car.
- We have also used this time to synchronize, since it is the first time we have all been back in person.

Friday 19th March 2021:

- Today we have discussed extensively the plans for the project
- We have agreed a budget organized by Tom
- Mahmoud will now produce his subsystem as a full size system.
- And Isaac will also produce his subsystem as a full size system.
- We have emailed jack with the required parts and other small parts and fixings have been obtained.

- At this point the chassis subframe is complete and is ready for further components to be built on top of it.
- Isaac and Mahmoud are ready to build their subsystem once the items arrive.
- We have designed most of the vehicle on solid works as a proof of concept using realistic measurements.
- We are working together carefully to make sure all the subsystems match up properly.

10.2 – Initial Subsystem Selection

Subsystems:

1st Chassis / rollcage

2nd Seats

3rd Steering

4th wheels

5th braking

6th bodywork

Tom: chassis rollcage, bodywork

Mahmoud: steering seating

Isaac: braking wheels

10.3 – Tom Taylor Logbook

Tom Taylor Engineering L3 Project Logbook

Team T.I.M Logbook – Tom Taylor

Friday 18th September 2020:

- We have held our first group meeting earlier today and have decided many details including: our roles, how the project will be laid out, and the priorities for assembling the vehicle. (all these details are available in the first entry in the meetings logbook.
- I made the teams page for the project to make sure all the documents and ideas are kept together, and we have all decided to store everything on there instead of on our own devices.
- No work has been allocated yet.

Friday 25th September 2020:

- We have gone through a PowerPoint as a class which details the separate stages for the project and the base requirements for the project. The PowerPoint can be found in the team T.I.M teams page or the engineering L3 teams page.
- I've seen some ideas for the chassis design. Which can be found on the team T.I.M page.
- I will schedule my own work up until around July and make a Gantt chart to stay on top of it (this will be based on the document provided by Vince)

Friday 2nd October 2020:

- I have now produced a Gantt chart on excel to log my progress and to keep track of what needs to be done. I've uploaded it to teams so Mahmoud and Isaac can use it and adapt it if they want.
- The Gantt chart shows me that we will be expecting to finish around halfway through may with the opportunity to overrun by a couple of weeks.
- The client requirements have been done now, and I will likely start work on the PDS document in the next week.
- Me and Isaac have decided to change tasks, I am now doing the bodywork as well as the other sub-systems I'm currently doing.

Friday 9th October 2020:

- Prepare some questions for the motor vehicle lecturers for next week.
- I have been working on the customer requirements document over the past week.

Friday 16th October 2020:

- I have completed the PDS for the chassis subsystem and will shortly be working on making some basic designs for the chassis.
- I will make 4 designs overall, 3 basic designs and then one of those designs will be made into a detailed final design.
    - These designs will be compared against the customer requirements and the PDS.
    - Produce a strengths and weaknesses matrix on those designs.

Tom Taylor Engineering L3 Project Logbook

Friday 6th November 2020:

- I have completed the 3 outline designs and have produced a document explaining the advantages and disadvantages of the three designs.
- I have also decided which design will go on to be developed.

Friday 13th November 2020:

- I will be completing the design evaluations today, this includes looking at the draft designs, comparing them against the PDS and figuring out which design matches the PDS in the best way.

Friday 20th November 2020:

- I talked to Mahmoud about his designs for the steering as he has completed his preliminary designs and needs to gain the approval of the group.

Friday 27th November 2020:

- Communicated with Isaac to look at his designs for the wheels.
- I have started the detailed design for the chassis.

Friday 4th December 2020:

- I have been working on the detailed design of the chassis.

Tuesday 22nd December 2020:

- I have been working to get to the Christmas milestone and have completed the detailed design.
- I have completed the plan of action and have started the process of making a work breakdown structure.

Friday 8th January 2021:

- I have had a meeting with the team to discuss where we all are in the project, we are running behind schedule, so we are working swiftly to get back to where we need to be.
- I have made a list of items and materials available to us right now, so we know what needs to be procured via college.
- Due to coronavirus lockdowns, we will be updating our planning documents and changing the timescale of the project to better reflect what we have time for.
- Updated Gantt chart has now been uploaded to teams for team members to use.

Friday 15th January 2021:

- We have had another team meeting, in summary we cannot proceed with the project in its current form, we have lost funding and Richards castle have cancelled the race event.
- I am going to reissue planning documents as needed to reflect the covid issues.
- I and the other guys are going to keep researching and preparing as If we could continue just in case the situation changes at the last minute.

Friday 29th January 2021:

- In a review of circumstances, the government has announced that schools and colleges will not be returning to in-person learning until early march at the latest, thus impacting the project.

Friday 19th March 2021:

- I have completed the budget for the three subsystems, and I have consulted with Isaac and Mahmoud to make sure they are happy and they have the parts they need.
- I have sent off the parts needed to jack and hopefully they will arrive soon.
- Once the parts arrive I can finish the chassis subsystem, the other subsystems are ready to be built on the chassis subframe as well.

Tuesday 30th March 2021:

- I have luckily been able to get a gasless MIG welder for this project, making it a lot easier to produce the chassis, this means I can use welds instead of having to buy expensive fittings and extra metal.
- The welding process is somewhat messy since it uses flux core wire instead of shielding gas, however the welds themselves are strong enough for this project.
- Work on the chassis subsystem is progressing well, I have switched from using bolts and retaining plates to welds.
- I have also issued the third version of the Gantt chart to better reflect the setbacks and delays we have had in this project.
- My hope is that we will meet these new deadlines however we have very little leeway if things go wrong from now. (this is definitely something to learn from in future)

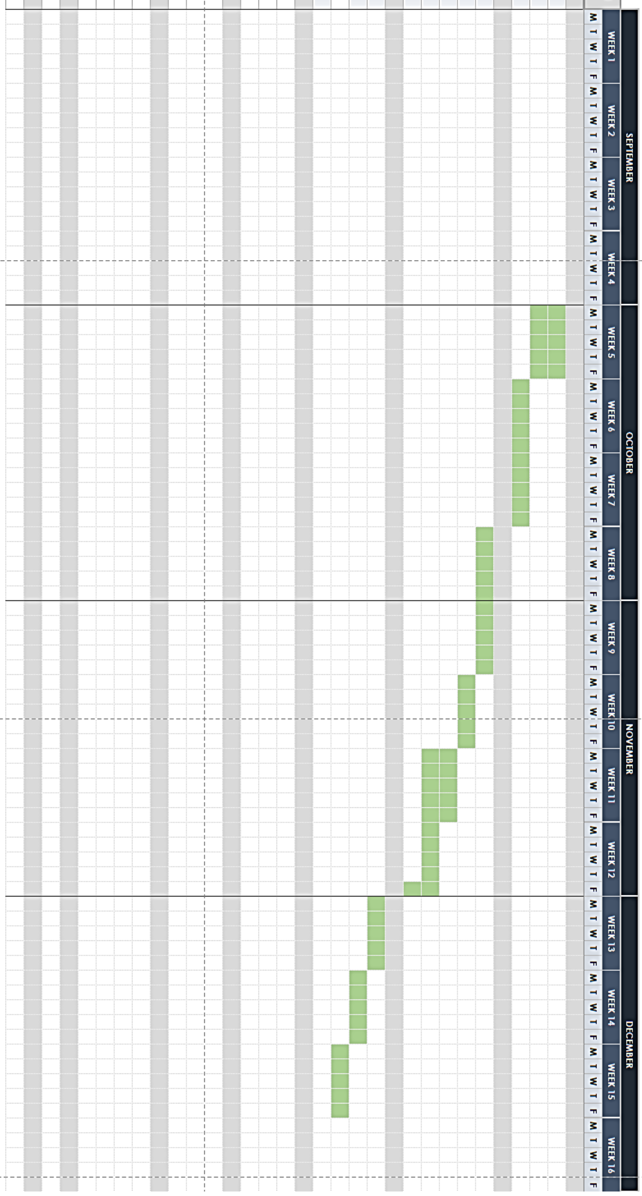
10.4 – First Issue Gantt Chart

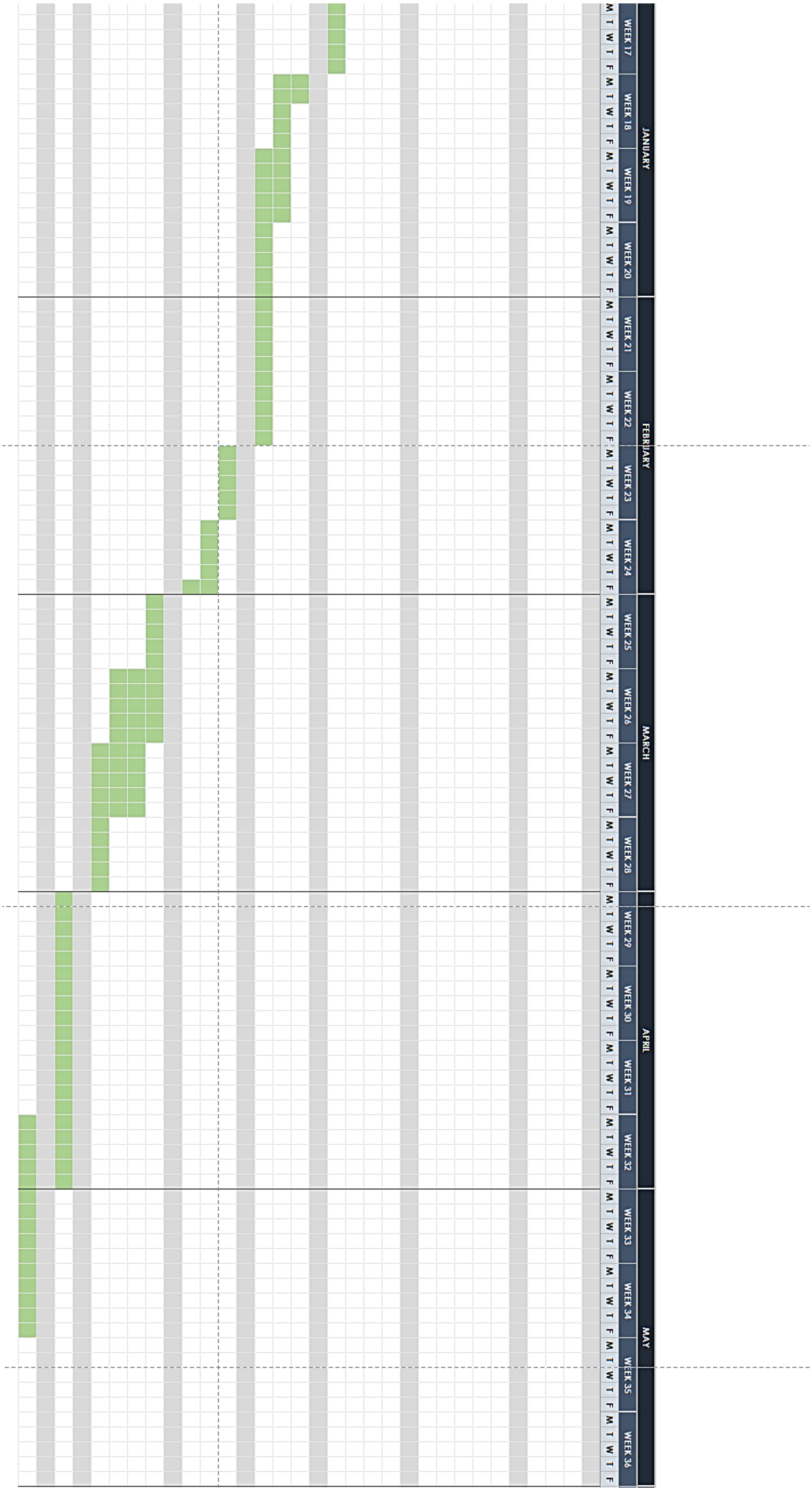
Team T.I.M Progression Tracker

PROJECT TITLE	Downhill racer project
PROJECT MANAGER	T
COMPANY NAME	Team T.I.M
DATE	29 September 2020

Revision Number	Version 1	Relased September 2020

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Specify					
1.1	Client Need		05/10/2020	09/10/2020	4	100%
1.2	What can be done?		05/10/2020	09/10/2020	4	100%
1.3	PDS		12/10/2020	23/10/2020	11	100%
2	Design					
2.1	Produce three designs		26/10/2020	06/11/2020	11	100%
2.2	Evaluate against PDS		09/11/2020	13/11/2020	4	100%
2.3	Justify design choice		16/11/2020	20/11/2020	4	100%
2.4	Produce detailed design		23/11/2020	04/12/2020	11	100%
2.5	Get approved by team		03/12/2020	04/12/2020	1	100%
3	Project Plan					
3.1	Produce plan of action		07/12/2020	11/12/2020	4	100%
3.2	Work breakdown structure		14/12/2020	18/12/2020	4	100%
3.3	Time schedule (gantt, pert charts)		21/12/2020	25/12/2020	4	0%
3.4	Present findings to group		04/01/2021	08/01/2021	4	100%
4	Implement					
4.1	Order parts		11/01/2021	13/01/2021	2	0%
4.2	Make parts		11/01/2021	22/01/2021	11	0%
4.3	Assembe		18/01/2021	12/02/2021	25	0%
5	Testing					
5.1	Is it fit for purpose? And why?		15/02/2021	19/02/2021	4	0%
5.2	Show results of evaluation against PDS		22/02/2021	26/02/2021	4	0%
5.3	Deliver Subsystem to the team		25/02/2021	26/02/2021	1	0%
6	Evaluation					
6.1	Evaluate against PDS		01/03/2021	12/03/2021	11	0%
6.2	WWW/EBI for subsystem		08/03/2021	19/03/2021	11	0%
6.3	WWW/EBI for project as a whole		08/03/2021	19/03/2021	11	0%
6.4	Suggestions for better ways of doing it		15/03/2021	26/03/2021	11	0%
7	Project report					
7.1	Produce project report		05/04/2021	30/04/2021	25	0%
8	Project presentation					
8.1	Produce project presentation		26/04/2021	14/05/2021	18	0%

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MAY
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WEEK 34
WEEK 35
WEEK 36

10.5 – Second Issue Gantt Chart

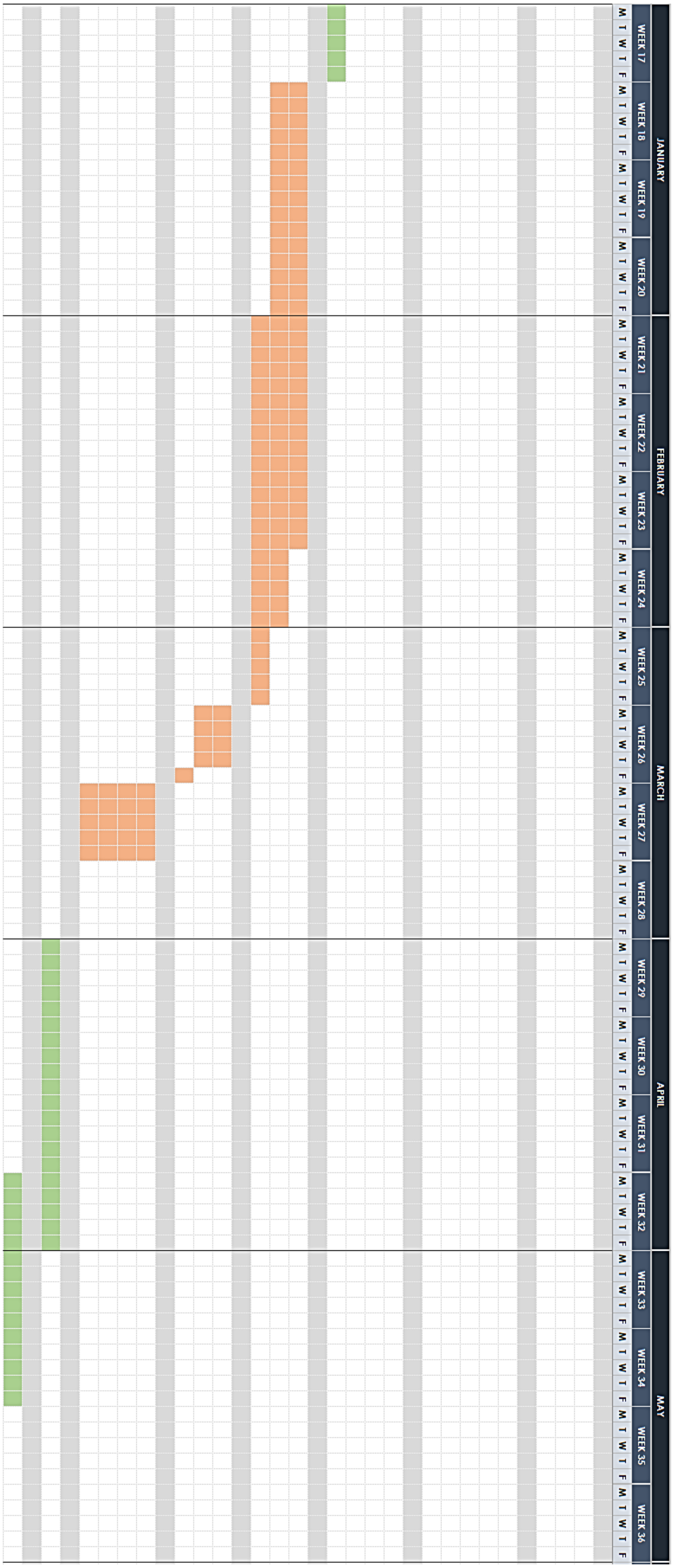
Team T.I.M Progression Tracker

PROJECT TITLE	Downhill racer project
PROJECT MANAGER	T
COMPANY NAME	Team T.I.M
DATE	08 January 2021

Revision Number	Version 2	Released January 2021

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Specify					
1.1	Client Need		05/10/2020	09/10/2020	5	100%
1.2	What can be done?		05/10/2020	09/10/2020	5	100%
1.3	PDS		12/10/2020	23/10/2020	12	100%
2	Design					
2.1	Produce three designs		26/10/2020	06/11/2020	12	100%
2.2	Evaluate against PDS		09/11/2020	13/11/2020	5	100%
2.3	Justify design choice		16/11/2020	20/11/2020	5	100%
2.4	Produce detailed design		23/11/2020	04/12/2020	12	100%
2.5	Get approved by team		03/12/2020	04/12/2020	2	100%
3	Project Plan					
3.1	Produce plan of action		07/12/2020	11/12/2020	5	100%
3.2	Work breakdown structure		14/12/2020	18/12/2020	5	100%
3.3	Time schedule (gantt, pert charts)		21/12/2020	25/12/2020	5	100%
3.4	Present findings to group		04/01/2021	08/01/2021	5	100%
4	Implement					
4.1	Order parts		11/01/2021	19/02/2021	40	0%
4.2	Make parts		11/01/2021	19/02/2021	40	0%
4.3	Assemble		01/02/2021	05/03/2021	33	0%
5	Testing					
5.1	Is it fit for purpose? And why?		15/03/2021	18/03/2021	4	0%
5.2	Initial Evaluation against PDS		15/03/2021	18/03/2021	4	0%
5.3	Deliver Subsystem to the team		19/03/2021	19/03/2021	1	0%
6	Evaluation					
6.1	Full evaluation against PDS		22/03/2021	26/03/2021	5	0%
6.2	WWW/EBI for subsystem		22/03/2021	26/03/2021	5	0%
6.3	WWW/EBI for project as a whole		22/03/2021	26/03/2021	5	0%
6.4	Suggestions for better ways of doing it		22/03/2021	26/03/2021	5	0%
7	Project report					
7.1	Produce project report		05/04/2021	30/04/2021	26	0%
8	Project presentation					
8.1	Produce project presentation		26/04/2021	14/05/2021	19	0%

SEPTEMBER: WEEK 1, WEEK 2, WEEK 3, WEEK 4; OCTOBER: WEEK 5, WEEK 6, WEEK 7, WEEK 8; NOVEMBER: WEEK 9, WEEK 10, WEEK 11, WEEK 12; DECEMBER: WEEK 13, WEEK 14, WEEK 15, WEEK 16 (M T W T F)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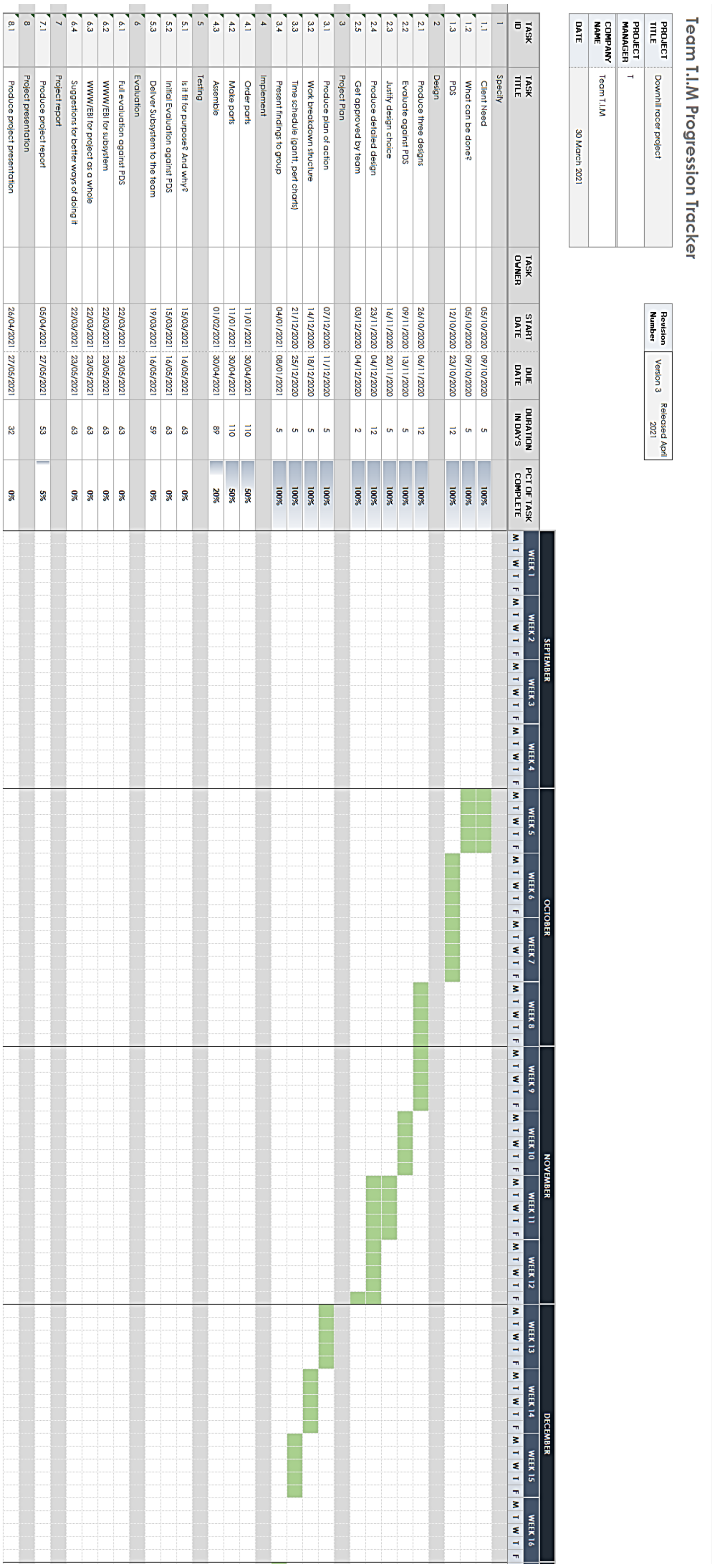
M T W T F

10.6 – Third Issue Gantt Chart

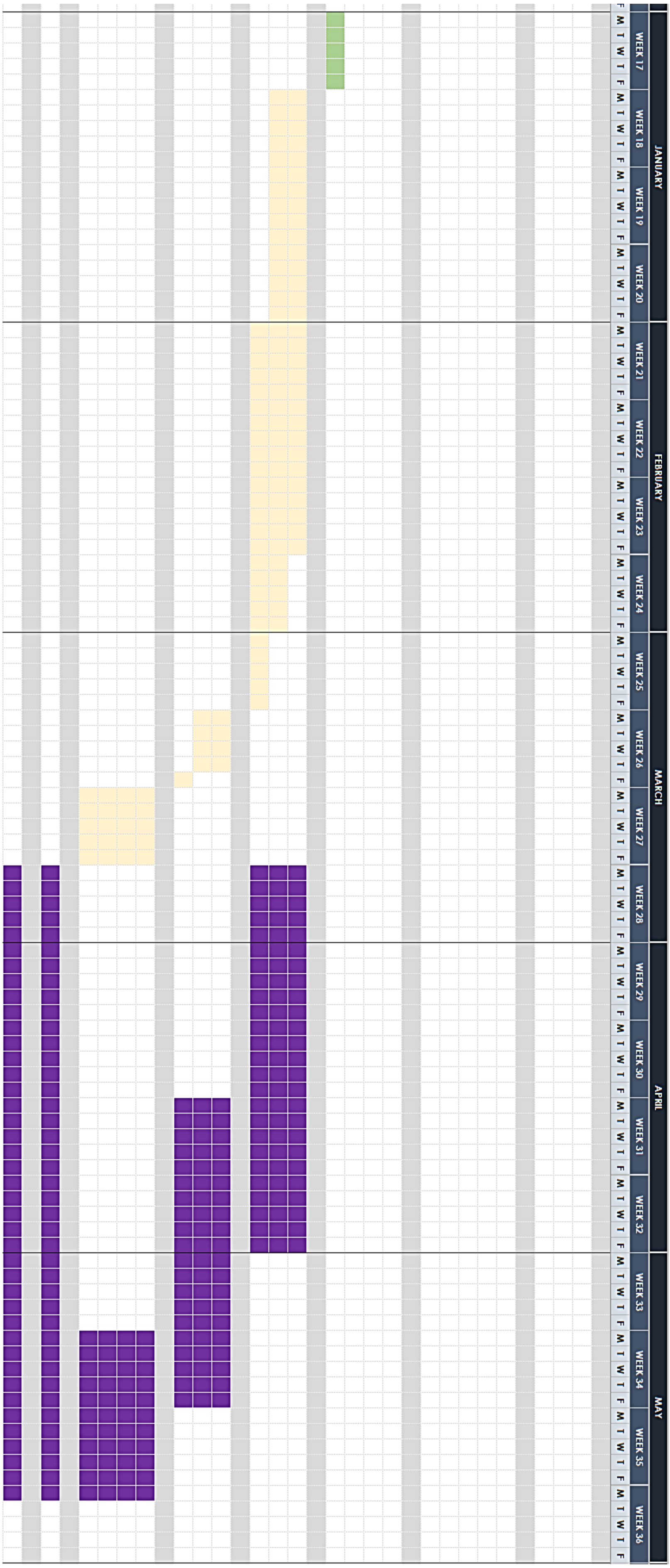


Team T.I.M Progression Tracker

PROJECT TITLE	Downhill racer project
PROJECT MANAGER	T
COMPANY NAME	Team T.I.M
DATE	30 March 2021

Revision Number	Version 3	Released April 2021

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Specify					
1.1	Client Need		05/10/2020	09/10/2020	5	100%
1.2	What can be done?		05/10/2020	09/10/2020	5	100%
1.3	PDS		12/10/2020	23/10/2020	12	100%
2	Design					
2.1	Produce three designs		26/10/2020	06/11/2020	12	100%
2.2	Evaluate against PDS		09/11/2020	13/11/2020	5	100%
2.3	Justify design choice		16/11/2020	20/11/2020	5	100%
2.4	Produce detailed design		23/11/2020	04/12/2020	12	100%
2.5	Get approved by team		03/12/2020	04/12/2020	2	100%
3	Project Plan					
3.1	Produce plan of action		07/12/2020	11/12/2020	5	100%
3.2	Work breakdown structure		14/12/2020	18/12/2020	5	100%
3.3	Time schedule (gantt, pert charts)		21/12/2020	25/12/2020	5	100%
3.4	Present findings to group		04/01/2021	08/01/2021	5	100%
4	Implement					
4.1	Order parts		11/01/2021	30/04/2021	110	50%
4.2	Make parts		11/01/2021	30/04/2021	110	50%
4.3	Assemble		01/02/2021	30/04/2021	89	20%
5	Testing					
5.1	Is it fit for purpose? And why?		15/03/2021	16/05/2021	63	0%
5.2	Initial Evaluation against PDS		15/03/2021	16/05/2021	63	0%
5.3	Deliver Subsystem to the team		19/03/2021	16/05/2021	59	0%
6	Evaluation					
6.1	Full evaluation against PDS		22/03/2021	23/05/2021	63	0%
6.2	WWW/EBI for subsystem		22/03/2021	23/05/2021	63	0%
6.3	WWW/EBI for project as a whole		22/03/2021	23/05/2021	63	0%
6.4	Suggestions for better ways of doing it		22/03/2021	23/05/2021	63	0%
7	Project report					
7.1	Produce project report		05/04/2021	27/05/2021	53	5%
8	Project presentation					
8.1	Produce project presentation		26/04/2021	27/05/2021	32	0%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10.7 – Client Requirements

Client requirements for the downhill racer for Team T.I.M

Aims:

- To produce a chassis for the downhill racer project, including the design manufacture and testing of the vehicle.
- And to complete the secondary sub-systems required for the vehicle to function properly.

Objectives:

- Utilise the formal project management techniques to plan and produce a chassis subsystem
- Follow the Gantt chart, to ensure tasks are being completed on time.
- Update the logbook periodically.

Customer requirements:

Not all will apply, some may be more relevant than others

1.0 Functionality (what the product should do)

1.1 The chassis needs to be able to drive down the Richards castle course without breaking.

2.0 Environmental conditions (dry/wet/windy)

2.1 The chassis needs to be able to withstand some bad weather for a while but it doesn't need to be completely weather-proof.

3.0 Size (a comment on size)

3.1 The chassis will be about the size of a standard go-kart.

4.0 Weight (a comment on weight)

4.1 The chassis will be as light as possible so it can be as agile as possible.

5.0 Aesthetics (look)

5.1 I will try to make it look as good as possible as it will be on show. I will likely go for an angular design as this will be easier to achieve and will still look good.

6.0 Ergonomics (ease of use)

6.1 This is not a big area of concern with the chassis, however it does need to be safe to use.

7.0 Reliability (comment)

7.1 Reliability is important for the chassis, if this component fails it could be very dangerous, therefore it needs to be built in a fail-safe way.

8.0 Maintainability (how easy to service/repair)

8.1 It should be easy to repair and maintain since it will be primarily welded together or bolted together and there will likely not be complex joints etc…

9.0 Manufacturability (how easy/quickly to build)

9.1 The chassis will be built of metal and should be fairly easy to manufacture, apart from welding I don't think any advanced techniques will be used.

10.0 Re-cyclability (can other products be made use of)

10.1 There is a lot of potential for reusing parts when manufacturing the chassis, I could use things like old bikes or scrap metal from other sources, (as long as it's the same material and can be welded / worked)

11.0 Compatibility (what other products must it interface with)

11.1 Compatibility is key for the chassis as all the other sub-systems will need to be anchored to the chassis. This will be a consideration for the design of the chassis.

12.0 Efficiency (energy usage)

12.1 The chassis will be designed in a way that will minimize waste or overengineering of the design.

13.0 Cost (how much will it cost to make)

13.1 I will try to minimize the cost by using recycled parts and low-cost solutions.

14.0 Compliance (what legislation/rules must be complied with)

14.1 The chassis will need to be compliant with the Richards castle rules and regulations.

15.0 Disposal (what happens after the race)

15.1 The vehicle will likely be used by one or all of us after the project. And we might put an engine in it.

Not all will be applicable – put N/A where not

10.8 – Product Design Specification

Team T.I.M Chassis Product Design Specification
1.0 Functionality (what the product should do)
1.1 Must not fall apart during service
1.2 Must be capable of driving
1.3 Must be manourverable
2.0 Environmental Conditions
2.1 Must be capable of withstanding rain for an hour
2.2 Must be capable of withstanding temperatures down to freezing
2.3 Must be capable of not coroding over time while covered
3.0 Size
3.1 Length must not exceed 2500mm
3.2 Width must not exceed 1500mm
3.3 Height must not exceed 1.5m
4.0 Weight
4.1 The chassis must not exceed 80kg
5.0 Aesthetics
5.1 The chassis does not have to be aesthetically pleasing however it would be be great if it was
5.2 Welding joints need to be covered up
6.0 Ergonomics
6.1 The chassis must be able to interface with the other subsystems
6.2 The driver needs to be able to get into the chassis easily
6.3 The driver must be able to get out of the chassis easily in the event of a crash or emergency
7.0 Reliability
7.1 Chassis must not fail during normal use
7.2 The chassis must be designed to fail in a safe way.
7.3 The chassis must have a lifespan of at least a year without being maintained
8.0 Maintainability
8.1 Chassis must be easily maintainable
8.2 It needs to be able to be painted or coated with a protective substance
9.0 Manufacturability
9.1 The chassis must be able to be manufactured relatively easily with the use of a welder and other basic tools
9.2 The construction will not feature especially complex techniques other than welding
10.0 Re-Cyclability
10.1 The chassis can be made from components such as old bike frames and other sources of scrap metal.
10.2 It can be made from any scrap metal as long as it meets the requirements of the chassis (for example must be able to take the load)
10.3 Thinner materials must not be used in safety critical components
11.0 Compatibility
11.1 Must be able to interface with the other subsystems of the project
11.2 It must be designed with compatibility in mind so changes to other subsystems are unlikely to cause significant issues
11.3 It should be designed with as many standard parts and practices as possible so parts can be easily replaced if neccesary

12.0 Efficiency	
12.1 The design will not be over-engineered	
13.0 Cost	
13.1 The cost will be minimized by using recycled parts and materials that are the right choice for the component being made	
13.2 The choice of material will also reflect the need to minimize costs, however this can't impact on the safety of the vehicle.	
14.0 Compliance	
14.1 The chassis construction must comply with the richards castle rules and regulations	
14.2 The chassis must be safe to drive	
15.0 Disposal	
15.1 The chassis along with the rest of the vehicle will be kept at one of the team member's houses and will hopefully be fitted with an engine	

10.9 – Feasibility Study

Team T.I.M Feasibility Study

This document is an investigation into realistic ways of producing the chassis for the gravity racer project.

Materials:

There are several materials which could be used in the chassis, for example:

- Aluminium
- Steel
- Iron
- Wood

In the chart below I will compare their physical properties to establish the best material.

Material:	**Aluminium**	**Steel**	**Iron**	**Wood**
Strength:	4	5	3	1
Workability:	4	2	4	3
Tooling required:	3	2	3	4
Safety in a crash:	4	5	2	0
Cost:	3	2	4	5
Availability:	4	4	3	5
Durability:	5	4	2	1
Maintainability:	5	4	2	2
Totals:	32	28	23	21

Both iron and wood can be eliminated because of their poor crash safety, as well as other factors, leaving us with aluminium or steel. Steel has a lower overall score and is cheaper than aluminium however it does weigh more and can be somewhat more difficult to work with because of the lack or malleability. The aluminium is the favoured material in this test, but it remains to be seen whether the material can be acquired within budget or if it can be sourced from recycled items. ***If this is possible aluminium should be used.***

Manufacturing:

There are multiple ways of approaching the manufacture of the chassis, one way would be to use a welder (SMAW since it is a relatively cheap and easy method). This method is preferable since it will create a much higher quality finished product and will be far stronger and more durable than other methods.

Another method would be to bolt the materials together, this could work for some of the chassis but not all of it. The strongest sections of the chassis (subframe) would really benefit from the use of welding instead of using bolts.

Overall, welding is the best solution because it will result in a far higher quality item and it will likely last a lot longer as a result.

Space:

In terms of space for the project, there is no issue, it can either be stored at my house or a friend's house.

Tooling:

Tooling is again not an issue and we have access to 90% of the things we might need to use (the other things are machines such as lathes and mills which may be available at college anyway).

10.10 – Notes from SMEs

Material for chassis:

Box section instead of tube, tube is more difficult to work with steel or aluminium can be used

Tube is more workable although it is difficult to fix together, box is stronger

Brakes:

Brakes on back could lock up

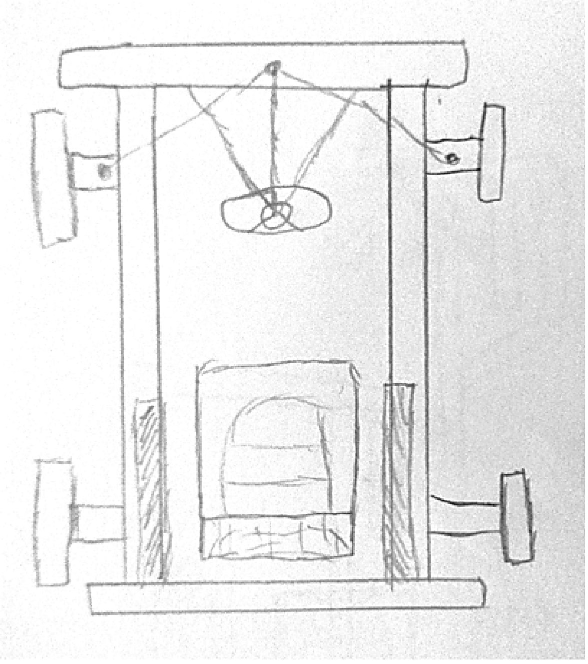
Front is more efficient

Both at same time is ideal

10.11 – Chassis Initial Design Evaluation Document

Chassis First Draft Designs

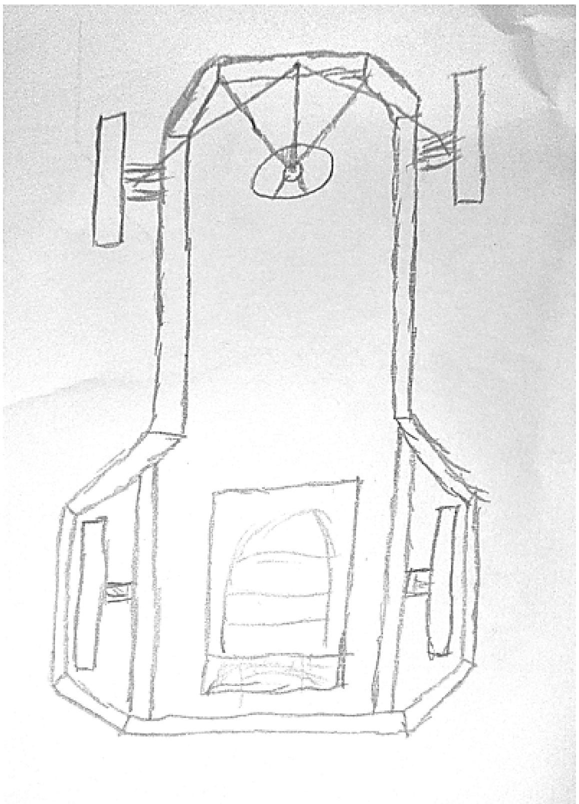
This document will detail the differences, advantages, and disadvantages of the three first draft designs I have produced for the chassis. As well as the Design choices made in the drawings.



Design 1:

Design 1 is a basic rectangular design which gets the job done. Made of box section it does not contain any difficult to manufacture curves or corners. This top-down view shows the overall layout of the chassis. Visible from this view are the two bars on either side of the chair. These bars are in place to provide support to the rear of the chassis, chair, and the rollbar. And can also provide some support to the driver in the event of a crash.

Wheel mounting is easiest with this design as there is plenty of space for wheels and any bearings / mechanisms that are attached to the wheels.



Design 2:

Design 2 is somewhat more complicated that design 1 as it features some chamfered corners and curves. At the rear of the vehicle the wheels are covered by an extension of the chassis, although this section is not load bearing in any way.

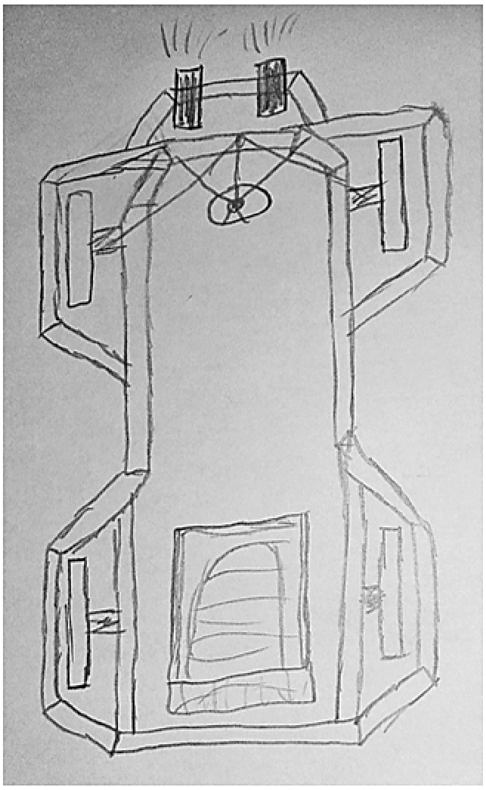
The wheels can be and probably will be hidden using some bodywork panels, which will improve the aerodynamics of the vehicle.

This design provides space for a bigger roll bar and a bit more space for the steering system. The chassis also has space for the bars on the sides of the driver's seat like design 1.

A key advantage of this design is that it has more space and is more aesthetically pleasing compared to design 1.

A disadvantage is that it is more difficult to manufacture as it contains chamfered sides and more overall components.

Design 3:



Design 3 is an advancement on design 2, with an extension of the chassis around the front wheels as well as the rear wheels, and the possibility to add a bulbar type attachment, which could hold headlights or something similar.

The front extension would have to be measured properly as to not interfere with the turning of the wheels which could be dangerous.

An important issue with this design is that with all the extra material being used it is much heavier than the other two designs, and this weight is not in the best place, (right at the front of the vehicle). This would likely give it worse handling compared to the other two designs and may make it difficult to drive.

A possible advantage is the extra protection provided by the front extension over the wheels, which could possibly help in a crash, but to be honest I do not think it is worth the extra weight and worse aesthetics.

Notes:

The materials used to manufacture any of the three designs is preferably aluminium (as discussed in the feasibility study document)

The base of the vehicle can be made using plywood, chipboard, or something similar.

The lead time of these materials is negligible since it is made using standard off the shelf materials (lots of which are recycled and available immediately)

Comparison:

	Design 1	Design 2	Design 3
Cost	3	2	1
Manufacturability	3	2	1
Weight	3	2	1
Safety	1	2	3
Handling	2	3	1
Aesthetics	1	3	2
Modularity	1	2	3
Aerodynamics	1	3	2
Total	**15**	**19**	**14**

From these results we have a clear indication that design 2 is the favoured choice, the comparison matrix shows that it leads in handling, aesthetics, and aerodynamics. The design is a good balance between the very minimal design 1 and the over the top design 3, design 1 is very simple and would be very easy to build and maintain, however it would not be a challenge to build and it would not have good aesthetics. Design 3 on the other hand has too much engineering put into it and looks bad as a result. It would also likely suffer from being quite heavy and less manoeuvrable. Design 3 does however have good modularity as a result of the extra parts of the chassis.

Design 2 is in the middle with improved safety over design 1 and improved modularity due to the rear wheel covers of the chassis.

Another point to make is the design 3 may have issues with steering if the front wheel covers were not far away enough from the chassis. Design 2 however does not have this issue as the rear wheels do not turn.

10.12 – Chassis Subsystem Plan of Action

Team T.I.M Project – Chassis Subsystem Plan of Action

The following is the plan of action for the manufacture and implementation of the chassis subsystem from 22/12/2020 until completion.

Current progress:

- The draft and final designs of the chassis have been completed.
- The feasibility study is complete and can be amended if needed.
- Client need / requirements and PDS are complete.
- Evaluation and justification against PDS are complete.

Next steps:

- The team can be shown the results of my work in a meeting and we can agree on the precise course of action we will take.
- In general, the next steps are to research material prices and calculate how much material is needed to proceed with manufacture.
- Required components will need to be worked into the budget of £200 and this needs to be agreed unanimously with the team.
- Planning documents (Gantt chart, pert chart, and work breakdown structure) will be produced to lay out exactly what has to happen to achieve the end product on time.
- Testing and evaluation must come next to ensure the product is correct and fulfils the original customer requirements.

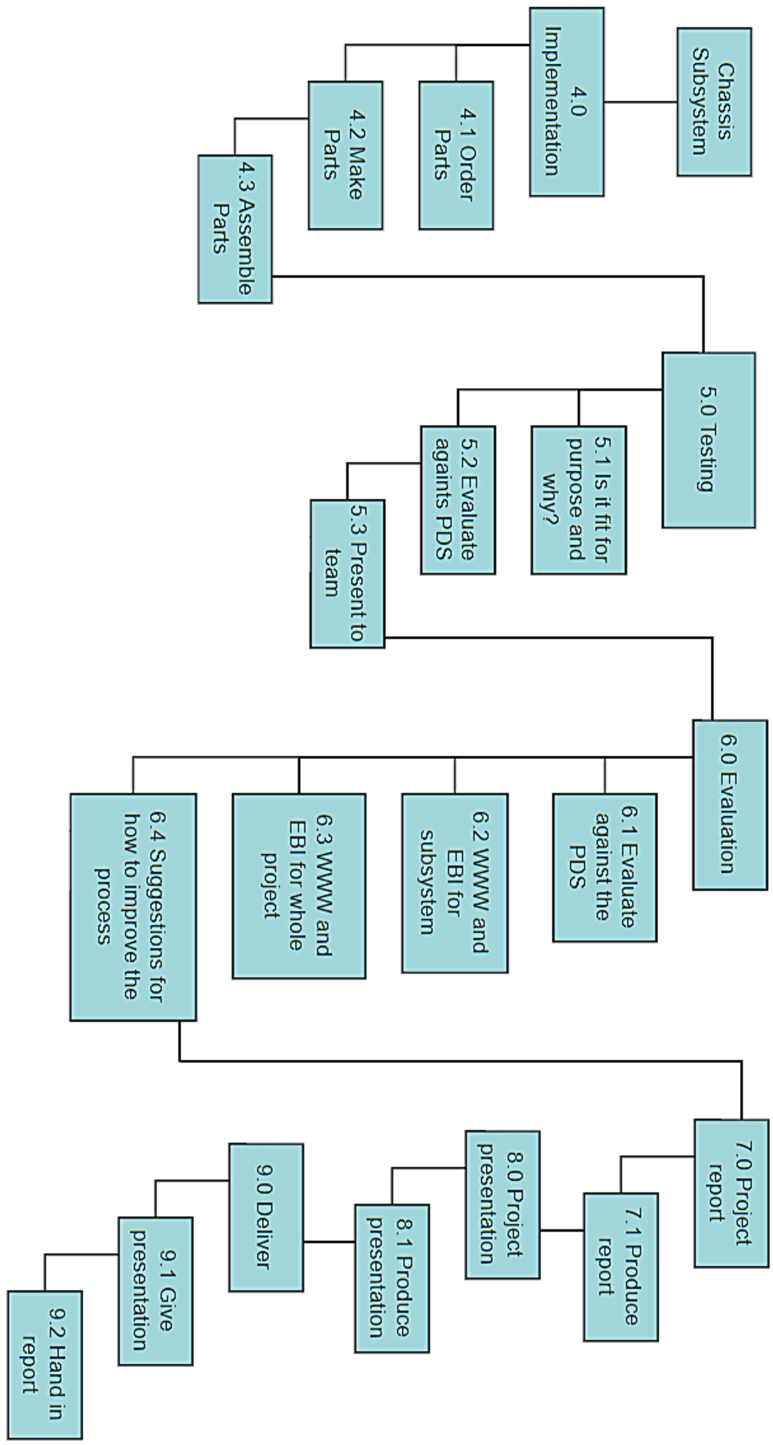
Am I on track:

- Currently yes, I have completed the documents up to this point and will be completing the Gantt chart and work breakdown structure afterwards in line with the main project Gantt chart.

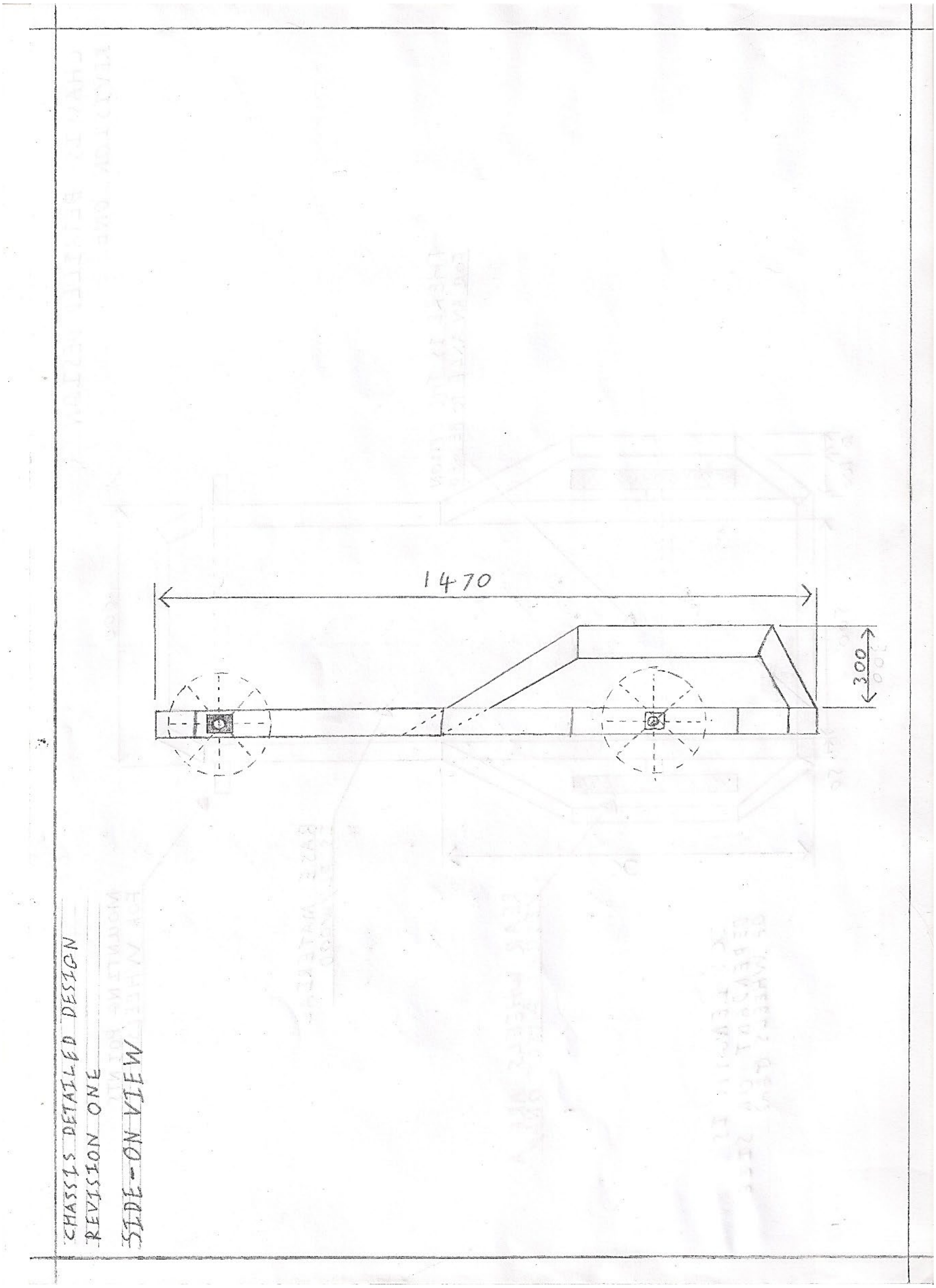
Is the team on track overall:

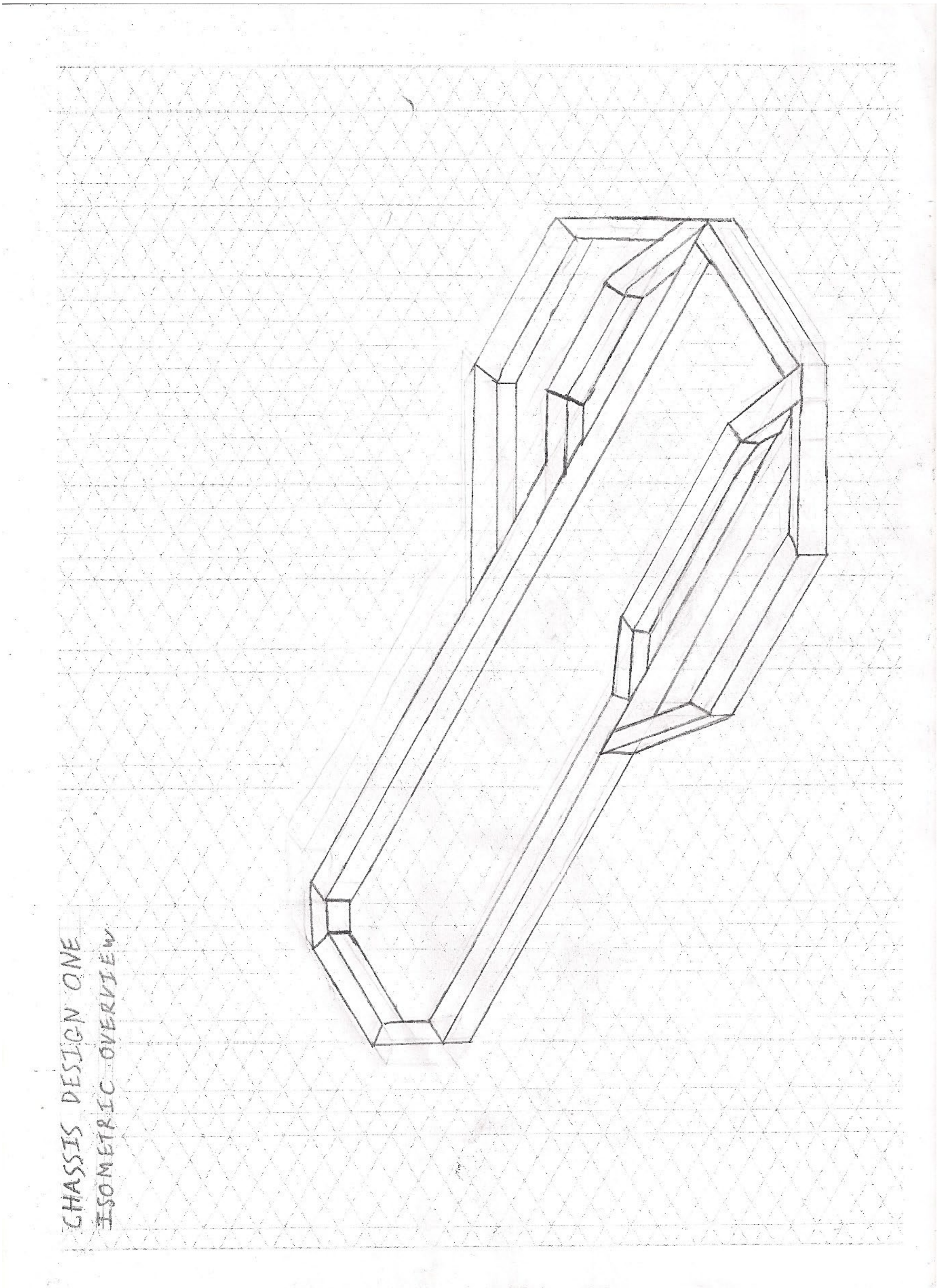
- Overall, we are slightly behind schedule however we are working hard to catch up again.

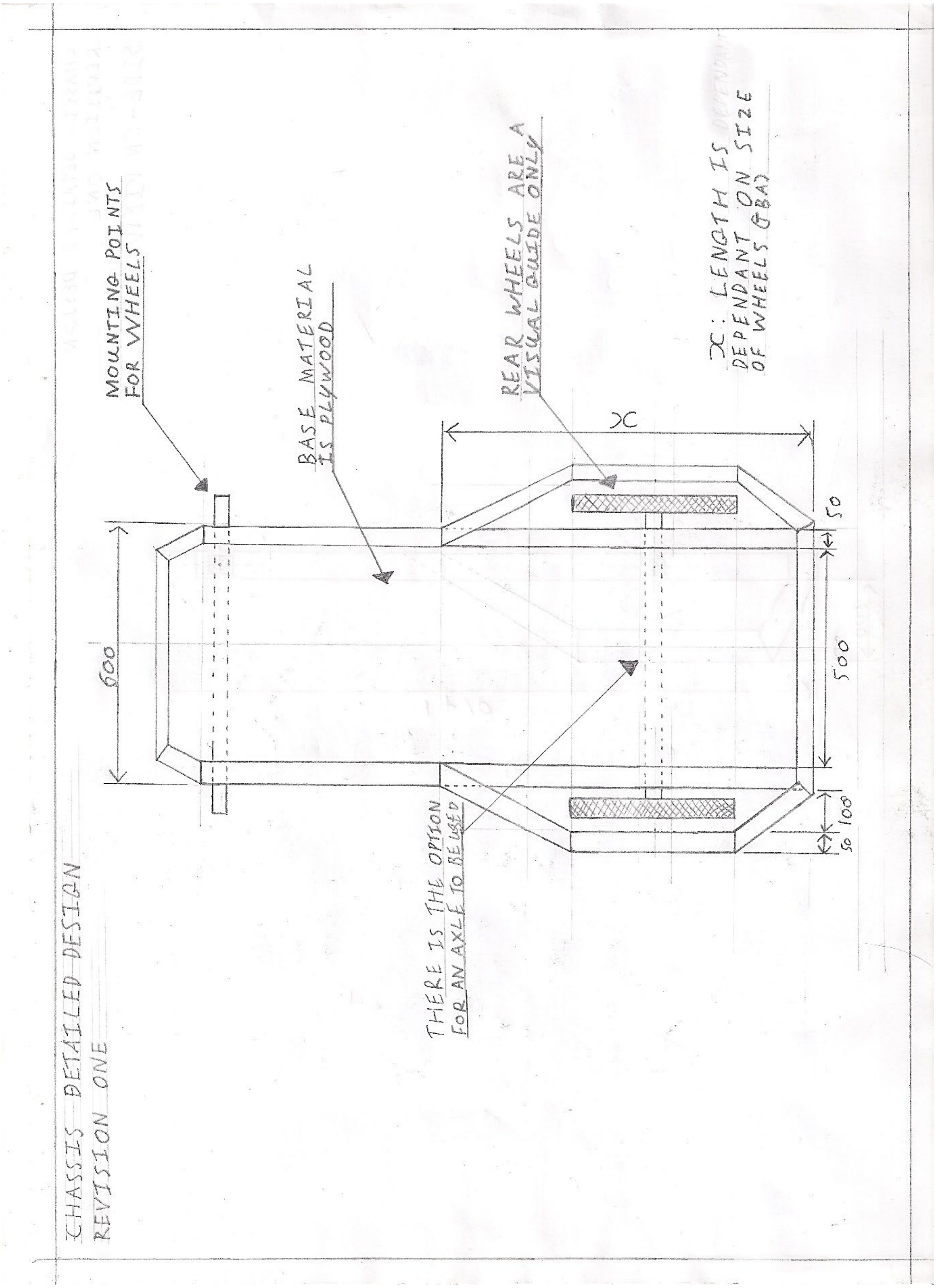
10.13 – Work Breakdown Structure



10.14 – Chassis Detailed Designs




CHASSIS DESIGN ONE
ISOMETRIC OVERVIEW


CHASSIS DETAILED DESIGN
REVISION ONE
MOUNTING POINTS FOR WHEELS
BASE MATERIAL IS PLYWOOD
REAR WHEELS ARE A VISUAL GUIDE ONLY
x : LENGTH IS DEPENDANT ON SIZE OF WHEELS (TBA)
THERE IS THE OPTION FOR AN AXLE TO BE USED
600
x
500
50
100
50

10.15 – Initial vs Final PDS

Inital PDS

1.0 Functionality (what the product should do)

1.1 The chassis needs to be able to drive down the Richards castle course without breaking.

2.0 Environmental conditions (dry/wet/windy)

2.1 The chassis needs to be able to withstand some bad weather for a while but it doesn't need to be completely weather-proof.

3.0 Size (a comment on size)

3.1 The chassis will be about the size of a standard go-kart.

4.0 Weight (a comment on weight)

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7.0 Reliability (comment)

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14.0 Compliance (what legislation/rules must be complied with)

14.1 The chassis will need to be compliant with the Richards castle rules and regulations.

15.0 Disposal (what happens after the race)

15.1 The vehicle will likely be used by one or all of us after the project. And we might put an engine in it.

Not all will be applicable – put N/A where not

Detailed PDS

1.0 Functionality (what the product should do)
1.1 Must not fall apart during service
1.2 Must be capable of driving
1.3 Must be manourverable
2.0 Environmental Conditions
2.1 Must be capable of withstanding rain for an hour
2.2 Must be capable of withstanding temporatures down to freezing
2.3 Must be capable of not coroding over time while covered
3.0 Size
3.1 Length must not exceed 2500mm
3.2 Width must not exceed 1500mm
3.3 Height must not exceed 1.5m
4.0 Weight
4.1 The chassis must not exceed 80kg
5.0 Aesthetics
5.1 The chassis does not have to be aesthetically pleasing however it would be be great if it was
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6.1 The chassis must be able to interface with the other subsystems
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7.0 Reliability
7.1 Chassis must not fail during normal use
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7.3 The chassis must have a lifespan of at least a year without being maintained
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14.0 Compliance
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15.0 Disposal
15.1 The chassis along with the rest of the vehicle will be kept at one of the team member's houses and will hopefully be fitted with an engine

10.16 – Richards Castle Technical Requirements

2 ***– Technical, Design and Structural Regulations***

If you have any queries or doubts when building or entering your soap box please call
Dave Pearce on 01584 876016

2.1 Maximum length 2500mm measured from front to rear of soapbox.
2.2 Maximum width 1500mm measured from outside to outside
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2.3 If you have a box that you think may exceed these dimensions please **contact us.**
2.4 Soap box can be fitted with 4,3,or 2 wheels, number of wheels will decide class and all wheels should be fitted with pneumatic tyres, (more than two "in line" wheels will not be allowed) and all wheels should be in road contact during normal running. **Ground clearance should be sufficient to clear the top and bottom of the starting ramp – 50mm minimum is recommended.**
2.5 Good brakes are essential and will be checked. If an axle has a braked wheel then both wheels on that axle should be braked. Both wheels must be braked on 2wheel soapboxes. Braking must be effective to hold the soapbox stationary on the starting ramp which has a gradient of approximately 1 in 8
2.6 Seats must be securely bolted to the soap box.
2.7 Soap boxes must be designed to carry one person only, in a feet first direction or in a traditional upright position if on a two wheeled entry
2.8 Any steering column, brake lever or other protrusion must be designed and fitted such that the risk of puncture injuries is minimised. A padded steering wheel/handlebar is recommended. Bar end-plugs are compulsory if handlebars are used.
2.9 Bodywork and controls must not impede the driver in exiting the vehicle unaided.
2.10 Any doors or hatches required for driver access must be readily operated from both inside and outside the vehicle without the use of tools.
2.11 Gravity propulsion only – i.e. no motors, no stored potential energy and no pedals used for propulsion, if two wheel soapboxes have pedals for support then chain must be removed.
2.12 No loose weights will be allowed inside or outside the soap box.

Richards Castle Soap Box Derby Rules and Regulations – 2020
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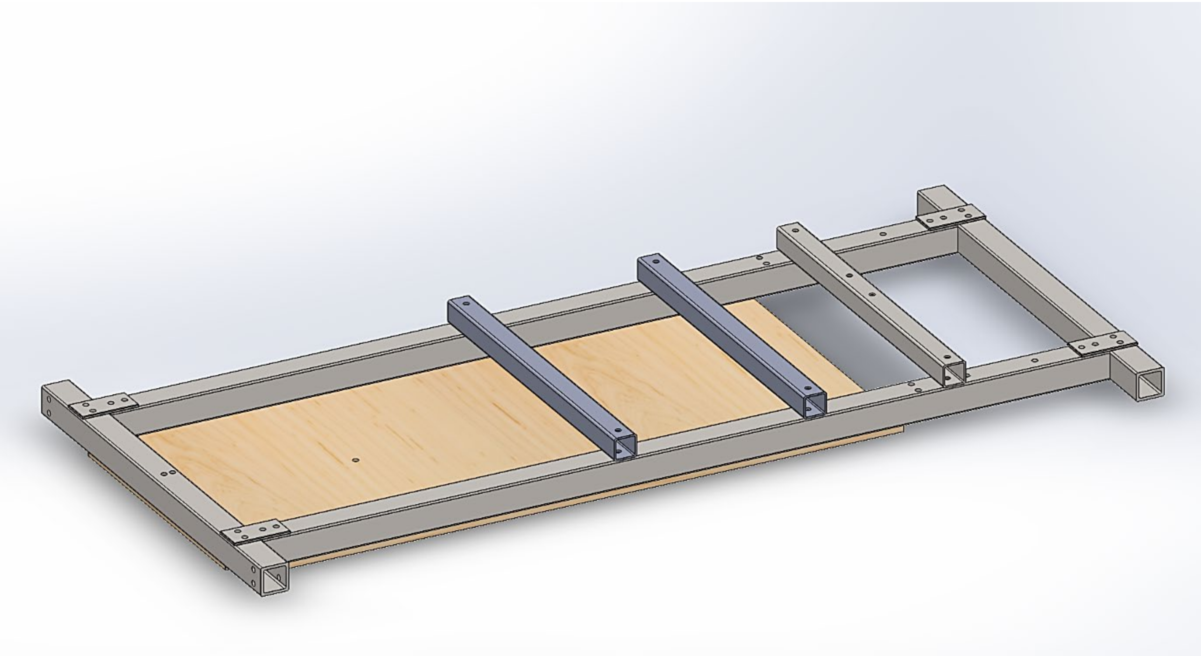
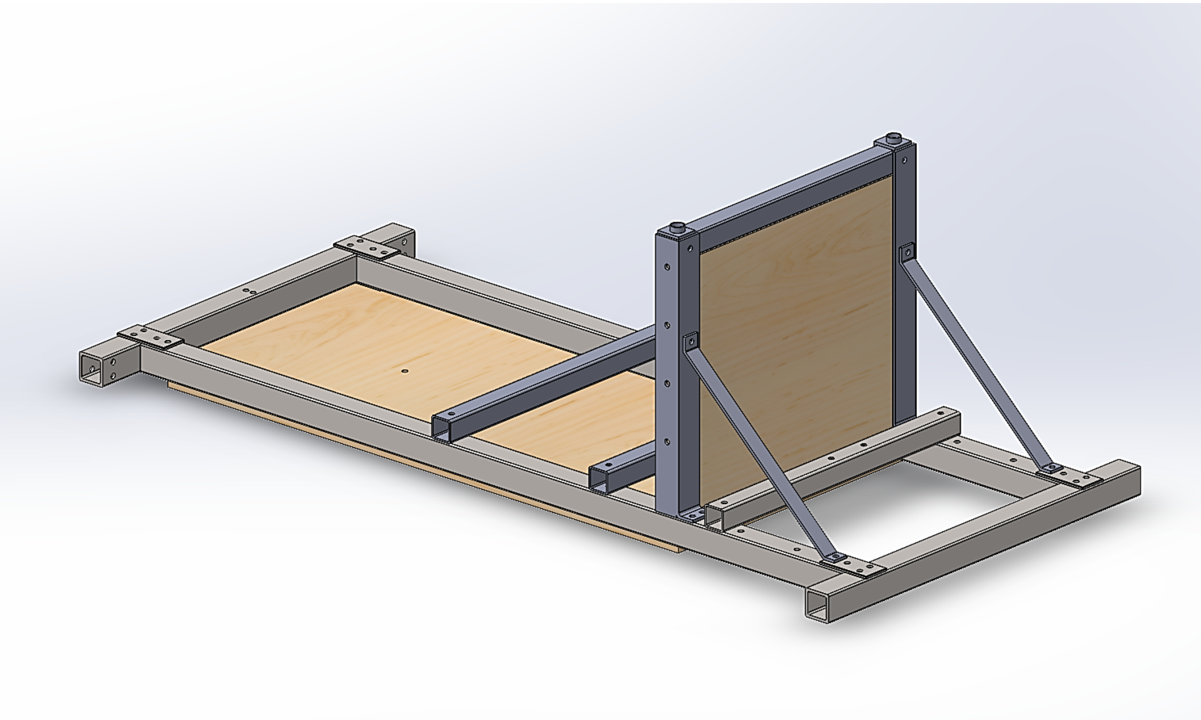
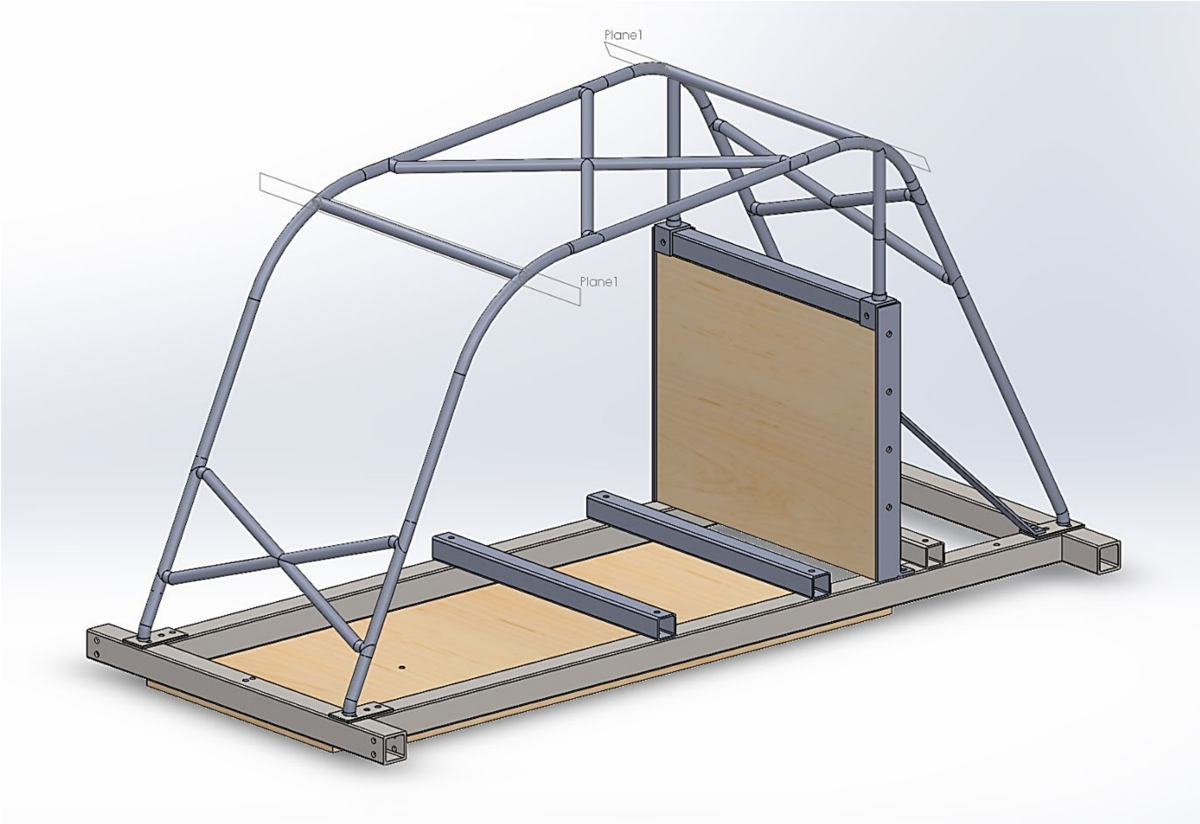
2.13 Seatbelts are highly recommended especially on heavier soapboxes.
2.14 All 4 wheel and heavy 3 wheel soap boxes must be fitted with a substantial roll bar. For soapboxes based on a conventional bicycle or tricycle frame a roll bar is not compulsory but a 3 wheeler constructed from tubular steel or similar then a roll bar is compulsory and must be of the specification as the 4 wheelers. (Please speak to Dave Pearce for clarification). All welding and general construction should be of a good standard. The roll bar should be suitably braced so as to adequately protect the driver in the event of a roll over. The roll bar should be at least 35mm above the driver's helmet when the driver is seated normally in the vehicle, and a second roll bar should extend at least 25mm beyond the driver's gloved hands when placed at 12 o'clock on the steering wheel. If you are in doubt as to what is 'substantial' please contact our scrutineer before or during construction so as to avoid disappointment on the day.
2.15 Steering must not have excessive free play or any characteristic tending to promote instability.

10.17 – Chassis SOLIDWORKS Cad Models



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