Project Plan

Autonomous Truck with Trailer

December 15, 2022

Version 0.2

ADAPT™

Status

Reviewed	Emil Wiman	2022-09-21
Approved	Shamisa Shoja	2022-09-21

Project Identity

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DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
0.1	2022-09-16	First draft	A.Sundstedt, T.Johansson	E.Wiman
0.2	2022-09-21	Second draft	A.Sundstedt, M.Axelsson, T.Johansson	E.Wiman

1 WHO IS THE CUSTOMER

The customer for this project is the examiner Daniel Axehill, who orders the product via another customer named Shamisa Shoja. Both Daniel and Shamisa are working at the division of Automatic Control at the Department of Electrical Engineering (ISY) at Linköping University.

2 AN OVERVIEW OF THE SYSTEM

The system is integrated on a miniature LEGO© truck with a trailer, which is equipped with a Raspberry Pi and a LEGO© EV3 unit. Previously, testing has been performed in a simulation environment and later been investigated inside the visualization arena *Visionen*, at Linköping University. The entire system is developed in the Robot Operating System (ROS1), which mostly uses the programming languages C++ and Python. To provide the system over different operating systems, Docker is used to enable developers to use the correct Linux Ubuntu version (20.04). Docker delivers software from a desired operating system in packages via OS-level virtualization, which makes every user run the same distributed system.

2.1 Purpose and goal

The purpose of this project is to develop an advanced driver support system, which provides a secure and effective way to navigate the truck in an environment with both static and moving obstacles. To do this, the goal is to increase the ability to maneuver in a terrain with moving obstacles and investigate how to handle the planning effectively. This is done to create a robust system, that can be used to demonstrate the division's research within autonomous vehicles and for education in advanced automatic control courses at Linköping University.

2.2 Deliverables

After the completion of the project, necessary documents and commercial content will be delivered to the customer. The documents and commercial content can be seen in Table 1.

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Table 1: The table specifies the documents that are to be delivered and their respective format.

Deliverable	Format
Requirement Specification	PDF
Project Plan	PDF
Time Plan	PDF
Design Specification	PDF
Test Plan	PDF
Test Protocol	PDF
Meeting Protocol	PDF
Time Report	Excel Document
Protocol of Toll Gates	PDF
User Manual	PDF
Technical Report	PDF
After Study	PDF
Poster	PDF/Physical
Project Movie	YouTube Video
Webpage	Electronic

2.3 Limitation

The project's limitations are mainly the project time and the resources. The existing hardware will be used and cannot be swapped to other resources. Additionally, no development of any vision system will be done, which would be needed in a real-world scenario.

3 PLAN FOR PROJECT PHASES

The project consists of three different phases, before, during and after. In this section the different phases are described.

3.1 Before start

In this phase the project is planned. For a detailed plan over the activities see Section 11. A Requirement Specification and a Design Specification will be written.

3.2 During the project

In this phase the more practical part of the project is executed. A more detailed version of the Design Specification will be written during this part and the requirements set in the Requirement Specification will be solved. If any requirements cannot be resolved there will be a renegotiation during this phase.

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3.3   After the project

In the after phase the project will be delivered to the customer and the project will then be closed. An evaluation of the project will also be a part of this phase.

4   ORGANIZATION PLAN

This section describes an organizational plan of the project and explanations of the different roles and responsibilities.

4.1   Organization plan and its roles

The organizational structure of the project is presented in Figure 1. The core is the project group, which includes all the group members, including the Project Leader. As the chart shows, the Project Leader mediate between the project group and the orderer. Preferably, the Project Leader communicates with the orderer and the customer, but it is possible for all the group members to lead a discussion as well.

The supervisor is the one providing technical expertise for the project. The supervisor can consult a real expert for more details in a question. The project members can also consult an expert directly for further details, especially if the supervisor lacks that specific knowledge or if the supervisor does not have the time to answer the question.

The customer in this particular case is the same person as the examiner. The customer is the person that initiated the project, as well as, the person that has the final word if the project meets the initial requirements. The customer intercede with both the Project Leader and the orderer.
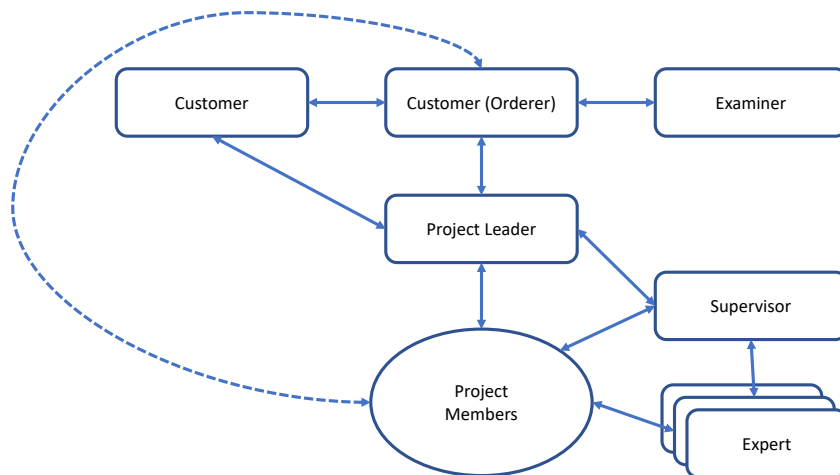

Figure 1: The organizational structure of the project.

4.2   The customer organization

The customers and the supervisor of the project all work at the division of Automatic Control (ISY). ISY is a large and established department at Linköping University that focuses on education and research. The department is, in addition to Automatic Control, also active in Communication Systems, Computer Engineering, Computer Vision, Information Coding, Integrated Circuits and Systems, Vehicle Systems and Administrative management.

4.3   Conditions for the cooperation in the project group

During the examination periods, it is not expected from the group members to work on the project. Group members only work during this time on their own initiative. Each individual is responsible to make up for the lost time during the examination period. It is not mandatory to work during weekends, but it is required if work needs to be done. Meeting forms are individually determined from occasion to occasion. Meetings can be in distance, hybrid or onsite.

4.4   Definition of work contents and responsibilities

This section specifies the different roles that are used during the project.

4.4.1 *Project Leader*

- Taking initiatives and making decisions.

- Maintaining contact with both customers and orderer.

- Dividing the work.

- Planning and leading project meetings.

- Making sure that the project is completed.

4.4.2 *Document Manager*

- Making sure that all the documents have the same structure.

- Providing document templates.

- Informing the group of the standards that are used and making sure that written documents fulfill these standards.

- Creating routines for handling documents.

4.4.3 *Test Manager*

- Making sure that tests are constructed.

- Making sure that the tests are completed.

- Evaluating the tests.

4.4.4 *Design Manager*

- Defining guidelines for the design.

- Deciding on how to build on the previous project work.

- Making sure that the design holds the principle.

4.4.5 *Software Architect*

- Making sure that the code follows the standard.

- Making sure that the version is correctly used.

5   DOCUMENT PLAN

When the project is completed, the documents and documentation stated in Table 2 will be produced. All the documents will be produced in English. Involved parties are the Project Group (PG), Orderer (O) and the Customer (C).

Table 2: The table showcases documents needed for the project, the purpose and when they are ready for delivery.

Document	Purpose	Target	Ready
Requirement Specification	Defines in concrete manner **what** the project should achieve, with specifications on the system and included subsystems.	PG, O, C	2022-09-21
Project Plan	Describes **how** the project will be executed. Including activities, delivers and involved parties.	PG, O	2022-09-21
Time Plan	Contains a description of **when** activities are executed and the duration of each activity. See Table 5.	PG, O	2022-09-21
Oral Presentation	Description of the (initial) system.	O	2022-09-21
Design Specification	Defines **how** the project's aim and requirements are to be fulfilled, including functional specification of the system.	PG, O	2022-10-05
Test Plan	Defines the tests performed in the project and the time they are achieved.	O	2022-10-05
Test Protocol	A summation of the test results and which requirements they fulfilled including when they were achieved.	O	2022-12-01
User Manual	A detailed description of the end product and how the hardware, software and environment is set up.	C	2022-12-05
After Study	A reflection of the project.	O	2022-12-05
Poster presentation	A poster presentation of the project focusing on the result and conclusion of the system.	C	2022-12-12
Technical Report	Documentation of the technical results of the project.	C	2022-12-12
Web page	Presenting the project and containing all the relevant documentation.	C	2022-12-12
Video	Short visual presentation of the final system.	C	2022-12-12
Developed code	Implemented code for future development is shared in the GitLab repository.	C	2022-12-12
Status Protocol(s)	Each week, the status of the project should be summarized and sent to involved parties.	PG, O, C	-
Time Report(s)	Each week, the time used for the project should be summarized and sent to involved parties.	PG, O	-
TG protocol(s)	Descriptions of decisions taken and deliveries at each TG.	O	-

6 DEVELOPMENT METHOD

During the project, the LIPS model (V model) will be used. Within the group, a more agile method in form of a Scrum model with tasks on a Kanban board will be used to track the group's progress.

7 REPORT PLAN

The group members are all responsible for reporting hours worked on the project each week. In the spreadsheet it should be specified how many hours was spent and what it was spent on. Each week the Project Leader should present the time worked on the project to the orderer.

8 MEETING PLAN

The meeting plan for the project group describes the outcome of the meetings. Each Monday the project group will have a meeting between 13.15-15.00 to discuss the weekly plans. During this meeting there will also be a review of the previous week to make sure that the project is keeping up with the Time Plan. Before the meeting the Project Leader will post an agenda for the meeting, proposing subjects for the group to discuss during the meeting. This agenda will be read by all the group members before the meeting starts. At the beginning of the meeting a secretary will be announced who is responsible for documenting key decisions in a prepared meeting document. The meeting document will follow a pre-made template.

When needed, the Project Leader has the right to set up mandatory meetings in order to make sure that the project is working according to plan.

9 RESOURCE PLAN

The resources of the project are described in this section. The given resources are expected to be able to fulfill the need of time, material and premises to be able to execute the project and fulfill the requirements.

9.1 Persons

The project group consists of seven students from Linköping University. Each student has a background in engineering and possesses relevant knowledge for the project. Every project member has a total of 240 hours to spend on the project.

9.2 Material

Material provided for the project consists of:

- Raspberry Pi
- LEGO$^{©}$ Truck
- EV3 LEGO$^{©}$ system
- Project computer with Linux
- Batteries, Battery re-charger, LEGO$^{©}$ parts

9.3 Work rooms

The project group will have access to a project room in B-huset located at Linköping University. There will also be a test environment, *Visionen*, available for the project.

9.4 Economy

There will be a total of 1680 hours for the group to spend in order to be able to accomplish the project and all the set goals.

10   MILESTONES AND TOLLGATES

This section describes the milestones and tollgates set for the project.

10.1 Milestones

In Table 3 important milestones of the project is listed.

Table 3: Milestones for the project and an explanation of each milestone.

No	Description	Date
1	Complete TG2 with margin in order to get feedback on first draft.	2022-09-16
2	Complete TG3 a day before deadline in order to have time to read through and correct mistakes.	2022-10-11
3	Complete TG4 a day before deadline in order to have time to read through and correct mistakes.	2022-11-23
4	Complete TG5 a day before deadline in order to have time to read through and correct mistakes.	2022-12-07
5	Complete TG6 five days before deadline in order to have time to read through and correct mistakes.	2022-12-14

10.2 Tollgates

Table 4 shows important TG for the project.

Table 4: The table showcase the different tollgates and what should be done at each tollgate.

No	Description	Date
1	At TG2 the Requirement Specification, Project Plan and a draft of the Design Specification are delivered.	2022-09-21
2	At TG3 the Design Specification and Time Plan are delivered.	2022-10-12
3	At TG4 the done requirements in the Requirement Specification are checked to make sure they are fulfilled.	2022-11-24
4	At TG5 the functionality, Test Protocols, User Manual and a presentation showing that all the requirements are fulfilled are delivered.	2022-12-08
5	At TG6 the Technical Report, evaluation of the project, poster presentation and a webpage describing the project and a film showing the product are delivered.	2022-12-19

11 ACTIVITIES

This section describes all the activities that are carried out during the project. The activities can be seen in Table 5.

Table 5: The table showcases the planed activities for the project and the estimated time required to complete the activities.

No	Activity	Description	Est. Time
	Documents		
1	Requirement Specification	Specify the requirements for the project and summarize in a Requirement Specification.	30
2	Project Plan	Planning for the project and summarize as a Project Plan.	15
3	Time Plan	Specify a general Time Plan for the project and summarize deadlines as a Time Plan.	10
4	Design Specification	Specify a technical solution to reach the project goal and summarize as a Design Specification.	80
5	Test Plan	Specify how project products will be tested and summarize as a Test Plan.	30
6	Test Protocol	In addition to the Time Plan, establish a Test Protocol.	10
7	User Manual	Formulate and set up a well written User Manual.	30
8	Technical documentation	Specify how the technical solution was made and summarize as Technical documentation.	100
9	After Study	Investigate how the Project Planned out and establish an After Study document.	20
	Commercial Content		
10	Poster	Summarize the project highlights in a Poster.	5
11	Webpage	Establish a Web page presenting the project.	5
12	Video	Create a movie which presents the project.	20
	Research and Education		
13	ROS research	Project group investigates how ROS works.	70
14	Understand the implemented code	Investigate and learn the code of last year.	90
15	Learn basic Git	Learn to use Git within the project group.	14
	Testing		
16	Test mounted sensors	Assure that the already mounted sensors work as intended.	10
17	Test last year's implementation	Get last year's project code to function.	70
18	Unit testing	Test specific functions and their functionality.	10
19	System testing	Conduct the tests specified in the Time Plan.	90
	MPC controller and State observer		
20	MPC controller and State observer research	Research state of the art MPC controller and state observer.	30
21	MPC controller and State observer implementation	Implement a MPC controller and a state observer.	50
	Predictor		
23	Predictor research (IMM)	Research IMM filter.	25
24	Predictor implementation	Implement a predictor for the truck.	100
25	Predictor time dependent	Assure that the predictor is time dependent, meaning that the time should be determined by the value of a variable representing time.	67
	Motion planning		
26	Research (POMDP)	Research POMDP (Partially Observable Markov Decision Process).	25
27	Motion planning research (static)	Research static motion planner.	20
28	Motion planning research (dynamic)	Research dynamic motion planner.	30
29	Motion planning implementation	Implement a working motion planning algorithm.	100
30	Motion planning time dependent	Assure that the motion planner is time dependent, meaning that the time should be determined by the value of a variable representing time.	67
	Visualization		
20	Research Visualization module	Research state of the art visualization.	10
21	Visualization implementation	Implement a visualization module.	20
	Other Activities		
31	Deliveries	TG meetings.	14
32	Meetings	Mandatory meetings which the whole group attends.	250
33	Administration	General administrative work.	10
34	Buffer	Time to allocate on different activities.	103

12   PLAN FOR CHANGES

In the event of changes throughout the project the following procedure should be used:

- Discussion of the changes with the project group and the supervisor to establish what needs to be done. Discussion should be held regarding the Requirement Specification, Time Plan or other documents that are affected.

- Discuss changes with the orderer. This should be done with a time margin to the deadlines.

- Orderer accepts or declines suggested changes.

13   QUALITY PLAN

To maintain a high quality throughout the project regarding the documentation and code structure, the project will follow some set guidelines. The Requirement Specification will also guarantee a standard of the product.

13.1   Reviews

All the documentation made will be reviewed by the group members. There will also be discussion regarding the documentation with the project supervisor and the orderer before publication. The code will follow the Google code standard for C++ and Python. The code will be merged via GitLab into the main project by sending a merge request. This request will be accepted only after a group member has reviewed the code. These procedures will make sure that the documentation of the project maintains a high standard throughout the project. [1]

13.2   Time Plan

A Time Plan for the project goals will be developed to ensure that the product will fulfill the requirements.

14   RISK ANALYSIS

In this section the possible risks that can arise during the project are listed.

- Internal conflicts.

- Project hardware material failure.

- The goals set up for the project are not achievable within the time frame.

15   PRIORITIES

Priorities are stated in the Requirement Specification.

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16 PROJECT CLOSING

At TG6 the decision should be made on whether the project should be closed. This will be based on the requirements and whether they are fulfilled or not.

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REFERENCES

[1] J. Rosengren et al. *Technical Documentation, Autonomous Truck with a Trailer*. 2021. URL: http://www.isy.liu.se/edu/projekt/tsrt10/2021/rev_truck/ (visited on 09/13/2022).