Procedure to Test Sense and Avoid Prototype

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I. Introduction

A. Purpose

This document describes the procedure to test the created sense and avoid prototype for small unmanned aircraft.

B. System Overview

The system is composed by a transmitting and a receiving subsystems. The transmitting subsystem uses sixteen IR LEDs controlled by an Arduino to send the sector information. The other subsystem uses four IR detectors to receive the sent data and an approximate transmitter's direction. A block diagram of the system is shown in figure 1.

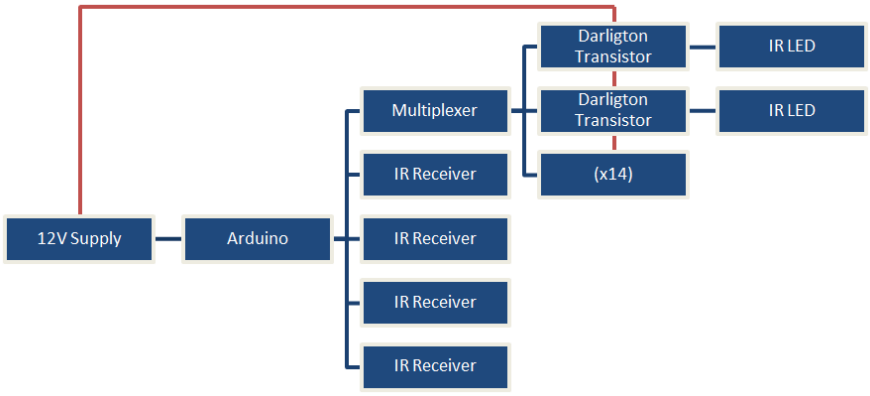


Figure 1: Block diagram of the IR Anti-Collision System

C. System Release Description

The two subsystems will be tested together, without any aircraft present, according to figure 2.

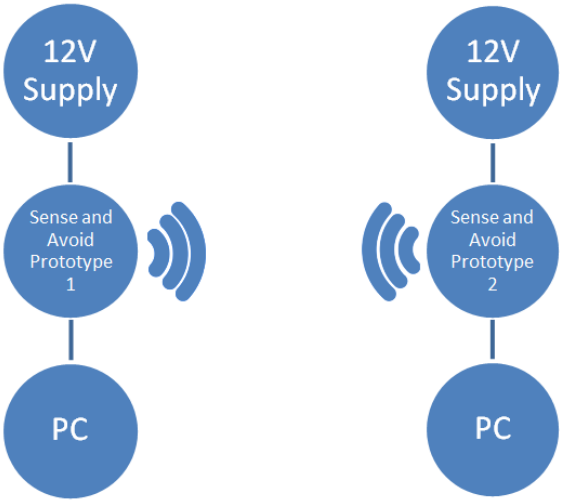


Figure 2: Block diagram of the Prototypes for the Test

The IR LEDs that will be used in the prototypes have a radiation angle as depicted in figure 3.

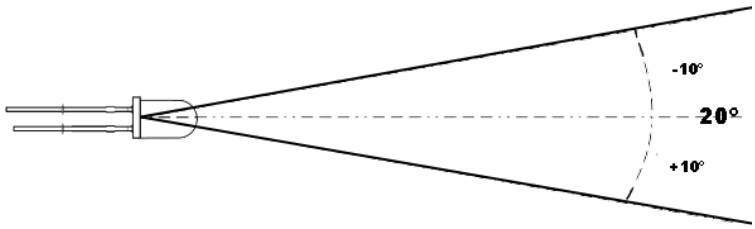


Figure 3: IR LED's radiation angle

The IR receivers that will be used in the prototypes have an angle of half transmission distance equal to $\pm 45^{o}$ as depicted in figure 4.

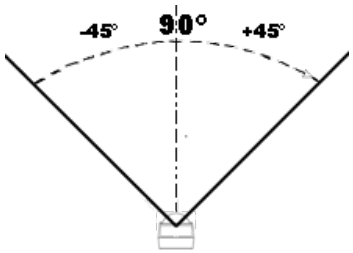


Figure 4: IR Receiver's angle of half transmission distance

D. Test Approach Description

To test the designed prototypes, several configurations of static and moving positions will be evaluated as well as with different heights between the prototypes. The test will be executed during day and night time.

II. Test Procedures

The prototype being tested is divided in two printed circuit boards, one is responsible for the transmission and the other for the reception. Both prototypes will have program Test, in section **??**, loaded into the Arduino memory.

The transmission board block diagram is represented in figure 5 and its diagram is shown in figure 6.

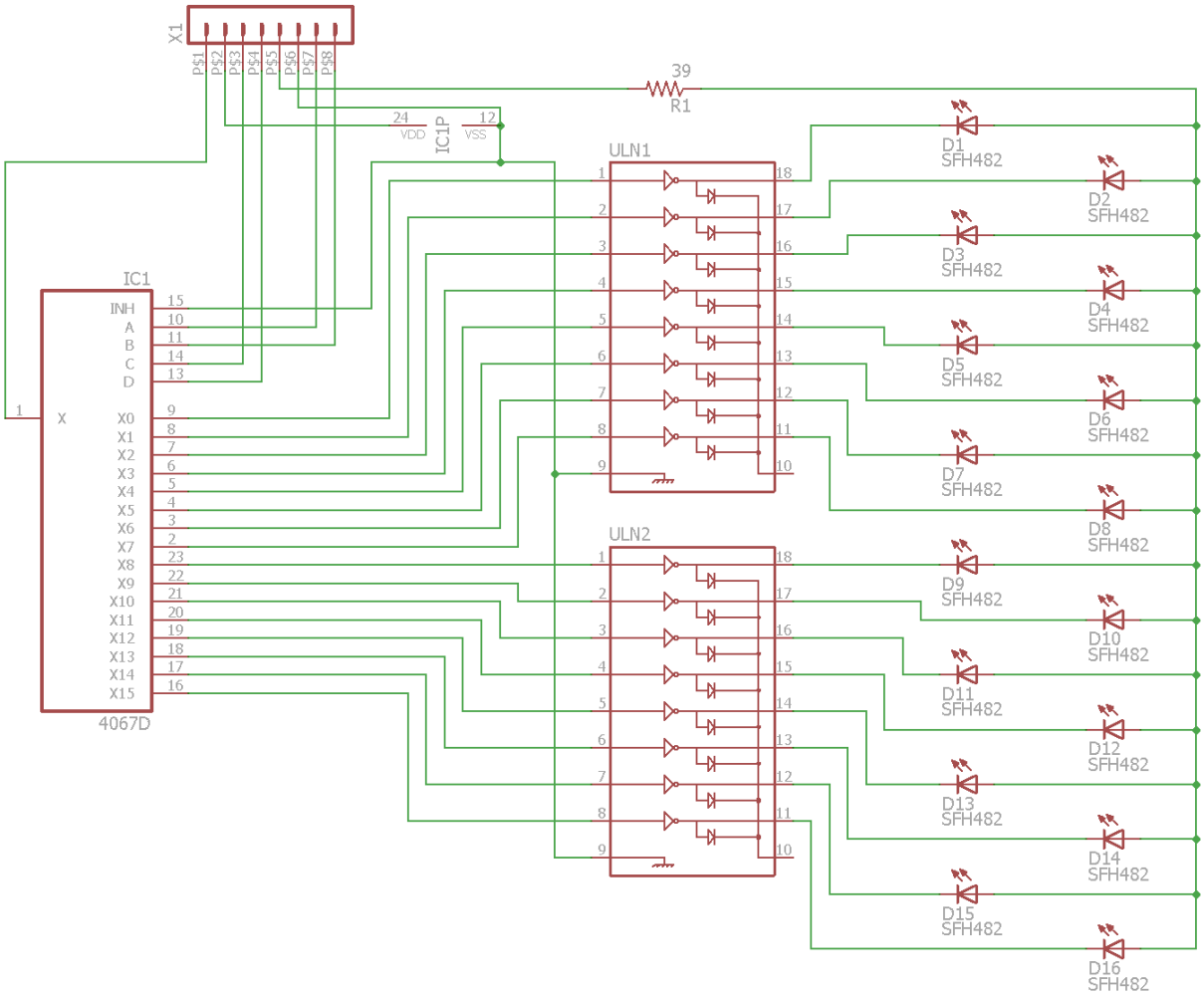


Figure 5: Block diagram for the transmitting board

The transmitted signal will be coded using a variation of the RC-5 protocol which, as can be seen in figure 7, uses bi-phase modulation (or Manchester code) and is composed by:

- two start bits always set to 1
- one toggle bit which will always be set to 0
- five bits with the aircraft category
- four bits which contain the LED's sector identification

Instead of using a 36kHz carrier frequency, 56kHz will be used.

The receiving board shall be connected according to figures 8 and 9.

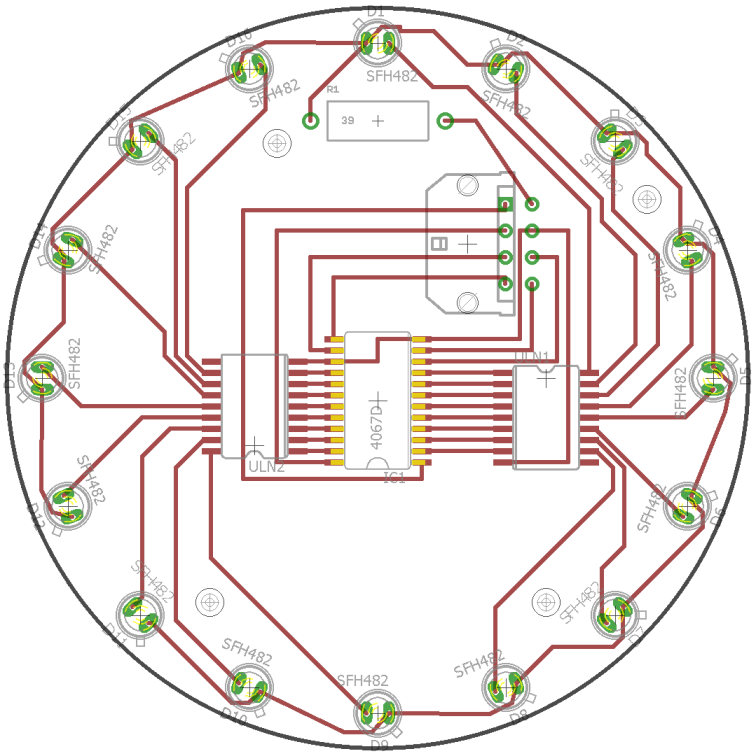


Figure 6: Diagram for the transmitting board

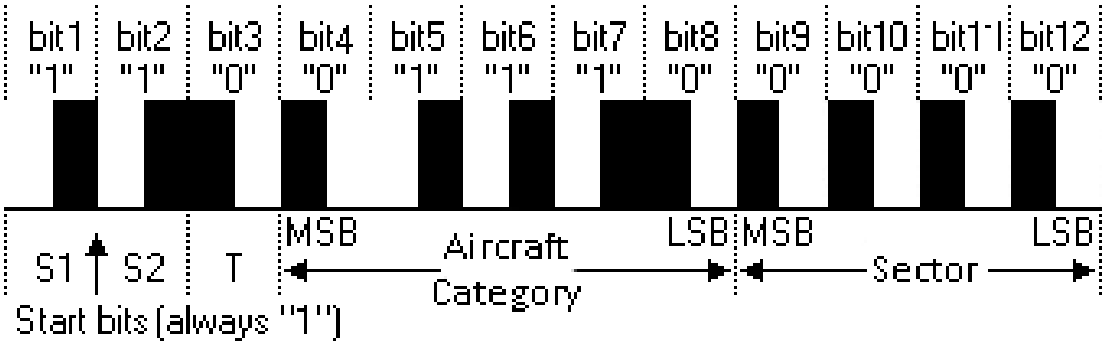


Figure 7: RC-5 coded signal

Both prototypes shall be mounted on a tripod, according to figure 10, to avoid reflections on nearby objects and to provide the ability to change the height of each prototype.

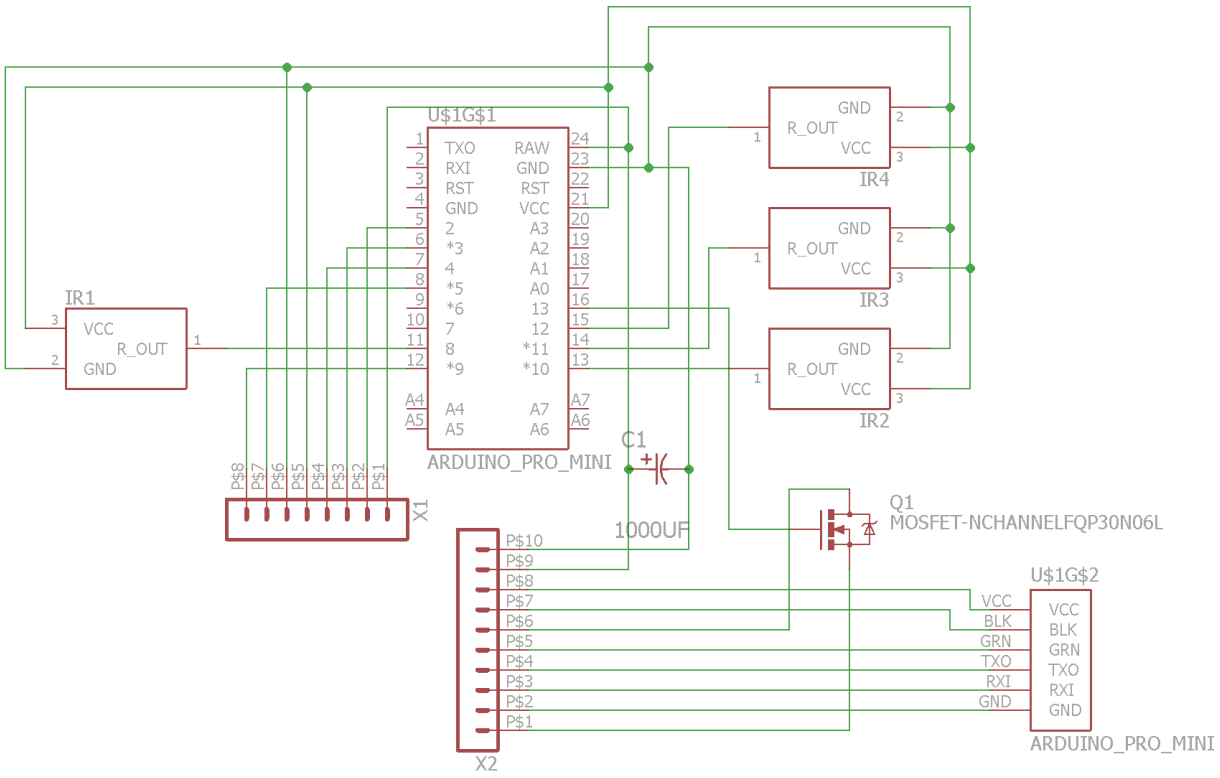


Figure 8: Block diagram for the receiving board

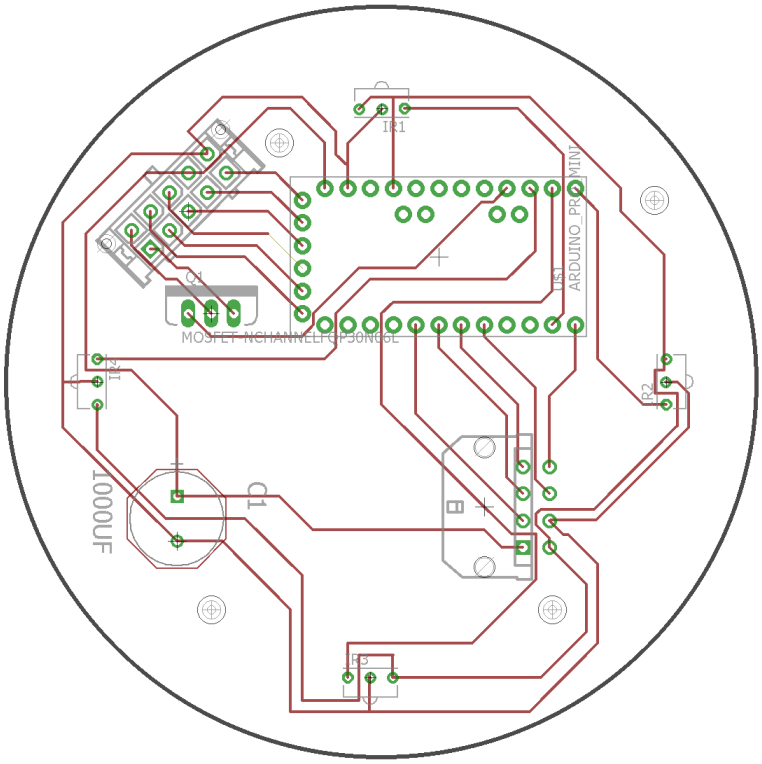


Figure 9: Diagram for the receiving board

A. *Requirements Testing*

1) Test Approach: To test the designed prototypes, several configurations of static and moving positions will be evaluated, as shown in figure 11. Static positions:

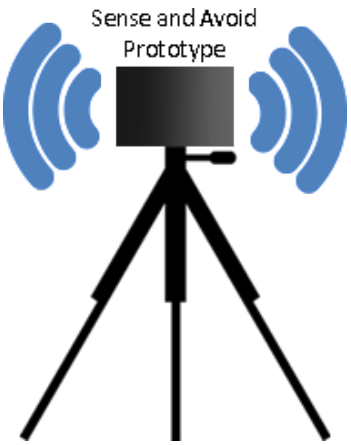


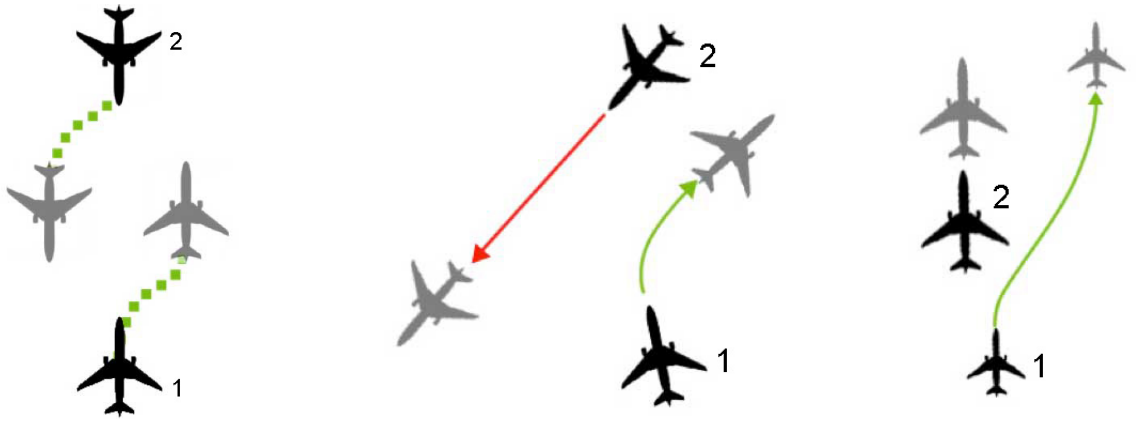
Figure 10: Prototype mount

- Head on (0° to 0°) - figure 11a
- Converging (+-45° to +-45°) - figure 11b
- Overtaking (0° to 180°) - figure 11c

Moving positions:

- Head on - figure 11a
- Converging - figure 11b
- Overtaking - figure 11c

The tests will be repeated with prototype 1 at a height of X and prototype 2 at X+1 from the ground.



(a) Head on approach (b) Converging approach (c) Overtaking approach

Figure 11: Different configurations to test: Head on, converging or overtaking approaches

2) Equipment Needed:

- Sense and Avoid Prototype (x2)
- Tripod (x2)
- PC (x2)
- 12V battery (x2)

B. Test Reporting Requirements

The tests will check if the designed prototype can provide sense capability.
Depending on the environment where the tests occur, there might be reflections.

C. Test Case 1

Prototype test with 'static head on approach' configuration. The test will follow the procedure in table I which tests the configuration shown in figure 11a. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table I: Procedure for prototype test with 'static head on approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place prototypes facing each other (0°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 PC2 'E0"R0'	
5	Wait 30 seconds	-	
6	Disconnect PCs from prototypes	-	
7	Disconnect battery from prototypes	Prototypes turned off	

D. Test Case 2

Prototype test with 'static converging approach' configuration. The test will follow the procedure in table II which tests the configuration shown in figure 11b. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table II: Procedure for prototype test with 'static converging approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place prototypes in two perpendicular lines facing their interception (+-45°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
5	Wait 30 seconds	-	
6	Disconnect PCs from prototypes	-	
7	Disconnect battery from prototypes	Prototypes turned off	

E. Test Case 3

Prototype test with 'static overtaking approach' configuration. The test will follow the procedure in table III which tests the configuration shown in figure 11c. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table III: Procedure for prototype test with 'static overtaking approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place one prototype behind the other (0° and 180°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 'E8"R0', PC2 'E0"R2'	
5	Wait 30 seconds	-	
6	Disconnect PCs from prototypes	-	
7	Disconnect battery from prototypes	Prototypes turned off	

F. Test Case 4

Prototype test with 'moving head on approach' configuration. The test will follow the procedure in table IV which tests the configuration shown in figure 11a. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table IV: Procedure for prototype test with 'moving head on approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place prototypes facing each other (0°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 and PC2 'E0"R0'	
5	Wait 10 seconds	-	
6	Move aircraft 1 two meters towards aircraft 2	PC1 and PC2 'E0"R0'	
7	Wait 10 seconds	-	
8	Turn each aircraft 45° to its right	PC1 and PC2 'E14"R0+R3'	
9	Wait 10 seconds	-	
10	Move aircraft 2 two meters in front	PC1 and PC2 'E13"R0+R3'	
11	Wait 10 seconds	-	
12	Move aircraft 1 two meters in front	PC1 and PC2 'E12"R3'	
15	Wait 10 seconds	-	
16	Move aircraft 2 two meters in front	PC1 and PC2 'E11"R3'	
17	Wait 10 seconds	-	
18	Move aircraft 1 two meters in front	PC1 and PC2 'E10"R2+R3'	
19	Wait 10 seconds	-	
20	Turn each aircraft 45° to its left	PC1 and PC2 'E12"R3'	
21	Wait 10 seconds	-	
24	Move both aircraft two meters in front	PC1 and PC2 'E11"R3'	
25	Wait 10 seconds	-	
26	Disconnect PCs from prototypes	-	
27	Disconnect battery from prototypes	Prototypes turned off	

G. Test Case 5

Prototype test with 'moving converging approach' configuration. The test will follow the procedure in table V which tests the configuration shown in figure 11b. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table V: Procedure for prototype test with 'moving converging approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place prototypes in two perpendicular lines facing their interception (+-45°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
5	Wait 10 seconds	-	
6	Move aircraft 2 one meters in front	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
7	Wait 10 seconds	-	
8	Move aircraft 1 one meter in front	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
9	Wait 10 seconds	-	
10	Move aircraft 2 one meter in front	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
11	Wait 10 seconds	-	
12	Turn aircraft 1 45° to its right	PC1 'E14"R0', PC2 'E15"R0+R3'	
13	Wait 10 seconds	-	
14	Move aircraft 2 one meter in front	PC1 'E13"R0', PC2 'E15"R3'	
15	Wait 10 seconds	-	
16	Move aircraft 1 one meter in front	PC1 'E12"R0+R3', PC2 'E14"R3'	
17	Wait 10 seconds	-	
18	Move aircraft 2 one meter in front	PC1 'E11"R3', PC2 'E13"R3'	
19	Wait 10 seconds	-	
18	Move aircraft 1 one meter in front	PC1 'E10"R3', PC2 'E12"R2+R3'	
19	Wait 10 seconds	-	
20	Turn aircraft 1 45° to its left	PC1 'E10"R0+R3', PC2 'E14"R2+R3'	
21	Wait 10 seconds	-	
22	Move each aircraft two meters in front	PC1 'E9"R3', PC2 'E13"R2'	
23	Wait 10 seconds	-	
24	Disconnect PCs from prototypes	-	
25	Disconnect battery from prototypes	Prototypes turned off	

H. Test Case 6

Prototype test with 'moving overtaking approach' configuration. The test will follow the procedure in table VI which tests the configuration shown in figure 11c. Both prototypes will be assembled on top of a tripod as shown in figure 10.

Table VI: Procedure for prototype test with 'moving converging approach' configuration

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script	Script listening to prototype	
2	Place one prototype behind the other (0° and 180°) 10 meters apart	-	
3	Connect batteries and PCs	Prototypes on	
4	Check PC for incoming data	PC1 'E8"R0', PC2 'E0"R2'	
5	Wait 10 seconds	-	
6	Move aircraft 2 one meter in front	PC1 'E8"R0', PC2 'E0"R2'	
7	Wait 10 seconds	-	
8	Move aircraft 1 two meters in front	PC1 'E8"R0', PC2 'E0"R2'	
9	Wait 10 seconds	-	
10	Turn aircraft 1 45 ° to its right	PC1 'E8"R0+R3', PC2 'E14"R2'	
11	Wait 10 seconds	-	
12	Move aircraft 1 two meters in front	PC1 'E7"R3', PC2 'E13"R2'	
13	Wait 10 seconds	-	
14	Move aircraft 2 one meter in front	PC1 'E7"R3', PC2 'E13"R2'	
15	Wait 10 seconds	-	
16	Move aircraft 1 two meters in front	PC1 'E6"R3', PC2 'E12"R1+R2'	
17	Wait 10 seconds	-	
18	Turn aircraft 1 45 ° to its left	PC1 'E6"R0+R3', PC2 'E14"R1+R2'	
19	Wait 10 seconds	-	
16	Move aircraft 2 one meter in front	PC1 'E7"R0', PC2 'E15"R2'	
17	Wait 10 seconds	-	
18	Move aircraft 1 two meters in front	PC1 'E5"R3', PC2 'E13"R1'	
19	Wait 10 seconds	-	
20	Move aircraft 2 one meter in front	PC1 'E6"R0+R3', PC2 'E14"R1+R2'	
21	Wait 10 seconds	-	
22	Move aircraft 1 two meters in front	PC1 'E4"R3', PC2 'E12"R1'	
23	Wait 10 seconds	-	
24	Disconnect PCs from prototypes	-	
25	Disconnect battery from prototypes	Prototypes turned off	