Procedure to Test Sense and Avoid Prototype with Aircraft

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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.

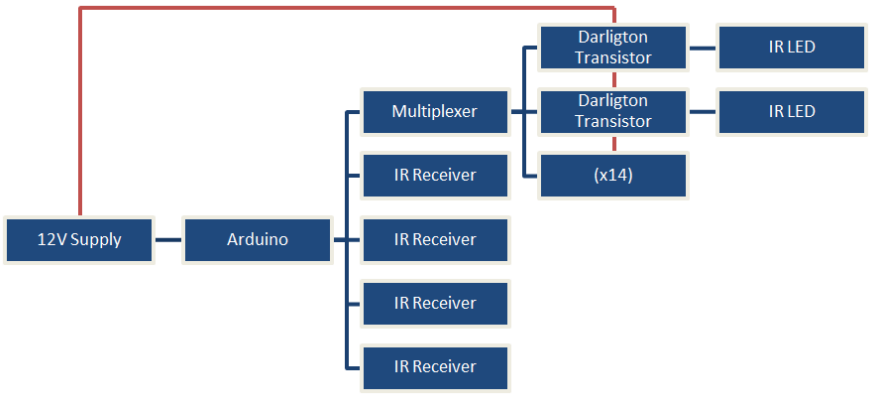


Figure 1: Block diagram of the IR Anti-Collision System

C. System Release Description

The two subsystems will be tested together, according to figure 2.

D. Test Approach Description

To test the designed prototypes, several configurations of static and moving positions will be evaluated.

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 'SenseAndAvoid.ino', loaded into the Arduino^{TM}memory.
The transmission board block diagram is represented in figure 3 and its diagram is shown in figure 4.

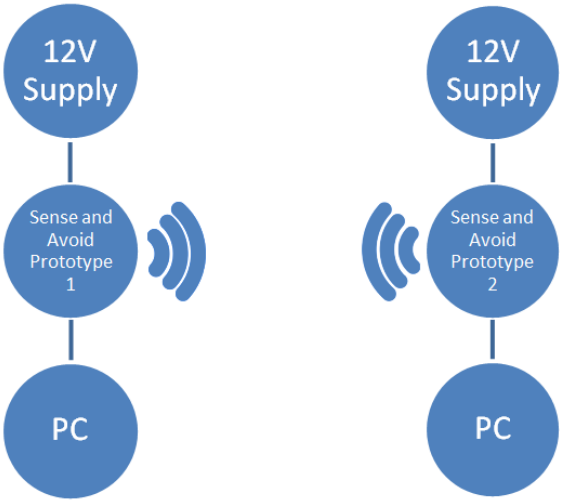


Figure 2: Block diagram of the Prototypes for the Test

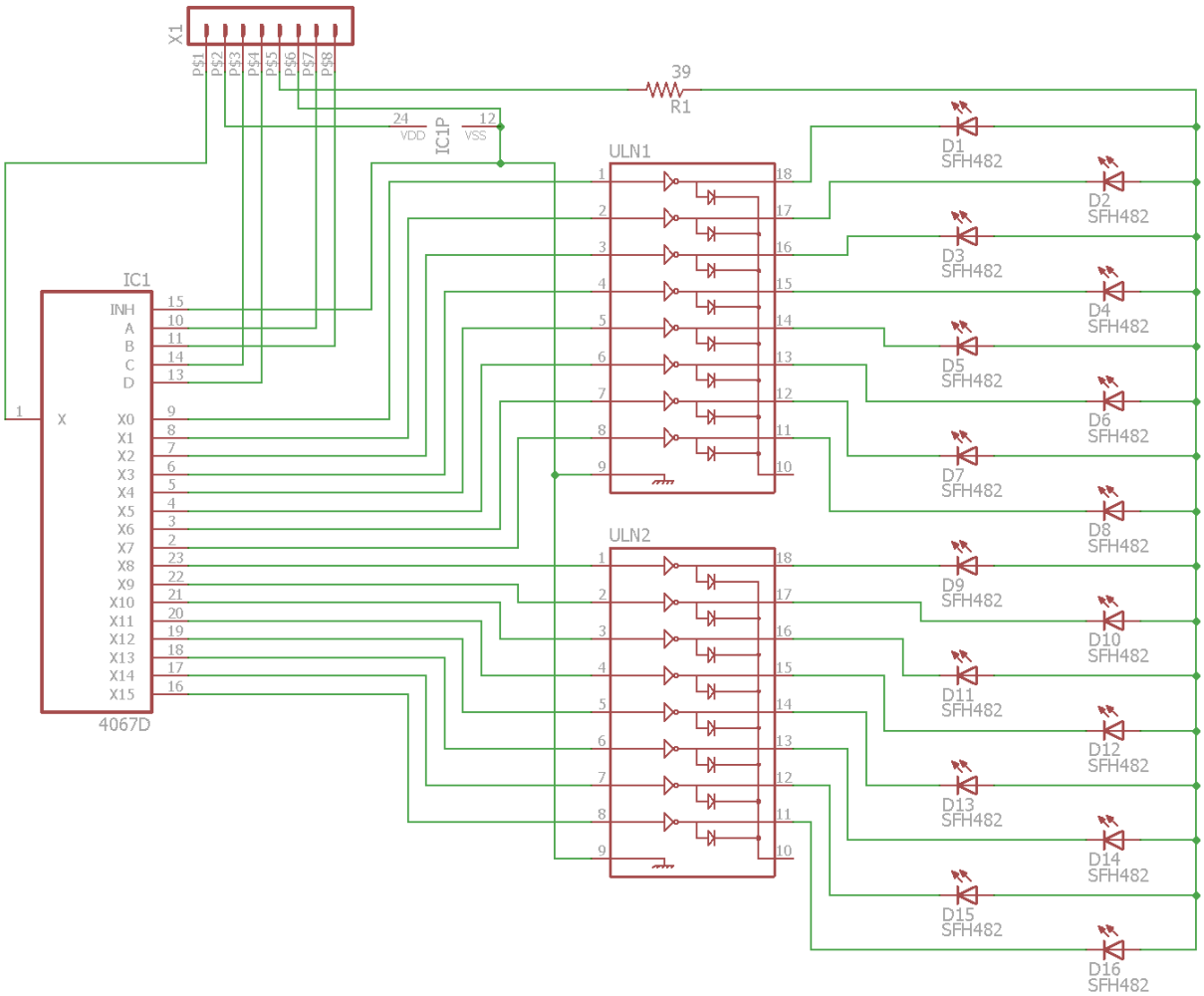


Figure 3: Block diagram for the transmitting board

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

- two start bits always set to 1

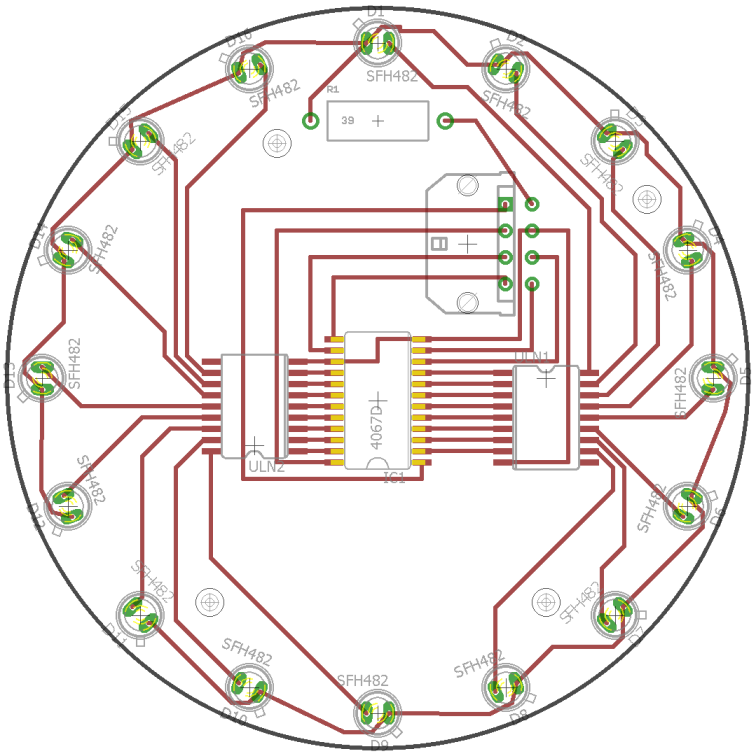


Figure 4: Diagram for the transmitting board

- 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

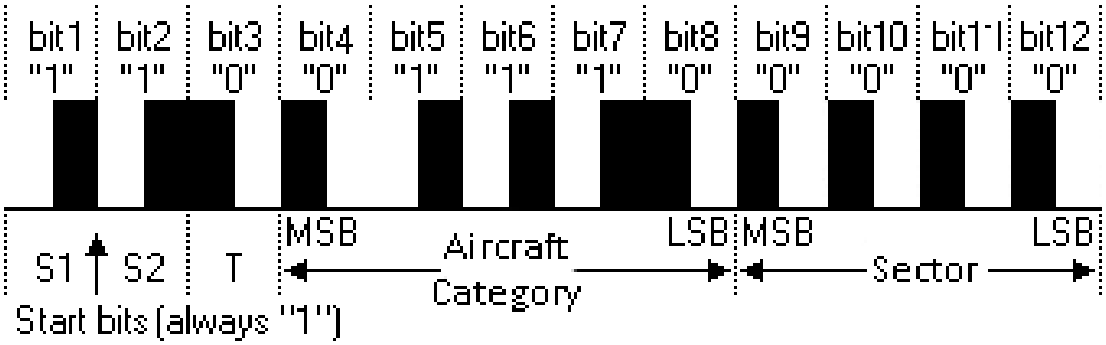


Figure 5: RC-5 coded signal

Instead of using a 36kHz carrier frequency, 56kHz will be used.
The receiving board shall be connected according to figures 6 and 7.

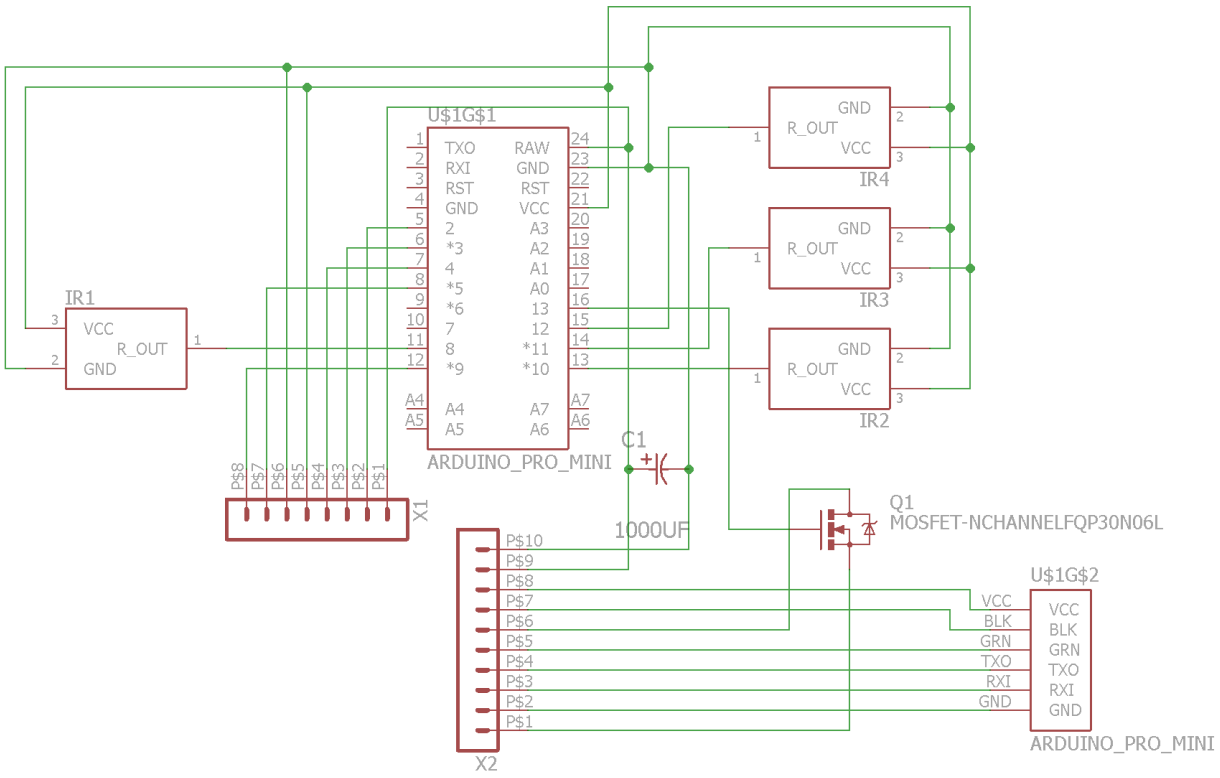


Figure 6: Block diagram for the receiving board

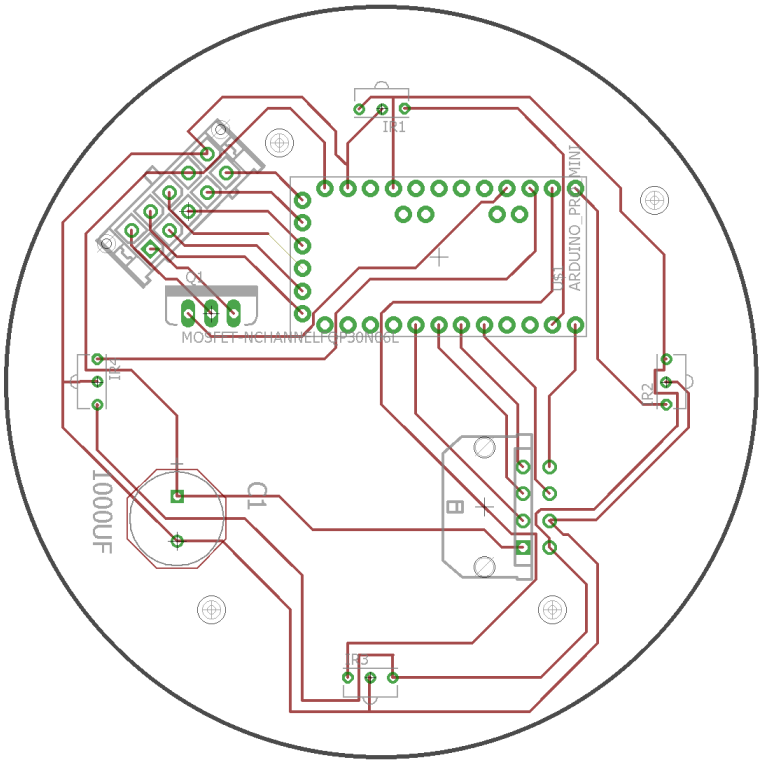


Figure 7: Diagram for the receiving board

One prototype shall be mounted on a tripod, according to figure 8, to avoid reflections on nearby objects, while the other shall be mounted on an aircraft.

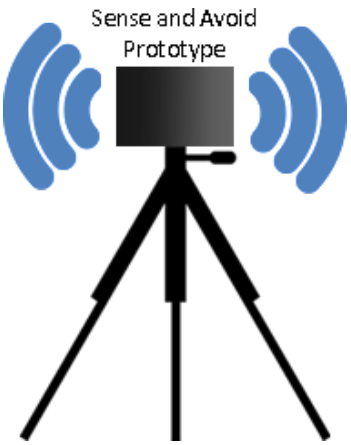


Figure 8: Prototype mount

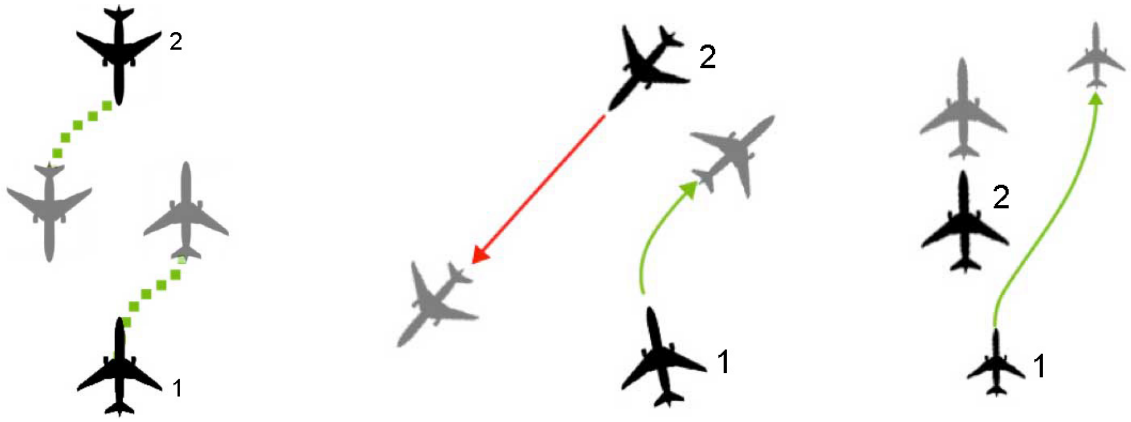
A. *Requirements Testing*

1) Test Approach: To test the designed prototypes, several configurations of static and moving positions will be evaluated, as shown in figure 9. Static positions:

- Head on (0° to 0°) - figure 9a
- Converging (+-45° to +-45°) - figure 9b
- Overtaking (0° to 180°) - figure 9c

Moving positions:

- Head on - figure 9a
- Converging - figure 9b
- Overtaking - figure 9c



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

Figure 9: Different configurations to test: Head on, converging or overtaking approaches

2) Equipment Needed:

- Sense and Avoid Prototype (x2)
- Tripod (x1)
- Quadcopter (x1)
- PC (x1)
- 12V battery (x1)

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 9a.

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

Step	Procedure	Expected Result	Pass/Fail
1	Turn PC on and run script X	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 PC from fixed prototype	-	
7	Disconnect battery from fixed prototype and turn aircraft off	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 9b.

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

Step	Procedure	Expected Result	Pass/Fail
1	Turn PC on and run script X	Script listening to prototype	
2	Place prototypes in two perpendicular lines facing their interception (+-45°) 10 meters apart	-	
3	Connect batteries and PC	Prototypes on	
4	Check PC for incoming data	PC1 'E14"R0+R1', PC2 'E2"R0+R3'	
5	Wait 30 seconds	-	
6	Disconnect PC from fixed prototype	-	
7	Disconnect battery from fixed prototype and turn aircraft off	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 9c.

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

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script X	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 PC from fixed prototype	-	
7	Disconnect battery from fixed prototype and turn aircraft off	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 9a.

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 X	Script listening to prototype	
2	Place prototypes facing each other (0°) 10 meters apart	-	
3	Connect battery and PC	Prototype on	
4	Check PC for incoming data	PC1 and PC2 'E0"R0'	
5	Wait 10 seconds	-	
6	Move aircraft two meters towards fixed prototype	PC1 and PC2 'E0"R0'	
7	Wait 10 seconds	-	
8	Turn aircraft 45° to its right	PC1 'E0"R0+R3' PC2 'E14"R0'	
9	Wait 10 seconds	-	
10	Move aircraft two meters in front	PC1 'E15"R0+R3' PC2 'E14"R0'	
11	Wait 10 seconds	-	
12	Move aircraft two meters in front	PC1 'E14"R3' PC2 'E13"R0'	
15	Wait 10 seconds	-	
16	Move aircraft two meters in front	PC1 'E13"R3' PC2 'E12"R0'	
17	Wait 10 seconds	-	
18	Turn aircraft 45° to its left	PC1 and PC2 'E13"R3'	
19	Wait 10 seconds	-	
20	Move aircraft two meters in front	PC1 and PC2 'E11"R3'	
21	Wait 10 seconds	-	
22	Disconnect PC from prototypes	-	
23	Disconnect battery from fixed prototype and turn aircraft off	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 9b.

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

Step	Procedure	Expected Result	Pass/Fail
1	Turn PCs on and run script X	Script listening to prototype	
2	Prototypes in perpendicular, fixed prototype 2 meters from the interception and aircraft 10 meters	-	
3	Connect battery and PC	Prototype on	
4	Check PC for incoming data	PC1 'E13"R0', PC2 'E1"R3'	
5	Wait 10 seconds	-	
6	Move aircraft two meters in front	PC1 'E13"R0', PC2 'E1"R3'	
7	Wait 10 seconds	-	
8	Turn aircraft 45° to its right	PC1 'E13"R0', PC2 'E15"R3'	
9	Wait 10 seconds	-	
10	Move aircraft two meters in front	PC1 'E12"R0+R3', PC2 'E14"R3'	
11	Wait 10 seconds	-	
12	Move aircraft two meters in front	PC1 'E11"R3', PC2 'E13"R3'	
13	Wait 10 seconds	-	
14	Move aircraft two meters in front	PC1 'E10"R3', PC2 'E12"R2+R3'	
15	Wait 10 seconds	-	
16	Turn aircraft 45° to its left	PC1 'E10"R0+R3', PC2 'E14"R2+R3'	
17	Wait 10 seconds	-	
18	Move aircraft two meters in front	PC1 'E9"R3', PC2 'E13"R2'	
19	Wait 10 seconds	-	
20	Disconnect PC from fixed prototype	-	
21	Disconnect battery from fixed prototype and turn aircraft off	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 9c.

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

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