Requirement Specification: Autonomous Rescue System with UAV and Tracked Vehicle

Version 1.5

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Document History

Version	Date	Changes made	Reviewer
0.1	2018-09-14	First draft	DR
0.2	2018-09-20	First revision	DR
0.3	2018-09-21	Second revision	DR
0.4	2018-09-28	Third revision	DR
1.1	2018-10-10	Requirement renegotiation	LB, EH
1.2	2018-11-19	Requirement renegotiation	DR, TB
1.3	2018-11-21	Requirement renegotiation	TB
1.4	2018-11-29	Requirement renegotiation	EO, LB
1.5	2018-12-01	Requirement renegotiation	TB, BL, LB

Contents

1 Introduction

This document is a requirements specification defined for a CDIO-project called "Autonomous rescue with a ground vehicle and a quadcopter" in the project course TSRT10, given at Linköping University. The purpose of this document is to specify clear goals for the project and define what requirements needs to be satisfied in order to fulfill the goals.

The requirements throughout this document will be listed in tables according to the following format:

Req. no.	Version	Description	Priority
1	Original	Description of requirement	1
2	Revised YYYY-MM-DD	Description of requirement	2

The priority level ranges between 1 to 3 and corresponds to the assessed significance of each requirement. Level 1 stands for the most basic level of requirements that must be implemented and satisfied first. These requirements must be fulfilled before the product is shipped to the customer. A requirement of level 1 has to be renegotiated if it is deemed to be redundant or too time and/or resource consuming to be implemented before the product shipment deadline. The level 2 requirements should be implemented in the final product, but it is possible that the implementation of all these requirements does not reach the final product. Level 3 are requirements that are nice to have if time and/or resources are available in the group and as long as the customer is willing to finance the extra expenses needed for implementation. Due to the nature of the implementation process, and the large group size, deviations may occur. It is therefore paramount to keep a constant dialogue with the client and customer throughout the project.

1.1 Parties

The parties in the project are the customer Torbjörn Crona at Saab Dynamics AB, the client Martin Lindfors at Linköping University, and the advisors Magnus Malmström at Linköping University and Erik Ekelund and Axel Reizenstein at Saab Dynamics AB. The final party is the project group led by project leader Linn Berntsson with Benjamin Lembke in charge of design, David Rydberg in charge of documentation, Dennis Edblom in charge of software, Edvin Hansson in charge of information, Emma Olsson in charge of ROS, Marcus Jackson in charge of hardware and Tobias Bengtsson in charge of product testing.

1.2 Purpose and Goal

The purpose of this project is to deliver an autonomous rescue system consisting of a simulated quadcopter and a ground vehicle. The quadcopter will be simulated and should identify all objects of interest in the simulation within a desired area and communicate their position to the vehicle on the ground and the user, autonomously, through a wireless link. Given the positional data, the ground vehicle should autonomously move to the provided positions of interest and return to its origin after doing so. The process should be continuously streamed to a laptop which provides the user with information about the ongoing operation. In this project, the group members will also gain experience of working on a project and in a group.

1.3 Application

The system is to use the available vehicles, the simulated quadcopter and ground vehicle, together with a base station. These should cooperate through custom software. The intended application of the system is to use the mentioned parts to find and aid people in need where terrain and weather may be harsh or otherwise difficult to search or explore on foot.

1.4 Background information

The project is provided by Saab Dynamics AB and was originally founded in 2012. The last time the project ran it was intended to be a mine detection and disarming system. Every year there has been continued development of the components used in this project.

This year a new purpose has been assigned to the final product. The system should now no longer work as a mine detection and disarming system, but instead be able to autonomously seek, find and assist people in distress.

One of the main focuses this year is communications, including the communication and coordination between the simulated quadcopter and the tracked vehicle.

1.5 Definitions

Here are the definitions which are used in this document:

- **Sauron** - A simulated drone/UAV.
- **Balrog** - The tracked ground vehicle used to deliver rescuing supplies.
- **AprilTag** - A matrix of bar codes that can be detected by the robots.
- **Person/people in distress** - The target(s) the autonomous vehicles will search for. Will be represented by AprilTags in both the real test area and in the simulated test area.
- **AprilTag box** - A representation of a person in distress as a box with AprilTags on all sides.
- **Supply** - A package that the robots will deliver to a person in distress. Will be represented by a standard empty 33 centilitre soda can.
- **Obstacles** - Objects designed to hinder movement inside the test area.
- **Operation** - The objective for the project. Sauron will identify a number of people in distress within the simulated test area, find their positions and send this data to Balrog. After obtaining the positional data from Sauron, Balrog should create a plan for how to deliver supplies to each of the given positions in the real test area and execute it autonomously. Balrog also identifies and avoids obstacles while moving around the test area. The operation ends when Sauron has made sure that there are no further people in distress within the test area, Balrog has delivered supplies to each of them, and both Sauron and Balrog have returned to the starting point.
- **Detection of people in distress** - A person in distress is considered to be detected when the frame from the simulated onboard camera on Sauron detects an AprilTag. Two neighboring detections means that two neighboring frames from the camera feed has detected an AprilTag.

- **Identification of people in distress** - A person in distress is considered to be identified when Sauron has had a 90% detection percentage during 2 s. Only identified people in distress will be visited by Balrog.
- **User** - A person interacting with the system.
- **SLAM** - Simultaneous Localization And Mapping.
- **LiDAR** - Light Detection And Ranging sensor.

1.6 Definition of Test Area

An overview of both of the test areas are described in Appendix A. The physical test area should be a large flat surface with obstacles and people in distress represented by AprilTag boxes. Sauron should search the simulated area, which is based on the physical test area, for AprilTags, and Balrog should move supplies to the AprilTag box position in the physical test area and avoid obstacles along the way.

1.6.1 Test Area Design Requirements

This section outlines the test area design requirements.

Req. no.	Version	Description	Priority
1	Original	The test area must be as described in Appendix A, Test Area.	1
2	Original	The test area must contain 1-4 people in distress.	1
3	Revised v1.4	The test area must be at least 8x8 m (LxW).	1
4	Original	The distance between every person in distress must be at least 2 m.	1
5	Revised v1.4	The distance between the starting positions and obstacles/person(s) in distress must be at least 1 m.	1
6	Original	The distance between an obstacle and a person in distress must be at least 1 m.	1
7	Original	The distance between two obstacles must be at least 1 m.	1
8	Original	The test area must be a flat horizontal surface with no bumps larger than 1 cm.	1
9	Original	The test area must only contain defined obstacles. (see req. 10).	1
10	Original	The size of the obstacles must be 0.5x0.5x0.5 m with tolerances of 0.1 m in each direction.	1
11	Original	The person/people in distress must be represented by a box with AprilTags on all sides. The box size must be 0.5x0.5x0.5 m with tolerances of 0.1 m in each direction.	1
12	Original	All AprilTags in the test area must be illuminated enough to be identified by Sauron and Balrog.	1
13	Original	The test area must not be too humid or have presence of fog, rain or snow that jeopardizes operational safety.	1
14	Added v1.3	The test area must built in a physical environment for Balrog and in a corresponding simulated test area for Sauron which is based on the physical test area.	1
15	Original	The operation objects shall be between 0.1x0.1x0.5 m and 1x1x1 m (LxWxH).	2
16	Original	The AprilTag box shall be as small as 0.3x0.3x0.5 m (LxWxH).	2
17	Original	The test area shall contain 5-10 people in distress.	3

2 Overview of the System

The following section strives to provide a simple first-glance view of the system and its sub-components. Following the overview of the full system, each subsystem has its own subsection which outlines its components. The product consists of three main platforms: the tracked ground vehicle (namely Balrog) and simulated quadcopter (namely Sauron) accompanied by the base station, i.e. a computer with the user interface.

2.1 Product Components

The tracked ground vehicle, Balrog, consists of the following components:

- RC hand controller
- Raspberry Pi
- Raspberry Pi camera
- Arduino x2
- Radio receiver
- 360 Rotational LIDAR
- IMU

The simulated quadcopter, Sauron, based upon the 3DR X8+ UAV, which is equipped with the following components in the simulation environment:

- RC hand controller
- Raspberry Pi
- Raspberry Pi camera
- WiFi range extender
- Radio transmitter/receiver
- PixHawk 2.4.5 with ArduCopter firmware including:
  - GPS
  - Barometer for altitude measurements
  - IMU with a magnetometer, accelerometer and gyroscope

2.2 Design Philosophy

The design philosophy implemented throughout the project is to construct a system that is as modular as possible.

Every subsystem should be as independent as possible from the others. They should be thoroughly tested individually before gradually being integrated into larger subsystems.

Increased modularity will provide the user and future development projects with an increased ability to repair, substitute or upgrade any subsystem with minimal implications for the rest of the system.

2.3 General Requirements

This section outlines the requirements specified for the project as a whole and the task the system is intended to solve.

Req. no.	Version	Description	Priority
18	Original	The project group must actively participate in the project's activities.	1

3 Tracked Vehicle Balrog

In the following section, the requirements for the ground vehicle are listed. The requirements are divided in two parts: the requirements from previous years are listed in subsection 3.1, while the requirements added in this project are listed in subsections 3.2 and 3.3.

3.1 Previous Requirements

Since the Balrog platform is a result of iterative modifications done during earlier project years some parts are assembled and tested. In order to not assume safety or functionality of the platform, a certain number of older requirements that the group's new requirement highly depend on shall be tested and satisfied.

Req. no.	Version	Description	Priority
19	Original	Basic functionality from last years project must be tested according to the test plan. The requirements that must be fulfilled are the following: 18a, 19a, 20a, 21, 22, 24, 33, 34, 35. [1]	1

3.2 Design Requirements

The following table lists the design requirements of Balrog that will demand physical changes of the vehicle. Note that due to the projects iterative nature the physical changes will be minor.

Req. no.	Version	Description	Priority
20	Original	The LiDAR sensor on Balrog must be replaced.	1
21	Revised v.1.4	The bias and variance of the new LiDAR sensor must be accounted for in the SLAM-algorithm.	1
22	Original	Balrog shall be able to pick up supplies given the position of the supplies.	3
23	Original	Balrog shall be able to carry 2-4 supplies at the same time.	3
24	Original	Balrog shall be able to drop a chosen supply of the ones it is carrying.	3
25	Revised v1.4	Balrog must be able to carry supplies.	3

3.3 Functionality Requirements

This section lists the functionality requirements of Balrog and will mainly be implemented in the vehicles software.

Req. no.	Version	Description	Priority
26	Original	Balrog must be able to process location data of 1-4 people in distress and calculate paths to their positions.	1
27	Original	Balrog must be able to autonomously move to 1-4 people in distress using the calculated paths to their positions.	1
28	Revised v1.4	a) Balrog must be able to complete its operation when the operation is carried out on the test area, with a time limit of 600 s.	1
		b) With a time limit of 300 s	2
29	Revised	Balrog must calculate the paths to the people in distress from its current position and follow them one at a time.	1
30	Revised v1.4	The calculated paths must go from current location to a person in distress, and then person to person (if more than one person is present). Then, when Sauron has found all, move from the last person to the starting location.	1
31	Original	Balrog must not deviate more than 0.1 m when autonomously moving along a calculated path.	1
32	Original	Balrog must not touch any obstacles when traversing its calculated path.	1
33	Revised v1.3	Balrog must be able to move from a current reference point in the Balrog SLAM coordinate system to a given location with a tolerance of 0.1 m.	1
34	Original	Balrog must not touch the person in distress when delivering supplies.	1
35	Original	A person in distress must be considered to be reached when Balrog stops within 0.2 m of the person.	1

Req. no.	Version	Description	Priority
36	Original	Balrog shall be able to convert a local SLAM coordinate to a global GPS coordinate.	2
37	Revised v1.3	Balrog shall be able to move from a current reference point (Balrog filtered GPS coordinate) to a given location (external simulated GPS coordinate) with a tolerance of 0.1 m.	2
38	Original	Balrog shall be able to drop supplies at target location with a tolerance of 0.2 m (measured from the nearest edge of the supply).	2
39	Original	It shall be possible for Balrog to return to the starting location between each person in distress.	2
40	Original	Balrog shall calculate a path that includes all known persons in distress within 5 s of receiving a new person's positional data from Sauron.	2
41	Revised v1.1	Balrog shall, when there are more than one person in distress in the queue and Balrog is to start on a new route, calculate a route to each of the people in the queue. Balrog shall then choose the shortest route and follow that route.	2
42	Original	The paths to people in distress shall be calculated using an optimal pathfinding algorithm, with a tolerance of 10 %.	2
43	Original	Balrog shall be able to process location data of 5-10 people in distress and calculate paths to their positions.	3
44	Original	Balrog shall be able to autonomously move to 5-10 people in distress using the calculated paths to their positions.	3
45	Original	Balrog shall autonomously plan a route that will visit four people in distress, pick up the correct supplies, drop the correct supplies at each person, and return to start location.	3

4 Simulated quadcopter Sauron

This section contains all requirements concerning the simulated quadcopter, namely Sauron. The requirements are divided in five categories. The *Simulation* section describes the requirements on the simulation environment in which Sauron is to operate. The *Previous requirements* section handles functionality that already exists in the system. Basic functionality and unsorted requirements are stated in *General functionality*. Requirements regarding the autonomy of the systems are stated in section *Autonomy*. The last section *Detection* contain all requirements regarding Sauron's ability of detection and identification.

4.1 Simulation

This section consists of the requirements regarding the requirements on the simulation environment in which Sauron is to operate. The simulation environment for Sauron will be implemented according to Appendix B.

Req. no.	Version	Description	Priority
46	Added v1.3	Sauron must be simulated in an virtual environment.	1
47	Added v1.3	Simulated people in distress, represented by simulated AprilTags, must be present in the virtual environment.	1
48	Added v1.3	The sensor data (mainly pitch, yaw, roll) for Sauron must be simulated.	1
49	Added v1.3	The camera feed from Sauron must be simulated.	1
50	Added v1.3	The AprilTag detection must be simulated and contain x-, y- and z-position of the tag, in the camera coordinate system (simulated camera as origin). The detection must also contain the ID of the tag and the timestamp of the image.	1
51	Added v1.3	All of the implemented functionality for Sauron must be implemented within the simulated environment, i.e. the requirements should be fulfilled within the simulated environment.	1
52	Added v1.3	Sauron's position must be determined by a simulated GPS.	1
53	Added v1.3	The simulated GPS position must contain noise with a standard deviation of 0.1 m.	1
54	Added v1.3	The simulated AprilTag camera detection coordinates must contain noise with a standard deviation of 0.05 m.	1
55	Added v1.3	The simulation must contain a user defined or randomized probability of detection for each AprilTag present in the virtual environment.	2
56	Added v1.3	The simulation must contain a user defined or randomized error detection probability, i.e. there must be an possibility that Sauron incorrectly detects people in distress which are not present in the virtual search area.	2
57	Added v1.3	Sauron shall be able to carry supplies in the simulated environment.	3

4.2 Previous Requirements

This section lists the requirements inherited from previous years, which are considered essential for the system's overall functionality.

Req. no.	Version	Description	Priority
58	Revised v1.3	Basic functionality from last years project must be tested according to the test plan. The requirement that must be fulfilled is 68. [1].	1

4.3 General Functionality

This section outlines the overall functionality of the quadcopter.

4.3.1 Design Requirements

This section lists the design requirements of Sauron and will mainly be implemented in the vehicles software.

Req. no.	Version	Description	Priority
59	Original	Sauron must have a maximum speed of 5 m/s.	1
60	Original	Sauron must be able to operate at a user specified height between 2 m and 10 m.	1
61	Original	Sauron shall be able to drop supplies with an accuracy of 0.5 meters from the location of a person in distress.	3
62	Original	Sauron shall be able to fulfill requirement 71 and requirement 57 and 61 in the same flight.	3

4.4 Autonomy

Here the requirements for autonomous functionality of the quadcopter are listed.

4.4.1 Design Requirements

The following table lists the design requirements of Sauron linked to autonomy.

Req. no.	Version	Description	Priority
63	Revised v1.3	A search plan must be prepared that Sauron must follow (within the simulation) when searching for people in distress.	1

4.4.2 Design Requirements

This section lists the design requirements of Sauron linked to autonomy.

Req. no.	Version	Description	Priority
64	Original	Sauron must, on command, autonomously take off to a pre-specified height anywhere above 2 m and below 10 m over the ground and stay there with a deviation not more than 0.2 m in height.	1
65	Revised v1.3	Sauron must, in a simulated test environment, autonomously follow a straight line parallel to the ground with a maximum deviation from the line of 0.1 m at a specified height of 2.5 m.	1
66	Revised v1.4	Sauron must, in a simulated test environment, hold a position with a maximum deviation from the position of 0.1 m during 5 s.	1
67	Revised v1.4	~~Sauron must, in a simulated test environment, autonomously take a 90 degree turn, parallel to the ground, with maximum deviation of 0.1 m from the line at a specified height of 2.5 m.~~	1
68	Revised v1.4	~~Sauron must, on command and from any current simulated GPS position, autonomously take the optimal path to another specified simulated GPS position by following a calculated trajectory from its current position to the specified position, with a tolerance of 10%.~~	1
69	Original	Sauron must be able to follow the plan from requirement 63 autonomously.	1
70	Original	Sauron must be able find and identify all people in distress in the test area within 300 s from takeoff.	1
71	Original	Sauron must be able to follow the plan from requirement 63, simultaneously search for and identify several people in distress, store their positions and head back to its starting position.	1
72	Original	Sauron shall, on command, autonomously land on flat ground from a maximum height of 4 m, within 10 s.	2
73	Original	Sauron shall be able to autonomously change operation height depending on terrain.	3

4.5 Detection

The requirements regarding object detection and identification for the quadcopter is listed below.

4.5.1 Design Requirements

The following table lists the design requirements of Sauron linked to detection and identification.

Req. no.	Version	Description	Priority
74	Original	One detection without any neighboring detections must be treated as a false alarm.	1
75	Revised v1.4	The identification must be treated as a false alarm when Sauron has been stationary above an AprilTag for 3 seconds, with a deviation less than 0.1 m, and has been trying to identify a person in distress during this time.	1

4.5.2 Functionality Requirements

This section lists the functionality requirements of Sauron linked to detection and identification.

Req. no.	Version	Description	Priority
76	Original	Sauron must have a 90% detection percentage during 2 s for a person in distress to be identified.	1
77	Original	Sauron must try to identify a person in distress when two or more neighboring detections are present.	1

5 Communication between Balrog, Sauron (simulated) and the Base Station

The following chapter describes the requirements on the communication between the different platforms.

5.1 Design Requirements

List of functional requirements for Balrog, Sauron (simulated) and the base station.

Req. no.	Version	Description	Priority
78	Original	Balrog must be able to receive location data through WiFi.	1
79	Original	Balrog must be able to send data to the base station through WiFi.	1
80	Original	Balrog must be able to receive data from the base station through WiFi.	1
81	Original	Balrog must continuously transmit its current position to the base station with an interval between transmissions below 1 s.	1
82	Revised v1.3	Balrog and the Sauron (simulated) shall be able to communicate directly with each other through WiFi.	2
83	Revised v1.3	Sauron (simulated) shall continuously transmit its position data to Balrog with an interval between transmissions below 1 s.	2
84	Revised v1.3	Balrog shall continuously transmit its position data to Sauron (simulated) with an interval between transmissions below 1 s.	2
85	Original	Balrog shall continuously send video data from its onboard camera to the base station with an interval between transmissions below 0.1 s.	2

5.2 Functionality Requirements

List of design requirements for Balrog, Sauron (simulated) and the base station.

Req. no.	Version	Description	Priority
86	Revised v1.3	The simulated Sauron must autonomously send position data to Balrog when it has identified a person in distress.	1
87	Revised v1.3	Balrog must autonomously send a confirmation to the simulated Sauron that it has received position data of a person in distress.	1
88	Revised v1.3	The simulated Sauron must autonomously send a confirmation to Balrog when it has found all people in distress on the map.	1

6 Operator Interface (GUI)

The following chapter describes the requirements on the operator interface, or GUI.

6.1 Design Requirements

This section lists the requirements inherited from previous years, which are considered essential for the system's overall functionality.

Req. no.	Version	Description	Priority
89	Original	The GUI must include a map over the area of operation.	1
90	Original	The GUI must draw the position of Balrog on a map.	1
91	Original	The GUI must draw the position of Sauron on a map.	1
92	Original	The GUI must draw the position of identified people in distress on a map.	1
93	Original	The GUI shall include a live streamed video from the onboard camera on Balrog.	2
94	Revised v1.3	The GUI shall include a streamed video from Sauron which is created inside the simulated environment.	2
95	Original	The map shown shall be based on actual images over the area of operation.	3

7 Safety Requirements

The following chapter describes the safety requirements on the system. These requirements are very important and should therefore be implemented in the early stages of the project.

Req. no.	Version	Description	Priority
96	Revised v1.4	~~A dead man's switch must be implemented on Balrog.~~	1
97	Revised v1.3	A safety check list for Sauron and Balrog must be created. The safety check list for Sauron does not have to be followed while the simulated Sauron is used.	1

8 Economy

The following chapter describes the economic requirements on the project.

Req. no.	Version	Description	Priority
98	Original	Each group member will spend 240 (±10) hours on the project.	1
99	Original	ISY will provide up to 40 hours of guidance.	1
100	Original	ISY will provide 1 project room on campus.	1
101	Original	Saab Dynamics will provide up to 40 hours of guidance.	1
102	Original	Expenses on extra project equipment will be paid by the customer upon their approval.	1

9 Delivery Requirements and Partial Deliveries

The following chapter describes the delivery requirements on the project. These requirements addresses the different tollgates and the deliveries the client and the customer should expect to receive at these tollgates.

Table 1: List of tollgates in the project.

Deliveries	**Date and time**
Tollgate 2	26/9 2018
Tollgate 3	8/10 2018
Tollgate 5	30/11 2018
Tollgate 6	13/12 2018

Req. no.	**Version**	**Description**	**Priority**
103	Original	A requirements specification shall be delivered at BP2.	1
104	Original	A verbal presentation of the system shall be given at BP2.	1
105	Original	A project plan (including a time plan) shall be delivered at BP2.	1
106	Original	A draft of a design specification shall be delivered at BP2.	1
107	Original	A design specification shall be delivered at BP3.	1
108	Original	A test plan shall be delivered at BP3.	1
109	Original	A complete test protocol shall be delivered at BP5.	1
110	Revised v1.4	A user manual shall be delivered at BP6.	1
111	Original	A technical documentation shall be delivered at BP6.	1
112	Original	An after study shall be delivered at BP6.	1
113	Original	A poster presentation shall be delivered at BP6.	1
114	Original	A web page shall be delivered at BP6.	1
115	Original	A product movie shall be delivered at BP6.	1
116	Original	An installation guide shall be delivered at BP6.	1
117	Original	Deliveries to the client and customer shall be delivered at the specific times described in table 1.	1

10 Documentation

The documentation serves as basis for communication between parties currently associated with this project and those who will be associated with it in the future.

Req. no.	Version	Description	Priority
118	Original	All documentation must follow the LIPS method [2].	1
119	Original	All code must be written according to the Google coding standard, see [4].	1
120	Original	A status report of the project must be delivered to the customer and to the client each week.	1

Document	Language	Purpose	Target group	Format/media
Requirement Specification	English	Describes what is meant to be produces and which requirements to be met.	Client /Customer	PDF/electronic
Project and Time Plan	English	Describes how the project shall be executed and existing assignments, who shall execute which task and how much time is calculated for each task.	Client/Customer	PDF/electronic
Design Specification	English	A detailed description of the construction of the projects systems.	Client	PDF/electronic
Technical Report	English	Description for the whole system and project?	Client/Customer	PDF/electronic
User Manual	English	Describes how the system is supposed to be used and handled	User	PDF/electronic
Installation Guide	English	Describes how the full system shall be installed.	User	PDF/electronic
Times Status Report	English	Describes the time consumption in the project.	Client/Customer	PDF/electronic
Status Report	English	Describes the current status of the project.	Client/Customer	PDF/electronic
After Study	English	Analysis on time consumption, work flow and problems during the project.	Client/Customer	PDF/electronic

REFERENCES

Written Sources

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[2] T. Svensson, C. Krysander och Studentlitteratur 2011, "Lips", Studentlitteratur AB Lund, [Internet]: `www.studentlitteratur.eng`

Oral sources

[3] Magnus Klofsten eller Daniel Axehill, "Föreläsning 2", TSRT10: Reglerteknisk projektkurs, Linköpings Universitet, 2018-09-12.

Internet sources

[4] `https://google.github.io/styleguide/cppguide.html`

Appendix A: Test Area

The test area is illustrated in figure 1 below. The size of the area is defined as 8x8 m (LxW). There are six obstacles present and four people in distress. The starting locations for the platforms Balrog and Sauron are also defined. The requirements in section 1.6.1, Test Area Design Requirements, has to be fulfilled when creating the test area.

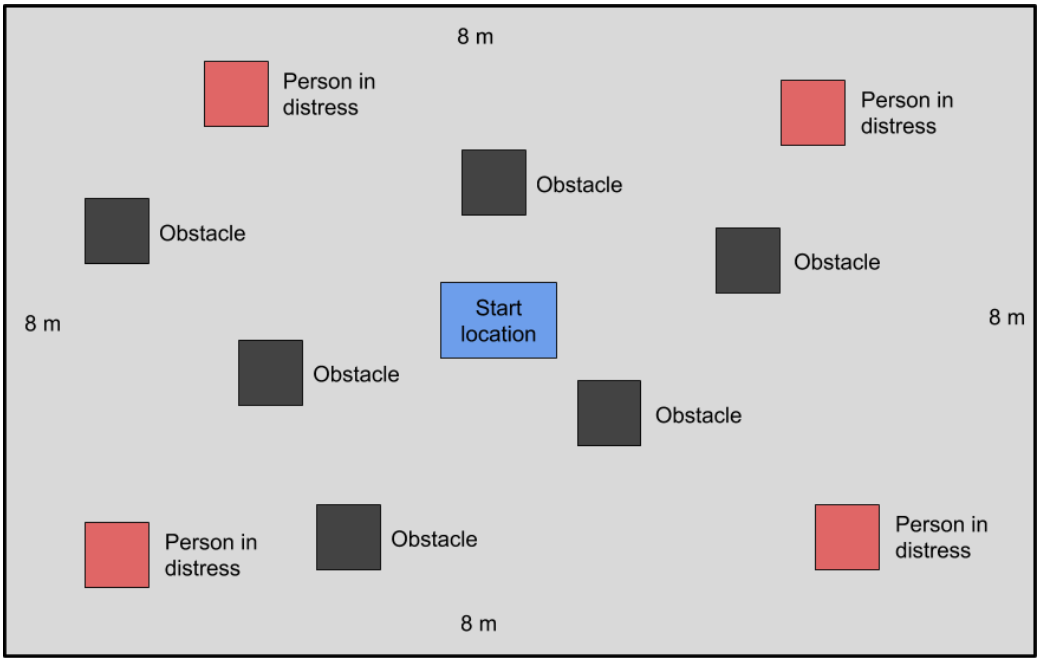

Figure 1: The test area for the project. People in distress, obstacles and start location are present.

Appendix B: Sauron simulation

The simulation environment for Sauron will be implemented in a way which provides a simple functionality transition to a physical UAV. The simulation of Sauron will therefore only return the current GPS position, the sensor data (pitch, yaw, roll) for Sauron, and its current camera feed. The simulation will also use another AprilTag detection software. This AprilTag detection software should return the same data as the AprilTag detection used in a physical real-world system. The data of interest is x-, y-, z-position of an AprilTag (camera as origin), the ID of the tag and the timestamp of the image. Noise will also be added to better simulate the system behaviour in reality. The simulated test area is based on the physical test area so its data can be used to aid Balrog under the mission.