Project Plan
Search and Rescue - Land

Version 1.0

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CONTENTS

1 INTRODUCTION

This is the project plan for the Search and Rescue — Land project, in the course TSRT10 Automatic Control — Project Course. The project was done in collaboration with SAAB Dynamics.

1.1 Customer and Orderer

The project was ordered by Jakob Åslund from the department of Electrical Engineering (ISY) at Linköping University. The customer is Torbjörn Crona from SAAB Dynamics.

1.2 Definitions

Below some definitions and acronyms are explained which are recurring in this document.

- **Rover** - Tracked vehicle driving autonomously that maps the test area and seeks distressed persons.
- **UAV** - A quadcopter flying autonomously and seeks distressed persons.
- **Agent** - participant in a mission, Rover and/or UAV.
- **Base Station** - A computer that handles the information from the Rover and UAV.
- **Distressed person** - In simulation, this is a virtual marker that should be found by the Rover and UAV. When doing real tests, this will be radio-controlled cars colored with bright colors.
- **SLAM** - Simultaneous Localization and Mapping
- **LIDAR** - Light Detection and Ranging
- **SIL** - Software In The Loop
- **Qualisys** - Sensor system in the room Visionen that uses cameras and reflective targets to deliver position data
- **ROS2** - "Robot Operating System", Framework for robot software development
- **No-fly zone** - A zone where the UAV is restricted from flying into
- **PDDL** - Planning Domain Definition Language
- **RPi** - Raspberry Pi
- **Pixhawk** - The flight controller *Pixhawk 4* that is mounted on the UAV
- **HW** - Hardware
- **SW** - Software
- **Rviz2** - A visualization manager that displays the generated map and agent positions during the mission.
- **Gazebo** - Simulation environment.
- **RC-car** - Small RC-cars controlled by the user, that are used to simulate distressed persons.

2 PROJECT OVERVIEW

This section outlines the purpose and goal of the project and the deliveries that are a part of the project.

This project has been ongoing for several years with a variety of purposes, and with incremental improvements.

2.1 Purpose and Goal

The main purpose of this project is to develop a Search and Rescue-system consisting of an unmanned ground vehicle, called the Rover, and an Unmanned Aerial Vehicle (UAV) collaborating to identify, track and supply people in distress. To accomplish this, the system should be able to map and navigate an area with people in distress. Specifically, the Rover should use a LIDAR-sensor to map the environment while searching for distressed people using a camera. The UAV will also be equipped with a camera, which it will use to search for distressed people from the sky.

Thus, the goal is to deliver a system according to the aforementioned specifications. The system should also follow design guidelines such as adhering to Google's code standard, developing the system in ROS2 and extending the docker integration of the current project.

2.2 Deliveries

All deliveries and delivery dates are listed in table 1.

Table 1: This table shows all deliveries, and their dates, in this project.

Delivery	Tollgate	Delivery date
Time report	-	Weekly
Status report	-	Weekly
Requirement specification	BP2	2022-09-21
Project plan including time plan	BP2	2022-09-21
Verbal presentation of the system	BP2	2022-09-21
Design specification	BP3	2022-10-06
Test plan	BP3	2022-10-06
Delivery of Milestone no. 4	BP4	2022-11-25
All functionality	BP5	Half week before delivery of project
Test protocol	BP5	Half week before delivery of project
User manual	BP5	Half week before delivery of project
Presentation showing that all requirements have been met	BP5	Half week before delivery of project
Delivery of project	-	at latest 2022-12-12
After study	BP6	2022-12-12
Poster presentation	BP6	2022-12-13
Web page and product movie	BP6	2022-12-15
Technical report	BP6	2022-12-19

2.3 Limitations and Delimitations

Some delimitations have been made to limit the scope of the project.

- The project is limited to only work indoors in the Visionen test site.
- The system is delimited to only supports a single Rover and a single UAV during missions.
- The project is delimited to assume that the environment seen by the LIDAR is static, except for the distressed persons.

3 PHASE PLAN

The project will be conducted according to the LIPS methodology [1]. LIPS divides the project into three major phases: before, during and after the project. These are described below.

3.1 Before the Project Starts

Before the project starts is the phase where the project is planned out. A requirement specification is written which defines the requirements on the finished product. This phase concludes with this project plan, which describes how the project will be conducted.

3.2 During the Project

During the project is the phase where the activities listed in the project plan will be carried out. The activities will be performed, documented and tested. During this phase, there is a constant communication between the project group and the orderer in the form of weekly status reports. Furthermore, the project members also keep in touch weekly and consult with the advisors weekly. This phase will be concluded with a system test.

3.3 After the Project

After the project is the phase where the project result will be transferred to the orderer, the project will be presented to the client, equipment, and hardware will be returned, and the project is completed.

4 PROJECT ORGANISATION

This section outlines the project organization and how different stakeholders relate to each other. A short description of the responsibilities of each role is also to be found.

4.1 Structure with the Customer

The project is executed as a collaboration between Linköping University and SAAB Dynamics. An overview of the project can be seen in Figure 1 where one can see how different parties relate to each other.

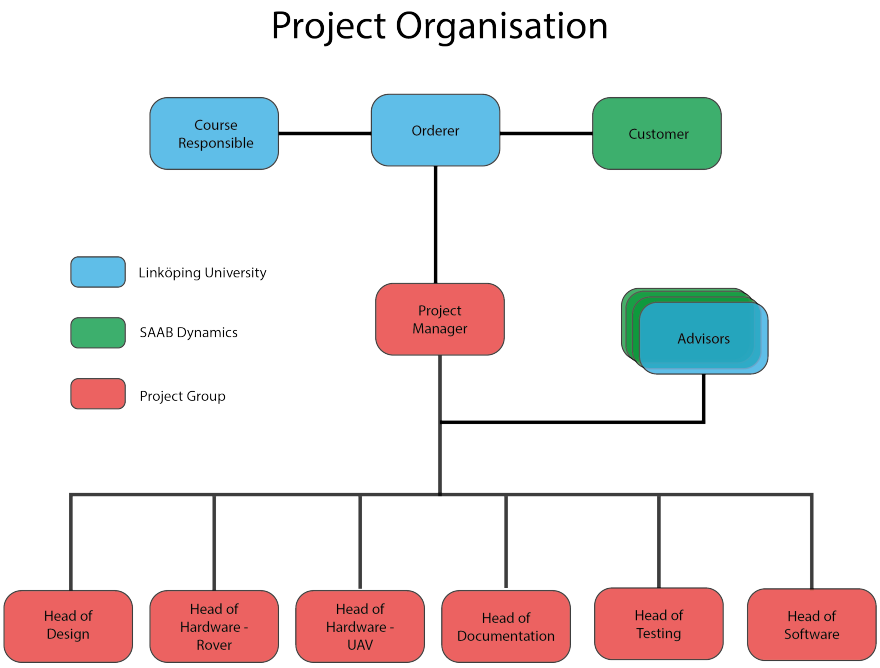

Figure 1: Schematic overview of the project organization.

4.2 Responsibilities for Each Role

The different roles and their responsibilities is presented below.

4.2.1 *Project Manager (PM)*

- Ensures that the project goals are achieved.
- Plans the ongoing work.
- Encourages the project members to work efficiently together.

- Handles the communication between the group, the orderer and the customer.
- Sends in a weekly time report to the orderer.
- Sends in a weekly status report to the orderer and customer.
- Assisting in solving internal conflicts, if necessary.
- Sends in all the documents.
- Booking manager

4.2.2 *Document Manager (DOC)*

- Plans the writing and verification of the documents.
- Ensures that the required documents are written and are handed in before deadline.
- Ensures that the document templates exist and are used.
- Ensures that the document revision control is executed in a correct manner.
- Ensures that the version management is used correctly.
- Ensures that the documents are properly read through before sending in.
- Has the final say if the group does not agree about decisions regarding documents.

4.2.3 *Head of Testing (HOT)*

- Plans and coordinates the testing of the system.
- Leads meetings regarding what tests are going to be performed.
- Ensures that test plan, test specifications and test protocols are written.
- Ensures that the testing shows that the requirements in the requirement specification regarding functionality are met.
- Makes sure that test equipment is prepared before tests.
- Has the final say if the group does not agree about decisions regarding testing.

4.2.4 *Head of Design (HD)*

- Has an overview of the design specifications
- Should be able to make decisions regarding the design when needed.
- Has the final say if the group does not agree about decisions regarding overall design decisions.
- Should make sure that the group has a logo and a functional website
- Responsible for the aesthetics: GUI, website and poster.

4.2.5 *Head of Hardware – Rover (HWR)*

- Maintains the Rover hardware.
- Makes sure that malfunctions on the physical Rover are resolved.
- Has the final say if the group does not agree about decisions regarding the hardware on the rover.
- Prepares the physical Rover and distressed persons RC-cars before tests.

4.2.6 *Head of Hardware – UAV (HWU)*

- Maintains the UAV hardware.
- Makes sure that malfunctions on the UAV are resolved.
- Has the final say if the group does not agree about decisions regarding the hardware on the UAV.
- Prepares the physical UAV before tests.
- Responsible for contact with the project group; **Search and Rescue – Underwater**.

4.2.7 *Head of Software (HOS)*

- Informs the group of the coding standard and controls that it is used properly.
- Ensures that the code is well-commented or/and documented.
- Has the final say if the group does not agree about decisions regarding software design.
- Responsible for the GIT repository, including pushing to the main branch.

5 DOCUMENTATION PLAN

The project will deliver the documents shown in table 2.

Table 2: This table shows the documents that will be delivered by the project.

Document	Description	Date
Requirement specification	Describes all the requirements that must be fulfilled in the project.	2022-09-21
Project plan	Describes how the project is to be executed and also contains activities and milestones.	2022-09-21
Time plan	Describes how much time each activity is planned to take.	2022-09-21
Design specification	Describes in detail how the different parts of the system are supposed to be constructed, implemented and how they interact with each other.	2-3 weeks after BP2
Test plan	Describes how the system is supposed to be tested in order to verify functionality.	2-3 weeks after BP2
Test protocol	Describes the results of all the performed tests.	Half week before delivery of project
User manual	Describes how the system is correctly used. An installation guide is also included which describes how the system is correctly installed.	Half week before delivery of project
Technical report	Describes in detail all the technical aspects of the system.	2022-12-19
After study	Contains a discussion about the work flow, time consumption, experiences, and problems encountered during the project.	2022-12-12

6 DEVELOPMENT METHODOLOGY

The idea is to make sure that there is always work to be done through defining activities, whilst making sure that the activities pertain to the most important goals in the project (i.e. avoiding activities that are busywork). The definition of milestones to strive for and activities to work with are defined in Section 11 and 12 respectively. Furthermore, a timetable for the different milestones and activities will be established, ready to be revised when necessary, in order to make sure that the goals are met at the end of the project. The group members will also have weekly meetings on Mondays to discuss the progress made last week, potential hiccups and plan the development for the week.

The documentation is planned to be updated continuously during the project to allow the group to continue developing the platform closer to deadline, and also ensuring that every new implementation is documented.

Software-wise, the software that is run on the HW is planned to be handled utmost most care. Separate branches in the git-repository for the hardware platforms will be maintained and only allowed commits or merges after these have passed the tests for the corresponding platform. Furthermore, all tests need to be passed before any changes are merged into the main branch.

7 QUALIFICATION PLAN

This section is devoted to the measures taken in order to ensure the quality of the final product. The section is split into Documentation, code, and functionality; representing a rough separation of areas which employ different measures of quality.

7.1 Documentation

The quality of the documentation is measured in the quality of the writing (i.e., absence of spelling errors, grammatical errors etc.), consistency across documentations and whether it is complete by its deadline. It is a group-effort to make sure that the documents fulfill a sufficient quality in regard to this measure, but it is the ultimate responsibility of the DOC to: spellcheck (with the help of other team members), provide templates for the documentation and make sure that the documents are ready by the submission date.

7.2 Code

The quality of the code is measured in the level of its adherence to the Google code standard, the quality of the comments in the code and the consistency of the code across the whole repository. It is also measured by the efficiency of the calculations and whether it fulfills all functionality. All the members are responsible for keeping up the quality in relation to the measure, however, it is the HOS who is ultimately responsible for making sure that the code follows the Google code standard before the project is finished and that the repository is maintained.

7.3 Functionality

The quality of the functionality is measured in whether the functionality requirements in the requirement specification are fulfilled, the quality of the functionality (i.e., is it a *good* solution?) and the repeatability of the functionality in tests. Ultimately, this measure of quality is a result of the effort of all the team members. It is, however, the responsibility of the HOT to make sure that the functionality is correctly evaluated throughout the project.

7.4 The Group's Education

It is the responsibility of every team member to attain any knowledge needed for their tasks. Additionally, the technical advisors can be of assistance if need be.

8 REPORTING PLAN

The project group is responsible for continuously updating the orderer and customer of the progress of the project. This update is summarized in the form of an updated timetable and short status report, which is then sent by the PM to the orderer at the end of every week. The status report is also sent to the customer.

8.1 Time Report

The orderer will receive an updated timetable at the end of every week, including an updated time plan and updated figures of the amount of time spent on the project.

8.2 Status Report

The orderer and customer will receive a status report detailing the progress of the project at the end of every week. The report summarizes the progress made, the current difficulties and potential next steps.

8.3 Meetings with the Orderer and Customer

There will be a weekly meeting between the orderer and project group, represented by the PM. These meetings are meant to update the orderer about and discuss the progress of the project. Further meetings may be considered when needed, and may be initialized by any of the parties involved, and in which the PM will represent the project group.

9 MEETING PLAN

The project group will have two scheduled meetings per week. One with only the project group on Mondays at 13:15-15:00. During these meetings, the group members will inform each other what they have been working on and what they will do the coming week. Another meeting will be held on Thursdays at 10:15-12:00 where a status briefing will be held. The advisors will also be available during this time and if the group finds it necessary they will join in and help with the current needs.

10 RESOURCE PLAN

This section presents the resources available to the project.

10.1 People

The project consists of seven students from Linköping University. The project has one advisor at the department of Electrical Engineering and three advisors at SAAB Dynamics.

10.2 Material

The material assigned to the project are properties of SAAB Dynamics and is made available to the group. This includes: a rover, a UAV, two RC-cars and three laptops along with other miscellaneous parts that may be needed. Software is made available through Git and can be used either on the project member's personal computer or one of the computers made available from SAAB Dynamics

10.3 Facilities

The project group has access to room 2A:590 in the B-building at Linköping University. It will also have access to the test site Visionen, also in the B-building.

10.4 Economy

The project's main economical resource is time. Each group member will contribute with 240 hours. The advisors from SAAB Dynamics and ISY will each provide 40 hours of counseling. Extra expenses other than the material assigned to the project (see Section 10.2) will be accounted for by SAAB Dynamics.

11 MILESTONES AND TOLLGATES

In order to make sure that the ultimate goal of the project is complete by the end of the project, the progress has been divided into a set of milestones. By planning around the milestones instead of the ultimate goal, the idea is that it will become clear quicker if the project group is falling behind the schedule and need to reevaluate some aspect of the goal. In this section these milestones are defined as well as the tollgates which signal when certain phases of the project are complete.

11.1 Milestones

The milestones in the project are ultimately goals to shoot for, but may be reevaluated during the course of the project. These milestones are presented in Table 3. In order for a milestone to qualify as having been reached, it must pass a test in which the milestone is evaluated. Should a milestone not be met by its date, then it should either receive a new deadline or rewritten to match changed circumstances in the project. The orderer will be informed when a milestone is reached, or failed to be reached in time.

Table 3: This table shows the milestones for the project.

No	Milestone	Date
1	The UAV can successfully communicate over the physical microRTPS-bridge	4/11
2	The cameras can successfully identify the distressed persons	4/11
3	The Rover can autonomously map and navigate an area	11/11
4	The Rover can track a moving distressed person while keeping a safe distance	23/11
5	The Rover and UAV can collaboratively identify, track and deliver supplies to distressed people	1/12

11.2 Tollgates (BP)

The major tollgates during the project are the BP:s (*"Beslutspunkter" in Swedish*) which aims to structure the work to help in documentation. During these tollgates, some documents and other work are handed over to the other parties in order to make sure that the project moves in a satisfactory way for all parties involved.

12 ACTIVITIES

In this section, all planned project activities are listed and defined.

12.1 General

Listed below are the general activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
1	Kickoff	Bowling and Burgers	-	14	-
2	Meetings	Monday and Thursday meetings	-	200	-
3	Lectures	The scheduled course lectures	-	28	-
4	System knowledge	Study the existing system	-	21	-
5	Installation	Install required software for system	-	38	-
6	BP2 and verbal presentation of system	Presentation of the system and have BP2 meeting	14, 15	14	74-77
7	BP3	Meeting for the delivered documents in BP3	16, 17	14	78-79
8	BP4	Meeting for delivery of Milestone no. 1-4 and presentation of a first draft of a working simulation environment for the system	-	14	80-81
9	Presentation BP5	Prepare and present the product to the customer and prove that the requirements are met	-	14	82-85
10	Project Conference	Prepare and present the project to other course participants.	-	21	-
11	Testing	Testing functionalities and verifying requirements	-	80	-
12	Collaborate with underwater	Discuss and integrate each project product	-	8	-
13	Administrative work	Administrative work for the project leader	-	40	-

12.2 Documentation

Listed below are the documentation activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
14	Requirement specification	Writing the requirement specification	-	48	74
15	Project plan and time plan	Writing the project plan and time plan	-	50	75
16	Design specification	Writing the design specification	-	75	62, 77
17	Test plan	Writing the test plan	-	30	79
18	Test protocol	Writing the test protocol	-	20	83
19	User manual	Writing the user manual	-	30	84
20	Technical report	Writing the technical report	16	75	86
21	After study	Writing the after study	-	14	87
22	Poster	Create a poster for the project	-	11	88
23	Web page	Create a web page for the project	-	21	89
24	Product movie	Film and edit a product movie	-	11	90
25	Time and status report	Write a status and time report every week	-	13	-

12.3 Rover

Listed below are the Rover activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
26	Tune control parameters	Tune the PID control parameters for the Rover	-	10	15-16
27	Work on image recognition	Work on recognizing the distressed persons from image	-	23	19
28	Implement image recognition on rover	Make the image recognition work on the rover's camera	-	6	19
29	Work on image tracking	Work on the image tracking software	27	50	23
30	Integrate with Qualisys system	Work on the implementation of Qualisys system for sensor data	-	20	17
31	Implement discovery algorithm	Implement discovery algorithm to map the whole area	-	50	22
32	Work on behavior tree of the Rover	Implement and refine behaviors in the Rover s behavior tree	31	50	22, 23

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Act. No	Activity	Description	Dep.	Time [h]	Req. No.
33	SLAM implementation	Implement SLAM using LIDAR and integrate with surrounding software	-	40	22
34	Rover Maintenance	Maintain all hardware for the Rover and make sure everything works	-	8	-

12.4 UAV

Listed below are the UAV activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
35	Onboard communication	Implement the microRTPS-bridge so that the communication between the Pixhawk and RPi works	-	40	30
36	Integrate with Qualisys system	Integrate Qualisys positioning for the UAV	-	20	31
37	Implement motion planner	Implement a motion planner for the UAV	-	40	33
38	Avoiding no-fly zones	Implement functionality in the motion planner to avoid no-fly zones	37	20	34
39	Take off service	Create a service for taking off	-	20	35
40	Land service	Create a service for landing	-	15	36
41	Tune flight parameter	Tune the PID parameters in the Pixhawk to achieve smoother flight	35, 36	6	37
42	Implement image recognition on UAV	Work on making the UAV recognize the distressed persons	27	8	38, 39
43	Simulated supply drop off	Implement dropping off imaginary supplies	37	25	40
44	Tracking persons	Implement tracking and following of distressed persons	42	20	42
45	Safety distance	Integrate a safety distance in the motion planner	37	15	44
46	Take off from Rover	Make sure the UAV can take off from the Rover	39	4	45
47	Land on Rover	Implement a service for landing on the Rover while it is stationary	40	5	46

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Act. No	Activity	Description	Dep.	Time [h]	Req. No.
48	UAV Maintenance	Maintain all hardware for the UAV and make sure everything works	-	10	-

12.5 Base Station

Listed below are the Base Station activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
49	Implement a task planner	Implementation of a task planner to complete a mission using the Rover and the UAV	-	70	50
50	Develop search algorithms	Develop search algorithms/strategy for searching for moving distressed persons with Rover and UAV	-	30	50, 54

12.6 Simulation environment

Listed below are the Simulation environment activities throughout the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
51	Stationary distressed persons	Implement simulation of stationary distressed persons	-	12	58
52	Moving distressed persons	Implement simulation of moving distressed persons	51	20	59
53	Different maps	Enable different environments to simulate in	-	7	61
54	No-fly zone	Visualize and implement no-fly zone in simulation	-	10	62
55	Move simulation from Base station	Move the simulation to its own git repository	-	15	55

12.7 GUI

Listed below are the Simulation GUI activities through the project.

Act. No	Activity	Description	Dep.	Time [h]	Req. No.
56	Visualize map	Visualize the map along with vehicles and mapped area	-	20	66
57	Create an interactive window	Interactive window with necessary buttons	-	10	67
58	Add functionalities	Connect buttons with certain functionalities	57	20	67
59	Integrate Rviz2	Integrate the visualization from simulation environment into GUI	-	15	66

13 TIME PLAN

The time plan can be seen in a separate document, titled *tidsplan.xlsx*.

14 QUALITY PLAN

The requirements presented in the document ”Requirement_Specification.pdf” might be renegotiated with the orderer. The time plan will be regularly updated during the project.

14.1 Inspection

All code written should carefully be implemented into the system.

14.2 Test Plan

The test plan will be in a separate document and referred to here.

14.3 Time buffer

The time plan will include a time buffer from which working time can be distributed to other activities when there is need for it.

15 RISK ANALYSIS

The risk analysis can be seen in a separate document, entitles *riskanalysis.pdf*.

16 PRIORITIES

The requirements listed in the document ”Requirement_Specification.pdf” all have a priority number. The requirements listed as level 1 has the highest priority and must be fulfilled in order to pass the project. Requirements on level 2 are expected to be fulfilled when the project is delivered, but should not be worked on before level 1 requirements are fulfilled. Level 3 requirements are only considered to be worked if all level 1 and 2 requirements are fulfilled. If some requirements cannot be met, they must either be renegotiated to another level or removed.

17 PROJECT CLOSURE

When the project is done, all hardware will be returned to SAAB Dynamics and the key to the project room will be returned to ISY. An after study, all software and documents will be handed in.

18 REFERENCES

REFERENCES

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