

Requirement Specification

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Version 1.0



Status

Reviewed	Martin Szilassy	2014-09-19
Approved	Hanna Nyqvist	2014-09-19



PROJECT IDENTITY

2014/HT, Invenire Periculosa
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Document history

Version	Date	Changes	Sign	Reviewed
0.1	2014-09-12	First draft.	MB	MS
0.2	2014-09-16	Comments from client	MB	MS
0.3	2014-09-16	Comments from client	MS	MB
1.0	2014-09-19	V 0.3 approved	MB	MS



1 Introduction

This project is a continuation of the development of an autonomous mine sweeping system. The project idea originates from Saab Bofors Dynamics.

This document contains an overview of the system and subsystems and specific requirements for the system and its subsystems. All of the requirements are listed in tables with a priority level of 1 to 3, where level 1 must be satisfied, level 2 should be satisfied and level 3 should be satisfied if time allows.

All requirements are specified in a table with four columns. The first column (from the left) specifies the requirement number, a serial number throughout the document. The second column indicates whether the requirement is a original requirement or a revised requirement. In the third column a short explanation of the requirement and what feature that must be fulfilled for the requirement to be met. The last column specifies the priority level of the requirement.

The requirement number consist of a value of type $x.y$, where x indicates the chapter number and y is an increasing number in order of appearance.

1.1 Background information

Mine sweeping is both a dangerous and tedious process. Traditionally this is done manually by systematically walking around an area equipped with a metal detector. Even if the search is carried out with great accuracy, a 100% clean area can never be guaranteed. If a machine was used rather than a human being the search would be carried out faster and without the risk of casualties.

Balrog is an already existing prototype of an autonomous mine sweeper which the customer wishes to improve in a number of areas.

1.2 Involved parties

The project organization consists of

- The customer contact at SAAB Bofors Dynamics: Torbjörn Crona
- The client at ISY, Linköping University: Hanna Nyqvist
- The adviser at ISY, Linköping University: Martin Lindfors
- The advisers at SAAB Bofors Dynamics: Stefan Thorstenson, Björn Johnsson and Carl Nordheim
- The project manager is Martin Szilassy
- The project group consists of (project manager included) eight students in applied physics and electrical engineering at Linköpings University



1.3 Goals

1. Change the main control unit on the robot to allow for more complex and accurate computations.
2. Evaluate the use of a laser scanner and/or stereo camera in addition to the ultrasonic sensors.
3. Improve the obstacle detection capabilities by adding new hardware and utilising the more powerful control unit.
4. Improve the positioning of mines by adding new hardware and utilising the more powerful control unit.
5. Improve the estimation of the robot's own position.

1.4 Usage

The finished product is to be used as prototype for future SAAB Dynamics autonomous mine sweeper development as well as future projects at Linköping University.

1.5 Definition of terms

The following list contains definitions of terms that will be used throughout the document.

- *Balrog* - The autonomous moving vehicle that will carry out the mine sweeping.
- *Hand controller* - A remote Xbox hand controller used to control the robot manually.
- *Mine* - A hidden object with huge destructive power. In this project the mines are represented by magnets, with a sufficiently large magnetic field to be detected and classified as a mine using the algorithms from previous year.
- *Obstacle* - Any kind of item (man made or not) that the robot is unable to travel through.
- *Main control unit* - The main computer on the robot.
- *Base station* - The computer containing a GUI from which the robot receives orders and to which it sends mapping information.
- *Search area* - The area where the system searches for mines. Defined in section 6.1.
- *Operator* - The person or persons operating Balrog.



2 Overview of the system

In this section a rough description of the system is given.

2.1 Description of the system

The entire system consist of Balrog with its main control unit, the hand controller and a base station. The hand controller is used for manual operations and to send simple commands while the base station is used for the autonomous driving and mapping.

2.2 Product components

- Balrog
 - Laser scanner
 - Stereo camera
 - Ultrasonic sensors
 - Inertial measurement unit (IMU)
 - Odometers
 - Magnetometer
 - WiFi communications
- Hand controller
- Base station
 - Computer
 - WiFi communications

2.3 Dependency to other systems

Balrog must have GPS-coverage at the starting point in order to enable absolute positioning of the map.

2.4 What is not included

The following listed things will not be regarded during the development of the system:

- Moving obstacles are not to be considered
- The size of the searchable area must be chosen so consideration of the battery life of Balrog can be neglected
- Mines or obstacles placed outside of the given area are not considered in the mine search



- If only the super sonic sensors are used for obstacle detection, the obstacle sides must be parallel or perpendicular to the initial direction of Balrog
- The case when the communication between the base station, Balrog and the hand-controller is not working will not be considered

2.5 Design philosophy

The system is to be considered as support for future project and shall be developed with that in mind. The code shall be very well commented so that it can be reused in future project, and the algorithms shall be as general as possible. Likewise this project is using last years project as foundation and as much code and design from previous years as possible shall be reused.

3 Administration

The administration chapter covers the requirements for the administration in the project.

Requirement	Type	Description	Priority
3.1	Original	The project group shall have weekly meetings	1
3.2	Original	The tutor should be invited, by the project leader, to all weekly meetings	1
3.3	Original	The project leader shall have weekly meetings with the client	1
3.4	Original	All group meetings shall be added to the common calendar	1
3.5	Original	The project work shall follow the LIPS model	1

4 New Hardware

The main control unit will be replaced by a new computer allowing more complex and accurate computations. In addition to this a laser sensor and/or a stereo camera will be added in order to enhance the map resolution and obstacle detection accuracy.

4.1 Requirements for new hardware

Requirement	Type	Description	Priority
4.1	Original	The new control unit shall be able to make use of the super sonic sensors for navigation	1



4.2	Original	The new control unit shall be able to receive control signals from the hand controller and execute accordingly, when in manual mode	1
4.3	Original	The new control unit shall be able to receive, process and forward signals from the odometer ARM processor	1
4.4	Original	The new control unit shall be able to send and receive information through the wireless network connection	1
4.5	Original	The new control unit shall present information according to the current user interface	1
4.6	Original	The new laser sensor shall be integrated into the system	1
4.7	Original	The performance of the laser sensor shall be evaluated and documented (light setting, range, sampling frequencies)	1
4.8	Original	Distance information shall be possible to acquire from the laser sensor	1
4.9	Original	The stereo camera shall be integrated in to the system	3
4.10	Original	The performance of the stereo camera shall be evaluated and documented (light setting, range, sampling frequencies)	3
4.11	Original	Distance information shall be possible to acquire from the stereo camera	3
4.12	Original	Different operating system options for Balrog's new control unit shall be evaluated	2
4.13	Original	The base station shall be able to communicate with at least the same command set as the current one after the installation of the new main control unit	1
4.14	Original	After the installation of the new main control unit, the hand controller shall be able to be used as before	1
4.15	Original	Balrog shall be equipped with a loud speaker for increased feedback to the operator	3



5 Communication

Requirement	Type	Description	Priority
5.1	Original	The robot shall communicate with the user through the base station	1
5.2	Original	Balrog shall at all times be able to be turned off by an emergency switch (located at the base station)	1
5.3	Original	Debug data (containing control signals and received commands) shall be sent over the data link and be accessible using the software running on the base station	2
5.4	Original	Sensor data for debugging shall be sent over the data link and be accessible using the software running on the base station	3

6 Navigation and Mapping

The system will be able to search a predefined area, draw a map of it and detect mines in said area.

6.1 Definition and limitations of the search area

The search area is the region of which the system draws a map and searches for mines in. The ground under Balrog must be of a kind so the robot can move around freely. The ground must be solid and smooth enough for the robot to operate. The area must not contain any steep cliffs higher than 10 cm or any slopes above 10°.

Surfaces of the obstacles in the area must be solid. Non-solid obstacles, such as high grass or water, is not permitted inside the search area.

The obstacles and mines detected in the area will be put on a map with a certain resolution. Mines smaller than the resolution will be detected. The obstacles must be at least 40 cm high.

In order for a region to be searchable it must be inside the search area and the minimum distance between two obstacles must be at least 1 meter. Area inside an obstacle is not searchable.

Requirement	Type	Description	Priority
		The resolution of the map shall be at least ...	
6.1	Original	... 20 cm	1
6.2	Original	... 10 cm	2
6.3	Original	... 5 cm	3



		The system shall be able to detect obstacles of any shape with a minimum diameter, in all directions parallel to the ground, of ...	
6.4	Original	... 20 cm	1
6.5	Original	... 10 cm	2
6.6	Original	... 5 cm	3
6.7	Original	The system shall be able to draw a 2D map of the searched area with a minimum resolution specified in 6.1	1
6.8	Original	The system shall be able to draw a 3D map of the searched area with a minimum resolution specified in 6.1	3
6.9	Original	The system shall be able to automatically plan and adapt a route for a search area	1
		During a 5 minute search, the system shall estimate its position relative to the starting point with a 95% confidence interval that is ...	
6.10	Original	... less than 2 meters	1
6.11	Original	... less than 1.5 meters	2
6.12	Original	... less than 1 meter	3
6.13	Original	The system shall be able to determine its current heading relative to its starting position, with an accuracy of 10 degrees	2
6.14	Original	The system shall make use of the laser sensor to improve the navigation and mapping	1
6.15	Original	The system shall make use of the stereo camera to improve the navigation and mapping	3
6.16	Original	The system shall be able to perform localization and mapping in real time	1
		The system shall search and map the whole searchable area in ...	
6.17	Original	... 80% of the runs	1
6.18	Original	... 90% of the runs	2
6.19	Original	... 99% of the runs	3
6.20	Original	The system shall be able to detect mines at visitable positions	1
6.21	Original	Algorithms for positioning using the laser sensor measurements fused with other sensor measurements shall be developed	1



6.22	Original	Algorithms for obstacle detection using the laser sensor shall be developed	1
6.23	Original	The robot shall be able navigate and create a map without the laser sensor in case it fails	2

7 Performance

Requirement	Type	Description	Priority
		The 95% confidence interval for mine positions relative to Balrog's current estimated position shall be ...	
7.1	Original	... less than 2m	1
7.2	Original	... less than 1m	2
7.3	Original	... less than 0.5m	3
7.4	Original	The sound "Fly you fools!" is to be played from the main control unit when a mine is detected	3
7.5	Original	The sound "Fly you fools!" is to be played from Balrog when a mine is detected	3

8 Stability and robustness

Requirement	Type	Description	Priority
		Balrog shall be able to detected more than ...	
8.1	Original	... 70% of the mines in the searchable area	1
8.2	Original	... 80% of the mines in the searchable area	2
8.2	Original	... 90% of the mines in the searchable area	3
		In a five minute run, Balrog shall find less than...	
8.3	Original	... 5 false mines	1
8.4	Original	... 3 false mines	2
8.5	Original	... 1 false mine	3

9 Economy

Requirement	Type	Description	Priority
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9.1	Original	Each member of the group shall work 240 hours $\pm 10\%$ with the project	1
9.2	Original	All extra purchases due to needs in the project shall be approved and payed by the customer or the client at ISY	1



10 Deliveries

Requirement	Type	Description	Priority
10.1	Original	A requirement specification shall be approved by the client no later than 2014-09-19	1
10.2	Original	A system draft shall be approved by the client no later than 2014-09-19	1
10.3	Original	A project plan shall be approved by the client no later than 2014-09-19	1
10.4	Original	A time plan (included in the project plan) shall be approved by the client no later than 2014-09-19	1
10.5	Original	A test plan shall be approved by the client no later than 2014-10-13	1
10.6	Original	A design specification shall be approved by the client by 2014-10-13	1
10.7	Original	A test protocol shall be approved by the client no later than 2014-11-28	1
10.8	Original	A user manual shall be approved by the client no later than 2014-11-28	1
10.9	Original	The final product shall be delivered to the customer no later than 2014-12-01	1
10.10	Original	A technical report shall be approved by the client no later than 2014-12-12	1
10.11	Original	A project reflection document shall be approved by the client no later than 2014-12-12	1
10.12	Original	A short status report shall be delivered to the client on a weekly basis	1
10.13	Original	A time report shall be delivered to the client on a weekly basis	1
10.14	Original	The project group shall attend the project conference (preliminary date 2014-12-15)	1



11 Documentation

Requirement	Type	Description	Priority
11.1	Original	Written language in all documents must be English	1
11.2	Original	The documents produced for the client and customer must be written in L ^A T _E X	1
11.3	Original	Each official meeting must result in a meeting minute	1
11.4	Original	All produced plots and graphs shall be vectorized if possible	1

11.1 Web page

Requirement	Type	Description	Priority
11.5	Original	The project must have a web page demonstrating the progress of the project	1
11.6	Original	The web page shall be up and running with information about the project participants no later than 2014-09-29	1
11.7	Original	The web page shall be updated at least every second week, starting no later than 2014-09-29	1

11.2 Video

Requirement	Type	Description	Priority
11.8	Original	A video, presenting and demonstrating the system, shall be posted on youtube.com no later than 2014-12-12	1
11.9	Original	The video shall be considered awesome by the client, customer and advisers (especially by Stefan Thorstenson)	3

11.3 Poster

Requirement	Type	Description	Priority
11.10	Original	A poster, describing the project, shall be produced no later than 2014-12-12	1



12 Requirements for further development

Requirement	Type	Description	Priority
12.1	Original	The project must be developed in a way so new components are easy to implement in the future	1
12.2	Original	The source code shall be well commented and follow the guidelines in the design specification	1