Project Plan:
Search and Rescue - Coordination Between Quadcopter and Rover

Version 1.1

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Document History

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0.1	2019-09-17	First draft.	JA
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1.1	2019-10-16	Added new activities.	JA

Contents

1 Introduction

This document is a project plan for the project *Search and Rescue* in the course TSRT10, *Reglerteknisk projektkurs, CDIO*, at Linköping University. An overview of the entire system is presented as well as clear descriptions of the different subsystem within it.

1.1 Customer and Client

The customer is Torbjörn Crona from Saab Dynamics and the client is Magnus Malmström from the department of Electrical Engineering (ISY) at Linköping University.

1.2 Definitions

This section lists and describes definitions and abbreviations that are used in this document.

- **Rover** - Tracked vehicle autonomously traversing the ground seeking out people in distress. Previously called Balrog.
- **Quadcopter** - Flying vehicle autonomously seeking out people in distress from the air. Previously called Sauron.
- **Qualisys** - Motion capturing system in one of ISY's research labs, Visionen. Used to track the Quadcopter and Rover.
- **Accessible area** - The area where it is possible for the Rover to move around and search.
- **Inaccessible area** - The area where only the Quadcopter can move around and search, due to the area being surrounded by walls. Inaccessible areas are obstacles as far as the Rover is concerned.
- **ROS** - Robot Operating System.
- **SLAM** - Simultaneous Localisation And Mapping.
- **Base Station** - Computer than handles information from the Quadcopter and Rover and also handles the GUI.
- **Obstacle** - Any object or feature that hinders the Rover.
- **Wall** - A vertical object that separates one part of an area from another, or makes up the boundary of an area. Walls are obstacles, not all obstacles are walls.
- **Distressed person** - A virtual marker that has to be found by the Rover or Quadcopter. Distressed persons are sensitive to percussive forces, therefore the Rover must not drive over them. Distressed persons can be considered obstacles and are defined as a circle with a radius of 0.1 m.

2 Project Overview

In the following section the purpose and goal with the project are explained. The different deliveries are presented and can be found in Table 1.

This project has been carried out for several years where improvements have been made every year. The initial long-term goal was to create an autonomous minesweeper which could find and clear a designated area of landmines. The way of doing this was by using a Rover. Two years ago a Quadcopter was added with the intention of cooperating with the Rover in the mission of finding and clearing landmines. Last year the same vehicles were used but the long-term goal changed from minesweeping to autonomous rescuing. The idea was to track down people in distress with the Quadcopter and then aid them using the Rover.

This year the long-term goal is still autonomous rescuing but with focus on adding more autonomy and improved cooperation between the vehicles. The Rover will now participate in the searching.

2.1 Purpose and Goal

The purpose of this project is to deliver an autonomous system consisting of a Quadcopter and a Rover which can search through a specific area and identify missing and/or injured people. The area shall be demanding, meaning that the Rover shall not be able to cover it by itself but must cooperate with the Quadcopter. The Rover shall carry the Quadcopter on top of itself, explore the area and identify people in distress until it finds an inaccessible area. When this happens the Quadcopter shall be deployed in order to explore the area of interest while the Rover continues its search. When the Quadcopter has finished exploring or is starting to run out of fuel it shall return to its original position on top of the Rover.

2.2 Deliveries

In Table 1 below all the deliveries are listed as well as the preliminary date of each delivery and to what tollgate they belong.

Table 1: All deliveries in the project.

Delivery	Tollgate	Delivery date
Time report	-	weekly
Status report	-	weekly
Presentation of current system	BP2	2019-09-25
Requirements specification	BP2	2019-09-25
Project plan	BP2	2019-09-25
Draft of a design specification	BP2	2019-09-25
Design specification	BP3	2019-10-02
Test plan	BP3	2019-10-02
Planning system for scanning an area	BP4	2019-11-13
Detection system for finding people in distress	BP4	2019-11-13
A Quadcopter able to fly autonomously	BP4	2019-11-13
Test protocol covering the two requirements above	BP4	2019-11-13
All functionality	BP5	2019-12-03
Complete test protocol	BP5	2019-12-03
User manual	BP5	2019-12-03
Presentation showing all the achieved requirements in the requirements specification	BP5	2019-12-03
Technical report	BP6	2019-12-16
After study	BP6	2019-12-16
Poster presentation	BP6	2019-12-16
Web page	BP6	2019-12-16
Demo film	BP6	2019-12-16

3 Phase Plan

This project is carried out according to the LIPS model [1] and it therefore contains three different phases: before, during and after the project. These are briefly explained below.

3.1 Before the Project Starts

Before the project, persons with different qualifications are assembled in order to match the customer's project directives. Each of the members is then assigned a specific role within the group. In dialogue with the client and customer a requirements specification is written to ensure that it follows the given project directive. Furthermore a project plan and a time plan are written.

3.2 During the Project

In this phase all implementation and testing is made by following the design specification and test plan. During this phase revisions to the requirements specification are possible with the client's approval. The project plan and time plan may also be updated. Everything from the technical solutions to how the system is used and installed will also be documented.

3.3 After the Project

When the final product is delivered to the customer the project is considered finished and all the members evaluate the project in an after study.

4 Project Organisation

In this section the organisation structure within the project group and between the project group and the outside parties will be described.

4.1 Structure with the Customer

The overview of the organisation is illustrated in Figure 1. The external personnel are represented with green boxes and the project members are represented with blue boxes. All members in the project group have been assigned different roles, which will be presented in section 4.2.

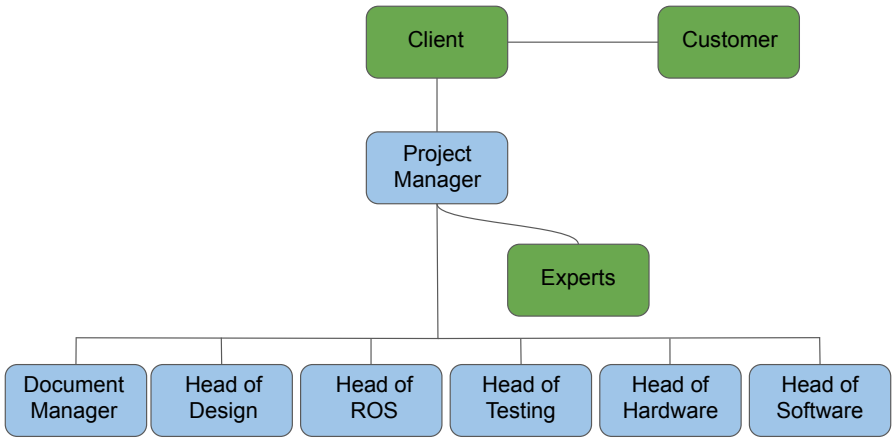

Figure 1: Organisation of the project. External personnel are represented by green colour and project members are represented by blue colour.

4.2 The Responsibility Definition for Each Role

In this section the different roles of the project will be presented and explained.

4.2.1 Project Manager (PM)

- Handling the communication between the group, the customer and the client.
- Planning the ongoing work.
- Following up and ensuring that the goals of the project are achieved.
- Encouraging the group to work efficiently together.
- Assisting in solving internal conflicts of the group, if necessary.
- Following up to ensure that the workload is distributed equally over the group.

- Sending status reports of the conducted work to the client and the customer, weekly.
- Sending time reports to the client, weekly.
- Setting up and planning meetings with the group.
- Updating the time plan in accordance with the group's decision.
- Ensuring the preparation of the oral presentations.

4.2.2 Document Manager (DOC)

- Planning the writing and the verification of the documents.
- Ensuring that the required documents are written and finished in time.
- Ensuring that there are document templates to all required documents.
- Ensuring that the document revision control is executed in a correct manner.
- Ensuring that the documents are proofread before they are handed in.
- Ensuring that a poster presentation is created.

4.2.3 Head of Testing (TST)

- Ensuring the writing of a test plan, test specifications and test protocols.
- Planning and coordinating the testing of the system.
- Planning full scale tests.
- Following up on the requirements specification to ensure that the testing shows that the requirements regarding the functionality are met.

4.2.4 Head of Design (DES)

- Responsible of the design specification and its layout.
- Responsible for the visualisation design.
- Ensuring that the GUI is working and is usable.
- Ensuring that a demo film is recorded and edited.

4.2.5 Head of Software (SOF)

- Informing the group of the coding standard and the revision control of the code.
- Ensuring that the code follows the coding standard and that it is well commented.
- Cooperating with Head of ROS to oversee the software design.
- Ensuring that a web page is created and updated.

4.2.6 Head of Hardware (HRD)

- Looking after the hardware to ensure that it is properly maintained.
- Receive reports of possible malfunctions of the hardware from the group and ensure that they are resolved.
- Ensuring that a risk analysis is conducted regarding the Quadcopter and the Rover.
- Ensuring the usage of Qualisys is working properly.

4.2.7 Head of ROS (ROS)

- Ensuring that ROS is implemented in relevant hardware.
- Ensuring that ROS works and is used properly.
- Planning the virtual environment.
- Ensuring that relevant simulations are implemented and working.

5 Documentation Plan

The documents that will be delivered during this projects are presented in Table 2.

Table 2: The document description and date of completion.

Document	**Description**	**Date**
Requirements Specification	Describes all the requirements that must be fulfilled in the project	2019-09-25
Project Plan	Describes how the project is to be executed and also contains activities and milestones.	2019-09-25
Time Plan	Describes how much time each activity is planned to take	2019-09-25
Design Specification	Describes in detail how the different parts of the system are supposed to be constructed and implemented	2019-10-02
Test Plan	Describes how the system is supposed to be tested in order to verify functionality	2019-10-02
Test Protocol, part of functionality	Describes the results of the performed tests on parts of the system	2019-11-13
Test Protocol, complete functionality	Describes the results of all the performed tests	2019-12-03
User Manual	Describes how the system is correctly used	2019-12-03
Technical Report	Describes in detail all the technical aspects of the system	2019-12-16
After Study	Contains a discussion about the work flow, time consumption, experiences and problems encountered during the project	2019-12-16

6 Development Methodology

All work will be done in parallel to make it more efficient. The configuration of the subgroups in which the work is carried out may vary depending on the current situation and might change depending on other events. The aim will always be to have subsystems with basic functionality working for demonstration or tests. A functioning backup will always be kept for all working systems. Subgroups should discuss ideas with other members of the group prior to implementation. All code should be reviewed prior to merging.

As work progresses the changes and updates will continuously be written in the documentation. Each subgroup is responsible for updating the corresponding documentation when adding new functionality or modifying old. Tests will be conducted when needed and documentation will be written in conjunction with corresponding test. All test documentation will follow the same template.

The group will meet at least twice a week and discuss the current state and future of the project. As for other meeting occasions the PM is responsible informing the group members. The project manager creates a protocol for each meeting, which the other members will have access to the evening before the meeting. The meetings are discussed more in depth in section 9.

Before any new functionality is implemented the already existing will be tested to make sure everything works as intended, otherwise some requirements might have to be renegotiated or added to the requirements specification.

7 Qualification Plan

The delivered product and the project at large need to uphold a high quality and therefore certain quality checks will be carried out under the duration of the project. The concerned areas are presented in this section.

7.1 Documentation

The DOC has the responsibility of ensuring the quality of the documentation and that it is finished before the deadline. All documentation must follow the same format and be consistent with regards to notation etc. and must also be proofread by the DOC and at least one more group member.

7.2 Code

The SOF has the responsibility of ensuring that the code is well commented, documented and follows the given coding standard. Throughout the course of project the code shall be reviewed continuously as progress is made.

7.3 Functionality

The TST has the responsibility of ensuring that tests are performed in order confirm whether functionality is up to standard or not. This will be done during the course of the project according to a test plan.

7.4 The Group's Education

If new knowledge is required to proceed with different tasks during the project it is up to the members in the project group to obtain these. There is some assistance in acquiring new knowledge in the form of technical advisors, one at Linköping University and two at Saab Dynamics.

8 Reporting Plan

During the whole project the PM is responsible for updating the client and the customer of the progress of the project. This is done by sending status and time reports.

8.1 Time Report

A time report will be sent to the client every Friday afternoon where the report includes the total hours spent by both the whole group and each group member. In the time report the modified weekly updated time plan will also be attached, to see the progress of the different activities.

8.2 Status Report

A status report of the progress will be sent every Friday afternoon to both the client and the customer. The report is a small summary of the work and progress of the project that have been done during the week.

8.3 Meetings with the Client and the Customer

The PM will have weekly meetings with the client. During this meeting the client will be updated on the progress of the project. There can also be other meetings between the group and the client and/or the customer, which can be held upon the request of either party.

9 Meeting Plan

The whole project group will have two meetings scheduled every week, one every Monday at 13:15-14:00 and one every Friday at 12:30-13:00. The Monday meeting is a summary meeting where every member will update the rest of what was done the last week and what is planned for the upcoming week. It will also contain a discussion session where the members can help each other if there is something someone is wondering about. The Friday meeting only consists of a quick update about the progress of work made during the week, and if there is some activity that needs more time to complete during the weekend.

10 Resource Plan

In this section the resources that are at disposal during the project are presented and contains information about which people, material, facilities and economy that the project can use.

10.1 People

The project group consists of seven members from the Applied Physics and Electrical Engineering program and the Mechanical Engineering program at Linköping University. The external resources are the three advisors assigned to the project, one from the department of Electrical Engineering at Linköping University and the other two from Saab Dynamics.

10.2 Material

The necessary equipment for the project is provided by Saab Dynamics where it currently consists of one tracked vehicle (Rover) and one UAV (Quadcopter). The Rover is equipped with GPS, IMU, odometers, camera, laser scanner, WiFi and Bluetooth. The Quadcopter is equipped with IMU, barometer, radio transmitter and WiFi. A laptop has also been made available to use in the project. The software from previous years is also at the group's disposal. Any further material that is needed might be purchased by Saab Dynamics upon their approval.

10.3 Facilities

The facilities intended for the project are an available project room and shared access to Visionen which is a test site located in the B-house at Linköping University.

10.4 Economy

The time budget for each group member is 240 hours, which sums up to a total time budget of 1680 hours for the group. The time budget for guidance from the advisors is 40 hours for the advisor from ISY and 40 hours from the two advisors from Saab Dynamics.

11 Milestones and Tollgates

The project has a goal which can be read about in section 2.1. To enable a clear view of how the project is progressing, different milestones and tollgates are used to ensure that the project is moving in the right direction.

11.1 Milestones

The milestones are more informal and set by the project members to have a better overview of in which order the project assignments should be executed. To reach the goal of the project, it has been divided into the milestones in Table 3 below. Every milestone will have its own test where a mission is set to be completed and if the mission is accomplished correctly, the test will be considered fulfilled.

Table 3: Milestones.

No	Milestone	Date
1	The Rover is able to scan an area and find inaccessible areas using SLAM and Qualisys for positioning.	2019-11-05
2	The Quadcopter is able to scan an area and detect people.	2019-11-05
3	The Quadcopter is able to take off from the Rover and land on the Rover at the same position as it took off from.	2019-11-12
4	The Quadcopter is able to take off from the Rover, the Rover changes its position and the Quadcopter is able to land on the Rover at this new position.	2019-11-12
5	The Rover is able to scan an area, find an inaccessible area and launch the Quadcopter which scans that area. The Rover continues its mission while the Quadcopter scans the inaccessible area. The Rover stops and remains stationary as the Quadcopter lands. Qualisys is allowed for positioning.	2019-11-27
6	Same mission as above but without Qualisys for positioning of the Rover.	2019-11-27

11.2 Tollgates

The project is following the LIPS model which divides the project into six different tollgates. Every tollgate contains several documents which shall be delivered at that tollgate to make sure that the project moves forward. It is also important that the customer agrees that the project is well executed and will deliver the correct product. All the tollgates can be seen in Table 1 in section 2.2.

12 Activities

All the activities throughout the project are listed in this section which then the time plan will be based on. Each activity will have the total amount of approximated time for that activity.

12.1 General

The following listed activities are the general activities through the project.

No.	Activity	Description	Dep.	Time [H]	Req. no.
1	Meetings	Monday and Friday meetings.	-	160	96-100
2	Lectures	Attendance at the two lectures.	-	21	-
3	Project managing time	Meeting time between the PM and the client.	-	7	-
4	Structure previous code	Review code from previous year, "clean up" and transfer relevant code.	-	30	125
5	Study previous documentation	Gain insight into the system from previous year.	-	15	101
6	Review code	Review all the code, comment and make sure it follows the Google coding standard.	-	20	123
7	System test	Each subtest of the system will be tested according to the test plan and test protocols will be filled out.	-	80	95
8	Full scale test	Test the entire system in a full scale test and test protocols will be filled out.	46	20	13-19, 32-33, 113
9	Presentation BP5	Prepare and present the full system with all functionality to the customer.	-	20	115, 118
10	Project conference	Preparing for and attending the conference at the end of the course.	-	42	-

Total time for *General*: 415 hours.

12.2 Documentation

The following section contain the documentation activities.

No.	Activity	Description	Dep.	Time [H]	Req. no.
11	Requirement Specification	Time to write a requirement specification.	-	70	102, 103, 116, 122
12	Project Plan + Time Plan	Time to write a project plan and a time plan.	-	55	102, 104, 122
13	Design Specification	Time to write a design specification.	-	90	105, 106, 122

No.	Activity	Description	Dep.	Time [H]	Req. no.
14	Test Plan	Time to write a test plan and test protocol.	-	30	107, 111, 114, 122
15	User Manual	Time to write an user manual.	-	35	115, 122
16	Technical Report	Time to write a technical report.	-	90	117, 122
17	Time and Status Report	Update the time and status report each week.	-	21	124
18	Demo film	Time to create a demo film.	-	15	121
19	Web page	Time to create and update the web page.	-	20	120
20	Poster	Time to create a poster for the project.	-	10	119
21	After Study	Time to write an after study.	-	12	118, 122

Total time for *Documentation*: 448 hours.

12.3 Quadcopter

In this section the activities for the Quadcopter are presented.

No.	Activity	Description	Dep.	Time [H]	Req. no.
22	Manual flight	Making sure it is possible to control the Quadcopter in stable flight manually using the remote control.	-	35	38-40, 95, 100, 101, 113, 114
23	ROS integration	Integration with the ROS devices, being able to send and receive information.	-	35	48, 69-72
24	Qualisys integration	Integrate Qualisys positioning for the Quadcopter.	-	15	43, 67, 107
25	Autonomous positioning	Implementing autonomous starting, landing and hovering capabilities for the Quadcopter.	22, 24	60	41-46, 49, 112
26	Autonomous path following	Implementing the possibility to continuously follow a path autonomously.	25	50	45, 50-56, 108, 110
27	Autonomous Rover interaction	Being able to both start from and land on the Rover.	26	30	48,60-66
28	Mission interaction	Get a search area command from the Rover, perform it and communicate the results.	26	35	5, 9, 10, 47-49, 53, 57-64, 66, 110, 111
29	Quadcopter test	Testing of the Quadcopter and its interaction with the rest of the system.	23, 27, 28	30	1, 7, 53, 102, 114
30	Refactoring of the flight controller	Rewriting of the code for the Quadcopter.	-	60	-

No.	Activity	Description	Dep.	Time [H]	Req. no.
31	Supervisor	Implement the mission supervisor for the Quadcopter.	-	10	-

Total time for *Quadcopter*: 360 hours.

12.4 Rover

In this section the activities for the Rover are presented.

No.	Activity	Description	Dep.	Time [H]	Req. no.
32	Rover test	Evaluate existing capabilities of the Rover.	-	10	2, 20, 21, 24, 95, 101
33	ROS installation	Installation and configuration of ROS on the Raspberry Pi.	-	12	23, 36
34	Hand controller	Integrate the hand controller with ROS.	33	5	35
35	Motor controller integration	Integrate the motor controller with ROS.	33	15	20
36	Wheel encoder integration	Integrate the wheel encoders with ROS.	33	15	20
37	SLAM	Integrate LiDAR sensor and SLAM-algorithm with ROS.	33	20	34, 108
38	Virtual Rover camera	Implement a virtual camera for the Rover. The camera view should be calculated using the position from Qualisys	-	15	11, 22, 31, 109
39	Mission planner	Create a planning algorithm that produces paths for the Rover to follow.	33	35	5, 9, 10, 12, 20
40	Movement planner	Implement a movement planner that computes velocities that makes the Rover follow the planned path.	33, 35, 36, 37	35	24-29, 32-34, 36, 108
41	Collaboration with the Quadcopter	Implement collaborative behaviours.	33, 35, 36, 37, 39, 40	25	7, 37
42	Supervisor	Implement the mission supervisor for the Rover.	-	30	-
43	Reconstruction of the Rover	Reconstruct the power supply for the different components of the Rover.	-	20	-

Total time for *Rover*: 237 hours.

12.5 Communication

In this section the activities concerning the communication are presented.

No.	Activity	Description	Dep.	Time [H]	Req. no.
44	ROS communication	Implement communication on each subsystem in ROS.	-	35	6, 69
45	Qualisys communication	Qualisys should transmit position data to ROS.	44	15	3, 67, 112
46	Communication network	Make sure all systems can communicate and exchange information.	44, 45	10	4, 7, 68, 70

Total time for *Communication*: 60 hours.

12.6 GUI

No.	Activity	Description	Dep.	Time [H]	Req. no.
47	Legacy GUI test	Evaluate the current GUI.	-	4	-
48	Rover position on map	Ensure that the Rover is visible on the map in the GUI.	-	4	71-73
49	Quadcopter position on map	Ensure that the Quadcopter is visible on the map in the GUI.	-	4	71-72, 74
50	Rover control	Add the capability for a user to control the Rover using the GUI.	-	8	71, 79
51	Quadcopter control	Add the capability for a user to control the Quadcopter using the GUI.	-	8	71, 80
52	Mission status	Show mission status in the GUI.	-	4	71, 82
53	Mission control	Add mission control capabilities to the GUI.	-	6	71, 78, 81
54	Distressed person placement	Add the capability to place distressed persons on the map using the GUI.	-	8	71, 81
55	Explored area	Show which areas have been explored including obstacles.	-	12	71, 75, 76
56	Show distressed persons	Show identified and unidentified persons in distress.	-	8	71, 77
57	Visualisation integration	Enable the map to be displayed using the projector system in Visionen.	-	7	4, 71, 83-94
58	Simulation	Create a simulation environment within the GUI able to test the mission without the hardware Rover and the hardware Quadcopter.	-	20	8

Total time for *GUI*: 93 hours.

Total time for all activities: 1613 hours

13 Time Plan

To view the time plan, see the separate document called *Time Plan* [2].

14 Alteration Plan

The requirements that are described in the document *Requirements Specification* [3] might be renegotiated during discussions with the client. The time plan will be updated and revised continuously during the project.

14.1 Inspection

Every document defined in section 5 will be reviewed by at least one of the project members in addition to the DOC. This is to ensure the quality and content of the documents. The code will be reviewed by at least one project member in addition to the code author(s) to ensure that it follows the given structure.

14.2 Test Plan

To view the test plan, see the separate document called *Test Plan* [4].

14.3 Time buffer

In the document *Time Plan* there will be a time buffer included. In this buffer 10% of the project time will be placed, and then used for activities where the planned time is exceeded. This time buffer will increase and decrease depending on how many hours that are used each week.

15 Risk Analysis

In this section the risks possible of encountering during the project will be presented. Suitable measures should be taken to avoid these risks.

15.1 General

General risks that must be taken into consideration are the following:

15.1.1 Students leaving

If one or more students leave the project group the requirements must be renegotiated to make sure that the project can be finished in time.

15.1.2 Hardware

The hardware must be kept in good condition to avoid permanent damage that could delay the project. If the hardware malfunctions the HDR is responsible for finding a solution. Since Saab Dynamics provides all hardware, it is most likely they who will provides new equipment if needed. For issues regarding Visionen or Qualisys, suitable help will be found.

15.1.3 Data loss

Gitlab will be used to make sure no data is lost during the project. All files and approved documents will be stored at LiU Gitlab.

15.2 Quadcopter

For the Quadcopter a special risk analysis will be conducted. The HRD is responsible for creating a safety protocol that must be followed when operating or working on the Quadcopter. Potential hazards when operating the Quadcopter could be batteries catching fire or propellers spinning at high speeds.

15.3 Rover

The Rover could run into objects and the batteries could catch fire if misused. To avoid this no one must be closer than 1 m to the Rover while it is in autonomous mode. The batteries must not be damaged and charging must be under supervision of a project member.

16 Priorities

All requirements have a priority level that indicates in which order the requirements should be prioritised. Level 1 is the highest priority and all those requirements must be fulfilled in order for the project to be regarded as passed. Work on level 2 or 3 requirements should be undertaken after all level 1 requirements are fulfilled. If time is running out or if some level 1 requirements cannot be met, they must either be renegotiated to another level or removed to make sure all level 1 requirements are completed upon delivery.

17 Project Closure

When the project is completed and finished all hardware will be returned to Saab Dynamics and the key to the project room will be returned to ISY. The project group will evaluate the project in an after study and all documents will be made available.

References

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

[2] Project group EAGLE with editor Jesper Ahlander. *Time Plan*. ISY, 1.1 edition, 2019.

[3] Project group EAGLE with editor Jesper Ahlander. *Requirement Specification*. ISY, 1.0 edition, 2019.

[4] Project group EAGLE with editor Jesper Ahlander. *Test Plan*. ISY, 1.0 edition, 2019.