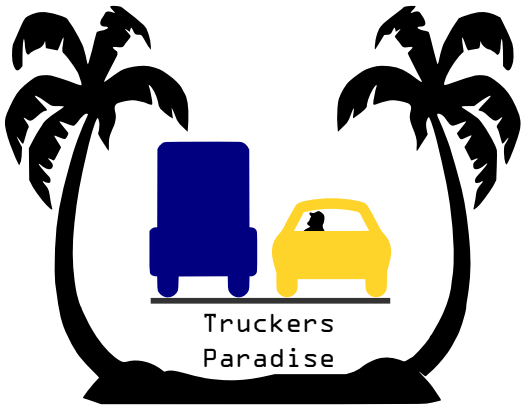
Project Plan
LiU Racetrack 2017

Version 1.0

Author: Truls Nyberg
Date: October 5, 2017



Status

Reviewed	Truls Nyberg	
Approved	Oskar Ljungqvist	

Course name:	Automatic Control - Project Course	E-mail:	axesk370@student.liu.se
Project group:	Truckers Paradise	Document responsible:	Truls Nyberg
Course code:	TSRT10	Author's E-mail:	truny887@student.liu.se
Project:	LiU Racetrack 2017	Document name:	project_plan_v_0_2.pdf

Project Identity

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Course Responsible:	Daniel Axehill, Linköping University **Phone:** +46 (0)13 28 40 42, **E-mail:** daniel@isy.liu.se
Advisors:	Olov Holmer, Linköping University **Phone:**+46 (0)13 28 16 17, **E-mail:** olov.holmer@liu.se

Group Members

Name	Responsibility	Phone	E-mail (@student.liu.se)
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Oscar Törnroth	Testing	073-0640797	oscto799
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Gustav Sandvik	Design	073-0293777	gussa744
Martin Olsson	Motion planner, car	070-7187739	marol219
Joakim Säfdal	Motion planner, truck with semi-trailer	070-7492814	joasa165

Document History

Version	Date	Changes made	Sign	Reviewer
0.1	2017-09-15	First draft.	Project Group	TN
0.2	2017-10-03	Revised after comments from orderer.	Project Group	AS
1.0	2017-10-05	Revised after comments from orderer.	Project Group	JS

Contents

1 Overview of the Project

The LiU Racetrack project is a part of the course Automatic Control - Project Course, with course code TSRT10, which is given by the department of Electrical Engineering, ISY, at Linköping University. The project should follow the LIPS project model [1]. This chapter describes the background of the project together with its purpose and goal. Finally the chapter describes the deliveries associated with the project to give an overview of all the documents, features and reports.

1.1 Background

The project LiU Racetrack was first initiated in the summer of 2011. Since then the project has been carried out each autumn for five years and now includes remotely controlled vehicles, IR-cameras, projector and intelligent algorithms. More specifically there exists a small-scale race track as well as a car and a truck with semi-trailer that are able to follow a reference trajectory. Additionally, the car has an overtaking system that allows the car to pass by static and slowly moving obstacles.

1.2 Purpose and Goal

This year's project have three main purposes. The first purpose is to further develop the system to make it more robust and reliable. This includes that the motion planner for the car plans the whole overtaking trajectory before an overtake is initiated as well as making the collision handler in the motion planner more computationally efficient. The second purpose is to develop a motion planner for the truck with semi-trailer such that the autonomous system automatically computes a reference trajectory around the racetrack and executes this planned trajectory. The system should also be able to perform various parking manoeuvres autonomously. The third purpose is to investigate if the same controller structure as for the truck with semi-trailer can be applied for the truck with dolly-steered trailer to make it follow a precomputed trajectory around the racetrack, both in backward and forward motion. The long term goal with the project is to construct a robust system that can be used for research in autonomous driving and education in advanced control courses.

1.3 Deliveries

The various reports, products and documents that should be delivered during the project are listed below. These are listed as various tollgates (TG).

At TG2 the following should be delivered:

- Requirement specification
- Project plan with time plan
- First draft of design specification

At TG3 the following should be delivered:

- Design specification
- Test plan

At TG4 the following should be delivered:

- Further development of the new trajectory tracking controller for the truck with dolly-steered trailer should be integrated in the system
- The new features in the overtaking algorithm for the car should be tested in simulation environment
- Further development of the trajectory tracking controller in forward motion for the truck with the semi-trailer should be integrated in the system and tested with good results

At TG5 the following should be delivered:

- The complete system which is certified to fulfill all the requirements that have been negotiated with the orderer
- Test protocol
- User manual
- A presentation that validates that the requirements are fulfilled

At TG6 the following should be delivered:

- Technical report
- An after study where the results and the used time is followed up
- Poster presentation
- Web page that describes the project
- A movie to publish

Furthermore, a time report for each specific activity and person as well as a status report should be delivered to the orderer at every week. The status report should also be delivered to the customer.

2 Phase Plan

The project will be divided into three phases: before, during and after [1]. This chapter will describe the different phases.

2.1 Before

At this phase the project group is created and the role for each member of the project group is decided. The requirements specification is also constructed to satisfy all goals in the project directive. The main guidelines and activities are discussed in the project group and a project plan is produced. The project plan also include a time schedule for each activity. At last a first draft of the design specification is established.

2.2 During

During this phase the project activities that lead to practical results are executed. First the design specification is finished where every new feature in the product is described, including implementation strategy. A test plan is also constructed. When these documents are established the project group begin to develop and implement the new features. During this phase the project manager delivers status and time reports to the orderer. The status reports are also forwarded to the customer.

2.3 After

In the last phase the project group creates a technical documentation, an after study, a poster and a user manual. A web page describing the project is also published together with a movie to advertise the product. The web page will contain all documentation of the project.

3 Organisational Plan

Figure 1 presents a visualization of the project organization and the following sections contains a brief explanation of the responsibilities of the project members.

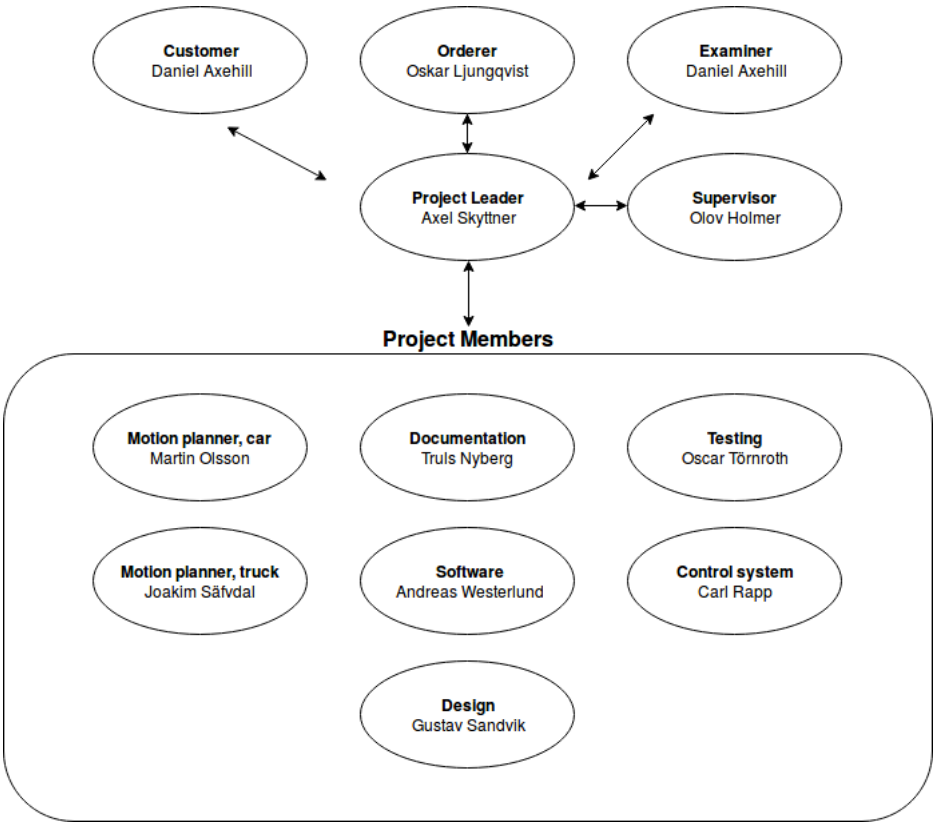

Figure 1: Project organization

3.1 Project roles

Following sections describe all the project roles.

3.1.1 Project Leader

This person is responsible for making sure that the project is finished and that all the mandatory requirements are fulfilled. In order to accomplice the previous tasks, the project leader is responsible to host regular meetings and keep everyone motivated and focused on their tasks.

3.1.2 Documents responsible

This person will make sure that all the documents are handed in and that they are properly worked through.

3.1.3 Test responsible

This person will make sure that the system is tested properly. There will be a test protocol and a test plan specified early in the project that will help the person responsible for testing.

3.1.4 Software responsible

This person will make sure that the given code standard is followed and act as a help resource when there is trouble with git.

3.1.5 Design responsible

This person will be responsible for the system as a whole and make sure that all the components of the system works together.

3.1.6 Motion planner responsible

Two persons will be responsible for the planning systems. They will focus on the planner submodule and will act as experts in this area to the rest of the team. One person will be responsible for the car's planner and one person will focus on the planner for the truck with semi-trailer.

3.1.7 Control systems responsible

One person will be responsible for the control systems. This person will focus on this part of the system and will act as an expert in this area to the rest of the team.

4 Documentation Plan

The documentation of the project will follow the standards in the project model LIPS. [1] All documents will be written in LaTeX and version controlled via a Git repository.

The documents listed in table 1 will be produced during the project.

Table 1: Target groups are Project Group (PG), Supervisor (SV), Customer, Orderer (OR) and Course Responsible(CR).

Document	Description	Target group(s)
Requirement Specification	Specification of the requirements that should be fulfilled at the deliveries of the project.	PG, CU, OR
Project Plan	Project overview and execution.	PG, SV, OR
Time Plan	Describes how the available time should be distributed among the different activities.	PG, SV, OR
Design Specification	A brief description of the system fulfilling the required specifications.	PG, SV, OR
Test Plan	Describes the tests to be made in order to verify the required specifications of the system.	PG, SV, OR
Test Protocol	The results of the tests in the test plan.	CU, OR
User Manual	Instructions of how to use the system.	CU
Technical Documentation	A detailed description of the entire system.	CU
Homepage	Public documentation of the project.	SV, CU
Poster	Summary of the system for advertising purpose.	CU
Advertising Film	Public advertising in video format.	CU
After Study	Summery and analysis of the project.	CR
Meeting Protocol	Notes from project meetings.	PG

5 Report Plan

Reporting the status of the project will be done both internally in the group and to the orderer. The status of the project will be reported in different ways. A time plan will be updated by the group members continuously where the amount of hours put into the different parts of the project is presented. The time plan helps the group and the orderer keep track on the work distribution and if the right amount of hours are put into the project. A verbal status report is covered at the group meetings. This gives the group members a chance to discuss what they are up to, what they are about to do and what they might need help with. Lastly the project leader will report directly to the orderer at weekly meetings where the status of the project will be discussed.

6 Meeting Plan

Group meetings will be held continuously during the different faces of the project. Each Monday at 10.15-12.00 the group will have a meeting at the project room. Before these

meetings the project leader will share the agenda for the day with the group via the common slack[2]. The group members are responsible for reading the agenda and prepare themselves for this meeting. At the end of the meeting the group will decide whether another meeting should take place before the following Monday and when this meeting should take place. The group member responsible for documentation will always act as the secretary of the meetings. Meeting protocols will be shared with the group via a slack channel.

7 Resource Plan

The resources in the project are everything that is necessary for the project to function from a practical point of view. The resources are divided in a few different categories. These categories are explained below.

7.1 Persons

The project group consists of eight members. All members are studying at the program Applied Physics and Electrical Engineering at Linköping University, but have done more or less different coursework during the past year. Therefore, the members have similar knowledge but slightly different area of expertise. The responsibilities in the project (see section 3.1) are distributed with respect to what the members are good at.

7.2 Material

The project members have access to the following materials:

- 1 stationary computer
- 1 projector
- 1 Mini Z racetrack
- 1 Kyosho dNaNo car
- 1 remote controlled truck
- Semi-trailer and dolly to attach behind the truck
- Hand controllers for the car and the truck
- 1 Raspberry Pi for communication with the truck

7.3 Work Rooms

The project group have been assigned a project room at the university where the hardware equipment is stored. All testing of the system will be performed in the project room. Except the project room, the group members have opportunities to book other available work rooms at campus.

7.4 Economy

Finance of hardware and other expenses are paid by the Department of Electrical Engineering (ISY) at Linköping university. Each group member has totally 240 hours to spend on the project. The group also have access to 40 hours supervised time during the entire project.

8 Milestones and Tollgates

In this section the milestones and tollgates of the project is given. The milestones can be seen in table 2 and tollgates can be seen in table 3.

Table 2: Table of milestones.

No.	Description	Date
1	The truck with semi-trailer can execute one lap around the racetrack using the lateral controller.	2017-10-09
2	The simulator can display a simple GUI.	2017-10-09
3	The code base has no unused code files.	2017-10-09
4	The code base has header comments on all files.	2017-10-09
5	The motion planner for the truck with semi-trailer can plan one lap.	2017-11-13
6	The simulator can display a trajectory given by the planner subsystem and has a GUI design that is ready for delivery.	2017-11-13
7	The truck with semi-trailer can do a lap forward with longitudinal control.	2017-11-13
8	The truck with semi-trailer can create a trajectory within 5 seconds, then follow the track and when finished the vehicle parks in a parking lot.	2017-11-13
9	The car makes an overtake with a success rate of 80%.	2017-11-13
10	The truck with dolly-steered trailer can reverse.	2017-11-27
11	All priority 1 requirements are fullfilled.	2017-11-27

Table 3: Table of tollgates.

T.G	Description	Date
2	Delivery of the requirement specification, project plan with time plan and sketch of design specification.	2017-09-18
3	Delivery of the design specification, test plan and test protocol.	2017-09-25
4	Delivery of system where milestone 1 to 9 is implemented.	2017-11-13
5	Delivery of the finished system, user manual and test protocol.	2017-12-04
6	Delivery of the technical specification, web page, poster, film and post study. The project is terminated.	2017-12-18

9 Activity List

The activity list will be divided into 8 sections: General and documents, simulator, motion planner for the car, motion planner the truck with semi-trailer, controller for truck with semi-trailer, controller for truck with dolly-steered trailer, system integration and code quality.

9.1 General and documents

General activities and documents are described in table 4.

Table 4: General activities and documents.

ID-no	Activity	Description	Time[h]
1	Requirement specification	Establishment of requirement specification.	170
2	Project plan	Establishment of project plan.	50
3	Time plan	Establishment of time plan.	10
4	Design specification	Establishment of design specification.	100
5	Test plan	Establishment of test plan.	40
6	Test protocol	Establishment of test protocol.	20
7	Technical documentation	Establishment of technical documentation.	70
8	User manual	Establishment of user manual.	30
9	Presentation	Preparation for the presentation at the project conference.	20
10	Web page	Establishment of web page for the project.	15
11	Poster	Establishment of poster for the project.	15
12	Video	Production of a video for the project.	20
13	After study	Execution of after study.	30
14	Meetings	Weekly group meetings.	192
15	Buffer	Buffer if something needs more time.	318

9.2 Simulator

Activities for the simulator is shown in table 5.

Table 5: Activities for the simulator.

ID-no	Activity	Description	Time[h]
16	Execute without hardware	Create a simulator that should be able to execute without any external hardware.	20
17	GUI, racetrack	Implement a GUI for the simulator that include the racetrack.	10
18	GUI, car	Implement a moving car, without motion model, in the GUI.	5
19	GUI, truck	Implement a moving truck with semi-trailer, without motion model, in the GUI.	5
20	Simulate trajectories	Extend the simulator with the ability to display the generated trajectories from the planner.	30
21	Simulate statical obstacles	Implement a feature in the simulator that creates static obstacles.	10
22	Simulate moving obstacles	Implement a feature in the simulator that creates moving obstacles.	20

9.3 Motion planner for the car

Activities for the motion planner for the car is shown in table 6.

Table 6: Activities for the motion planner for car.

ID-no	Activity	Description	Time[h]
23	Pre study	Pre study for motion planner.	20
24	Multiple Werling steps	Develop the motion planner to use multiple Werling steps when creating a trajectory.	20
25	Multiple Werling steps real time	Optimize the motion planner so it can plan a new trajectory in multiple Werling steps in real time.	40
26	Cost Function	Improve the cost function to make the motion planner choose trajectories more suitable for an overtake.	20
27	Time Efficiency, investigate	Investigate where, in current implementation, performance needs to be increased to make the motion planner more time efficient.	20
28	Time Efficiency, develop	Develop the motion planner to be more computationally efficient.	20
29	Follow moving obstacles	Develop the motion planner to create trajectories that follow moving obstacles, without stopping, when no overtake is possible.	40
30	Overtaking trajectory	Develop the motion planner so it can generate a trajectory for overtaking an obstacle moving in the same direction, using several Werling steps.	80

9.4 Motion planner for the truck with semi-trailer

Activities for the motion planner for the truck with semi-trailer is shown in table 7.

Table 7: Activities for the motion planner for truck with semi-trailer.

ID-no	Activity	Description	Time[h]
31	Pre study	A pre study for suitable motion planner structure.	20
32	Create reference trajectory	Implement the planner so that a reference trajectory can be calculated for smaller segments of the track.	70
33	Create reference trajectory whole track	Implement the planner so that a reference trajectory around the whole track can be calculated.	30
34	Generate reference trajectory under 5 seconds	Optimize the planner so the reference trajectory around the whole track is calculated under 5 seconds.	30
35	System start-up	Implement the planner with the rest of the system so that a reference trajectory is calculated when the system is started and the truck with semi-trailer is used.	10
36	Detect new obstacles on the track	Implement detection of new obstacles on the calculated reference trajectory.	20
37	Recalculate reference trajectory	Implement functionality for recalculating the reference trajectory when obstacles appears on the reference trajectory.	20

9.5 Low-level controller for the truck with semi-trailer

Activities for the low-level controller for the truck with semi-trailer is shown in table 8.

Table 8: Activities for the low-level controller for the truck with semi-trailer.

ID-no	Activity	Description	Time[h]
38	Pre study	Pre study for a low-level controller for the truck with semi-trailer.	20
39	Development of the longitudinal controller	Development of the longitudinal controller for the truck with semi-trailer.	30
40	Development of the lateral controller	Development of the lateral controller for the truck with semi-trailer.	30
41	Controller implementation	Implement the selected controller from the pre study in C++.	30
42	Parameter tuning	Tuning of controller parameters such that the performance requirements are fulfilled.	10
43	Safe-mode	Implement a ”safe-mode” for the truck with semi-trailer, the angle between the truck and the semi-trailer should never be greater then 90 degrees.	10

9.6 Low-level controller for the truck with dolly-steered trailer

Activities for the low-level controller for the truck with dolly-steered trailer is shown in table 9.

Table 9: Activities for the low-level controller for the truck with dolly-steered trailer.

ID-no	Activity	Description	Time[h]
44	Pre study motion model	Decide which motion model should be used for the truck with dolly-steered trailer.	20
45	Develop motion model	Develop a motion model for the truck with dolly-steered trailer.	20
46	Model implementation	Implement the motion model for the truck with dolly-steered trailer in C++.	20
47	Develop controller	Develop the controller for the truck with dolly-steered trailer using the same structure as the one implemented for the truck with semi-trailer.	10
48	Implement controller	Implement the controller for both the 2-trailer and the semi-trailer truck in C++.	30
49	Parameter tuning	Tuning of controller parameters such that the performance requirements are fulfilled.	20

9.7 System integration

Activities for integration of all systems is shown in table 10.

Table 10: System integration activities.

ID-no	Activity	Description	Time[h]
50	GUI integration	Integration of GUI features.	20
51	Testing of requirements	Testing and verifying of requirements of priority 1.	40

9.8 Code quality

Activities for the code quality is shown in table 11.

Table 11: Code quality activities.

ID-no	Activity	Description	Time[h]
52	Clear out unused code files	No unused code files should be delivered in the finished visual studio solution.	20
53	File comments	All code files should include a descriptive file comment at the top.	20
54	Code standard OSAAR_2013.cpp	The source code in OSAAR_2013.cpp should be refactored to comply with Google C++ style guide.	20
55	Code standard racetrack.cpp	The source code in racetrack.cpp should be refactored to comply with Google C++ style guide.	20

10 Time Plan

A time plan for the project has been made and can be seen in Appendix A. Each group member will register its own hours worked on each activity and the time plan will then be updated and modified every week.

11 Risk Analysis

The greatest risks involving the project is delayed deliveries. This might occur if something surrounding the hardware breaks, if a group member gets ill over an extended period or because of internal arguments. To prevent any of these events from delaying the project the group will do the following:

- If something concerning the hardware breaks the orderer will be contacted immediately and the future of the project will be discussed. The members will handle the hardware with care so that the risk of breaking the equipment is minimized.
- If a group member gets sick the workload of the other group members will increase. If this makes delivery on time difficult the orderer will be contacted as soon as possible. To prevent this from happening the group will aim on not having members with exclusive knowledge of the system. This way the work can continue even if someone gets ill.
- It is important to solve internal conflicts as soon as possible. If the conflicts can't be solved by the involved group members alone, the project leader will help them solve the problem. Therefore it's vital that the arguing group members themselves asks for help if help is needed.

References

[1] Tomas Svensson and Christian Krysander. *Project model LIPS*. Studentlitteratur, 2011.

[2] Slack Technologies. Slack. `https://slack.com/`, 8 2013. Collaborative software.

A Time Plan

Modifierad plan

Projekt: LiU Racetrack

Projektgrupp:	Truckers Paradise	**Datum:** 4/11/2016	**Granskad:**
Beställare:	Oskar Ljungqvist	**Version:** vecka 14	
Kurs:	TSRT10	**Utfärdare:** AS	

	AKTIVITETER	TID	VEM	TIDPLAN (när), veckonummer																
Nr	Beskrivning	timmar	Initialer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
	Produktutveckling:																				
1	Simulator: Execute without hardware	20	aw,tn					20													20
2	Simulator: GUI, racetrack	10	aw,tn						10												10
3	Simulator: GUI, car	5	aw,tn						5												5
4	Simulator: GUI, truck	5	aw,tn						5												5
5	Simulator: Simulate trajectories	30	aw,tn							30											30
6	Simulator: Simulate statical obstacles	10	aw,tn							10											10
7	Simulator: Simulate moving obstacles	20	aw,tn										20								20
8	Motion planner car: Pre study	20	mo,ot,as				8														8
9	Motion planner car: Multiple Werling steps	20	mo,ot,as					5	5	5			5								20
10	Motion planner car: Multiple Werling steps real time	40	mo,ot,as										20	20							40
11	Motion planner car: Cost Function	20	mo,ot,as										10	10							20
12	Motion planner car: Time Efficiency, investigate	20	mo,ot,as					10	10												20
13	Motion planner car: Time Efficiency, develop	20	mo,ot,as										10	10							20
14	Motion planner car: Follow moving obstacles	40	mo,ot,as										20	20							40
15	Motion planner car: Overtaking trajectory straights	80	mo,ot,as												40	40					80
16	Motion planner truck: Pre study	20	js, aw, tn				9														9
17	Motion planner truck: Create reference trajectory	70	js, aw, tn					35	35												70
18	Motion planner truck: Create reference trajectory whole track	30	js, aw, tn						30												30
19	Motion planner truck: Create reference trajectory under 60 seconds	30	js, aw, tn							15			15								30
20	Motion planner truck: System start-up	10	js, aw, tn										10								10
21	Motion planner truck: Detect new obstacles on the track	20	js, aw, tn							10			10								20
22	Motion planner truck: Recalculate reference trajectory	20	js, aw, tn										10	10							20
23	Controller truck with semi-trailer: Pre study	20	cr,gs,as				5														5
24	Controller truck with semi-trailer: Development of the longitudinal controller	30	cr,gs,as							30											30
25	Controller truck with semi-trailer: Development of the lateral controller	30	cr,gs,as					20	10												30
26	Controller truck with semi-trailer: Controller implementation	30	cr,gs,as					5	10	5			10								30
27	Controller truck with semi-trailer: Parameter tuning	10	cr,gs,as						5				5								10
28	Controller truck with semi-trailer: Safe-mode	10	cr,gs,as												10						10
29	Controller truck with dolly: Pre study motion model	20	cr,gs,as				6														6
30	Controller truck with dolly: Develop motion model	20	cr,gs,as										5	5	10						20
31	Controller truck with dolly: Model implement	20	cr,gs,as												20						20
32	Controller truck with dolly: Develop controller	10	cr,gs,as												10						10
33	Controller truck with dolly: Implement controller	30	cr,gs,as													30					30
34	Controller truck with dolly: Parameter tuning	20	cr,gs,as													20					20
35	Code quality: Clear out unused code files	20	alla					10	10												20
36	Code quality: File comments	20	alla					10	10												20
37	Code quality: Code standard OSAAR2013.cpp	20	alla					10	5	5											20
38	Code quality: Code standard racetrack.cpp	20	alla					10	5	5											20
39	System integration: GUI features	20	gs											20							20
40	System integration: Test and verifying of requirements	40	gs, ot												20	20					40
41	Reservtid	218	alla																	204	204
	Dokumentation:	timmar	Initialer	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
42	Kravspecifikation	70	alla		106	65															171
43	Projektplan	30	alla		2	47															49
44	Tidsplan	20	alla			11															11
45	Designspecifikation	120	alla			4	82	7													93
46	Testplan	40	alla			5	35														40
47	Testprotokoll	20	alla				5										15				20
48	Teknisk dokumentation	70	alla															70			70
49	Användarhandledning	30	alla														30				30
50	Hemsida	15	alla																15		15
51	Poster	15	alla																15		15
52	Film	20	alla																20		20
53	Efterstudie	30	alla																30		30
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54	Förberelse presentation	20	as,alla																20		20
55	Presentation	8	as,alla																	8	8
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56	Projektmöte	192	as,alla		12	12	10	16	16	16			16	16	16	16	16	8	8		178
57	Beställarmöte	12	as,alla		0	0	8	1	1	1			1	1	1	1	1	1			17
58	Handledarmöte	40	as,alla		0	0	0	3	3	3			3	3	5	3	3	5			31
	Milstoplar:			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
59	Milstolpe 1									må											0
60	Milstolpe 2									må											0
61	Milstolpe 3									må											0
62	Milstolpe 4									må											0
63	Milstolpe 5									må											0
64	Milstolpe 6														må						0
65	Milstolpe 7														må						0
66	Milstolpe 8														må						0
67	Milstolpe 9														må						0
68	Milstolpe 10																må				0
69	Milstolpe 11																må				0
	Beslutspunkter:			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
70	Beslutspunkt 2						må														
71	Beslutspunkt 3							må													
72	Beslutspunkt 4														må						
73	Beslutspunkt 5																	må			
74	Beslutspunkt 6																			må	
	Summa antal timmar:	1920		0	120	144	168	##	##	##	0	0	170	115	132	130	65	84	108	212	1920