Test Protocol

Autonomous Reversing Truck

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Version 1.2

TRUCKVISION

Status

Reviewed	2019-12-06	Theodor Westny
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DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
0.1	2019-09-12	First draft.	Tobias Nyberg	Tobias Nyberg
1.0	2019-09-17	Updated to 1.0.	Theodor Westny	Theodor Westny
1.1	2019-12-04	Tests after new requirements.	Theodor Westny	Theodor Westny
1.2	2019-12-06	Tests changed after req. 14 renegotiated	Alexander Källström	Alexander Källström

1 INTRODUCTION

This document presents how the requirements in the *Requirement Specification* will be tested and how they are verified. Each requirement is listed and below the requirement the test is described. As in the *Requirement Specification*, the requirements are divided into different modules.

1.1 Definitions

- **ROS** - Robotic Operative System, an open source software library which simplifies writing modular code for robotic applications
- **Visionen** - A research arena for robotics applications at Linköping University
- **QualiSys** - Positioning system used in Visionen

2 SYSTEM OVERVIEW

In this section all general requirements are described with its associated test.

Requirement	Revising	Description	Priority
1	Original	Requirements that the project group are unable to fulfill should be renegotiated with the orderer well before the deadline	1
		Test Description: This requirement will be seen as fulfilled if all requirements are negotiated before 2018-11-26	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The requirements were negotiated in time	Pass
2	Original	The obstacles should be able to be placed arbitrary	1
		Test Description: Verify that the truck can complete missions for an arbitrary set of obstacles	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The obstacles can be placed arbitrary	Pass
3	Original	The construction of the truck should be improved, the camber angle of the front wheels should be reduced	1
		Test Description: Verify structure improvement by measuring the camber angle before and after. Deem fulfilled when camber angle is less than before	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	Camber angle reduced	Pass
4	Original	All sensor values should be able to be visualized	1
		Test Description: Fulfilled once all sensor have been published on a ROS topic	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	All data is being published	Pass

3 TRAILER TRACKING SYSTEM

This section includes the tests concerning the trailer tracking system.

Requirement	Revising	Description	Priority
5	Original	There should exist one computing unit for sensor data collection and computation	1
		Test Description: Verify that there is one computing unit for sensor data collection and computation	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	There is one computing unit	Pass
6	Original	There should exist one or two sensors in the trailer tracking system	1
		Test Description: Verify that the trailer tracking system has one or two sensors	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The trailer tracking system has two sensors	Pass
7	Original	The sensor(s) should be able to estimate the position of the trailer when in field of view with an error of no more than 2 cm	1
		Test Description: Place the trailer on at least five different locations in field of view of the trailer tracking system. Measure that the sensor(s) can estimate the position of the trailer, with an error of no more than 2 cm, at all locations	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The trailer tracking system can estimate the position	Pass
8	Renegotiated	The sensor(s) should be able to estimate the trailer angle with respect to the loading bay (when in field of view) with an error of no more than 5°	1
		Test Description: Place the trailer on at least five different locations in field of view of the trailer tracking system. Measure that the sensor(s) can estimate the trailer angle (with respect to the loading bay), with an error of no more than 5°, at all locations	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-12-04	Can estimate the angle in the specified range	Pass
9	Original	Estimated position and orientation should be published through a ROS node	1
		Test Description: Verify that a ROS node exists where all estimated states are published	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The data is being published	Pass

4 STATE OBSERVER

Below are the tests for the requirements regarding the state observer.

Requirement	Revising	Description	Priority
10	Original	A motion model of the vehicle should be used within the state observer	1
		Test Description: Verify that a motion model is used in the state observer	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The state observer uses a motion model	Pass
11	Original	The state observer should use data from the inertial sensors on the truck	1
		Test Description: Check the state observer and the data it uses. Verify that data from the inertial sensors are used	
Trial	**Date**	**Comments**	**Pass/Fail**

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Requirement	Revising	Description	Priority
1	2019-11-29	The state observer uses the data from the sensors	Pass
12	Original	The state observer should handle measurements from QualiSys	1
		Test Description: QualiSys data is published on a ROS topic. Requirement is fulfilled once data from this topic is utilized in the state observer	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The state observer uses the data from Qualisys	Pass
13	Original	The state observer should handle measurements from the trailer tracking system	1
		Test Description: Trailer Tracking System data is published on a ROS topic. Requirement is fulfilled once data from this topic is utilized in the state observer	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The state observer uses the data from TTS	Pass
14	Renegotiated	The state observer should handle measurements that are asynchronous	1
		Test Description: Verify by confirming that the state observer performs well when the different kinds of measurements are out of sync.	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	Time-updates are done with a set frequency of 80Hz. However, measurement updates are done when new data is received meaning the filter handles asynchronous measurements.	Pass
15	Original	All raw sensor values should be published through a ROS node	1
		Test Description: Fulfilled once all sensors have been published on a ROS topic	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	All data are being published	Pass
16	Original	The state observer should be able to estimate the position of the trailer with a maximum error that is 50 % of the maximum error from sensors, excluding the trailer tracking system	1
		Test Description: Place the truck inside Visionen and let it move a certain distance while estimating the states with the state observer. After stopping, measure the real position of the truck and compare against the estimated states. Repeat the process at least five times and verify that the maximum error is always less than 50 % of the maximum error from sensors	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The state observe estimates the position within the required limits	Pass
17	Original	Estimated states should be published through a ROS node	1
		Test Description: Verify that a ROS node exists where all estimated states are published	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The states are being published	Pass
18	Original	The state observer should estimate the initial heading of the system, i.e. the yaw angles of the dolly, trailer and truck, with a maximum error of 5°	2
		Test Description: Place the truck, dolly and trailer with non-zero initial angles and verify that the state observer calculates the yaw angles with an maximum error of 5°. The requirement will be seen as fulfilled if the maxmium error is 5° 5 times in a row	

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Requirement	Revising	Description	Priority
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The state observer can estimate the heading, with Qualisys	Pass
19	Original	The trailer position and orientation should be estimated without the use of QualiSys. The estimate should be with a maximum error that is 80 % of the maximum error from the inertial sensors, i.e. the gyroscope and odometer	2
		Test Description: Remove the trailer-data from Qualisys and check the estimate of the the trailer position and orientation. Verify that the maximum error is less than 80 % of the maximum error from the inertial sensors. The requirement is fulfilled if the maxmium error of the estimate is below the limit throughout one route to a loading bay	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	-	-

5 MOTION PLANNER

This section includes the tests concerning the requirements for the motion planner.

Requirement	Revising	Description	Priority
20	Original	Graph search using the heuristic look-up table should on average be at least 10 time faster than using the euclidean distance	1
		Test Description: Do a graph search 10 times with heuristic look-up table and 10 times with euclidean distance, compare the averages of the two methods. If the average for the heuristic look-up table is at least 10 times faster the requirement is fulfilled.	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The heuristic look-up table is at least 10 times faster.	Pass
21	Original	The lattice planner should be able to find a solution to the goal (given any start and end point) in the Visionen arena in less than 1 second	1
		Test Description: Place start and end points on different positions in Visionen. Let the lattice planner find a solution, and measure the time. If the time is less than 1 second for 5 different start and end points the requirement is fulfilled	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The planner is faster than 1 second for 5 different positions	Pass
22	Renegotiated	The resulting end position of the trailer at the loading bay should be no more than 5 cm off the reference position	1
		Test Description: Let the system perform a parking at the loading bay, measure the distance from the reference position. This will be done 5 times and if the position is less than 5 cm off the requirement is fulfilled	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-12-04	Does park in the required distance 5 times in a row	Pass
23	Original	The motion planner should receive the estimated states from the state observer	1
		Test Description: Estimated states generated by the state observer is published on a ROS topic. Fulfilled once the motion planner subscribes to this topic and utilizes the states when planning	

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Requirement	Revising	Description	Priority
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The planner receives the states	Pass
24	Original	The motion planning module should be able to handle other starting configurations than all angles equal to zero	2
		Test Description: For 10 different starting configurations with non-zero angles, verify that the motion planner completes the missions for said configurations	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The planner handles non-zero starting angles	Pass
25	Original	Optimal path planning should be done in receeding horizon fashion with a fix frequency of 1 Hz	2
		Test Description: Complete 5 missions with set frequency of 1 Hz and verify success	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The path planning is done in receednig horizion and fulfilles the required frequency	Pass

6 SOFTWARE QUALITY

Testing regarding the requirements of software quality is described below.

Requirement	Revising	Description	Priority
26	Original	Code written by the group should comply to the Google code standard (https://google.github.io/styleguide/cppguide.html)	1
		Test Description: Verify that all files fulfill the Google code standard	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The code fulfilles the code standard	Pass
27	Original	Any new modules should be based on ROS	1
		Test Description: Verify that all new modules are based on ROS	
Trial	**Date**	**Comments**	**Pass/Fail**
1	2019-11-29	The new modules are based on ROS	Pass

7 DELIVERY

No special tests are needed for deliveries. All deliveries are connected to a toll gate and therefore no additional test will be needed.