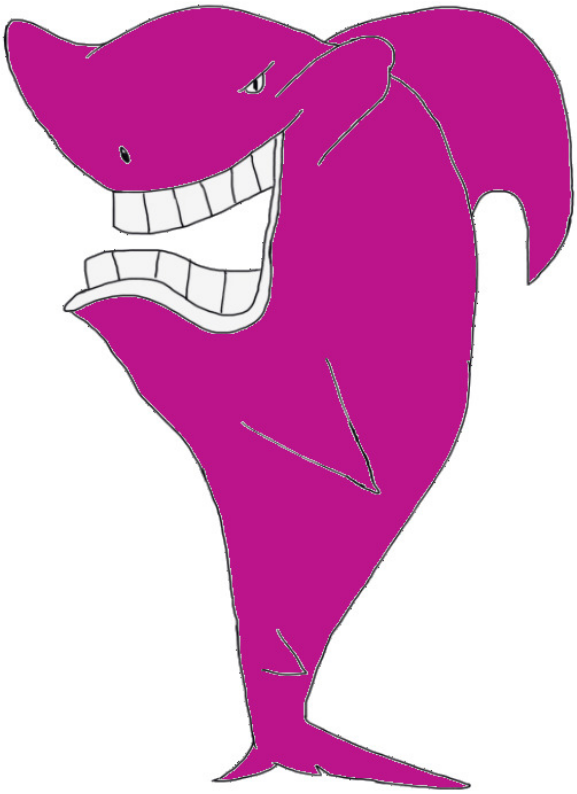
Project Plan

Editor: Oscar Hörberg

Version 1.0



Status

Reviewed	granskare	2015-09-23
Approved		

PROJECT IDENTITY

2015/HT, Ross Haj
Linköping University, Dept. of Electrical Engineering (ISY)

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Contents

Document history

Version	Date	Changes	Sign	Reviewed
0.1	2015-09-16	First draft	SÖ, HF	OH
0.2	2015-09-21	Second draft	SÖ, HF, JH	AH
1.0	2015-09-23	Second draft	AH	OH

1 Who is the customer

The customer is Saab Bofors Dynamics and the client is Hanna Nyqvist at the Department of Electrical Engineering at Linköping University.

2 An overview of the project

This project will develop Balrog, an autonomous demining crawler. The main focus will be on developing Balrog's navigation and ability to diagnose and filter bad sensor values. In the following section an overview of the project is given.

2.1 Purpose and goals

The main purpose of the project is to educate the project members in project based work. The project will provide practical training and will be using the LIPS platform.

The main goals of the project are, as stated in the requirement specification:

1. Improve the estimation of the crawler's position
2. Add a barometer to the crawler in order to enable positioning in 3D
3. Thorough documentation of the performance of every sensor connected to the crawler
4. Create sensor models for all sensors
5. Implementation and documentation of a navigation filter
6. Developing an algorithm detecting when a sensor is reliable/unreliable

2.2 Deliveries

The following table shows the deliveries during and after the project.

Delivery	**Date**
First version of requirement specification to client	2015-09-10
First version of project plan and system draft to client	2015-09-14
Final version of requirement specification, project plan and system draft to client	2015-09-22
First version of system design specification and test plan to client	2015-10-01
Final version of system design specification and test plan to client	2015-10-13
User manual to customer and client	2015-11-27
Final product to customer	2015-12-01
Installation guide to customer and client	2015-11-27
Technical documentation to client	2015-12-10
Project reflections to client	2015-12-10

2.3 What is not included

Parts outside the specification requirements will not be considered.

After the the project group has dissolved, it will not be possible to acquire any sort of support from the group members.

3 Plan for the project phases

This section describes the three phases of the project.

3.1 Before the project

Before any sort of modifications are made to the technical platform, a preparation and planning phase will be executed. This phase focuses on producing documents which holds information about how the project is to be conducted. These documents are the project requirements, a work and time plan and a system draft, which describes the different technical parts of the project platform.

The preparation phase also contains time for the group members to get an overview of the work that has been done by previous project groups. This is also where the group gets acquainted with some of the tools that will be used during the project (such as git, LaTeX etc.).

3.2 During the project

The execution phase is where all technical modifications to the system are made. These will follow the design specification and time plan from the previous phase. The plans will continuously be refined as the group moves forward and gains more experience.

The main points of this phase are:

- Writing a design specification
- Continuously document the modifications to the system
- Continuously report time and progress to the client
- Have group meetings to discuss progress, implementations and future plans
- Implement what is specified in the design plan
- Thoroughly test all implementations
- Sensor testing, modelling and evaluation
- Make sure the requirement specification is fulfilled

3.3 After the project

This phase includes delivering the technical platform to the customer, along with technical documentation and a user manual.

During this phase the project group will also attend a project conference where the work will be presented. A written evaluation of the project will also be produced.

4 Organisation plan

This section explains how the project is organised, including which parties are involved and the different roles within the group.

4.1 Project organisation

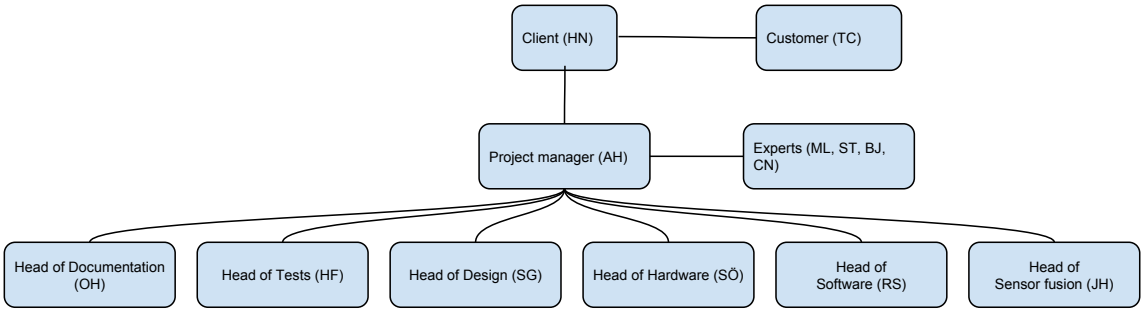

Figure 1: Project organisation

4.2 Definition of work contents and responsibilities

This section contains a short description of the responsibilities associated with the project roles.

4.2.1 Project manager (PM)

The project manager is responsible for

- Handling all contact with the client and the customer
- Making sure a time and progress report is sent to the client each week
- Preparation and management of group meetings
- Handling conflicts within the group
- Ensuring that the project is progressing in the right pace

4.2.2 Head of Documentation (DOC)

The Head of Documentation is responsible for

- Making sure all documents, besides code, follow a consistent structure
- Making sure all documents are proof read thoroughly before submission (this task can be delegated by DOC to other group members if needed)
- The storage of both physical and digital documents

4.2.3 Head of Tests

The Head of Tests is responsible for

- Making sure there is a documented framework for testing
- Producing a test plan
- Making sure the test plan is followed
- Follow up if a test fails

4.2.4 Head of Design

The Head of Design is responsible for

- Producing guidelines for the design of the technical platform
- Making sure the design requirements in the requirement specification are fulfilled
- Developing the sensor diagnosis functionality

4.2.5 Head of Hardware

The Head of Hardware is responsible for

- The integration of new hardware
- Making sure hardware malfunctions are resolved as quickly as possible
- Evaluation and documentation of sensors

4.2.6 Head of Software

The Head of Software is responsible for

- Making sure the code standard is followed
- Maintaining the git repository

4.2.7 Head of Sensor Fusion

The Head of Sensor Fusion is responsible for

- The development of the sensor fusion algorithm used to navigate Balrog

4.3 Conditions for cooperation within the project group

A group contract, which holds the guidelines for how work within the group is to be conducted, has been produced and shall be followed by the group.

5 Document Plan

The following section contains a plan for all documents in the project. The majority of all documents will be produced using LaTeX, although some documents might be produced using other tools such as MS Excel.

All documents will have version control with the convention that all drafts will have the version number 0.x where x will increase for every new version. Once a document has been approved by the customer the version will change to 1.0 and further changes will result in version 1.1, 1.2 and so on.

Document	**Author/ approved by**	**Purpose**	**Written in**	**Distribution**	**Ready**
Requirement specification	OH	Definition of the requirements of the product	LaTeX	HN,ML	2014-09-22
Project plan	OH	A plan of how the project will be carried out	LaTeX	HN	2015-09-22
Time plan	OH	A plan of when the activities will be done and who is responsible for them	Excel	HN	2014-09-22
System draft	SG	A first sketch of how the robot will be designed	LaTeX	HN,ML	2015-09-22
Design Specification	SG	A detailed plan of how the robot will be designed	LaTeX	HN,ML	2015-10-13
Test plan	HF	Definitions of different tests the robot will perform	LaTeX	HN,ML	2014-10-13
User manual	OH	A manual over how to use the robot	LaTeX	HN,ML	2015-11-27
Test protocol	HF	Result and analysis of the perfomance of each test in the test plan	LaTeX	HN,ML	2015-11-25
Technical documentation	OH	A technical documentation describing how the product works	LaTeX	HN,ML	2014-12-10
Project reflections	OH	A document analysing how the project was carried out.	LaTeX	HN	2014-12-10
Time and status report	AH	A weekly report of how much each person has contributed to the project and a description of passed and failed activities	Excel	HN	Start: week 38
Meeting minute	OH	A documentation over what has been said and done in each meeting	Google Docs	HN,ML	Start: week 39

6 Development Method

The group will work in smaller group, where each group is responsible for the development of a subsystem. There will be communication between the subgroups in order for everyone to get an overview of the total system and thus be able to handle dependencies between the subsystems.

Implementation and documentation will be conducted simultaneously.

The code will be saved in a Git repository, using feature based branching. Only tested and commented code will be merged into the master branch. The code will be documented using Doxygen.

7 Training plan

The group is responsible for educating and training the members, if necessary. Areas of education include git and the Google Code Standard.

8 Status and Time Report

The Project Leader will send a time and status report to the client on the first working day of each week. The time report will include how much time each group member spent working during the past week. The status report will show what goals were reached by the group.

The Project Leader will also meet the client continuously during the project, in order to give progression reports.

9 Meeting plan

A group meeting mandatory for all group members will be held each Monday between 12 and 1 p.m.. The purpose of this meeting is for the group members to report their progress, explain eventual difficulties and inform about what they will work on the coming week.

The Project Leader will make the agenda for the meeting available to the other group members 24 hours before the start of the meeting. If group members want to add something to the agenda they will send an email to the project leader before 24 hours before the start of the meeting. If there are big problems that needs to be discussed, another group meeting will be scheduled in case there is insufficient time in the weekly meeting.

A meeting protocol will be written each meeting.

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 in their final year at Linköping University. Six students are from the applied physics and electrical engineering programme and one student is from the industrial engineering and management programme.

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

- Martin Lindfors, tutor att ISY (30 hours)
- Björn Johansson, Carl Nordheim and Stefan Thorstenson, technical experts at Saab Bofors Dynamics (50 hours)

Representing the client is Hanna Nyqvist, ISY, and customer is Torbjörn Crona, Saab Bofors Dymanics.

10.2 Material

The Balrog and all its parts are provided to the project group by Saab Bofros Dynamics, who owns the crawler. The systems consists of a tracked vehicle (the Balrog) with a computer and the sensors: IMU, ultra sonic, odometers, laser sensor, barometer and a GPS. Any new material is ordered by contacting Saab.

The project group is provided two laptops by ISY at LiU. New material may be granted by ISY if they receive and approve requests from the group.

10.3 Project rooms

The project group has been assigned a room in the B building at campus Valla, Linköping University. This will be used together 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. As mentioned in paragraph 10.1 above the project has access to totally 80 hours of tutoring from technical experts from ISY and Saab Bofors Dynamics.

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 requirement specification are approved by the client	2015-09-22
2	Design specification and test plan are approved by the client	2015-10-13
3	A first version of a filter implemented	2015-10-30
3	Ability to read data from the barometer	2015-11-06
4	Have a sensor model for each sensor mounted on Balrog	2015-11-13
5	Ability to detect and shut down a sensor that is delivering unreliable data (without resulting in a crash in the rest of the system)	2015-11-13
6	Ability for the position of Balrog to be as accurate as stated in the requirement specification	2015-11-25
7	All priority 1 requirements in the requirement specification are fulfilled	2015-11-30

11.2 Tollgates

The project has five tollgates.

No	Description	Date
2	Approval of requirement specification, project plan and system draft. Decision to start execution phase	2015-09-22
3	Approval of design specification and test plan. Decision to continue execution phase	2015-10-13
4	Approval of the sensors and the sensor models. Handover of sensor test protocols and presentation. Decision to continue execution phase	2015-11-02
5	Approval of product functionality. Handover of test protocol, user manual, installation guide and presentation. Decision to deliver	2015-11-20
6	Approval of delivery. Handover of technical documentation, project evaluation, project home page, poster presentation and video presentation. Decision to resolve project group	2015-12-11

12 Activities

12.1 Documentation

Nr	Activity	Description	Time (h)
1	Requirement specification	Discussing and writing the requirement specification.	80
2	Group contract	Discussing and writing a group contract.	2
3	Project plan	Discussing and writing the project plan.	30
4	Planning activities	Discussing and planning activities	35
5	Time plan	Discussing and writing a time plan	20
6	System drawing	Discussing and writing a system drawing	18
7	Design specification	Discussing and writing a design specification	120
8	Test plan	Discussing and writing a test plan	22
9	Test protocol	Discussing and writing test protocols	6
10	Technical documentation	Discussing and writing a technical documentation	110
11	User manual	Discussing and writing a user manual	6
12	Evaluation	Discussing and writing an evaluation	58
13	Poster	Discussing and producing a poster which displays the project	16
14	Movie	Discussing and producing a movie which shows the project	33
15	Version control rules	Discussing and producing rules for how version control is to be conducted	5
16	Presentation	Discussing and producing a presentation of the project	3
17	Website	Discussing, producing and update a website which shows the project	18

12.2 Administration

Nr	Activity	Description	Time (h)
18	Project management	Managing the project so the group completes the product.	26
19	Project group meetings	Weekly meetings to keep the group up to date on the status of the ongoing activities.	100
20	Client meetings	Meetings with the client and the project manager to keep track of the project status.	14
21	Customer meetings	Meetings with the customer, including a visit to the facilities of the customer.	29

12.3 Education

Nr	Activity	Description	Time (h)
22	Lectures	Attending lectures given in the project course.	14
23	Software development startup education	Educate the group about how to use the version handling system, the rules of coding and the software to be used when programming (compiler/IDE)	21

12.4 Pre-implementation Research

Nr	Activity	Description	Time (h)
24	Research IDE, unit testing system and build system	Research and decide if/what specific software is going to be used for development.	21
25	Research mapping on last years Balrog	Find out how the mapping implementation on last year's Balrog was done, and what can be used for the current Balrog.	8
26	Research how to use/integrate pre-defined map.	Find out how the filter can use the predefined map to improve localisation	8
27	Research and describe system flow	Study, understand and evaluate the system flow used of the Balrog of last year. Describe the system flow that will be used this year.	14
28	Research Matlab vs C++	Studying the pros and cons of implementing code in Matlab versus coding in pure C++. Find out if there is a possibility of automatically and correctly converting the code from Matlab to C++.	5
29	Research barometer	Study, understand and evaluate the barometer to be used in this project.	26
30	Research old GUI and describe new GUI	Study, understand and evaluate the GUI from last year. Specify the changes that have to be made.	11
31	Research methods for sensor modelling	Try to find a consistent method of how to find sensible sensor models	53
32	Research localisation	Find a theoretical solution to the localisation problem, i.e what type of filter seems reasonable to use	31
33	Research last year's localisation	Study last year's filter and see if it is a good basis	6
34	Research SDSP (Sensor Diagnosis and Signal Processing)	Study material about sensor diagnosis. Find methods that seems reasonable for our project.	32

12.5 Current Balrog

Nr	Activity	Description	Time (h)
35	Evaluate current sensors	Check that measurements are obtainable and recalibrate if needed. Produce and execute a test plan for finding out the performance of the sensors mounted on Balrog	36
36	GUI	Find out what last year's GUI is able to display	3
37	Test Propulsion system	Evaluate the propulsion system's performance. Document the performance and what needs to be improved.	8

12.6 Base Station GUI

Nr	Activity	Description	Time (h)
38	Show position	Ability to show Balrog's position and its uncertainty on a map.	23
39	Draw map	Ability to receive and draw a map of Balrog's environment.	17
40	Show and log sensor values	Implement a feature that shows and logs sensor values and sensor status in the GUI in real time.	19
41	Show search area on map	Display the probabilty that balrog has been at a certain position on the map. Show whether the whole search area has been explored or not	18
42	Ability to enable/disable sensors	Implement support to enable and disable sensors from the GUI	14

12.7 IMU with barometer and magnetometer

Nr	Activity	Description	Time (h)
43	Obtain measurements from the IMU	Install the sensor (not necessarily on Balrog) and test displaying the measurements	4
44	Evaluate barometer	Construct and follow a test plan to evaluate the performance of the barometer in different environments. Document the result.	6
45	Evaluate IMU	Construct and follow a test plan to evaluate the performance of the IMU in different environments. Document the result.	4
46	Calibrate barometer	Calibrate the barometer, so that it delivers as accurate data as possible	4
47	Calibrate IMU	Calibrate the IMU, so that it delivers as accurate data as possible	2
48	Develop API to access barometer data	Create an API so that the rest of the system easily can obtain measurements from the barometer	5
49	Mount IMU on Balrog	Mount IMU on Balrog	4

12.8 Ultrasonic sensors

Nr	Activity	Description	Time (h)
50	Obtain measurements from the Ultrasonic sensor	Install the sensor (not necessarily on Balrog) and test displaying the measurements	4
51	Evaluate ultrasonic sensor	Construct and follow a test plan to evaluate the performance of the ultrasonic sensor in different environments. Document the result.	3
52	Calibrate	Calibrate the ultrasonic sensor, so that it delivers as accurate data as possible	3
53	Develop API to access ultrasonic sensor data	Create an API so that the rest of the system easily can obtain measurements from the ultrasonic sensor	7
54	Mount ultrasonic sensors on Balrog	Mount ultrasonic sensors on Balrog	6

12.9 Setup of Development Environment

Nr	Activity	Description	Time (h)
55	Set up development PC's, build systems and version control	Install necessary software on the computers used by the group members. Set up a version control system.	4

12.10 Sensors

Nr	Activity	Description	Time (h)
56	Log sensor data	Log sensor data internally on balrog with time stamp	4
57	Sensor model odometer	Study the sensor and create a sensor model	11
58	Sensor model laser sensor	Study the sensor and create a sensor model	10
59	Sensor model ultra sound sensor	Study the sensor and create a sensor model	6
60	Sensor model magnetometer	Study the sensor and create a sensor model	10
61	Sensor model IMU	Study the sensor and create a sensor model	10
62	Sensor model barometer	Study the sensor and create a sensor model	10
63	Document odometer	Document the performance. Document the performance in different environments	4
64	Document laser sensor	Document the performance. Document the performance in different environments	4
65	Document ultra sound sensor	Document the performance. Document the performance in different environments	3
66	Document magnetometer	Document the performance. Document the performance in different environments	5
67	Document IMU	Document the performance. Document the performance in different environments	5
68	Document barometer	Document the performance. Document the performance in different environments	4

12.11 Sensor Diagnosis and Signal Processing

Nr	Activity	Description	Time (h)
69	Process sensor data	Transform raw sensor data to correct units according to the sensor model	24
70	Analyse sensor data	Save sensor values and analyse them. Mark them unreliable or reliable	30

12.12 Positioning and mapping

Nr	Activity	Description	Time (h)
71	Implement motion model	Implement a motion model of Balrog in the sensor fusion algorithm.	14
72	Implement odometer	Implement handling of odometer data in the filter	12
73	Implement IMU	Implement handling of IMU data in the filter	10
74	Implement barometer	Implement handling of barometer data in the filter	10
75	Implement GPS	Implement handling of GPS data in the filter	6
76	Implement laser sensor	Implement handling of laser sensor data in the filter	8
77	Implement ultrasonic sensor	Implement handling of ultrasonic sensor data in the filter	8
78	Know the probability if a position has been visited	Save the all positions that have been visited with probability	7
79	Know the probability if the whole search area has been explored	Implement the route planning	4
80	Know the current position	Implement a filter that keeps track of the current position with a confidence interval	7
81	Use map for positioning	Implement method for adding predefined maps to the algorithm.	4
82	Communication	Send localisation and mapping data to base station	4
83	SLAM-mapping	Implement positioning with laser scanner and ultrasonic sensors without a predefined map	8

12.13 System Tests

Nr	Activity	Description	Time (h)
84	Test SLAM	Test the SLAM algorithm.	2
85	Test sensor models	Test sensor models. Evaluate if the models are accurate enough.	6
86	Test sensor diagnosis system	Test if the diagnosis system can tell when a sensor is reliable/unreliable	14
87	Test positioning	Test if the positioning system knows the current position with the accuracy defined in the requirement specifiction.	16

12.14 Other

Nr	Activity	Description	Time (h)
88	Give Presentation	Present	14
89	Buffer	Time buffer for activities	239

13 Time table

For a time table, see separate document: Time Table.

14 Plan for changes

Any changes in the requirement specification is to be discussed and approved by the client.

Changes in internal documents will be discussed and dealt with on group meetings.

The project and time plan will be changed when needed, in agreement with the client.

15 Quality plan

This section describes how code and documents will be examined in order to ensure their quality, i.e. readability is high, correct language is used and syntax conventions are followed.

15.1 Review

Every document is to be reviewed by someone who is not the author. The Head of Documentation will ensure this happens and decide weather a document is ready to be delivered

15.2 Test plan

The Head of Tests will produce a test plan, which states how a test is going to be carried out and when. It is also the Head of Tests' responsibility to enforce the test plan.

Each subsystem is to be tested according to the test plan before it is integrated in the technical platform.

16 Risk analysis

A risk analysis has been made in the table below. The table layout is as listed by order of columns:

1. The problem is stated
2. The impact on the project on a scale 0-5 is stated
3. The probability that the problem occurs is stated on a scale 0-5
4. The risk is stated as probability times the impact
5. A prevention to the problem is suggested
6. A solution to the problem is suggested

Problem	**Imp**	**Prob**	**Risk**	**Prevention**	**Solution**
Someone gets ill long term	2	2	4	Don't stress the other members too much	Redistribute the work. Inform the client.
The code gets lost	5	1	5	Use Git	Rewrite the code
Conflicts in the group	3	3	9	Work for a good working environment	Try to first solve the problem within the involved group members otherwise turn to the project manager
One or many members drops out	3	1	3	Have a good working environment, so none drops out because of that.	Redistribute the tasks and maybe renegotiate the requirements
Hardware malfunction	4	2	8	Be careful when handling hardware. Make sure all hardware is functioning properly in an early state of the project.	Order new hardware

16.1 Sensors

If the sensors do not work as good as expected the accuracy of the navigation problem can be hard to achieve. If "smart algorithms" are not enough, the requirements might be renegotiated.

16.2 Bad code

If the code that the last group has written is bad and not functioning as per the technical document or requirement specification, time has to distributed to fix the problems. If rewriting the code affects the time plan, the requirements have to be renegotiated.

16.3 Group conflicts

Any problem regarding group dynamics should be solved by talking to each other about the problem. Firstly, try to solve the problem with the group members concerned. Secondly involve the group manager and if necessary also the rest of the group.

17 Priorities

The main priority of the project group is to ensure all level 1 requirements in the requirement specification are fulfilled. Priorities with level 2 and 3 will follow if there is sufficient time. No lower level priority will be considered before all higher level priorities are fulfilled.

18 Project closing

The project is closed after it has been presented by the group at a conference. After that an evaluation will be handed to the client and all code and documentation will be delivered to ISY and Saab Bofors Dynamics.

References

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