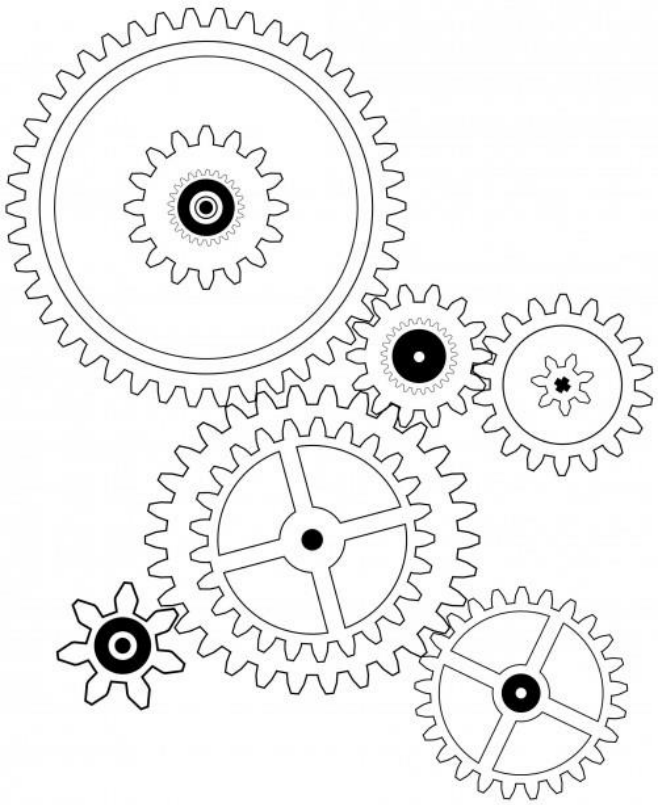
Test Plan

Smart Quarter Vehicle

Status: Finished



Name	Student nr
William Marcelissen	507428
Chris van der Spek	561633
Gerran Jansma	521675
Teun van den Burg	530770

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1 Introduction

All of the requirements are set up and approved by the client. To prove the requirements will be met at the end of the project several tests will be executed. These tests will prove the SMV is able to perform certain manoeuvres or meet certain specifications which are recorded in the set of requirements.
This document will describe a matching test for every requirement. This document also contains the preparation, resources and materials needed to successfully perform the test.

1.1 Test Definition

Req_ID	Requirement	Test method	Entrance Criteria	Measurement	Acceptance Criteria	Status

Req_ID
The ID of the requirement this test case is linked to.

Requirement
The description of the requirement this test case is linked to.

Test Method
Description of the test.

Entrance Criteria
Criteria which have to be met before the test case can be executed.

Measurement
Description of the measurements which have to be conducted in order to prove that the system conforms to the respective requirement.

Acceptance Criteria
What are the boundaries where the measurement should be within, in order to classify this test-step as passed?

Status
Status can be either one of the following:

PRE Preliminary, not yet approved by team and client
DEF Defined, approved by all stakeholders
REJ Test rejected, removed from scope
FAIL Test failed
PASS Test passed

1.2 Test strategy

When the concerned product is ready and the entrance criteria are met the test can be performed. The test strategy will follow the path displayed in figure 1.

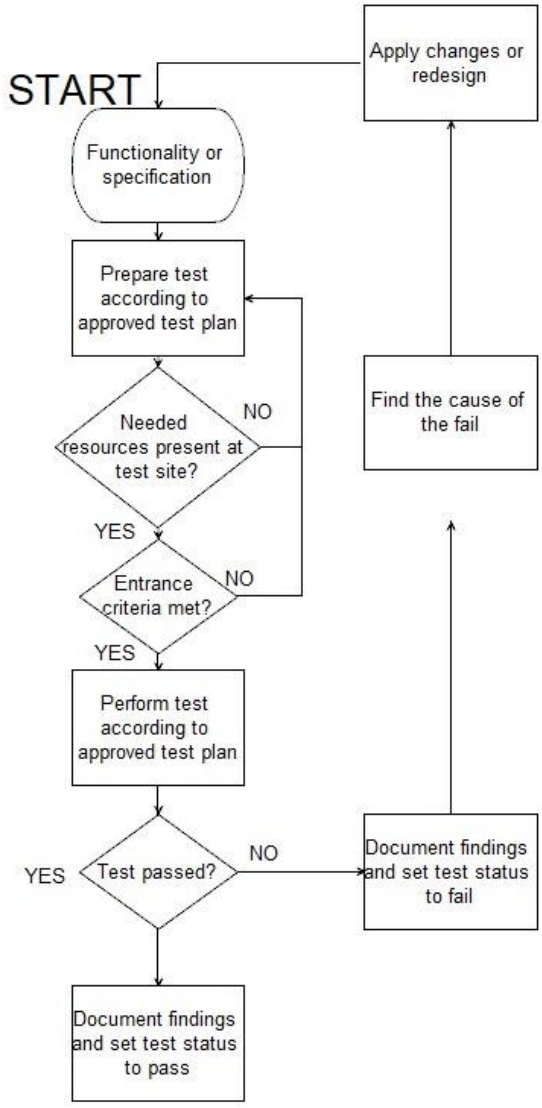

Figure 1 Test strategy

2 Test Preparation

2.1 Test Facilities & resources

Facility or resource	Test number	Time of occupation
Indoor space 3.5 by 6.5 [m] with smooth and clean surface	ALL TESTS	2 weeks
Master computer and (drone) camera	ALL TESTS	2 weeks
PC to program SMV	ALL TESTS	2 weeks
Masking tape	TEST 1	3 days
Tape measure	TEST 1; TEST 6; TEST 9; TEST 12; TEST 13;	4 days
Protractor	TEST 5; TEST 7; TEST 8	2 days
Scope	TEST 3; TEST 4	2 days
Weight of 3[kg]	TEST 16	1 day
Calliper	TEST 16	1 day
Stopwatch	TEST 6; TEST 10	2 days

2.2 Responsibilities during test

During the test period Chris van der Spek is head of testing. Therefore Chris van der Spek is responsible for the test, test equipment, surroundings and the SMV. But tests can be performed by different project group members.

2.3 Conditions to be met before starting the test phase

Before entering the test phase the product has to be finished. This means all components are assembled and the software is programmed. Also external equipment such as the existing master computer must be running and be connected to the SMV so it can send the predefined path to the SMV's microcontroller.

When these conditions are met the entrance criteria 'System is running' is met.

3 Test Cases

Req_ID	Test method	Entrance Criteria	Stimuli	Measurement	Acceptance Criteria	Status
FR01	The SMV must be able to follow a predefined path by communicating to an existing master computer.	Let the SMV follow a predefined path by communicating to the master computer.	Master computer gives SMV the command to follow the predefined path.	The predefined path will be outlined[1)]. A visual inspection will conclude if the SMV stays between boundaries	SMV must be between the boundaries of the road[1)] in the predefined path which will be 0.32 [m] wide.	PRE
FR01.1	Smart modules must be able to steer via a predefined path.(See appendix II)	Visual control if two modules steer and let the SMV follow a path (within certain tolerances) with multiple corners both to the left and to the right.	Master computer gives SMV the command to follow the predefined path.	The predefined path will be outlined[1)]. A visual inspection will conclude if the SMV stays between boundaries	SMV must be between the boundaries of the road[1)] in the predefined path which will be 0.32 [m] wide.	PRE
FR02	Let the SMV, with four connected modules, run the predefined path	- System must be running - Path must be known - Path must be set out on the floor	- Start the system	- Visual, see if SMV follows predefined path	- SMV must stay in lane [1]	PRE
FR02.1	Lock modules by software. Check if they are locked.	- System must be running	- Lock the modules via software	- See if modules are locked.	Wheels are locked	PASS
FR03	The chassis must include a battery to run a predefined path	Let the SMV run the predefined path on 1 charge.	Master computer gives SMV the command to follow the predefined path	Visual inspection if the SMV succeeds in completing path on a battery charge	SMV drives the predefined path wireless	PASS
FR04	Visual inspection, retrieve RPM data.	- Connect scope or PC to driver motor.	- None	- Turn driver motor, see if rpm signal appears on scope.	- Signal should be present and clear.	PASS
FR05	Visual inspection, retrieve steering angle data.	- Connect scope or PC to steering motor. - SMV must be connected to PC to set a steering angle	- Set steering angle	- Create a steering angle and see if signal appears.	- Signal should be present and clear.	PASS
PR01	Drive one lap wireless to confirm the communication is wireless.	The SMV will not be wired and not physically connected to the master computer.	Starting the protocol of driving one lap.	Visual, see if the SMV will drive one lap wireless.	When the SMV completes the predefined as desired.	PASS
PR02	Calculate the steering angle with Ackermann principal. Use this steering angle for the SMV as input and measure it.	To entrance the test it needs to be applied.	Use the calculated steering angle as input for the SMV.	Draw the angles of the steering from the SMV on the ground and draw the ''Ackermann principal''. Measure it and compare it.	When the SMV measurement is between +/- 5 degrees with the calculated angle.	PRE
PR03	Measure the speed average by travel distance and time	System running	Start the SMV to drive.	Test track with the total distance. Measure the time with an stopwatch.	When the SMV reaches a speed of 0.1 [m/s]	PASS
PR04	Put the 30 degrees steering angle in the system of the SMV and	System running.	Start the SMV to get the input steering angle.	Visual, draw the angles of the steering from	The steering angle is the same as the	PASS

	measure it.			the SMV on the ground and measure the angle.	input steering angle.	
PR04.1	Put the 50 degrees steering angle in the system of the SMV and measure it.	System running.	Start the SMV to get the input steering angle.	Visual, draw the angles of the steering from the SMV on the ground and measure the angle.	The steering angle is the same as the input.	FAIL
PR04.2	Make a turn with a turning radius of 0.9[m]	System running.	Start the SMV to drive.	Draw starting position. SMV will turn around and draw the end position. Measure this.	When the turning radius is equal to 0.9[m] or smaller.	PASS
PR05	Drive the predefined path for one hour	System running.	Start the SMV to drive.	Timing from start till an hour.	When the SMV has been driving at least for an hour.	PRE
PHR01	Visual inspection	-		Identity check	Approved when wheel are the same	FAIL
PHR02	Measure the distance between the left outside wheels tot the right outside wheels	-No steering angle is applied		Distance	Distance ≤ 17.86cm	PASS
PHR03	Measure the length of the modules.	-	-	Distance	Distance ≤ calculated dimension(set of requirements)	PASS
PHR04	Visual inspection	-	-	Identity check	Approved when connections are standardized	PASS
PHR05	Visual inspection, check of modules are rigid after 15 minutes of operation	-Vehicle drives the predefined path for 15 minutes	Start the SMV time	Check Structural rigidity by checking the mounting hardware	No mounting hardware has come lose after operation	PASS
PHR06	Apply a three kilogram weight in the middle of the vehicle and measure the bending in the mid-point of the platform	-Vehicle is in stationairy position -No steering angle is applied -Only four modules have to be installed	Apply a weight	Bending in the middle of the vehicle	Bending ≤ 10mm	PRE
PHR07	NA	-	-	-	-	-
PHR07.1	NA	-	-	-	-	-

1) see appendix: Road information

4 Test forms

Test ID	TEST 1 (FR01; FR01.1; FR02; FR03; PR01)	
Necessary resources	- Masking tape - Tape measure - Indoor space of 3.5 by 6.5 [m] with smooth and clean surface - Master computer and (drone) camera - PC to program SMV	
Entrance criterium #1	System is running[2)]	
Entrance criterium #2	Path is set out	
Entrance criterium #3	Path is known by master computer	
	Measurement	
Test Passed?	YES	
Comments:	-	
Test conducted by:	Chris,Gerran,Teun,William	
Date:	22-12-2017	

Test ID	TEST 2 (FR02.1)	
Necessary resources	- PC to program SMV	
Entrance criterium #1	System is running[2)]	
	Measurement	
	-	
Test Passed?	YES	
Comments:	-	
Test conducted by:	Chris	
Date:	20-12-2017	

Test ID	TEST 3 (FR04)	
Necessary resources	- Scope	
Entrance criterium #1	Connect driver motor RPM sensor to scope	
	Measurement	
	-	
Test Passed?	YES	
Comments:	-	
Test conducted by:	Chris	
Date:	20-12-2017	

Test ID	TEST 4 (FR05)	
Necessary resources	- Scope	
Entrance criterium #1	Connect steering motor RPM sensor to scope	
	Measurement	
	-	
Test Passed?	YES	
Comments:	-	
Test conducted by:	Chris	
Date:	20-12-2017	

Test ID	TEST 5 (PR02)
Necessary resources	- Protractor - PC to program SMV
Entrance criterium #1	System is running[2)]
	Measurement
Test Passed?	YES
Comments:	Used radius of 0.34 m
Test conducted by:	Chris
Date:	20-12-2017

Test ID	TEST 6 (PR03)
Necessary resources	- Measuring tape - Stopwatch - PC to program SMV - Indoor space of 3.5 by 6.5 [m] with smooth and clean surface
Entrance criterium #1	System is running[2)]
	Measurement
Test Passed?	YES
Comments:	Precise driving
Test conducted by:	Chris, William, Gerran, Teun
Date:	12-12-2017

Test ID	TEST 7 (PR04)
Necessary resources	- Protractor - PC to program SMV
Entrance criterium #1	System is running[2)]
	Measurement
Test Passed?	YES
Comments:	-
Test conducted by:	Chris
Date:	12-12-2017

Test ID	TEST 8 (PR04.1)
Necessary resources	- Protractor. - PC to program SMV
Entrance criterium #1	System is running[2)]
	Measurement
Test Passed?	NO
Comments:	Max steering angle is 40 degrees
Test conducted by:	Chris
Date:	12-12-2017

Test ID	TEST 9 (PR04.2)	
Necessary resources	- Measuring tape - PC to program SMV - Indoor space of 3.5 by 6.5 [m] with smooth and clean surface	
Entrance criterium #1	System is running[2)]	
	Measurement	
Test Passed?	YES	
Comments:	SMV can make quite smaller angles, a radius of 0,9 meters is easily reached	
Test conducted by:	Chris, William, Gerran, Teun	
Date:	12-12-2017	

Test ID	TEST 10 (PR05)	
Necessary resources	- Stopwatch. - Masking tape - Tape measure - Indoor space of 3.5 by 6.5 [m] with smooth and clean surface - Master computer and (drone) camera - PC to program SMV	
Entrance criterium #1	System is running[2)]	
	Measurement	
Test Passed?	YES	
Comments:		
Test conducted by:	Chris, William, Gerran, Teun	
Date:	22-12-2017	

Test ID	TEST 11 (PHR01)	
Necessary resources	- Visual inspection	
Entrance criterium #1	The used RC truck wheel must be available	
	Measurement	
Test Passed?	NO	
Comments:	Design was not possible with truck wheel due to small in wheel space for hub	
Test conducted by:	Teun	
Date:	12-12-2017	

Test ID	TEST 12 (PHR02)	
Necessary resources	- Measuring tape	
Entrance criterium #1	No steering angle is applied	
	Measurement	
Test Passed?	YES	
Comments:	Depending on how tight the wheels are locked, 17,86 cm is reached	
Test conducted by:	Chris	
Date:	12-12-2017	

Test ID	TEST 13 (PHR03)
Necessary resources	- Measuring tape
Entrance criterium #1	
	Measurement
Test Passed?	YES
Comments:	69 mm
Test conducted by:	Teun
Date:	12-12-2017

Test ID	TEST 14 (PHR04)
Necessary resources	- Visual inspection
Entrance criterium #1	
	Measurement
Test Passed?	YES
Comments:	
Test conducted by:	Chris
Date:	12-12-2017

Test ID	TEST 15 (PHR05)
Necessary resources	- Visual inspection - Masking tape - Tape measure - Indoor space of 3.5 by 6.5 [m] with smooth and clean surface - Master computer and (drone) camera - PC to program SMV
Entrance criterium #1	- Vehicle has driven the predefined path for 15 minutes
	Measurement
Test Passed?	YES
Comments:	
Test conducted by:	Chris
Date:	12-12-2017

Test ID	**TEST 16 (PHR06)**	
Necessary resources	- A three kilogram weight	
Entrance criterium #1	- Vehicle is in stationary position - No steering angle is applied - Only four modules have to be installed	
	Measurement	
Test Passed?	YES	
Comments:		
Test conducted by:	Chris	
Date:	8-1-2018	

2) According to chapter 2.3

Appendix: Road information

Because of the fact that the SMV will be a scale 1:14 project that is compared with the dimensions of a real semi-truck, the road is also scaled 1:14. The justification of the road dimensions are based on the stated information released by CROW[1)].

Table 1 guidelines ETW public roads outside build-up areas by CROW

	ETW type I	ETW type II
Maximum allowed speed	60 [km/h]	60[km/h]
Amount of lanes	One	One
Total width (Verhardingsbreedte, see figure 2)	4,50 – 6,20 [m]	<4,50 [m]
Width lane (Rijloper, see figure 2)	3,00 – 4,50 [m]	Equals to total width

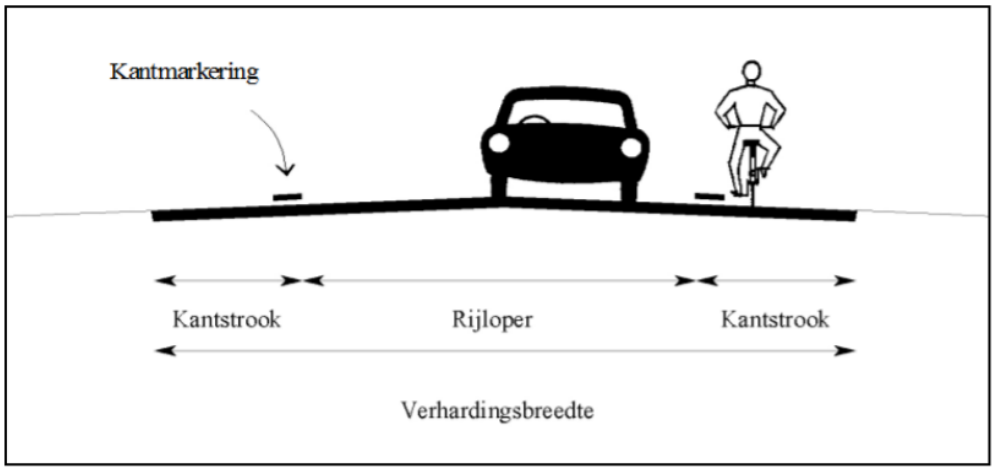

Figure 2 definitions road sections by CROW in Dutch

For the predefined path dimensions, the ETW type I dimensions are chosen with the maximum lane width of 4,50 [m]. The maximum dimension is chosen to give the SMV as much space as possible between the recommended road dimensions. Figure 3 clarifies the road dimensions when scaled down to scale 1:14

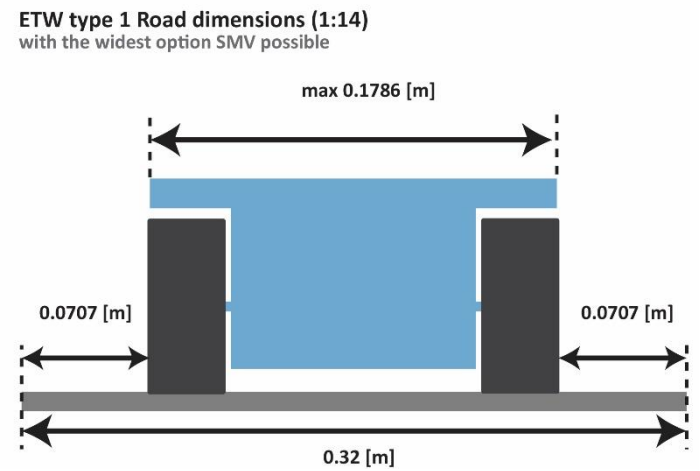

Figure 3 ETW type 1 road dimensions scaled down (1:14)

Sources:

Unknown, CROW. (2013). *Kantstroken op erftoegangswegen buiten de bebouwde kom*. 02-10-2017. https://www.swov.nl/file/13352/download?token=S9pB6p0N

[1] CROW is a knowledge organization in the infrastructure, traffic, and transport working field. CROW recommendations and guidelines are not stated in the dutch law, but the dutch road operators do use the CROW recommendations and guidelines to substantiate their decisions to the Dutch government.