Fontys
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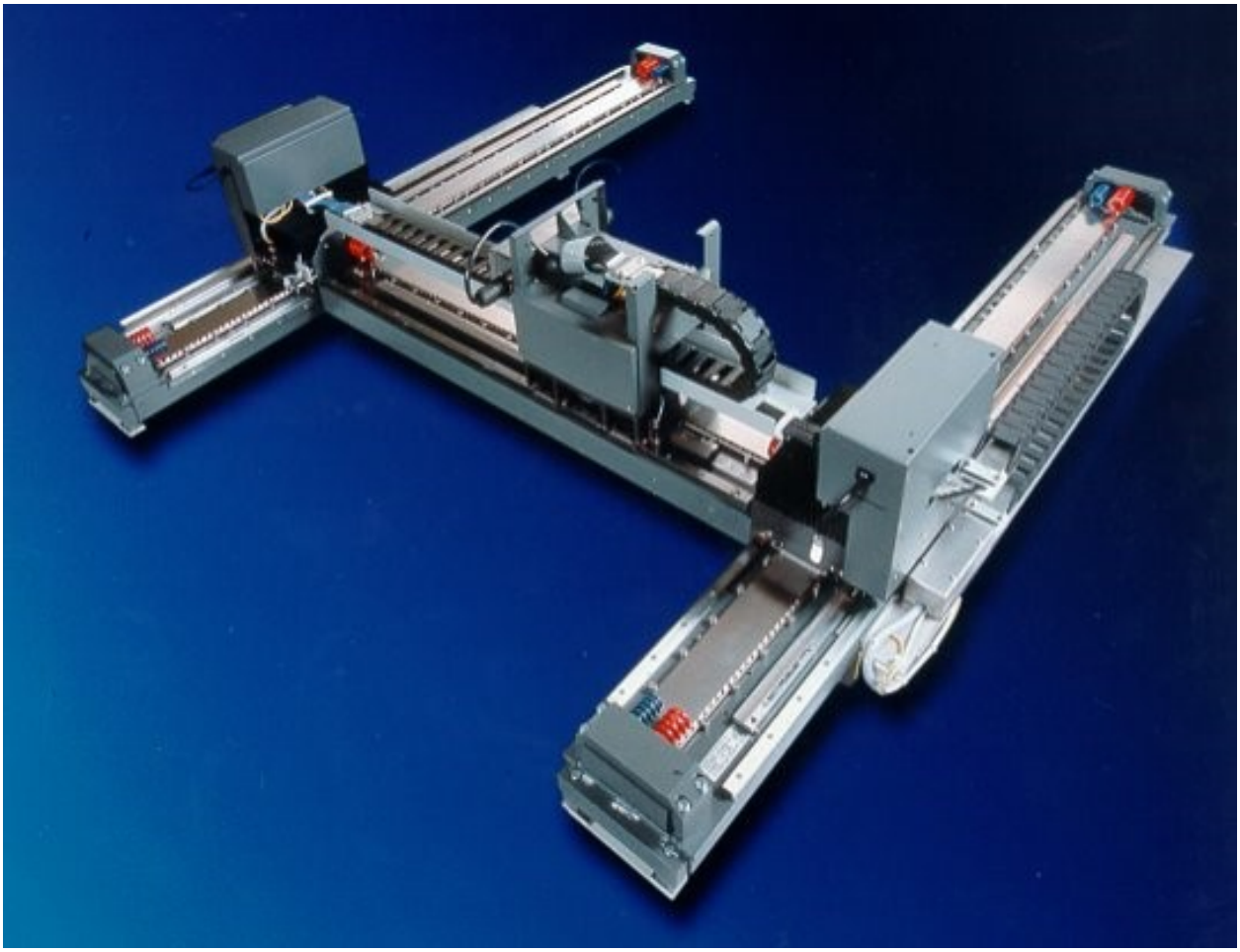
H-DRIVE PRECISION XY-STAGE CONTROL

— Plan of approach —



By: S7 Project Team
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1. Introduction

At the fourth year of their Mechatronics bachelor study, students at the Fontys University of Applied Science in Eindhoven go through a semester of theoretical and practical studies designed to specialize them in a mechatronics aspect of their choice (Advanced Motion Control, Adaptive Automation Systems, and Innovation Engineering). One of the requirements of this specialization semester, "Semester 7", is for the students to partake in a complex mechatronic project - the subject of this document. The project will take place during a full academic semester, in which a group of eight mechatronic students will carry out the development, restoration and revival of a planar positioning system known as "The H-Drive". Planar positioning systems are machines capable of positioning themselves (or an object) in two dimensions and are often used as part of an assembly line to arrange and assemble a product. This project is a continuation of the work performed by a previous team of engineers and those that came before it. Originally, the H-Drive was designed by the company Assembléon as part of a prototype for a high precision industrial pick-and-place machine for the assembly of printed circuit boards. However, throughout the years since its creation, the H-Drive shifted roles and was used for different research purposes, was relocated several times, and eventually found itself at the Nexus facility of Fontys Engineering in an inoperable condition (with a set of missing, malfunctioning, or outdated essential components). In working order, the H-Drive is a true, robust, mechatronic system and may therefore be beneficial for enriching the educational experience for students at Fontys Engineering and allow them to gain hands on experiences and visualize complex concepts in practice. The previous team took steps towards the restoration of the machine yet were not able to finalize the process in time and the system remains incomplete and out of order. It is therefore desired by the client, Mr. van Lierop that the current team will continue the efforts from where the previous team left and strive to restore the machine to working order.

As described in their project report [REF], the previous project team was confronted with a set of challenges hindering or limiting their achieved results. They mainly focused on realizing a safety system and protocols (requires finalization and refinement), developed a power division PCB with galvanic separation, and selected key hardware components based following research. By means of literary research, experimentation, consultation with industry experts, and utilization of the Agile project management methodology, the current project team must work towards the main goal of having the system ready for use with at least one working motor (X axis motor), along with proper documentation, by the end of "semester 7". Among others, the team will have to perform tasks such as finalizing the safety system, ordering / assembling system hardware, validating the built-in encoders, improving cable management, etc. Due to the complexity of the project, its dangers, and challenges, the team will maintain a realistic approach during the development. Through stakeholder involvement and consultation (i.e., client, school tutor) the project scope and its goals will possibly be adjusted or refined along the way to guarantee the feasible satisfaction of the involved parties.

The outline of the plan of approach document is as follows: The current chapter details the background of the project and serves as an introduction to the topics and questions discussed within it. Chapter 2 picks up the pace and dives into the definition of the project, elaborating on it with details such as its goal, justification, user-requirements, boundaries, and the desired result. In Chapter 3, the methodology of the project will be deliberated upon, along with explanations over its composing core phases. The fourth chapter covers the management and organizational processes of the project and its control factors (such as feedback, documentation, time, quality, utilized resources, etc.). Next, Chapter 5 provides the risks assessment for the project, followed by its budget and planning elements in Chapter 6. Finally, the 7th chapter of this document will conclude the plan of approach with additional clarifications and elaborations over the project and its team.

2. Project Definition

The mechatronics department of Fontys University of Applied Sciences in Eindhoven features a H-drive High-precision XY Platform for a couple of years. This precision platform was previously used as a prototype for Philips Pick-&-place machines. The development of this machine took place at the TU/e, after which it served as research material for a while. However, this machine became unnecessary for the TU/e, after which Fontys took the machine over. The aim of Fontys is to make this machine fully operational again so it can be used as teaching and demonstration material for control engineering courses. This project is the continuation of the work of previous teams who have worked on the H-drive.

2.1 Problem Definition

At this moment the H-drive is not operational wherefor it cannot be used for educational purposes. The system of interest is not safe, it is not possible to determine the position of the axes and the hardware is unsafe and not documented.

Safety of the machine is important for safe testing and operation. When the H-drive is operating it is dangerous to be close to the system because of the high speed and acceleration used in combination with the inertia of the machine which results in high forces. Further on, it is not possible to determine the position of the axes, which is needed to have a fully functional machine. In addition, the hardware is unsafe to work with, not documented, certain components are outdated, cables are not correctly wired, etc. A solution must be found for these problems in order to be able to make the H-drive High-precision XY Platform functional again.

2.2 Project goal

The final objective of the overall project is to get the system of interest, also known as the H-drive, fully operational again so it can be used for educational purposes. The final objective for this S7 project 2021 is having the system ready for use with at least one working motor (X axis motor). The final objective can be divided into the following sub-objectives: H-drive system meets all safety requirements, Implementation of measuring the position of the axes and clean-up of all the Hardware.

The objective “H-drive meets all safety requirements” will have the highest priority, as this is a crucial task to guarantee safety during testing and operation of the system. Previous teams focused on realizing a safety system and protocols which requires finalization and refinement. They decided to use a Safety Programmable Logic Controller (PLC) from Beckhoff, which will be used to complete this goal. The focus for this objective will be on the implementation of the hardware and the validation of the system, as well as finding out what the exact safety requirements are and how to meet them.

Thereafter the objective “Implementation of measuring the position of the axes” will have the second highest priority. Incremental encoders have been integrated into the H-drive, but it needs to be determined if those are still working.

Subsequently the objective “Clean-up of all the hardware” will have the third highest priority. To get the whole system working again it is important that all the hardware of the system is cleaned up and all the equipment used for the power supply and control of the system is safe to use. This is important to guarantee safety while the system is operating. The previous team made two panels which are easily accessible. One cabinet contains all the power supply units and the other contains all the units needed for the control of the system. Both cabinets are not closed off meaning everyone who passes by the machine can easily access the equipment which can be dangerous when they don’t know how the H-drive works.

Aside from the cabinets the unnecessary hardware should be removed from the H-drive and the cables should be examined and cleaned up in a neat way.

To achieve the final objective all the sub-objectives must be completed. If the team manages to complete the sub-objectives within the time given the team can focus on completing the final objective of this S7 project. The minimum goal of this project is to achieve all the sub-objectives, as there are a lot of risks which can cause delay in the planning.

At the end of the project a written report, research documents, codes of the system, manual of the system, dynamic model of the setup, electrical schematics, demo videos of the working setup and a presentation will be given to the tutor Chris Remmers and to the client Nelis van Lierop.

2.3 User requirements

Table 2.1: User requirements

#	Description	MoSCoW
	Safety Requirements	
UR.1	Safety Fence including protection against possible objects coming from the H-drive.	Must
UR.2	Door reedswitch	Must
UR.3	Emergency stop(s) placed within reach. Both within and outside the perimeter.	Must
UR.4	Safety light Red, Orange and Green.	Must
UR.5	Warning indentification for pototential dangers within the perimeter of the machine.	Must
UR.6	The door has to have a safety lock.	Should
UR.7	A safety protocol for using the machine has to be created.	Must
	Hardware Requirements	
UR.8	Improve the cable management of the machine	Must
UR.9	Fit the elektronics within a dedicated eletrical box(es)	Must
UR.10	Clean the three encoders	Must
UR.11	Remove obsolete elektronics from the machine.	Should
UR.12	Test the encoders for functionality.	Must
UR.13	Clean the bearings within the machine.	Must
UR.14	Make documentation of the hardware used in the machine.	Must
UR.15	Test safety elektronics.	Must
UR.16	Use a Safety PLC for the machine.	Must
UR.17	Connect an adequate real time Simulink controller.	Must
UR.18	Redesign the PCB for the for the interface print	Must
	Software Requirements	
UR19	Use original control software	Must
UR20	Write improved control software	Must
UR21	Program safety features within the Safety PLC	Must

Table 2.2: Stakeholders

Type of stakeholder	Name
Project owner	Nelis van Lierop
Motorcontrol Hardware/Software supplier	ProDrive
Safety manager Fontys	Ed Honing
Project tutor	Chris Remmers

2.4 Project Boundaries

Inside the scope:

- **Creating safe working conditions:** The first tasks to be performed will be about "Safety". This includes all tasks that ensure that working on the set-up can be done safely. These tasks include integrating a safety PLC, fitting a lock on the door and redesigning the electricity. For the client, safety is an important part and is preferred over a fully functioning machine.
- **Research into the functioning of the encoders:** After that, the status of the current encoders on the XY stage will be determined. Since there are long delivery times on parts, this is important to carry out in the beginning. Measurements will be taken with an oscilloscope to determine if the encoders are functioning properly.
- **Performing a hardware clean-up:** A hardware clean-up will then take place. During this clean-up, all hardware in and around the machine is checked. Any unnecessary parts will be removed or replaced.
- **Make the X-axis functional:** Finally, there shall be looked at making the X-axis functional. Before starting this task, sefety must be in order and a hardware clean-up must be performed.
- **Calibration of encoders:** The current incremental encoders need to be calibrated before they can be tested. Without calibibration of the encoders it's not possible to ensure that they work properly. Also the Heidenhain encoders need to be calibrated when they are implemented on the H-drive.

Outside the scope:

- **Create a manual for using the XY stage:** For the current project, a manual will be superfluous as the machine will not be fully functional by the end. However, some sub parts will fully work at the end. Therefore, the documentation during the project is sufficient to allow the next project group to continue.
- **Redesign of primary components:** The project group tries get the subcomponents working with the components that are currently present. Since the XY stage is mechanically very complex, it will not be possible to redesign critical parts. These parts are for example the motors, guide and the base.

The client has indicated the priority of the various tasks. This showed that the client prefers the full functioning of the safety system and good documentation. Since the documentation has been deteriorated in previous years, it is important to document everything properly this year and verify it with the client.

3. Phasing

3.1 Agile method

Agile is a methodology used to manage a project. The methodology uses four values and twelve principles to organize the project. The four values of Agile are:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

The method works with short- and long-term sprints (tasks) and the execution of those. After every sprint the results will be checked to see if they fulfill the requirements of the task. This results in a high level of customer involvement because every sprint will be reviewed by the team members as well as the customer(s).

A benefit of this method is it makes it possible to adapt and mature the project plan and design throughout the project. For example, if some requirements would change the agile method makes it possible to easily adapt to those changes. In conclusion, this approach of project management ensures that the project team can consistently deliver products and tasks without any delayal by new or amended requirements.

The agile method states a certain number of basic rules the project team must follow. Therefor these methodology basics are included in appendix A.

3.2 Scrum method

Scrum is an evolution of agile management. It's based on a set of defined practices and roles. These things must be involved during the project. The Agile methodology basics are the foundation of the scrum method. All team members should be content with using scrum to make it as effective as possible.

Within the scrum method every team consists of three different roles.

- **Scrum master:** the scrum master is the person that leads the team and guides the team members to comply with the rules and processes of the method. The master also tries to keep everybody motivated and eager to improve the product.
- **Product owner/Client:** the client is the person that representants the stakeholders of the project. Their task is to translate the vision of the project to the team. They are also responsible to inform the project group if any requirements would change.
- **Team:** the team consists of a group of professionals with the necessary technical knowledge who will develop the project. Every team member should commit to every sprint in the same way.

3.3 Project sprints

This project will consist of 5 main sprints. Every sprint will have a timeframe of four till six weeks. the length of the sprint is based on the number of tasks to be done. Some sprint will run parallel to each other. This is the case because the project team has eight members, so they will be divided into two groups of four people. The main sprints of the project are:

- Project orientating (4 weeks)
- Safety (4 weeks)
- Positioning and measurements (6 weeks)
- Hardware cleanup (4 weeks)
- X-axis functional (6 weeks)
- Verification & Validation (2 weeks)

Phase I - Project orientation

The first sprint of the project is project orientation. Since the project has been running for several years, it is important that all old documentation is searched, organized, and supplemented. In addition, it is important that the project team knows how the machine works and how everything is connected. In this way, the project can be successfully proceeded after this sprint. Every group member will be working on this sprint as the entire team needs to know what has to be done and how the machine is put together.

Phase II - Safety

Once the first sprint has been completed, the safety phase will begin. During this phase, the focus of the project will be on how to use the machine safely. In addition, it is important that the regulations, regarding safety, are met. For example, part of this sprint will be to tidy up the cage around the machine. This is currently already present, but the requirements have not yet been met. There will also be research into things that can go wrong so that those can be prevented. Since safety is very important, four full weeks will be spent on this sprint. As mentioned before, the safety of the project is very important. Therefore, this task requires a minimum of four people to complete the task.

Phase III - Positioning and measurements

During this phase, the focus of the project will be on the positioning of the stages. It is very important in the later sprints that these elements work fully. Within this sprint, for example, the encoders will be tested. If these are defective, a solution will be devised as soon as possible. Placing new encoders is a difficult task, as they are incorporated in the linear rail. Therefore, this sprint will be started as early as possible, possibly already parallel to another sprint. During this phase, the PLCs will also be worked on so that they are working. This will be combined with the safety in connection with the safety PLC. This sprint requires four people and can therefore easily be performed simultaneously with the safety phase. For this sprint 6 weeks has been calculated as it can be a lot of work if the old encoders do not work.

Phase IV - Hardware cleanup

The fourth sprint will be devoted to redesigning the machine. This therefore concerns the electrical, mechanical, and old components. At the moment there are still a lot of old parts in the machine. These will be removed and replaced if necessary. In addition, all electrical parts must be rewired as this is currently very messy. This task will be performed by about four people; therefore, this task will have some overflow with the previous sprint. If it is concluded in the previous sprint that the encoders need to be replaced, this will be a task that is partially performed in this phase. That is why six weeks have been planned for this task so that there is room for delay.

Phase V - X-axis functional

The fifth sprint concerns getting the X-axis working. As soon as all previous sprints have been performed, this can be started. A lot needs to be done to make sure the X-axis is functional. Think, for example, of writing the software, the communication between the drivers and the control system. Since this sprint

contains so many tasks, almost the entire project team will be working on this. The communication between Prodrive and the project team is very important during this phase. Prodrive has experience with motor drivers. In addition, they know a lot about high-speed systems. This can be very helpful during this sprint. Most costs will probably be incurred during this phase. All purchases must be carefully discussed with the client and the supervisor so that no bad purchases are made. As soon as the X-axis is functional, it must be tested. This takes a lot of time, which is why six weeks have been scheduled for this phase. The previous sprints may have been completed earlier, if this is the case then more time will be available for this task.

Phase VI - Verification & Validation

The project will be completed during the last sprint. This includes testing the X-axis, completing the final report, and verifying the requirements. A presentation will also be prepared during this phase. This must be presented at the end of the project.

4. Project Control

This chapter will function as an overview of the project organization and management which will ensure that the project can be carried out in a well-ordered manner.

4.1 Organization

Client:	Nelis van Lierop
Company:	Fontys University of Applied Sciences
Project Lead:	Kevin Vos
Group Members:	Teun Wijfjes Karlijn Seelen Elfiera Wiriaatmadja Or Efrima Collin Raaijmakers Roderik Tiebosch Toby van Dueren den Hollander
Project Tutor:	Chris Remmers

More contact information can be found in the General information section at the start of this document.

4.2 Time & Planning

The project will be carried out for seventeen academic weeks, starting from the 13th of September until the 28th of January. The detailed planning and phases following this time course is mentioned in Chapter 3.
The project sprints are organized on a web-based collaboration tool called *Trello*, as seen in Figure **??**. Throughout the course of the project, several deliverables are expected by the proposed deadlines, which is explained in Chapter 6.

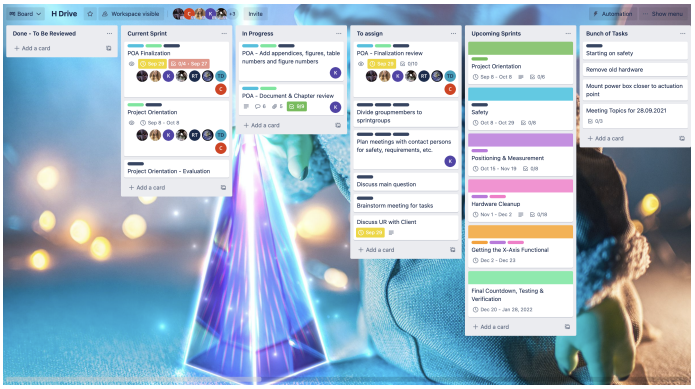


Figure 4.1: Trello screenshot

4.3 Project procedure

To ensure the project stays on schedule, reporting and consultation routines are set for the project. These are listed below:

1. **Project tutor meeting:** The project tutor will be informed about the status of the project on a weekly meeting. The meeting is set every Tuesday at 09:30 This makes sure the project tutor has a profound vision of the progress of the project.
2. **Client meeting:** There are several requirements and agreement set by the client. A meeting with the client will be set up after each requirement milestone has been achieved or if the presence of the client is needed.
3. **Group member meeting:** The group member meeting is set to be every Wednesday at 10:00. After the meeting, group members will proceed to work on the task for the week. The length of this groupwork is dependent on the project planning and task load of the week.

Deliverables Quality Assurance

Several guidelines are set as a mean to guarantee the quality of the project deliverables. Ultimately, the project must deliver practical simulations and solutions as well as the documentations.

Product

To ensure the quality of the product, some guidelines are set:

- The physical product and simulations must meet the requirements set in this document.
- To ensure safety, a qualified party must be present during testing on the physical machine.
- System testing will be carried out at the end of each requirement milestone for the client to validate before carrying on to the next milestone.

Documentation

To deliver sufficient documentation for the project, some guidelines are set:

- All documentation related to the project will be stored on the project group onedrive folder.
- Documentations are stored in their respective folders in the onedrive. This allows group members can easily track and review these documents throughout the course of the project.
- At the end of the project, a final report should be written. The report should cover all progress, solutions and recommendations for the next group who will carry on with the project.

5. Risks

It is important to take risks into account for a complex project. Managing risks at an earlier stage will ensure that there are no unexpected hiccups in the progress of the project. The effect of risks coming into play should be minimized as much as possible. Therefore, steps need to be taken in order to reduce the chance of a risk occurring. The higher the risk score, the more chance there is that it will incur a substantial project delay.

5.1 Process risks

Ongoing risks should be noticed as early as possible. This will make sure that action can be taken against this risk in order to minimize the damage to the project result. Risks that can occur during this project are as follows:

- Not enough time. Not having enough time for reaching the project goal will be devastating for the project result. It is possible that not all of the user requirements will be met and the project result is insufficient as a result of this.
- Absence certified person installing/handling of safety equipment.
- Insufficient support external experts. External support might be needed in the project for controlling the dedicated hardware.
- Late arrival ordered products.
- No clear project objective. The objective of the project and tasks within the project should be clear to all project members. Project members will work towards a goal that is not clearly formulated according to their beliefs causing problems reaching the correct goal.
- Unreasonable deadlines. Deadlines set by project members or project tutor should be realistic. Tasks might accumulate over time.
- Unclear or not complete previous project documentation.
- Incomplete project planning. The planning should be complete with enough segregation in order to get a complete picture of the entire project. It will be important to spend a considerable amount of time in the beginning of the project to ensure that a feasible planning is made and can be pursued by all the project members.
- Further COVID-19 lockdown procedures. There is a slight chance that there will be more infections after the easing of current lockdown procedures.
- Communication problems. Communication problems take time to solve. It is possible that project members get a task assigned that he or she is unaware of.
- Absence project members. Project members can become sick or miss a train or bus. This can have an impact on the task that the project member is working on.
- Absence project tutor. The absence of the project tutor can be detrimental to the progress of the project.

5.2 Risk classification

The risks mentioned in this chapter should be classified by means of risk priority. The higher the risk priority the more chance there is that the risk can occur and have dangerous consequences for the project result. The following formulas are used to calculate the risk priority and risk degree.

*Risk degree = risk impact * probability*

*Risk priority = risk impact * vulnerability*

Table 5.1: Impact scale

Rating	Name	Progress loss
5	Extreme	More than one month
4	Major	Two weeks to a month
3	Medium	One to two weeks
2	Minor	One day to one week
1	Incidental	Less than a day

Table 5.2: Probability scale

Rating	Name	Chance of occurrence
5	Extreme	75 - 100%
4	Major	50 - 75%
3	Medium	25 - 50%
2	Minor	10 - 25%
1	Incidental	0 - 10%

Table 5.3: Vulnerability scale

Rating	Name	Description
5	Extreme	Disastrous for project result
4	Major	Project result at serious risk
3	Medium	Project result at risk
2	Minor	No severe damage to project result
1	Incidental	No lasting damage for project result

Table 5.4: Classification scale

Process risk	I	P	V	Risk degree	Risk priority
Not enough time	4	3	5	12	60
Absence certified person	3	2	5	6	30
Insufficient support external experts	3	2	3	6	18
Late arrival ordered products	3	2	2	6	12
No clear objective	2	2	3	4	12
Unreasonable deadlines	2	3	2	6	12
Unclear previous project documentation	2	3	2	6	12
Incomplete project schedule	2	2	3	4	12
Lockdown procedures	1	2	4	2	8
Communication problems	1	2	2	2	4
Absence project members	2	2	1	4	4
Absence project tutor	2	2	1	4	4

5.3 Risk reduction

The following measures can be taken to reduce the chances of a risk occurring in the first place.

- **Not enough time.** Proper task division will ensure that all the project members have an even workload. This is essential for using time in the most optimal way. Weekly progress meetings are needed to keep a close eye on the progress of the project. Realistic goals should be made and discussed with the client when necessary.
- **Unreasonable deadlines.** Tasks can take longer than what was foreseeable. It is therefore necessary to take slack into account with tasks that have an uncertainty of time to complete.
- **No clear project objective.** The project should be very clear at the start of the project. The project members should arrange meetings with the client and project tutor so that everyone is on the same page. The goal of the first pair of meetings is to get a clear view of the project and what is to be expected of the project members. Questions that arise about the project definition should be asked in the beginning of the project.
- **Communication problems.** The communication lines within the group should be kept short. There should be no hesitation to ask questions in the project group and to ask for elaboration on a particular subject. These questions should be tackled as soon as possible such as during the meetings or right after.
- **Incomplete project planning.** A clear goal should be established from the start of the project, without it a complete project planning is out of the question. Ensure that enough time is spent on segregating tasks and having a clear picture of how to work towards a goal. The planning should be evaluated every progress meeting, changes should be made if needed.
- **Absence project members.** Planning with absence of project members in mind is necessary per task. This can mean assigning multiple project members on a task or assigning a substitute project member per task.
- **Absence project tutor.** The role of the project tutor is to keep the progress of the group in check and recommend changes when required. The project members should have a clear planning of the project. In case of absence of the project tutor the group should arrange a meeting to assess progress and to see if changes to the planning should be made.
- **Insufficient support external experts.** The system contains state of the art new Prodrive products. Project members need to get familiarised with these products by means of datasheets and product pages. It is essential to establish clear expectations
- **Further COVID-19 lockdown procedures.** With the easing of the current lockdown procedures there is a possibility of a new infection "wave". The project members should be notified if anyone has symptoms within the project group. Self-tests are available via https://www.zelftestonderwijs.nl/ allowing for regular preventative testing.
- **Late arrival ordered goods.** It should be clear what needs to be ordered in the beginning of the project. Products can be ordered earlier so that arrival times should not interfere with the project planning. With the worldwide chip shortage there should be extra caution of the lead time for ordering chips.
- **Absence certified person installing/handling of safety equipment.** Installing the safety equipment should be done earlier on in the project to allow slack in the planning before the safety equipment is actually needed.
- **Unclear or not complete previous project documentation.** It is possible for project members to contact the old project groups and the client for elaboration on certain parts of the project.

6. Budget & Planning

Managing the budget and the planning of a project beforehand is always difficult. The budget is a crucial part for the client. The planning is needed for a clear overview of what needs to happen at what moment. It also helps to assess the goals of the client that needs to be achieved within the project duration.

6.1 Budget

The budget for this project is set at €3.000. Currently, it is uncertain to say what part of the budget will be used. This is highly dependent on certain factors such as proper functioning of the incremental encoders and quality of electrical/mechanical work provided by previous project groups. At the start of the project the encoders will be tested. A meeting with the client will be planned if the encoders do not function as intended, new encoders will be a big investment and a huge risk for the functioning of the machine. Based on the reports of previous projectgroups an overview has been created with possible components that needs to be bought for this project which is found in Table 6.1.

Table 6.1: Possible future spendings of budget

Description	**Quantity**	**Price**	**Total price**
Electrical cabinet 800x800x400mm	1	€320,00	€320,00
Phoenix connector for Prodrive Arcas controller	1	€3,04	€3,04
Sub-D15 cables	3	€6,75	€20,25
Braided earth lead	2	€6,21	€12,42
Total			€355,71

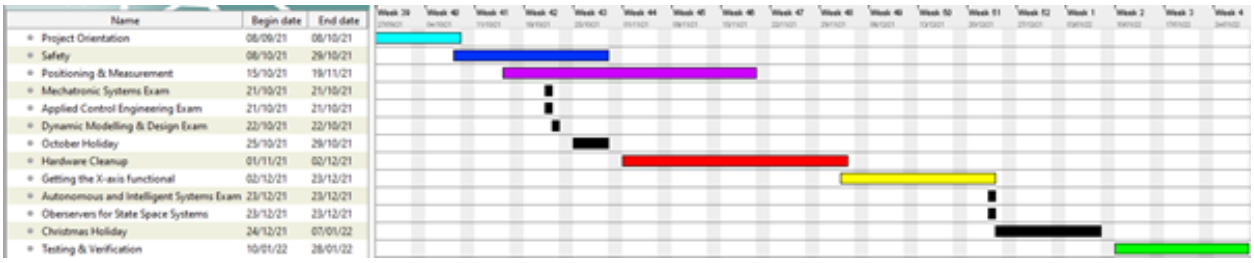
6.2 Planning

The project group has chosen to apply the agile framework with Scrum. The Scrum method consists of "sprints" in which multiple tasks are completed within an agreed upon time. The project group holds progress meeting to discuss the tasks and to see the progress of the current sprint. The project is split up into six main sprints. The names and start and end dates of the sprints are defined in Table 6.2.

Table 6.2: Sprint dates

Sprint name	**Start date**	**End date**
Project orientation	08-09-2021	08-10-2021
Safety	08-10-2021	29-10-2021
Positioning & measurement	15-10-2021	19-11-2021
Hardware cleanup	01-11-2021	02-12-2021
Getting the X-axis functional	02-12-2021	23-12-2021
Testing & verification	20-12-2021	28-01-2022

The Planning is visualized as a Gantt-chart in Figure 6.1 to clearly show the overlapping of the sprints. Holidays and exams are also accounted for in this planning.



Name	Begin date	End date
Project Orientation	08/09/21	08/10/21
Safety	08/10/21	29/10/21
Positioning & Measurement	15/10/21	19/11/21
Mechatronic Systems Exam	21/10/21	21/10/21
Applied Control Engineering Exam	21/10/21	21/10/21
Dynamic Modelling & Design Exam	22/10/21	22/10/21
October Holiday	25/10/21	29/10/21
Hardware Cleanup	01/11/21	02/12/21
Getting the X-axis functional	02/12/21	23/12/21
Autonomous and Intelligent Systems Exam	23/12/21	23/12/21
Oberservers for State Space Systems	23/12/21	23/12/21
Christmas Holiday	24/12/21	07/01/22
Testing & Verification	10/01/22	28/01/22

Figure 6.1: Ghant-chart planning

7. Bibliography

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A. Agile Methodology basics

Agile Methodology basics

- The highest priority is to satisfy the client throughout the hole project. This means that the client should receive deliverables of the sprint results so they can comment on the results.
- Welcome changing requirements, even late during the project. This principle makes sure that the project can be adapted to changes.
- Deliver sprint results frequently, from a couple of days to a couple of weeks. Depending on the task. The preference should be for short timescales so any needed changes can be implemented directly.
- The agile principle states that communication with all stakeholders is critical during the project. Commonly, this involves a weekly short meeting with the project team and any stakeholders.
- The project should be built around motivated individuals. It's important that everybody receives the support they need. If necessary, a project leader can be chosen to motivate everybody.
- The method of trading information to other team members should be preferably a face-to-face conversation. This will make sure that the communication is the most efficient and effective.
- The agile methodology aims to provide complete and working sprint results. This goal should always come first. The other requirements such as project documentation become second.
- During the project there should be continuous attention to improve the product, after each sprint there should be a drive to improve the previous one.
- The methodology states that the project should aim to get enough done to complete the project.
- Agile is based on the belief that you need motivated, autonomous, and skilled teams to be able to deliver the best results and products. To achieve this the members should have the freedom to innovate as they see fit.
- The team should have regular reviews on the performance and results, this will trigger team members to speak freely and discuss possible problems.