Requirements Specification
LiU Racetrack 2018

LiU Racetrack 2018
Author: Oskar Karlsson
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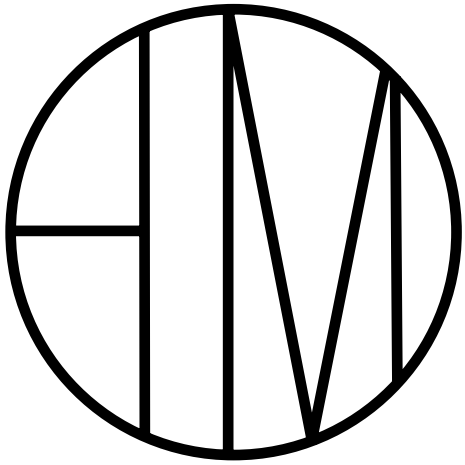

Status

Reviewed	Jacob Mourad	2018-11-26
Approved	Oskar Ljungqvist	2018-11-26

Project identity

2018 HT, LiU Racetrack 2018
Department of Electrical Engineering - Linköping University

Name	**Role**	**Email**
Tomas Busk (TB)	Responsible for LEGO Truck	tombu079@student.liu.se
Mergim Dushku (MD)	Responsible for Migration to ROS	merdu044@student.liu.se
David Forsberg (DF)	Responsible for Migration to Visionen	davfo471@student.liu.se
Marcus Hall (MH)	Responsible for Simulation Enviroment	marha585@student.liu.se
Oskar Karlsson (OK)	Document Manager	oskka906@student.liu.se
Kim Larsson (KL)	Software Architect	kimla207@student.liu.se
Jacob Mourad (JM)	Project Leader	jacmo228@student.liu.se
Sara Nilsson (SN)	Test Manager	sarni339@student.liu.se

Orderer: Oskar Ljungqvist, Linköping University, +46 70 577 18 68, oskar.ljungqvist@liu.se
Course responsible: Daniel Axehill, Linköping University, +46 13 28 40 42, daniel.axehill@liu.se
Advisor: Olov Holmer, Linköping University, +46 13 28 16 17, olov.holmer@liu.se

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Document history

Version	**Date**	**Changes**	**Performed by**	**Reviewed by**
0.1	2018-09-14	First draft	Project Group	OK
0.2	2018-09-21	Revised after comments from advisor.	Project Group	OK
0.3	2018-09-24	Revised after comments from orderer.	Project Group	OK
1.0	2018-09-28	Approved by orderer.	Project Group	KL
1.1	2018-10-18	Revised after comments on Test Plan from orderer.	Project Group	MD
1.2	2018-11-13	Renegotiated requirements with orderer.	Project Group	KL, JM, MH, MD
1.3	2018-11-26	Renegotiated requirements with orderer.	Project Group	JM

1 Introduction

This document is the requirements specification for the project LiU Racetrack at Linköping University. LiU Racetrack has been running each year since 2011 and this year the main goals is to migrate the system to ROS and to Visionen, further improve the simulator and develop an autonomous truck with trailer using a LEGO EV3 unit.

1.1 Considered parties

A total of five different parties are involved in the project. These are:

- The project group, consisting of eight students from Linköping University studying different master programmes in electrical engineering, mechanical engineering and computer engineering.
- The orderer - Oskar Ljungqvist, department of automatic control at Linköping University.
- The customer - Daniel Axehill, department of automatic control at Linköping University.
- The advisor - Olov Holmer, department of vehicular systems at Linköping University.
- The course responsible - Daniel Axehill, department of automatic control at Linköping University

For a detailed description of the project organization, see the project plan.

1.2 Purpose and goal

The purpose for the project is to create a robust system to be used in research and education in advanced control courses at Linköping University. The goals for this year are to deliver a module-based system implemented in ROS with a performance at least as good as the original system and to deliver an autonomously driving LEGO truck with a dolly-steered trailer. The LEGO truck shall have the ability to execute advanced parking-maneuvers such as parallel-parking and reversing up to a loading-bay. The existing parts in the original system will be evaluated based on their performance to conclude which of them performs good and which need to be revised.

1.3 Background

Autonomous vehicles, especially cars and trucks, is an exciting research field with a lot of research done by both the industry and universities around the world. Because of this the division of Automatic Control (RT) at Linköping University has created a framework of RC-cars, infrared cameras and tracking-algorithms. This system is used to test scaled autonomous vehicles in a safe but realistic environment. This is the framework that this project is based upon.

1.4 Definitions

- **Original system** - Refers to the system developed prior to the start of this year's project.
- **ROS** - Robot Operating System.
- **roscore** - Is the main-program for the ROS setup. This program runs on the *master-node*.
- **RC-car** - Radio Controlled model car.
- **Visionen** - Visionen is an area located at Linköping University, often used to present various types of projects. This report will mention *Stora Visionen* and *Lilla Visionen*, which are two different areas that are located in Visionen.

1.5 Example requirements

The requirements are listed in tables such as in table 1. Each requirement has an unique ID-number (Marked X in table 1) and is either original or renegotiated. An original requirement is a requirement that has not been changed since the original approval of this document. A renegotiated requirement is a requirement that has been changed after the original approval of this document, the date of the renegotiation is also included. Each requirement is assigned a priority, where a priority of 1 has to be fulfilled upon delivery, a priority of 2 should be fulfilled if there is excess time to do so and a priority of 3 should only be fulfilled if there is extra time and interest for it.

X	**Original or Reneg.**	This is an example requirement.	**1,2 or 3**

Table 1: Example requirements

2 System Overview

The system as a whole is made up of a set of vehicles controlled via a RC-controller by a computer running programs for ex. motion planning, collision control and trajectory following. The system also consist of a simulator that models the car and semi-trailer truck and simulates the trajectory following behavior of these. This year has three main goals for the system. The first goal is to modularize the original system and migrate it to a ROS-based implementation. The original system's different parts are to be evaluated and considered for improvements as well as making the new system compatible with the Visionen arena. The second goal is to further develop an autonomous LEGO truck fitted with a LEGO EV3 unit and a dolly-steered trailer. The project group shall implement functionality so that the LEGO truck will be able to drive autonomously and perform various advanced parking maneuvers. The third goal is to develop a new simulator in cooperation with another project group of this year's course. This is to maintain a concise simulator that can be used in various projects and making it easier to scale against new upcoming projects. Table 2 describes the requirements for the general system.

X	**Version**	Description	**Priority**
1	**Original**	Requirements that the project group find unable to fulfill before the delivery must be renegotiated with the orderer well before the deadline.	**1**
2	**Original**	The different parts of the original system shall be evaluated and considered for improvements.	**1**
3	**Original**	The currently used positioning system shall function similarly to the positioning system used in Stora Visionen.	**1**
4	**Original**	The IR-diodes for the positioning system shall be synchronized with the camera shutter to increase its performance.	**3**

Table 2: Requirements for the general system

3 Simulator

The simulator is supposed to be a renewed version of the existing one. It is to be implemented using the *Gazebo simulator* (http://gazebosim.org/), which is tightly connected to ROS, as well as the *Rviz tool* (http://wiki.ros.org/rviz). The simulator is to be developed together with another project called *Visionen Drone Project* and the goal is to have a robust system which can be used in several both existing and upcoming projects. Table 3 describes the requirements related to this simulator.

5	**Reneg. v1.2**	A simulator environment shall be implemented using Gazebo and Rviz.	**2**
6	**Reneg. v1.2**	The simulator shall contain models of the car, LEGO truck and the truck with both semi-trailer and dolly-steered trailer.	**2**
7	**Reneg. v1.2**	The new simulator will be able to simulate different scenarios and visualize them.	**2**
8	**Reneg. v1.2**	The simulator shall be designed and implemented together with the "*Visionen Drone Project*".	**2**
9	**Reneg. v1.2**	There should be implemented more than one map.	**3**
10	**Reneg. v1.2**	The user should be able to easily choose between different maps through a user-friendly interface in the simulator.	**3**
11	**Reneg. v1.2**	The user should be able to build their own maps through the graphical interface in the simulator.	**3**

Table 3: Requirements for the simulator

4 Migration to ROS

The original system shall be modularized and migrated to ROS which is a set of libraries for doing just so. By using ROS a developer may implement a modularized system with specified interfaces between each other. This makes the system highly flexible since each module, also called *nodes*, may be replaced as long as the interface is the same. Table 4 describes the requirements related to this work.

12	**Reneg. v1.3**	As big part as possible from the current system will be migrated to ROS.	**1**
13	**Original**	The original system will be modularized into ROS-nodes for ease of use and further development.	**1**
14	**Original**	Every interface between ROS-nodes shall be thoroughly chosen and documented.	**1**

Table 4: Requirements regarding the migration to ROS.

5 Migration to Visionen

The original system is currently located in a specific project room which is to be reconstructed. The project hardware is therefore to be moved to the Visionen arena where the goal is to create a main area for robotics and automation that the university can use for projects and to display to the public. The goal of this migration is that the new setup will not lack any functionality from the original setup in the project room. Table 5 describes the requirements associated to this migration.

15	**Reneg. v1.3**	The original system shall be migrated to its new location in Visionen without any functionality loss.	**2**

Table 5: Requirements regarding the migration to Visionen.

6 LEGO truck

One of the main goals of the project is to develop a autonomous LEGO truck fitted with a LEGO EV3 unit. This LEGO truck is to be implemented using ROS and shall communicate with the *roscore* running on the computer. Associated with the LEGO truck the project group shall implement a motion planner, a regulator for trajectory following and an observer. The LEGO truck shall also be able to perform advanced parking manoeuvres by combining forward and backward movements. Table 6 describes the requirements associated to the LEGO truck, however, the requirements for the parking feature is stated in table 7.

16	**Original**	The LEGO truck shall consist of a ROS-node which communicates with the workstation.	**1**
17	**Reneg. v1.3**	A state observer for the LEGO truck shall be developed.	**2**
18	**Original**	A motion planner shall be developed for the LEGO truck.	**1**
19	**Original**	The motion planner should at maximum take 2 seconds to create a reference trajectory.	**1**
20	**Original**	A regulator for trajectory following shall be developed for the LEGO truck.	**1**
21	**Original**	While the LEGO-truck is following a reference trajectory of the figure eight, either by driving forward or backwards, the lateral deviation should stay within 5 cm of the reference trajectory 95% of the time.	**1**
22	**Original**	While driving around the figure eight, both forward and backwards, the heading deviation of the LEGO-truck should stay within 3 degrees for 95% of the time.	**1**
23	**Original**	The LEGO truck shall be able to reverse through the whole course.	**2**

Table 6: Requirements for the LEGO truck.

7 Parking feature

The project group is to implement a parking feature mainly for the car and secondly for the truck with a semi-trailer. The aim for the parking function is to be used whenever a takeover can not be performed due to a stationary object blocking the path. The car should then park to the side of the road and await the moving of the obstacle. Table 7 states the requirements associated with the autonomous parking of the vehicles.

24	**Reneg. v1.2**	A functioning parking system shall be developed for the car.	**2**
25	**Reneg. v1.2**	If the reference trajectory is blocked and no overtake is possible the car shall look for an appropriate space to park.	**2**
26	**Reneg. v1.2**	The car shall be able to park on a straight part of the racetrack.	**2**
27	**Reneg. v1.2**	The parked car shall at most be parked 3 cm from the racetrack edge.	**2**
28	**Reneg. v1.2**	When the reference trajectory is clear the car shall start moving along the trajectory again.	**2**
29	**Original**	The LEGO truck shall be able to place itself by a loading bay located to its rear.	**1**
30	**Original**	The LEGO truck shall be able to parallel park into a parking spot.	**1**
31	**Reneg. v1.2**	The car shall be able to park to the side of the road while in a curved section of the course.	**2**
32	**Reneg. v1.2**	A functioning parking system shall be developed for the truck with the semi-trailer with the same functionality as the system developed for the car.	**3**

Table 7: Requirements for the parking features of the different vehicles.

8 Code quality

In order to maintain good quality of the code throughout the whole project, the project group shall follow and fulfill the requirements listed in table 8.

33	**Original**	All code written by the group shall comply with the Google Style Guide (https://google.github.io/styleguide/cppguide.html)	**1**
34	**Original**	Each file shall be commented with a description describing its content.	**1**
35	**Reneg. v1.3**	~~Unused code files shall not be included in the final Visual Studio solution.~~	~~**1**~~

Table 8: Requirements regarding the code quality.

9 Finance

Table 9 states the requirements associated with the resources for the project.

36	**Original**	Each member of the project group shall spend 240 ± 24 hours on the project.	**1**
37	**Original**	Total tutoring time the project group shall receive is 40 hours.	**1**
38	**Original**	All hardware needed for the project shall be provided by the customer.	**1**

Table 9: Requirements regarding the finance of the project.

10 Delivery

Table 10 states the requirements of the deliveries to be made.

39	**Original**	TG 2. By 2018-09-26 the following shall be delivered: Requirement Specification, first draft of Design Specification, Project Plan including a Time Plan and a verbal presentation of the system.	**1**
40	**Original**	TG 3. By 2018-10-03 the following shall be delivered: Design Specification and Test Plan.	**1**
41	**Reneg. v1.2**	TG 4. By 2018-11-16 the following shall be delivered: The reference trajectory regulator for the LEGO truck shall be able to drive around a 8-shaped course both forwards and backwards in Visionen.	**1**
42	**Original**	TG 5. By 2018-12-07 the following shall be delivered: Test Protocol, User Manual, everything shall function and the fulfillment of the requirements shall be presented in a presentation.	**1**
43	**Original**	TG 6. By 2018-12-14 the following shall be delivered: Technical Documentation, After study, presentation of poster, web page finished, film to publish.	**1**

Table 10: Requirements for the deliveries of the project.

11 Documentation

The documents stated in table 11 shall be delivered and presented during the project. The target groups are: Project group (PG), Customer (C), Course responsible (CR) and Orderer (O).

Document	**Description**	**Target group (s)**
Requirements Specification	Specifies the requirements that shall be fulfilled at the final delivery of the project.	PG, C, O
Project Plan	Defines the methods used by the project group in order to accomplish the tasks given to them. It gives an overview of the organization, milestones and deliveries for the project.	PG , O
Time Plan	Specifies how the activities shall be distributed between the project members throughout the project and how much time to put into each activity.	PG, O
Design Specification	Describing how the different parts of the project shall work and how the shall be implemented.	PG, O
Test Plan	Describing the tests used to verify that the requirements are fulfilled.	PG, O
Test Protocol	A list of the requirements that shall be tested and whether they fulfilled or not.	O
User Manual	Describes how the system shall be used and how to solve common issues that might occur during use.	C
Technical Documentation	Describes how the system works in detail once implemented as well as some improvements that can be made in future projects.	O
After Study	Describes how the project has gone, what went well, what could be done better and how it could be used in a future project.	O, CR
Poster	A short summarizing poster of the project giving an overview of the project and its features.	C
Advertising Movie	A video of the system in action that demonstrates its features.	C
Web page	Web page that presents the project with the relevant documents.	C
Meeting protocol	Notes on what have been said during project meetings.	PG
Status Report	Status of the project that shall be delivered every week.	PG, C, O
Time Report	Report of activities and time spent that shall be delivered every week.	PG, O

Table 11: Documents to be produced during the project.