



Consiglio Nazionale delle Ricerche

Rapporto Tecnico

A wireless real-time response box

**A tool for interaction with Virtual Reality
while running on a treadmill**

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Introduction and Goals

Virtual reality used during locomotion is an environment that introduces important distortions in the perception of body movements.

Studies show that while walking on a treadmill, the optical flow¹ speed is perceived as slower than the actual walking speed if the two speeds are matched. It is not known if it applies also to treadmill running.

Because of the differences of the two gait modes that concern mainly the biomechanical aspects, it is reasonable to think that the proprioceptive setting could be very different and that data referred to walking could not be applied confidently to running. This means that further analysis is necessary for future development of treadmill-mediated virtual environments that could involve not only walking but also running.

For this analysis, a staircase test will be performed, in which the stimulus magnitude of each trial is selected by an algorithm based on the subject's previous responses. While running, the participants will be presented with a visual scene projected on a screen and instructed to estimate if it is slower or faster than the actual running speed.

This basic idea has highlighted a number of issues to be solved in order to carry out correctly the protocol from a point of view of the psychophysical tests and for the safety of the participants.

- Psychophysics:
 - It is necessary that the subject's answers are directly processed by the PC, without the intervention of the operator.
 - The answers have to be submitted immediately to the PC since they are needed for the staircase test to continue.
- Safety:
 - The subject has to be able to run freely.

The goal was to build a system that could solve all these issues.

¹ Optical flow or optic flow is defined as the pattern of apparent motion of objects in a visual scene caused by the relative motion between the observer and the scene.

Materials and Methods

The biggest issue to solve was getting directly the subject's answers and to be able to integrate them into Unity². This is because the prosecution of the staircase test is based on the previous answers.

There were different commercial products, but none of them could address every issue.

It was necessary to develop and build a system that could fit exactly the needs for the test.

Multiple meetings were necessary to define the first prototype of a system that:

- enabled us to directly get the answer from the subject
- had one button per hand, so that the use would be easier for the subject during the run
- permitted real-time communication directly with the PC
- could be easily integrated into the Unity Virtual Reality environment.

For this test, what matters is the answer and not the exact response time, so this information and requirement is not needed.

Building of the system

The system was built according to the diagrams in Annex A.

It consists of:

- Two switches
- An Olimex MOD-BT board
- A PIC12F1840 microchip
- A battery

The battery is rechargeable with a micro-USB cable.

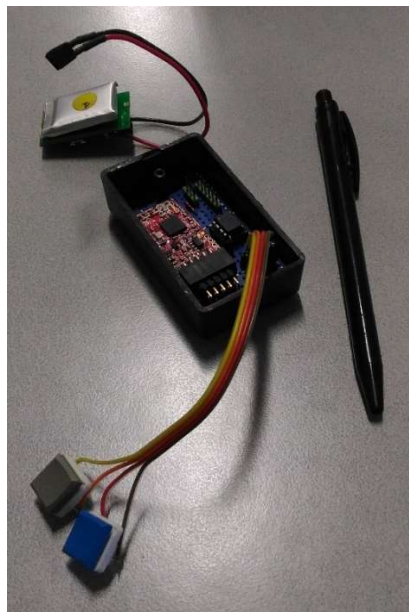
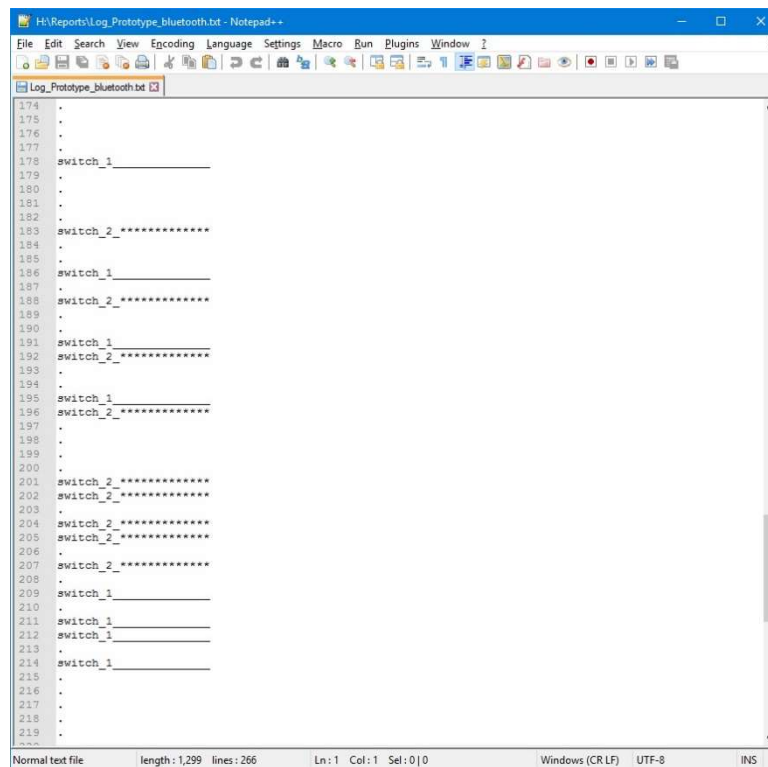


Figure 1 First prototype of the system to get the subject's answer

² <https://unity3d.com/unity>

The system transmits ASCII characters.



```
174 .
175 .
176 .
177 .
178 Switch_1
179 .
180 .
181 .
182 .
183 Switch_2 *****
184 .
185 .
186 Switch_1
187 .
188 Switch_2 *****
189 .
190 .
191 Switch_1
192 Switch_2 *****
193 .
194 .
195 Switch_1
196 Switch_2 *****
197 .
198 .
199 .
200 .
201 Switch_2 *****
202 Switch_2 *****
203 .
204 Switch_2 *****
205 Switch_2 *****
206 .
207 Switch_2 *****
208 .
209 .
210 .
211 Switch_1
212 Switch_1
213 .
214 Switch_1
215 .
216 .
217 .
218 .
219 .
```

Figure 2 Log file of the transmitted ASCII characters.

The system communicates these characters thanks to the modifications to the firmware performed with MPLAB X IDE.

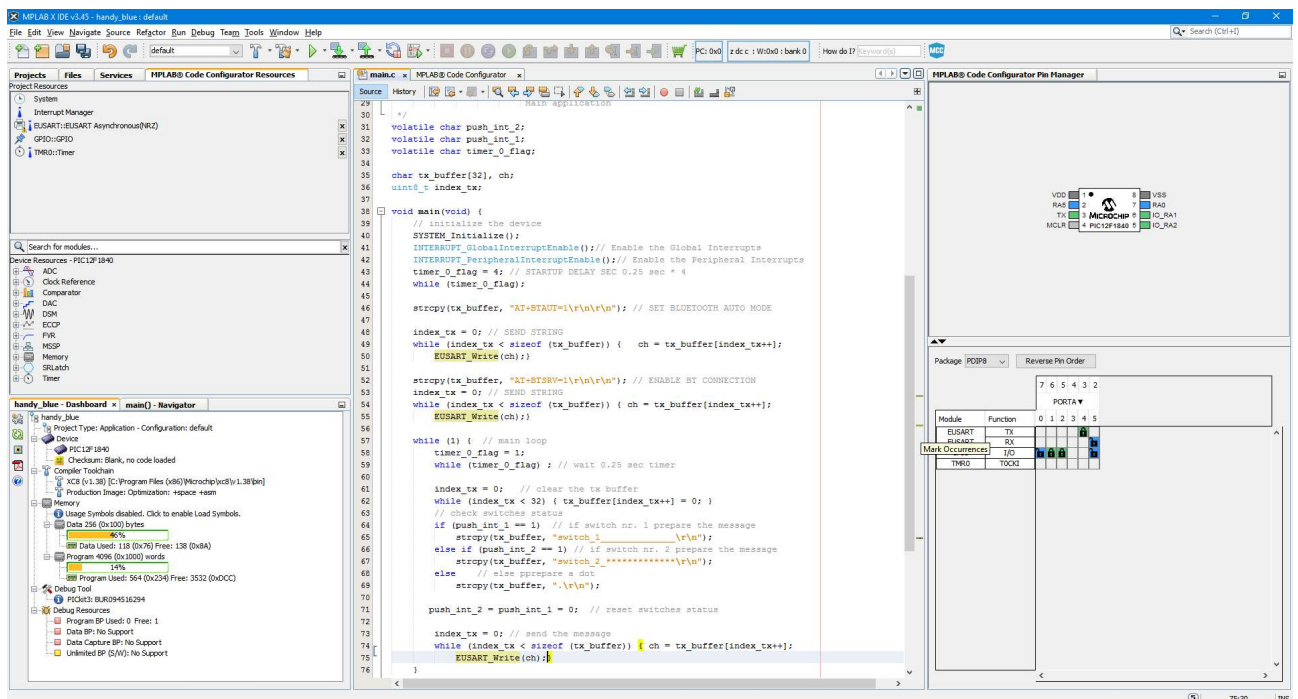


Figure 3 MPLAB X IDE interface

First tests were performed using the second prototype of the system.



Figure 4 Second prototype of the system

The switches were put into Falcon® Tubes³ to make them easier to handle during running. This was thought as a temporary solution, but after many tests, it proved to be the most comfortable option during running.

The board case was put into a smartphone armband in order not to hinder the subject. In addition, the cables were tied to the arms with elastic bands with Velcro closure.

After preliminary assessments, the prototype was modified to be more comfortable to wear.

Customised Case

The provisional case was too cumbersome and difficult to put into the smartphone armband. It was also necessary to remove the battery from the case to charge it.

So it was decided to design a customised case to be printed with a 3D printer.

The case was designed using FreeCAD, a parametric 3D modeller, and printed with a Renkforce RF1000 Single Extruder 3D printer.

³ <http://falcon.corning.com/>

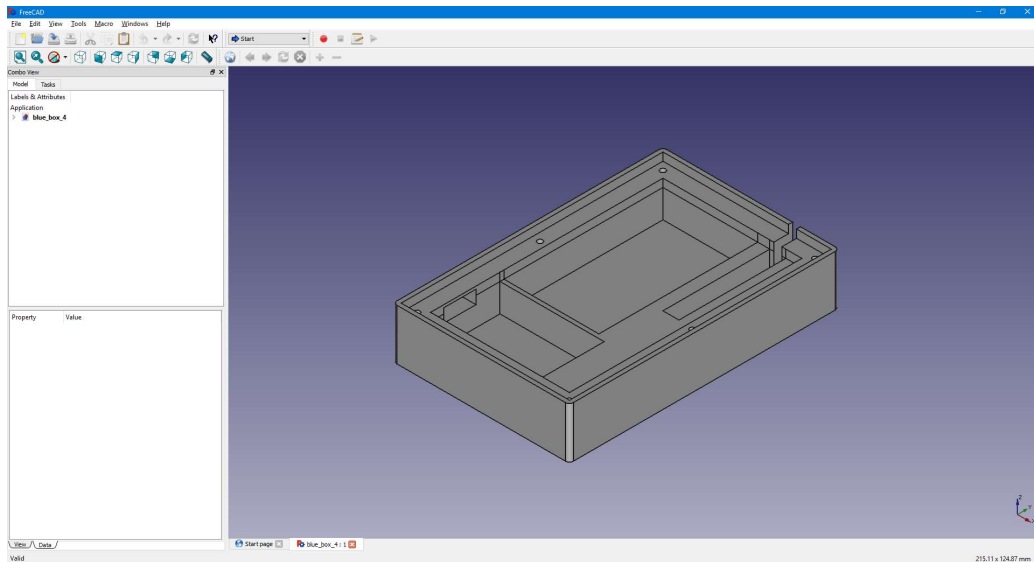


Figure 5 FreeCAD user interface

Further information about the design and the 3D printer used can be found in Annex B.

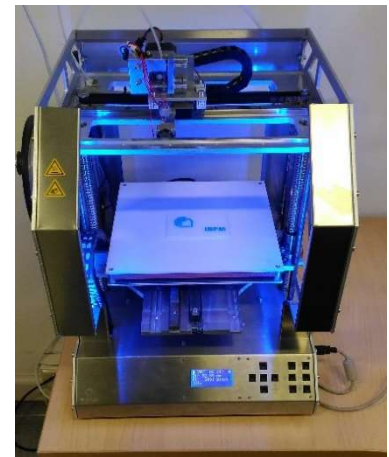
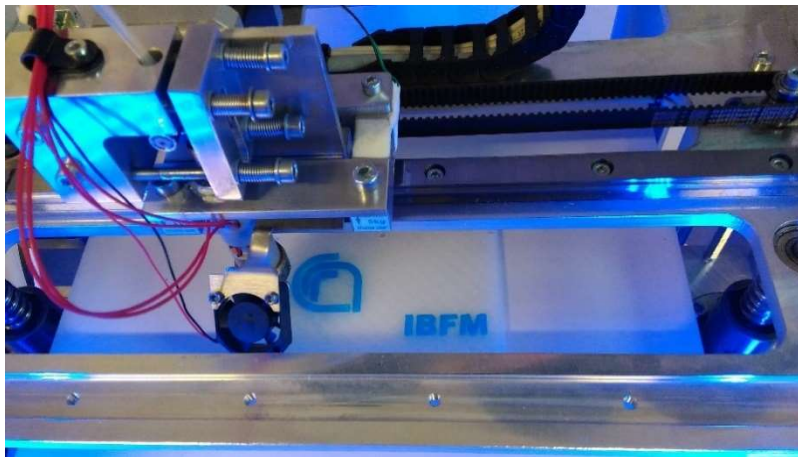


Figure 6 3D printer

Software used

- MPLAB X IDE is the software program to develop applications for Microchip microcontrollers and digital signal controllers that was used to work on the system. It was used to integrate the communication protocol for the system into the firmware that was then transmitted to the chip through PICkit™ 3 (In-Circuit Debugger/Programmer).
- Eagle is the PCB (Printed Circuit Board) layout software that was used to design the connections between the hardware components of the system
- Tera term is an open source terminal emulator supporting serial port connections. This free software was used to check the communication between the system and the PC through the COM port.
- Inkscape is a vector graphics editor. It was used for manipulating the logo of CNR to be imported for 3D printing
- FreeCAD is a parametric 3D modeller that was used to design the case for the system to be printed with the 3D printer

- Repetier is a free software used to manage the printer and print the 3D object.
- The printer is a Renkforce RF1000 Single extruder by Conrad and the case was printed using PLA filaments (3mm PLA filaments).

Results

The system was successfully used as a part of the setup employed to conduct experiments on speed perception during running in virtual environments.

The experiments were performed at the COPE Lab⁴ (Control & Perception Lab - University of Fribourg - Bd de Pérolles 90 - CH 1700 Fribourg) under the supervision of Prof. Jean-Pierre Bresciani.

These experiments were carried out to acquire data for:

- A doctoral project by Martina Caramenti
- A master thesis in Sport Sciences and Movement by a student of the University of Fribourg.

These experiments were performed having the participant running on a treadmill placed in front of a big screen as shown in Figure 7.

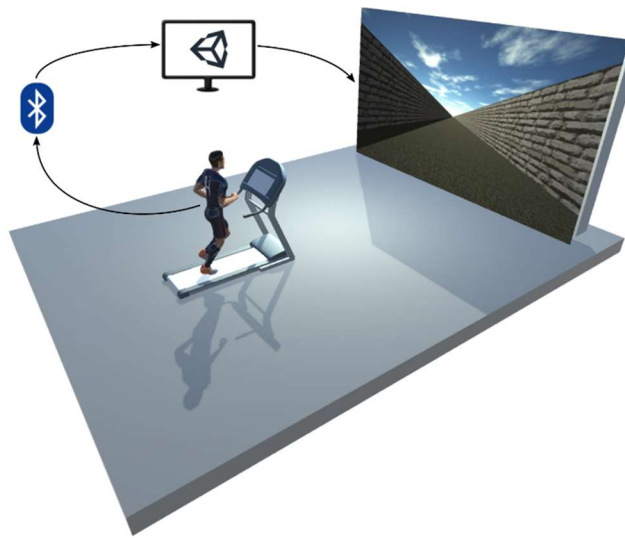


Figure 7 Setting of the tests performed at the COPE Lab in Fribourg (Suisse).

The system was being worn as shown in Figure 8.



Figure 8 Response device.

⁴ <http://www.unifr.ch/med/copelab/home>

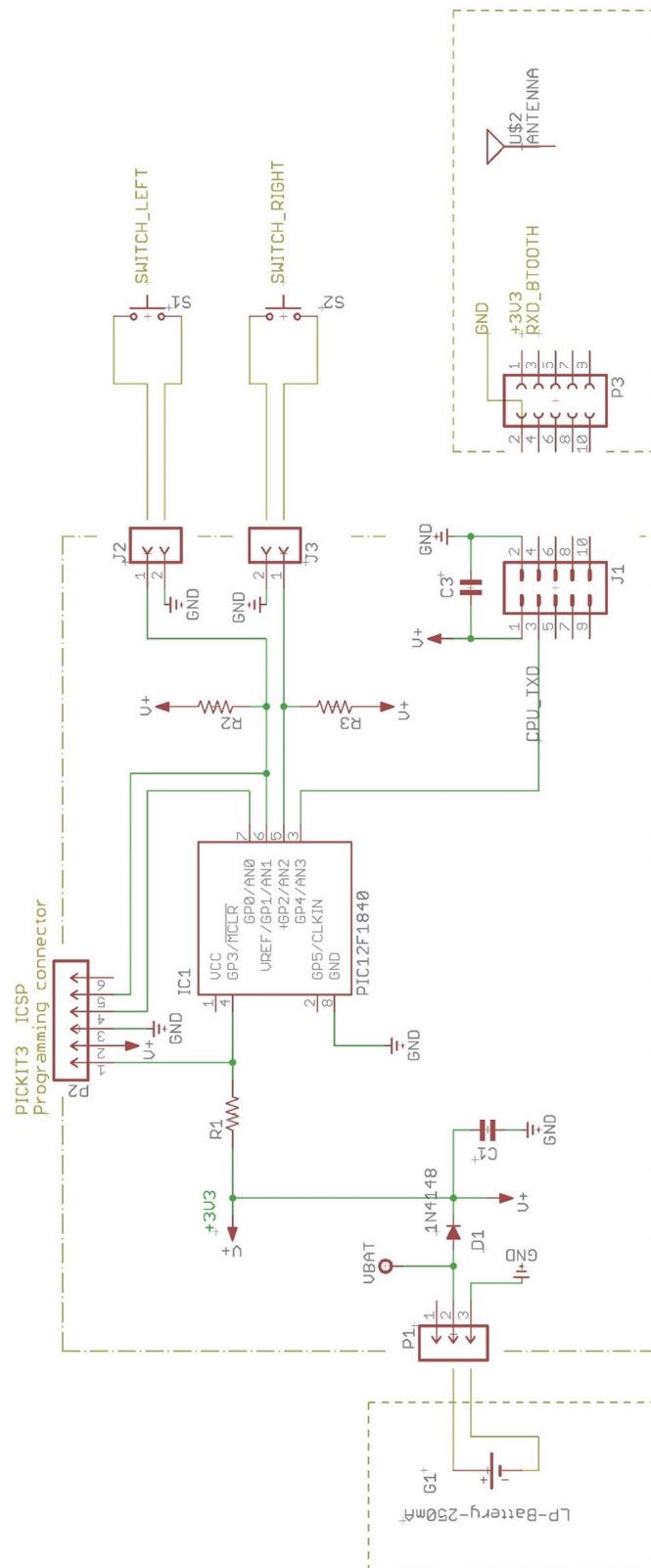
Websites

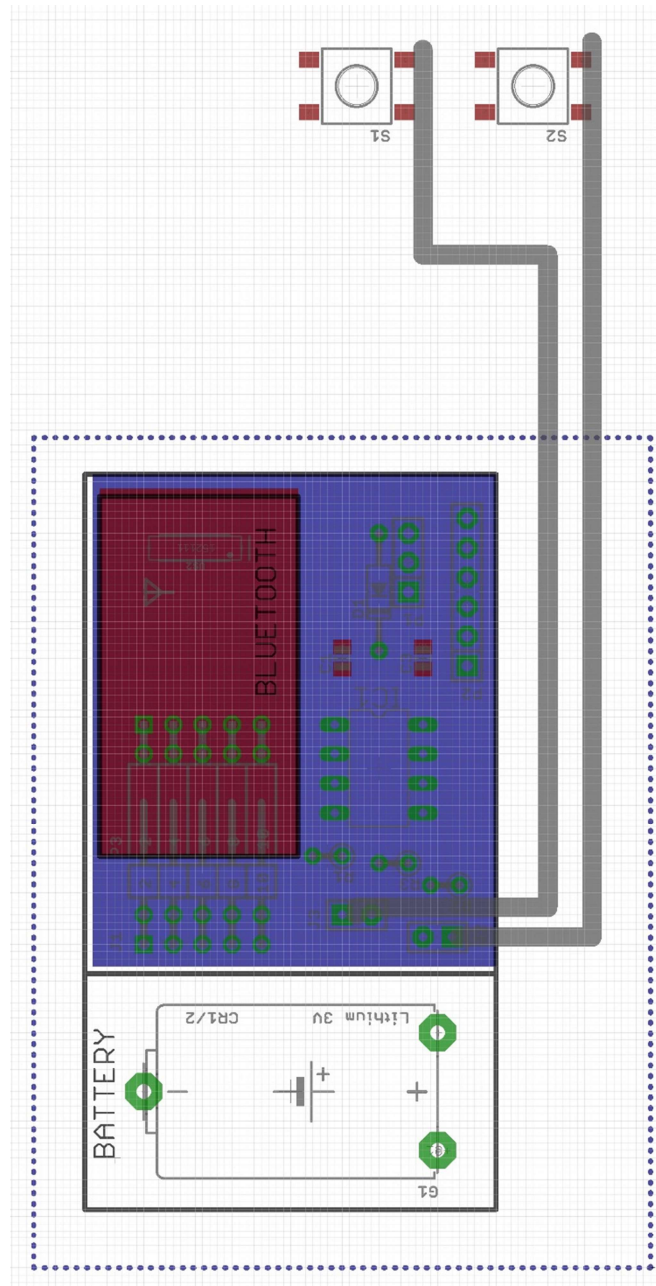
- MPLAB X IDE
<http://www.microchip.com/mplab/mplab-x-ide>
- PICkit™ 3
<http://www.microchip.com/Developmenttools/ProductDetails.aspx?PartNO=PG164130>
- Eagle
<http://www.autodesk.com/products/eagle/overview>
- Olimex MOD-BT board
<https://www.olimex.com/Products/Modules/RF/MOD-BT/>
- PIC12F1840 microchip
<http://www.microchip.com/wwwproducts/en/PIC12F1840>
- Tera term
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- Inkscape
<https://inkscape.org/en/>
- FreeCAD
<http://www.freecadweb.org/>
- Repetier
<https://www.repetier.com/>
- Renkforce RF1000
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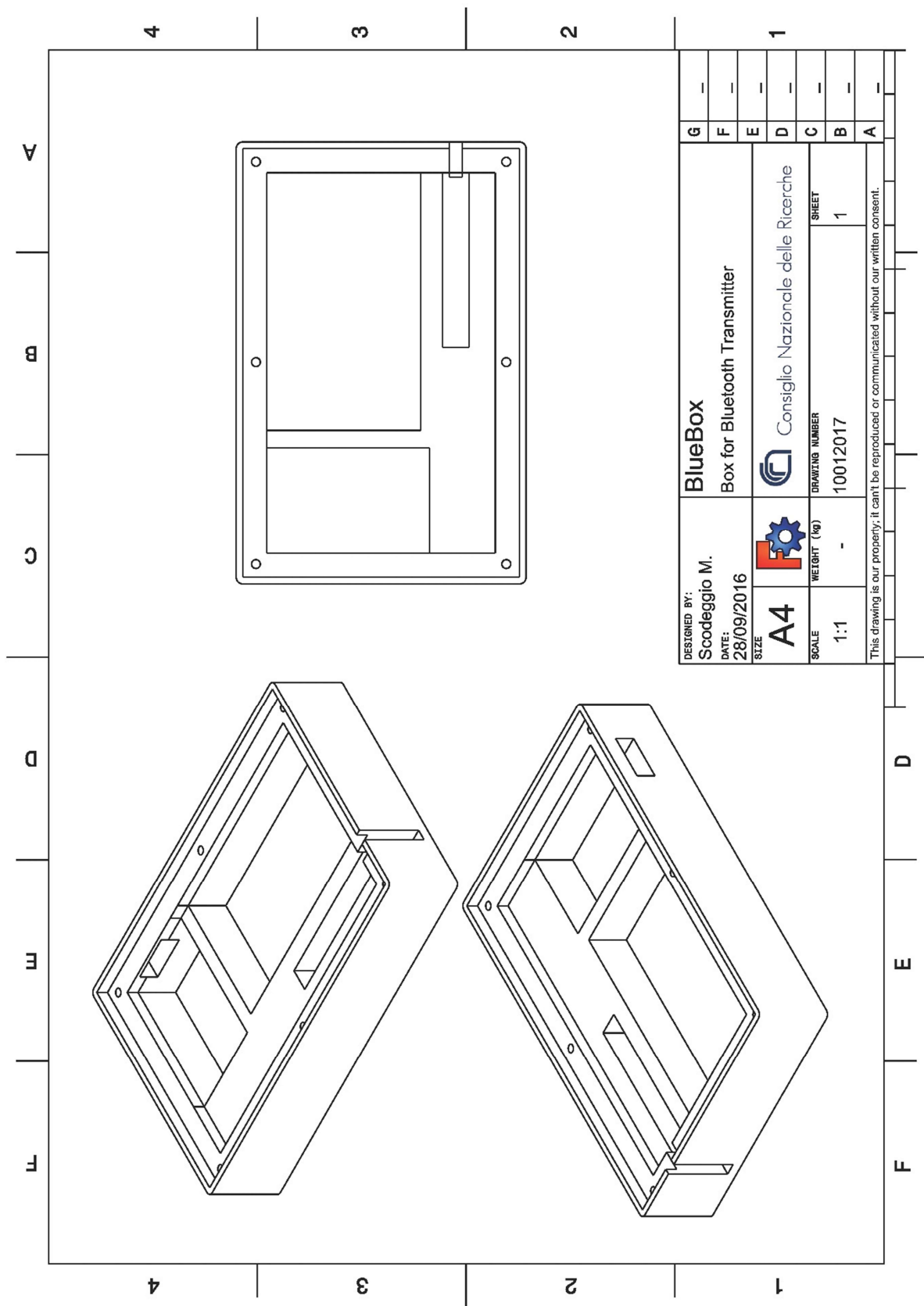
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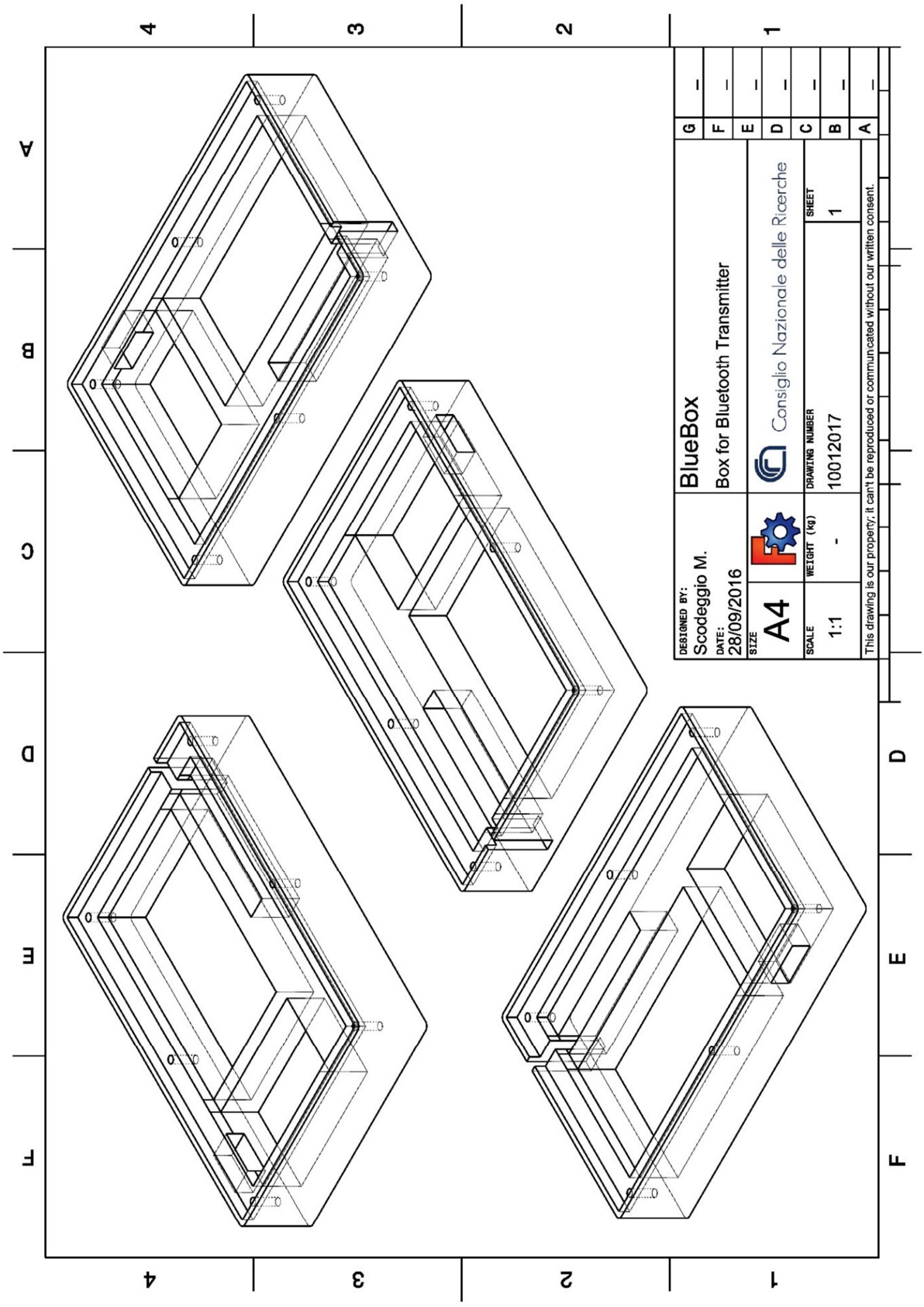
Annex A

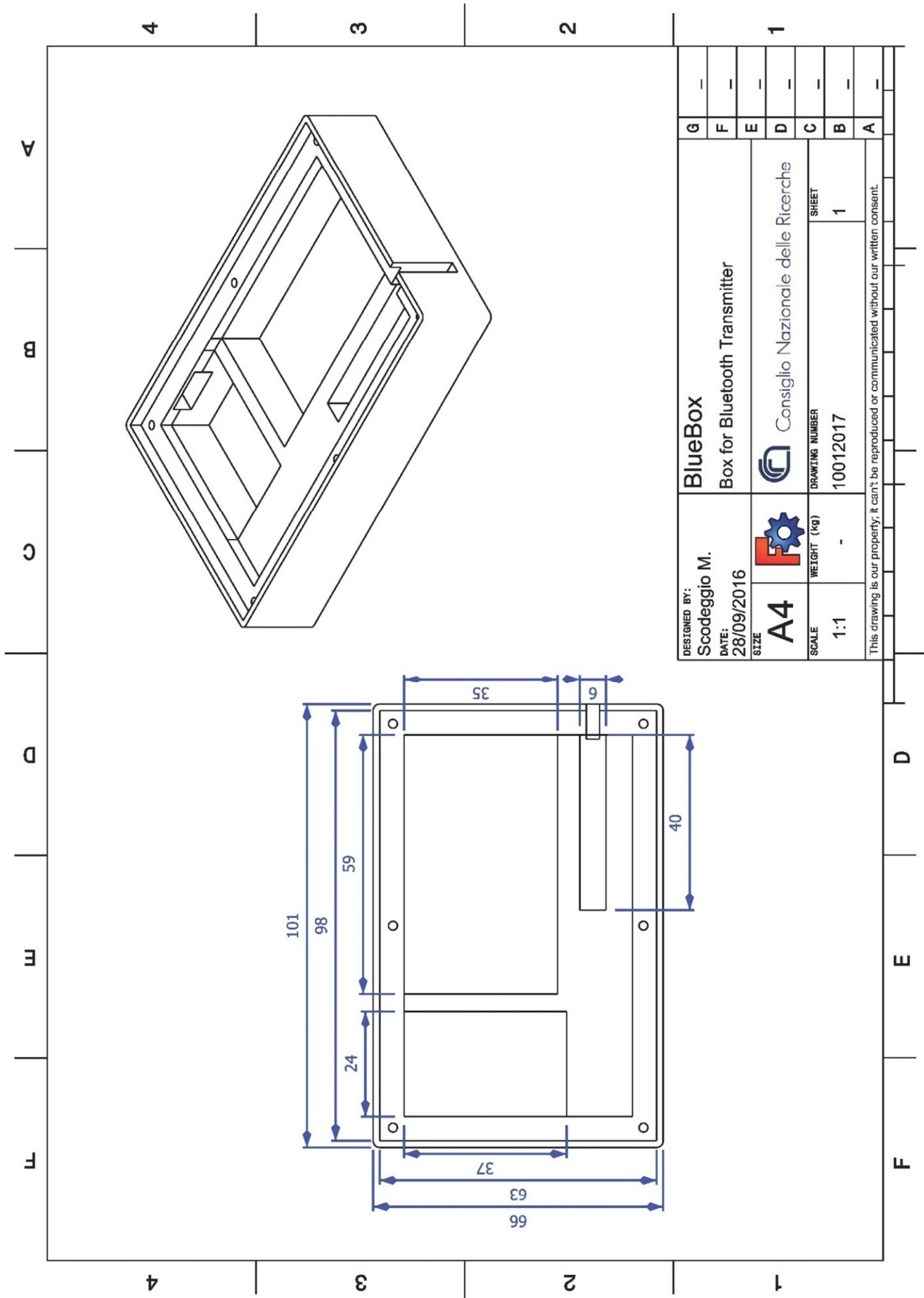





Annex B







DESIGNED BY: Scodiggio M. DATE: 28/09/2016		BlueBox		G	-
		Box for Bluetooth Transmitter		F	-
		Consiglio Nazionale delle Ricerche		E	-
		SHEET		D	-
SIZE A4	WEIGHT (kg)	DRAWING NUMBER	SHEET	C	-
1:1	-	10012017	1	B	-
This drawing is our property. It can't be reproduced or communicated without our written consent.				A	-

