Project Plan

Editor: Erik Bodin

Version 1.1

Status

Reviewed	Erik Bodin	2016-10-12
Approved	Martin Lindfors	2016-10-13

PROJECT IDENTITY

2016/HT, TIGER
Linköping University, Dept. of Electrical Engineering (ISY)

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Contents

Document history

Version	**Date**	**Changes**	**Changed by**	**Reviewed**
0.1	2016-09-16	First draft	*	EB
0.2	2016-09-19	Second draft	*	EB
0.3	2016-09-22	Updated according to rest list	*	IS
1.0	2016-09-23	Approved	*	EB
1.1	2016-09-26	Updated according to final comments	IS	
1.2	2016-10-12	Updated to fit approved design specification	IS, HW	

1 Customer

The customer is Saab Dynamics, represented in the project by Torbjörn Crona. The client is Martin Lindfors at the Department of Electrical Engineering at Linköping University.

2 Project Overview

This document describes a cooperative research project between Linköping University and Saab Dynamics. More specifically it defines the criteria by which the project will be judged.

The long term goal of this project is to produce an autonomous minesweeper, sometimes referred to as "Balrog". Primary focus for this year's project is to design a high precision positioning system in order to facilitate higher level functionality such as mapping, route planning, and automatic control.

2.1 Purpose and goals

This project is primarily meant to be educational, as a part of the larger CDIO initiative.

The robot is intended to be used as a platform for further research and development at Linköping University.

Refer to the requirements specification [2] for details of the requirements, an overview is given below.

1. Estimate the robot's position
2. Perform mapping of the immediate area
3. Plan routes to systematically search a given area
4. Implement autonomous control to follow those routes
5. Create modular and well documented code to enable further development

2.2 Deliveries

This project follows the LIPS model, which provides strict deadlines at predefined breakpoints. These breakpoints and the associated dates are enumerated below.

Delivery	**Date**
First version of requirements specification to client	2016-09-09
First version of project plan and system draft to client	2016-09-15
Final version of requirements specification, project plan and system draft approved by client	2016-09-20
First version of system design specification and test plan to client	2016-09-27
Final version of system design specification and test plan approved by client	2016-10-06
User manual to customer and client	2016-12-05
Final product to customer	2016-12-05
Technical documentation to client	2016-12-05
Project reflections delivered	2016-12-10
Project conference	2016-12-19

2.3 Scope

This project concerns the production of software for positioning, mapping, navigation and automatic control of the Balrog. The exact details are available in the requirement specification.

The Balrog platform and the associated sensor hardware as well as the software for communication with these through MATLAB® are provided by Saab Dynamics. Modifications to these are however within the scope of this project and will therefor be handled within the project time when shush modifications are required.

3 Project Phases

This project can roughly be divided into three discrete periods. Preparatory work, design work, and a debriefing after these are finished.

3.1 Before the project

The preparatory section primarily consists of producing most of the administrative documents that provide structure to the remainder of the project.

These documents consist of:

- This project plan and its associated time plan
- A requirements specification
- A system draft
- A group contract

The heads of design and software will also provide the other members with tutorials to clarify the tools used for collaborative software development. This covers a tutorial in git as well as one to teach the code standard that will be used.

3.2 During the project

The bulk of the project is the software development for Balrog. At the start of this phase the system draft will be expanded into a complete design specification.

Once the design specification has been completed the actual software design can begin.

The main goals of this phase are to complete the following things.

- Expand the system draft into a design specification
- Design models and develop software
- Fulfill the criteria in the requirements specification
- System testing
- User manual

  This phase ends at BP5 when the software is finished and delivered. In addition to this the test protocol and a user manual should be delivered.

3.3 After the project

Once the project is completed and the robot has been delivered there is some further administrative work to be done. This includes:

- A project evaluation
- A technical report
- A poster describing the robot
- A website describing the project
- A video presentation
- A verbal presentation for a project conference

4 Project Organisation

In this section the project organisation is explained. It specifies the involved parties and the internal organisation within the group.

4.1 Organisation

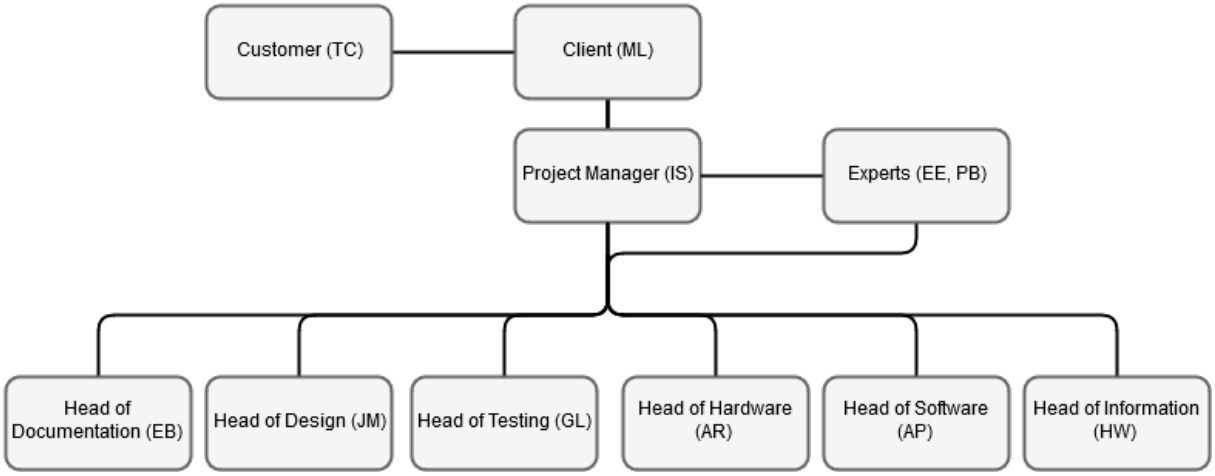

Figure 1: Project organisation

4.2 Definition of work contents and responsibilities

This section contains a description of the project roles. The project roles describe what members have what responsibilities. In individual cases responsibilities can be delegated to other group members.

4.2.1 Project manager (PM)

The project manager is responsible for

- Preparation and management of meetings
- Contact with the client and the customer
- Ensuring that the weekly update of the time report is sent to the client
- Ensuring that the weekly update of the progress report is sent to the client and the customer
- Ensuring that the project is progressing at the right pace
- Handling of internal conflicts
- Motivation and support of the project members

4.2.2 Head of Documentation (DOC)

The Head of Documentation is responsible for

- Ensuring that all written documents, besides code, follow a consistent structure
- Providing templates for the documentation
- Making sure all written documents are proof read thoroughly before submission
- The storage of both physical and digital documents

4.2.3 Head of Testing

The Head of Testing is responsible for

- Production of a test plan
- Ensuring that the project follows the test plan
- Investigation in case of failed tests
- Constructing a documented framework for testing

4.2.4 Head of Design

The Head of Design is responsible for

- Production of guidelines for the design
- Ensuring the design requirements in the requirements specification are fulfilled
- Determination of guidelines for documentation of the design

4.2.5 Head of Hardware

The Head of Hardware is responsible for

- Ensuring hardware malfunctions are handled as quickly as possible

4.2.6 Head of Software

The Head of Software is responsible for

- Making sure code standards are being followed
- Maintaining the git repository

4.2.7 Head of Information

The Head of Information is responsible for

- Ensuring the video, poster and web page are produced on time
- Ensuring the web page is updated when progress in the project is being made

4.3 Conditions for cooperation within the project group

All members are to follow the group contract which was signed by the group on Monday 2016-09-12.

5 Document Plan

This is a complete list describing all the documents that are going to be written during the course of this project. In addition to defining what documents are going to be produced it also specifies what party has to approve the document.

All documents start at version 0.1. Increasing numbers describe iterations of various drafts, and once a document has been approved by the client it becomes version 1.0.

Document	Author/ approved by	Purpose	Distribution	Ready
Requirements specification	*/ML	Definition of the requirements of the product	ML	2016-09-20
Project plan	*/ML	A plan of how the project will be carried out	ML	2016-09-20
Time plan	*/ML	A plan of when the activities will be done and who is responsible for them	ML	2016-09-20
System draft	*/ML	A first sketch of how the robot will be designed	ML, PB	2016-09-20
Design Specification	*/ML	A detailed plan of how the robot will be designed	ML, PB	2016-10-06
Test plan	*/ML	Definitions of different tests the robot will perform	ML, PB	2016-10-06
User manual	*/ML	A manual over how to use the robot	ML, EE	2016-11-20
Test protocol	*/ML	Result and analysis of the performance of each test in the test plan	ML, PB	2016-11-20
Technical documentation	*/ML	A technical documentation describing how the product works	ML, PB	2016-12-11
Poster	HW/ML	A poster describing the project	ML	2016-12-11
Video	HW/ML	A short video that can be used to promote the Balrog and te course.	ML	2016-12-11
Project reflections	*/ML	A document analysing how the project was carried out.	ML	2016-12-11
Time and status reports	IS	A weekly report of how much each person has contributed to the project and a description of passed and failed activities	ML	-
Meeting minutes	*/EB	A documentation over what has been said and done in each meeting	ML	-

(*) Multiple authors

6 Development Method

The robot consists of several subsystems and each person will in principal be assigned to one subsystem. However the assignments are not set in stone. As an example it is likely that more people will be devoted to the positioning subsystem in the beginning of the project and as the project progresses resources will be relocated as needed.

The subgroups will communicate and share ideas, questions, problems, solutions etc.

All previous documentation and code is stored in a git repository, which will be used during this project as well. Feature based branching will be used, where only approved code will be merged with the main branch.

All source code produces in the project will conform to the code standard introduced by the Head of Software and the Head of Design. All documentation will follow the LIPS standard.

Documentation of the work is to be done continuously during the project.

7 Training Plan

The Head of Software is, with the help of the Head of Design, responsible for educating every group member that could potentially write source code in the code standards applicable to the project.

The Head of Software is also responsible for giving the whole group an introductory tutorial in the source control system git.

8 Status and Time Report

The Project Manager will ensure that the Client and Customer are updates on the progress of the project by:

- Making sure a progress report for the previous week is available to the Client and Customer at 8 AM every Monday.
- Making sure the time report of the previous week is available to the Client at 8 AM every Monday.

The status report will describe what work has been done in the project during the previous week, and indicate any reached goals. The time report will include the time used by each member during the previous week, as well as the total amount of time spent on the project by all members.

In addition to this, the group will meet with the Client when necessary, in order to keep him updated on the progress.

9 Meeting Plan

A mandatory group meeting will be held each Monday between 13.15 and 15.00. The purpose of this meeting is mainly to evaluate the work of the previous week, and plan the upcoming week's work but also share progress made during the weekend or just discuss potential issues.

Absence from these meetings has to be announced at the latest the day before. If a majority of the group find it appropriate these meetings can be moved in time.

If there is a request to discuss something special during a meeting the rest of the group should be informed of the topic prior to the meeting, preferably as far in advance as possible.

A meeting protocol will be written each meeting.

There might be more meetings of a "less formal" type outside these scheduled hours where attendance is not mandatory (but encouraged) and protocol may not (always) be written.

10 Resource Plan

This section describes the resources that will be used during the project.

10.1 Personnel

This project group consists of seven students at Linköping University. Five students are from the applied physics and electrical engineering programme and two students are from the mechanical engineering programme.

The group has access to several people with technical knowledge regarding the project.

- Erik Ekelund, technical expert at Saab (40h)
- Martin Lindfors, client at ISY (50h)
- Per Boström, technical export at ISY (50h)

Representing the customer is Torbjörn Crona from Saab Dymanics.

10.2 Material

The Balrog and all its parts are provided to the project group by Saab Dynamics, the owner of the crawler. The system consists of a tracked vehicle (the Balrog) with a computer and the following sensor suite: IMU, ultrasonic distance measurement, odometers, LIDAR, barometer, and a GPS. Any new material is ordered by contacting Saab.

Saab also provide the group with a laptop for controlling the Balrog.

10.3 Project rooms

The project group has been assigned a room in the B building at campus Valla, Linköping University. This can be used in conjunction with other rooms around the campus.

10.4 Economy

Each project member has 240 hours ± 10% to spend in the project. This gives a total of 1680 hours. The group aims to divide these hours evenly over the entire duration of the project.

11 Milestones and Tollgates

11.1 Milestones

The project has seven milestones defined in the table below.

No	Description	Date
1	Project plan, system draft and requirements specification are approved by the client	2016-09-20
2	Design specification and test plan approved by the client	2016-10-07
3	First version of computer vision algorithm implemented	2016-10-28
4	First version of control algorithm implemented	2016-11-17
5	First version of navigation algorithm implemented	2016-11-22
6	First version of communication module implemented	2016-10-21
7	First version of SLAM algorithm implemented	2016-11-01
8	All subsystems integrated	2016-11-23
9	All priority 1 requirements fulfilled	2016-11-25

11.2 Tollgates

The project has four tollgates.

No	Description	Date
2	Approval of requirements specification, project plan and system draft. Decision to start execution phase.	2016-09-20
3	Approval of design specification and test plan. Decision to continue execution phase.	2016-10-07
5	Approval of product functionality. Handover of test protocol, user manual, installation guide and presentation. Decision to deliver.	2016-12-01
6	Approval of delivery. Handover of technical documentation, project evaluation, project home page, poster presentation and video presentation. Decision to dissolve project group.	2016-12-16

12 Activities

12.1 General

Nr	Activity	Description	Depends on	Time (h)
1	Research last years Balrog	Research last years Balrog to see what features could possibly be reused and further developed in this years Balrog.	-	3
2	Communication between systems	Implement communication between the different subsystems	-	30

12.2 GUI

Nr	Activity	Description	Depends on	Time (h)
3	GUI wireless communication	Develop wireless communication	-	10
4	GUI communication Balrog	Implement communication functions on Balrog	3	40
5	GUI communication PC	Implement communication functions on PC	3	20
6	GUI Graphical interface	Implement graphical interface for the GUI	-	30
7	GUI Remote navigation	Implement remote navigation from GUI	4,5,6	16

12.3 Positioning and Mapping

Nr	Activity	Description	Depends on	Time (h)
8	Research computer vision	Research computer vision	-	16
9	Research laser-based SLAM	Research laser-based SLAM	-	16
10	Research dead reckoning	Research dead reckoning algorithms	-	16
11	Implement SLAM	Implement the chosen SLAM algorithm	9	30
12	Implement computer vision	Implement the chosen computer vision algorithm	8	30
13	Verify motion model	Verify and implement the motion model from previous years	-	16
14	Extend SLAM	Combine CV, SLAM and dead reckoning implementations into a combined SLAM algoritm.	11,12,13	20
15	Extend Mapping	Extend the SLAM-map to contain a grid-map of explored and unexplored tiles.	14	30
16	Exploration requirements	Develop requirements and conditions for a tile to be explored.	15	20
17	Test localization	Test the localization algorithm	14	60

12.4 Navigation

Nr	Activity	Description	Depends on	Time (h)
18	Research navigation	Research different navigation search algorithms	-	20
19	Exploration search	Implement the exploration search algorithm	18	60
20	Navigation	Develop an algorithm to calculate reference trajectory to a position for the controller	19	40
21	Obstacle avoidance	Implement the algorithm used for obstacle avoidance	20	20
22	Trajectory update	Further Implementations to the navigation algorithm to handle trajectory updates	20	20
23	Test navigation	Test the navigation algorithm	-	30

12.5 Control

24	Research control	Research which control strategies are to be used	-	10
25	Control Strategy	Implement the control strategy	24	30
26	Control parameters	Estimate Control Parameters	25	20
27	Obstacle handling	Add obstacle avoidance to prevent collision in case of faulty path	25	20
28	Test controller	Test the functionality of the controller	-	20

12.6 Documentation

Nr	Activity	Description	Depends on	Time (h)
29	Requirement specification	Discussing and writing the requirement specification.	-	40
30	Group contract	Discussing and writing of a group contract.	-	3
31	Project plan	Discussing and writing the project plan.	-	30
32	Planning activities	Discussing and planning activities	-	25
33	Time plan	Discussing and writing a time plan	32	20
34	System draft	Discussing and writing a system draft	-	30
35	Design specification	Discussing and writing a design specification	34	85
36	Test plan	Discussing and writing a test plan	35	24
37	Test protocol	Discussing and writing test protocols	-	9
38	Technical documentation	Discussing and writing a technical documentation	35	140
39	User manual	Discussing and writing a user manual	35,38	9
40	Evaluation	Discussing and writing an evaluation	-	20
41	Poster	Discussing and producing a poster which displays the project	-	16
42	Movie	Discussing and producing a video which shows the project	-	33
43	Presentation	Discussing and producing a presentation of the project	-	18
44	Website	Discussing, producing and update a website which shows the project	-	20

12.7 Other

Nr	Activity	Description	Depends on	Time (h)
45	Project group meetings	Weekly meetings to keep the group up to date on the status of the ongoing activities, and tollgate meetings	-	128
46	Lectures	Attending lectures given in the project course.	-	28
47	Code standard tutorial	Educate the group in the rules of coding and the software to be used when programming (compiler/IDE)	-	3
48	Git tutorial	Educate the group about how to use the version handling system,	-	3
49	Project management	Managing the project so the group completes the product.	-	32
50	Give Presentation	Present	-	14
51	Customer meetings	Meetings with the customer, including a visit to the facilities of the customer.	-	28
52	Buffer	Hours available for distribution	-	253

13 Adjustments

Adjustments to the official documents of the project are to be handled as follows:

When the possible need for changes to the requirements specification is first observed, the client will be notified. When the need for change is clear a meeting will be held with the client to discuss the changes and get approval. Changes to the time and project plan will also be discussed with and approved by the client.

Any adjustments to internal documents will be handled internally at group meetings.

14 Quality Plan

This section describes how the components of this project will be examined in order to ensure their quality.

The quality of the code-base is the Head of Software's responsibility. He is to make sure that submissions follow the agreed upon standard and that version control is properly used. In order to facilitate this he will hold an introduction on source control before actual software development begins.

The Head of Documentation is the person primarily responsible for the quality and proof-reading of submitted documentation, but this is a task that easily can be delegated. In order to maintain quality and work efficiently the group will try to maintain an open dialogue with the client, and get feedback continuously.

All members of the group have 24/7 access to all documentation, and work is performed collaboratively. Because of this close cooperation each section of text ends up being read by multiple people before the documentation is actually finalized. Older versions of the documentation is available for everyone through ShareLaTeX, along with the shared workspace.

In order to maintain the quality of the work throughout the project a test plan will be written along with the design document. This will help provide insight not only into how well code is written, but also how well the design actually fulfills this project's criteria. This feedback is the primary mechanism to evaluate whether or not the design is sufficient.

15 Risk Analysis

The project is at risk of severe delays if some specific scenarios occur. In order to minimize the risk and to provide methodology to manage such delays the topics have been expanded upon in the following sections.

15.1 Sensor malfunction

If the sensor suite is not performing to the expected standard then the project requirements will have to be renegotiated or the sensors upgraded/repaired by Saab Dynamics.

Fulfilling the project criteria requires that the positioning is precise. The quality of the robot's positioning is directly dependent on the quality of the sensors and therefore the maintenance and performance of the sensor suite is of crucial importance to the success of this project.

15.2 Bad code

The primary way to prevent bad code and troublesome maintenance is to proactively work to keep the software to a high standard. Some precautions have been taken in order to do this, such as preparing a tutorial for the group describing our code standard and proper usage of version control software. There is also a strong focus on providing documentation of the project, which should help maintain an organized code base.

In the worst case scenario time will have to be explicitly rescheduled in order to restructure and refactor the code. This might in turn force a requirements renegotiation and should be avoided at all costs.

15.3 Data loss

Because this project is primarily software almost all of the work is digital. In order to mitigate the risk of losing all the data the distributed version control system is used. A primary repository is provided by IDA at Linköping University, but the distributed nature of git means that once work starts there will be multiple working copies should gitlab suffer catastrophic infrastructure failure.

15.4 Hardware theft

Because this project uses fairly expensive equipment theft is a natural concern. While theft is considered a low-risk threat the group has been provided a lockable room for interim storage of the robot and the provided laptop. While the robot is expensive it is also a very specialized piece of hardware, and therefore it is unlikely to be targeted.

16 Priorities

The requirements specification contains an exhaustive list of all the things that need to be completed during this project, along with their relative importance.

Level one requirements are necessary in order to consider the project a success, while level two requirements are not strictly necessary. Level three requirements should be considered 'extra' and it is likely that not all of them are met.

17 Finalization of Project

When the project enters the finalization stage an evaluation should be provided to the client, along with the software and its documentation.

For the project to be considered finished some specific points need to have been addressed.

- Documentation delivered to and approved by customer
- Poster, video, and website completed
- Robot presented to customer
- Results presented to other course participants at seminar

Once the project is completed the robot is to be given to Saab Dynamics, along with code and documentation. The software along with its documentation will also be provided to ISY in order to facilitate further development of the platform for other groups of students in the coming years.

References

[1] *LIPS – nivå 1. Version 1.0.* Tomas Svensson och Christian Krysander. Compendium, LiTH, 2002.

[2] *Requirements Specification* TIGER Project Group. Document, 2016.