Telemetry (TM) and Telecommand (TC)

To make a Telecommand (TC) equipment and a space environment model.

Let us introduce ourselves

- Bíró Zsófia
- Debrecen, Hungary
- Medgyessy Ferenc Secondary Grammar and Art School, Debrecen, Hungary
- I want to become an electric engineer

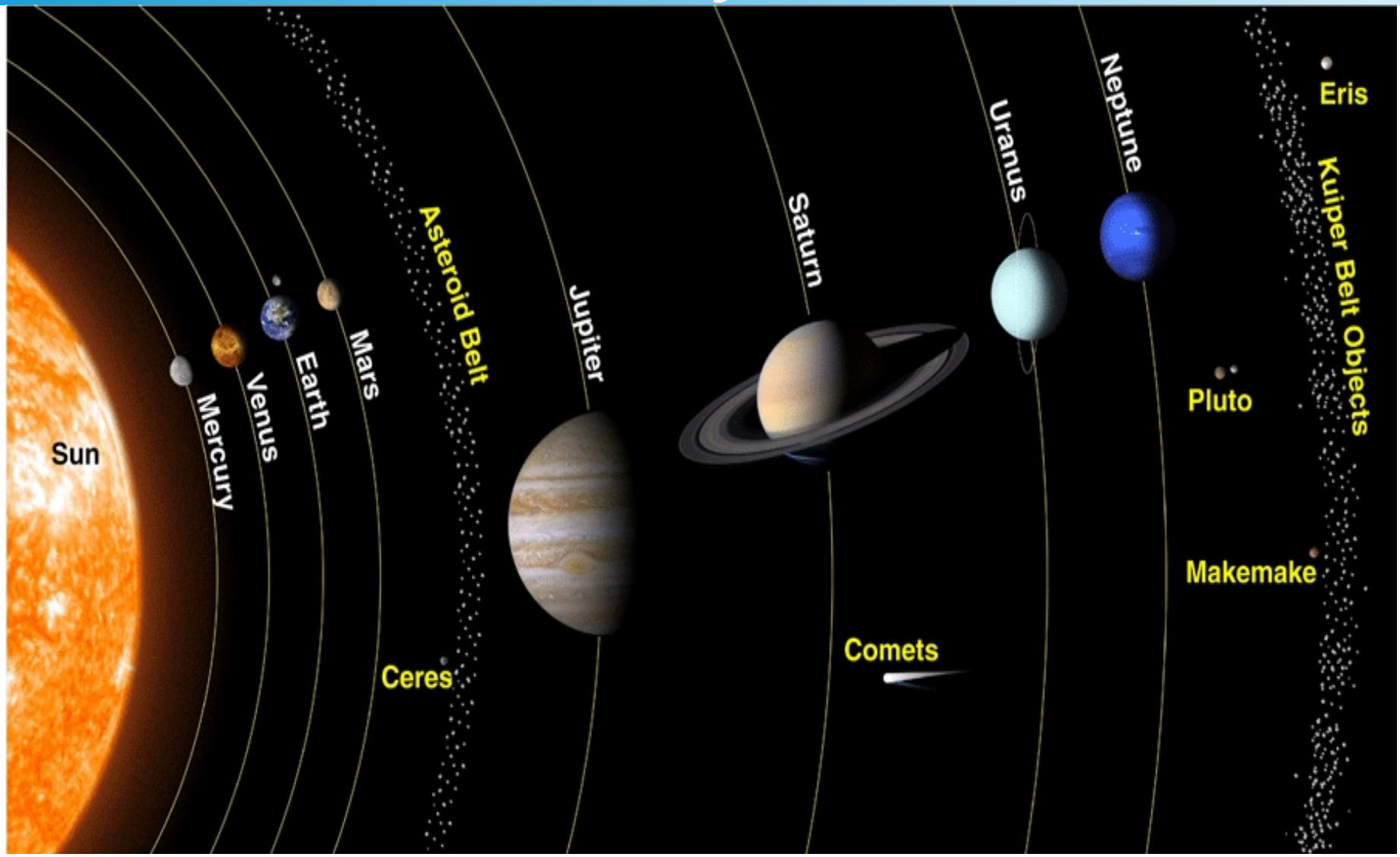
- Tiefenbeck Flórián
- Taksony, Hungary
- Fazekas Mihály Primary and Secondary School, Budapest, Hungary
- I want to become an aerospace engineer

The task

Telemetry (TM) and Telecommand (TC)
To make a Telecommand (TC) equipment model.

Student version:
- to make a Remote Commander Sequencer HW
- which can control a remote equipment
- with an **automatic sequencer which can send a series of different commands** and to check them.
- To **understand** all of the necessary **knowledge** around the particular task and
- to **build the model environment.** (idea from: Bebesi Zsófia, Opitz Andrea, Werovszky Veronika)

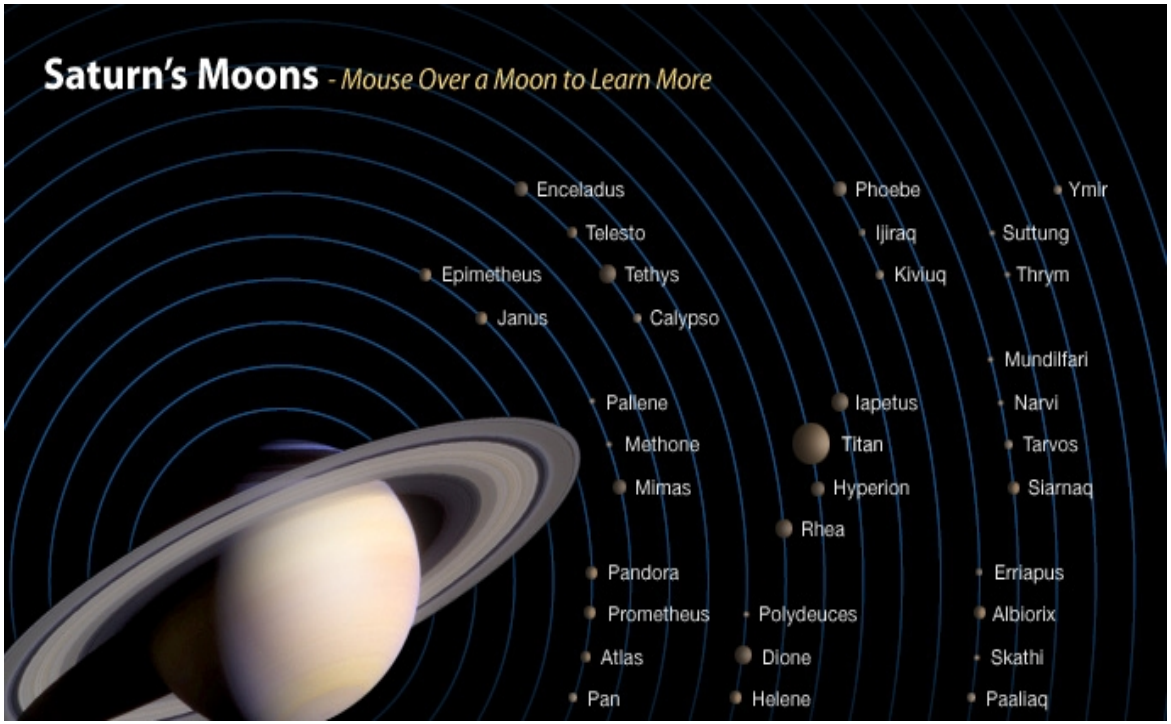
Solar System



[1] Sistema Solar Wiki:Solar-System-lrg.sp.png
http://sistema-solar.wikia.com/wiki/File:Solar-system-lrg.sp.png

Enceladus

- Sixth- largest moon of Saturn (500km across)
- 14th-E ring
- Water ice => reflective
- William Herschel- Voyager1, Voyager 2 [2]

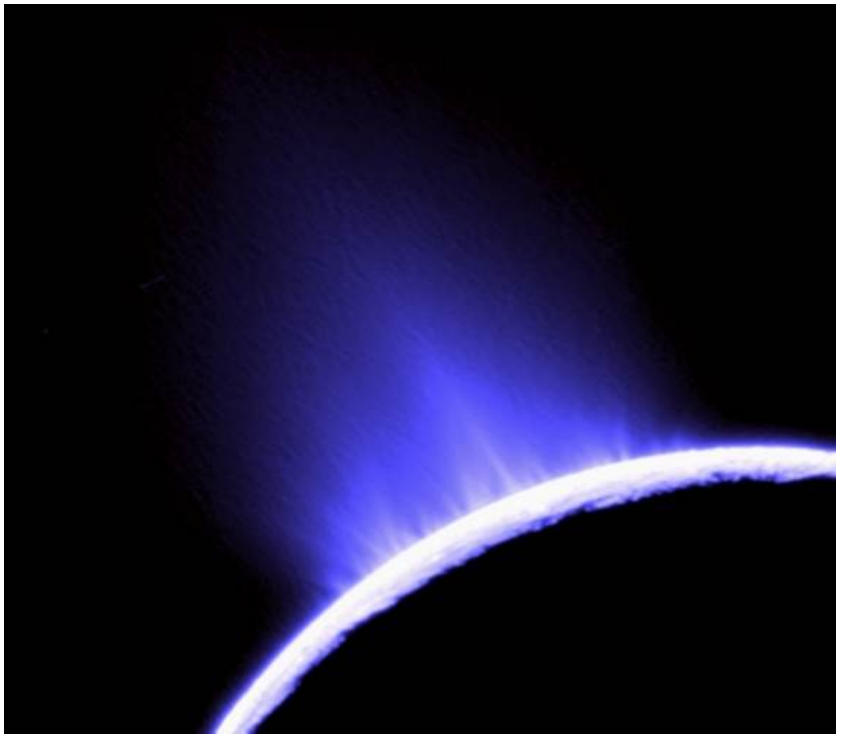


[2] A busy neghborhood: Some of Saturn's larger moons, 3/25/2016, https://arstechnica.com/science/2016/03/saturns-inner-moons-may-have-formed-only-recently-from-a-giant-ring/]

Enceladus

- Cassini
- Active eruptions

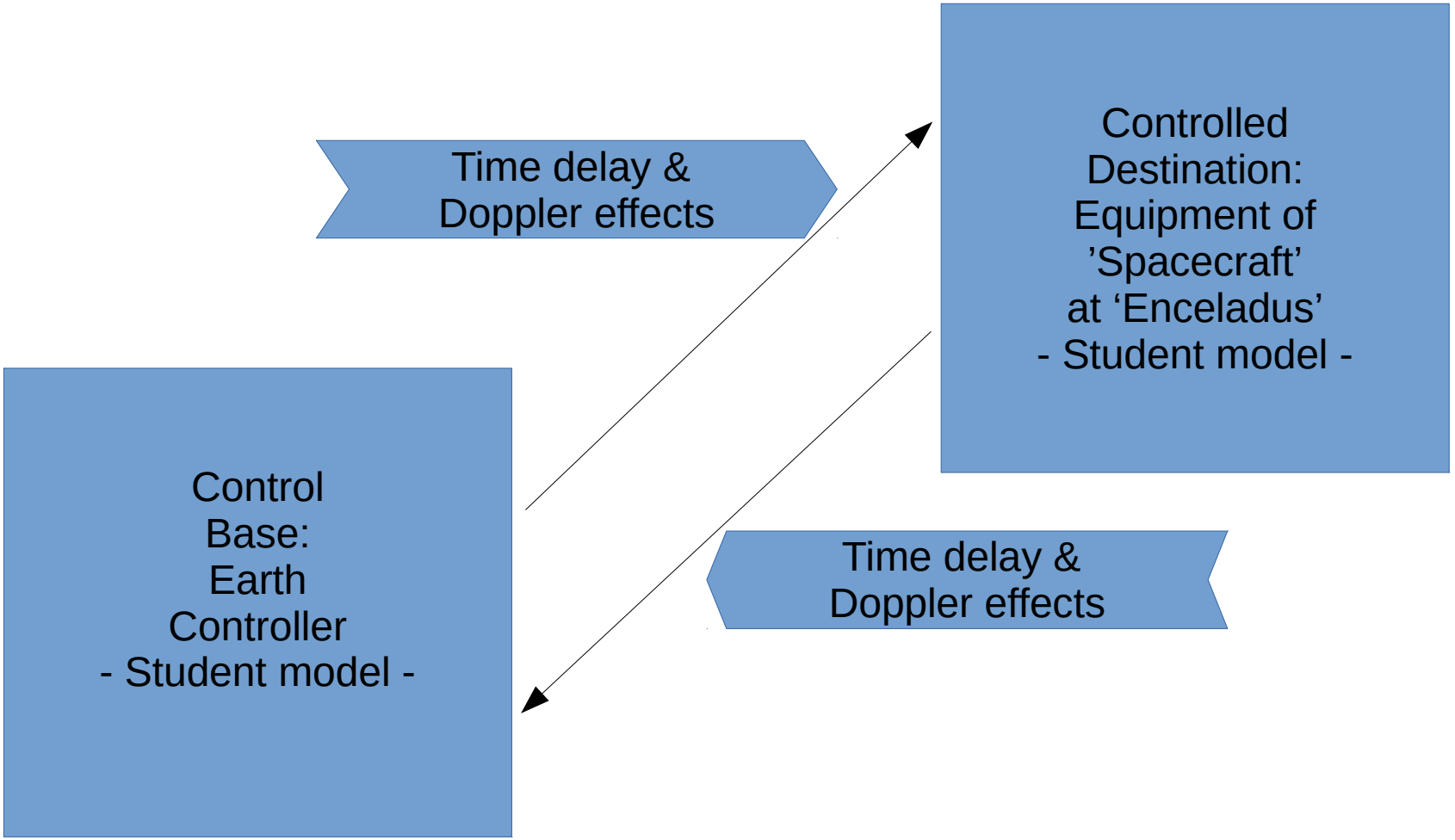
[3]



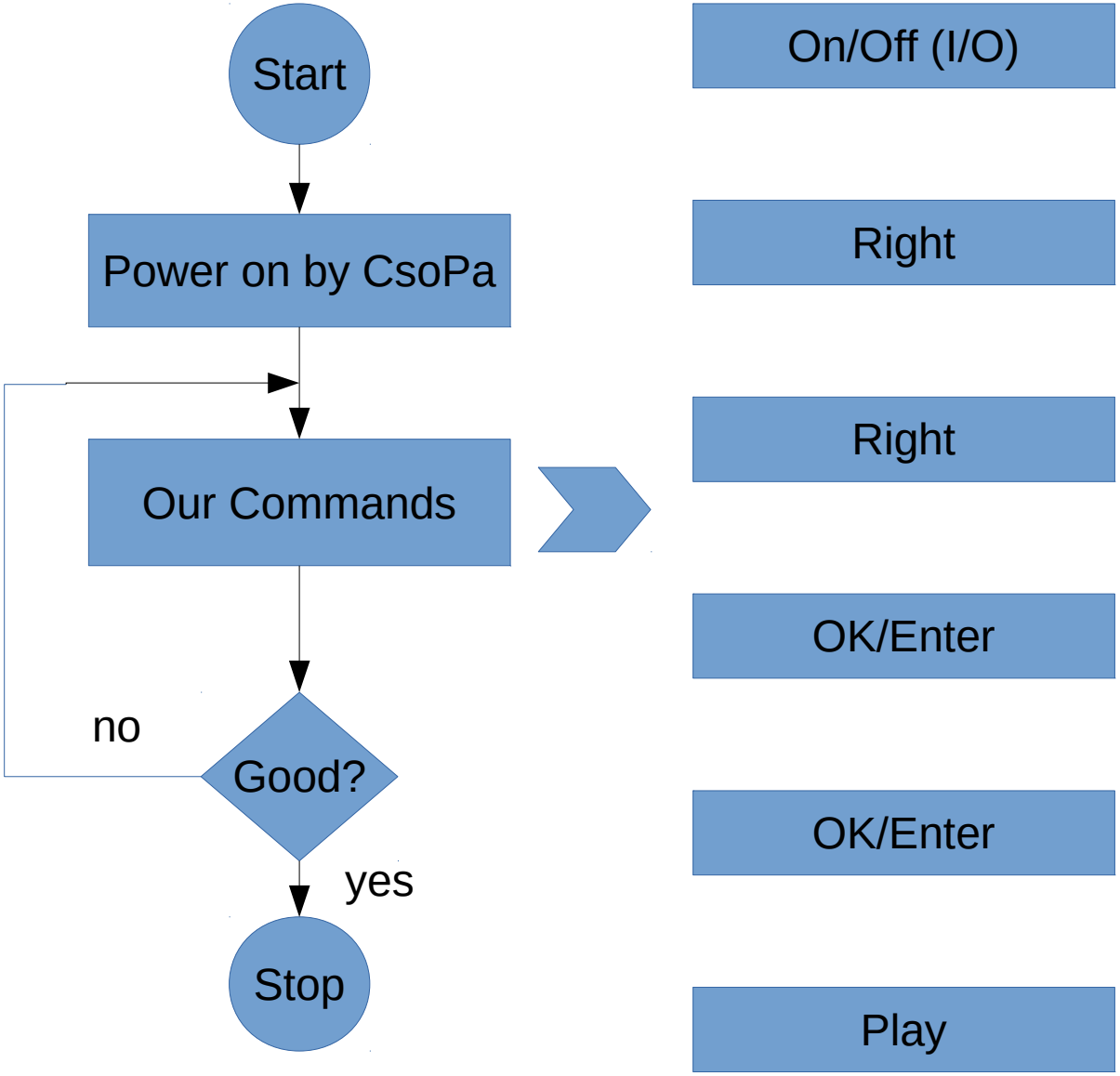
[4]

[3] [A Cassini űrszonda hamarosan a Szaturnuszba csapódik, NASA, 2017/04/27 http://ecolounge.hu/ur/a-cassini-urszonda-hamarosan-a-szaturnuszba-csapodik]
[4] [Astronomi Picture of the Day, Enceladus Ice Geysers, 2017/10/13 https://apod.nasa.gov/apod/ap071013.html]

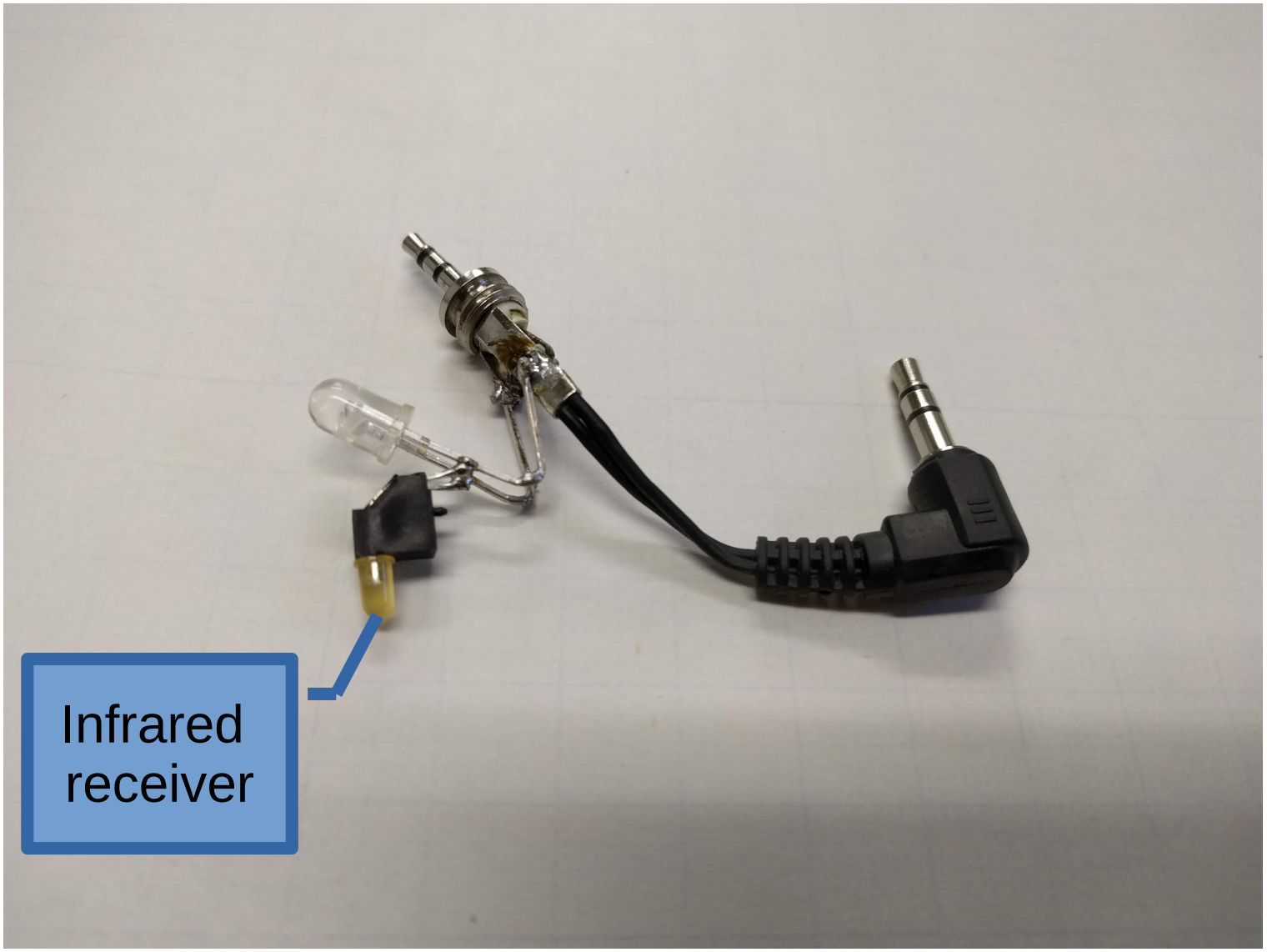
HW Block-diagram



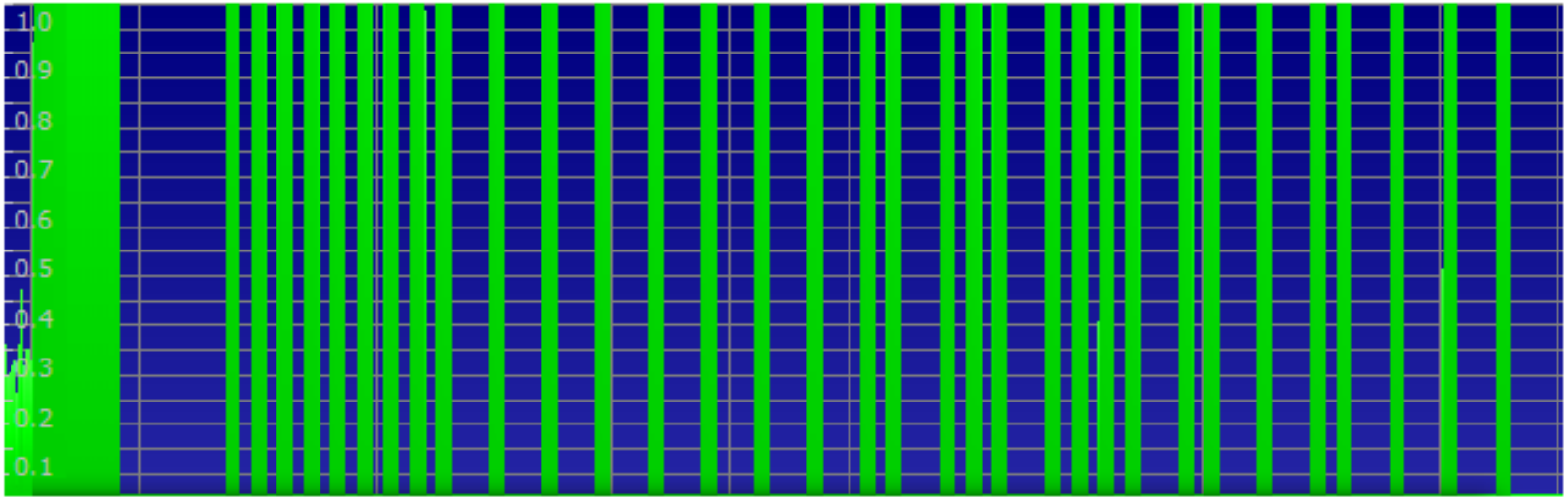
Flow diagram

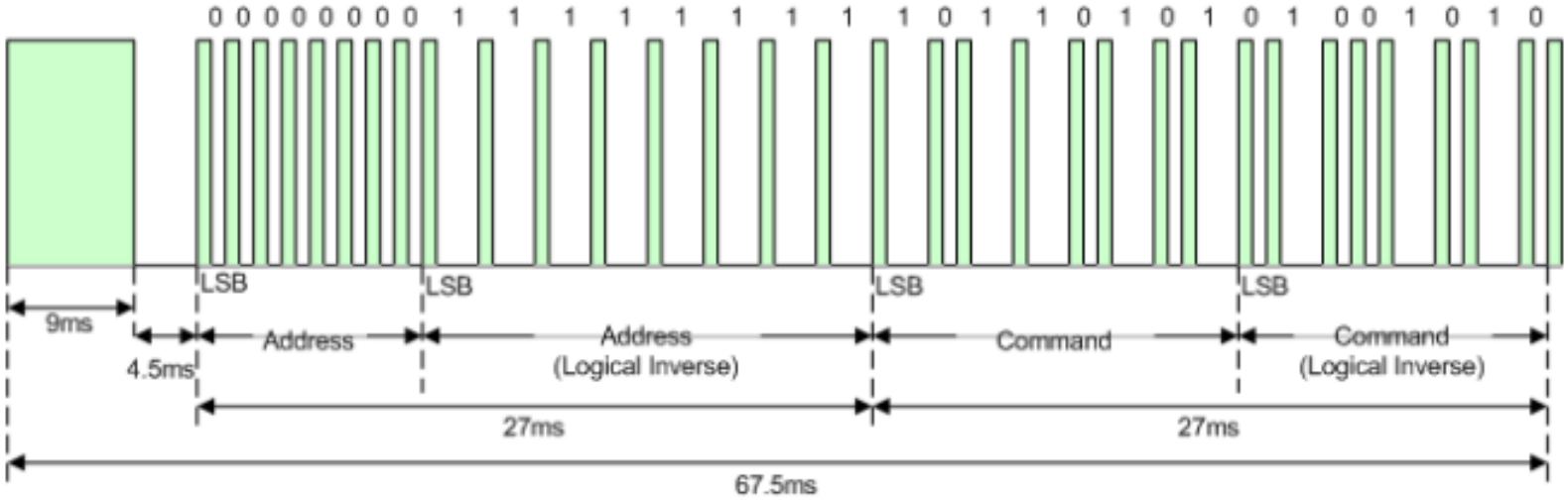


Our measurements



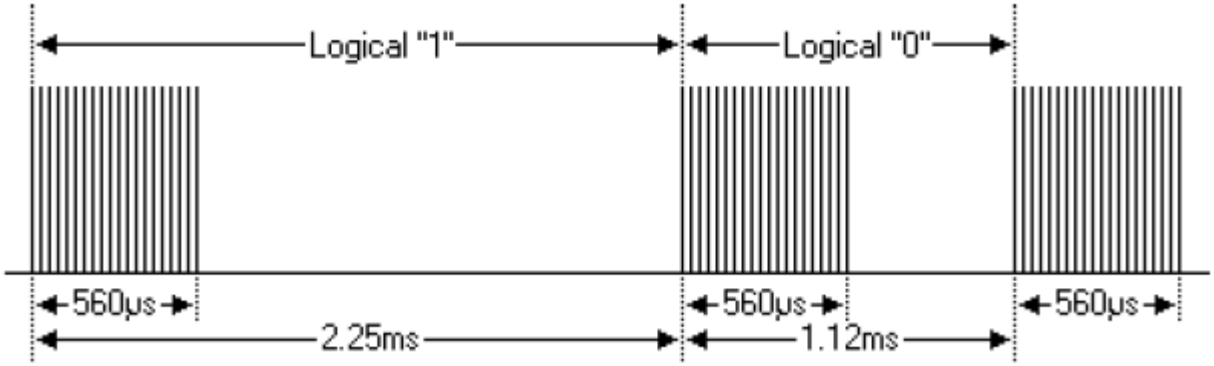
Our measurements

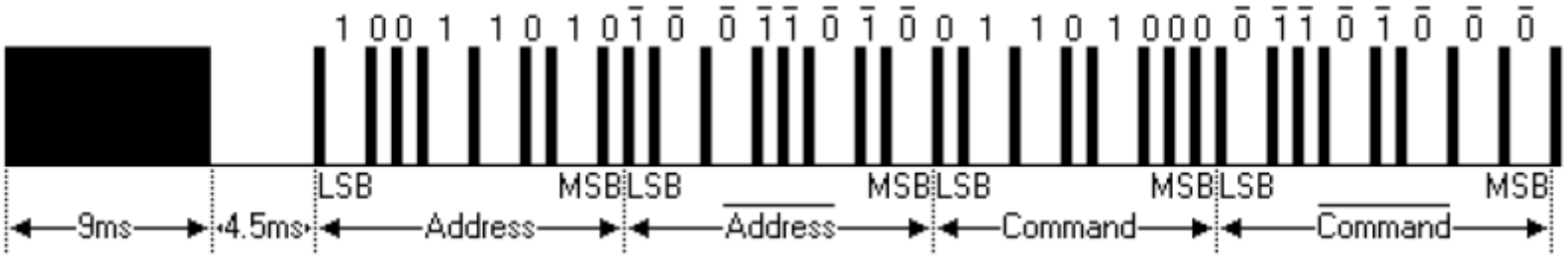




NEC protocol

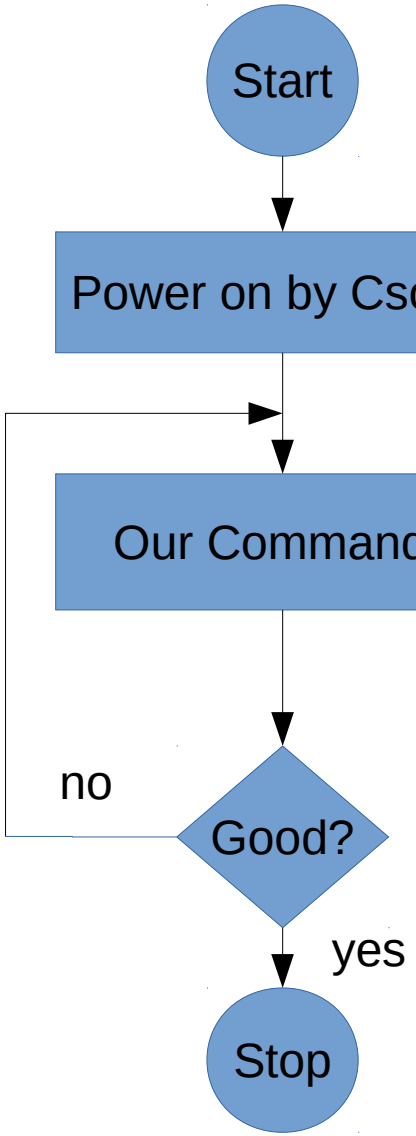
- 8bit address and 8bit command
- Transmits twice
- 38kHz





[5] SB-Projects:NEC protocol; 2018. 01. 01. https://www.sbprojects.net/knowledge/ir/nec.php]

Flow diagram – Measured signs



On/Off (I/O)

Wait 15s

Right

Wait 2s

Right

Wait 2s

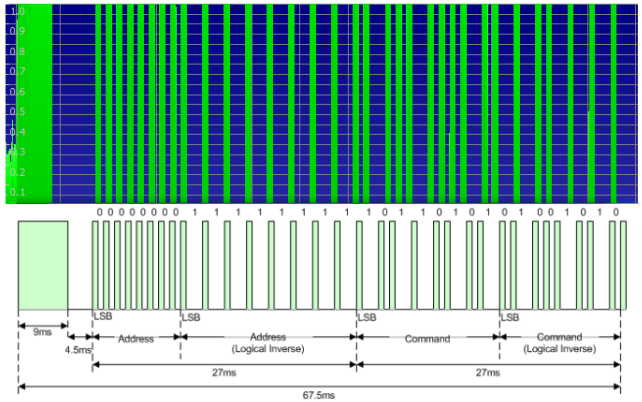
OK/Enter

Wait 2s

OK/Enter

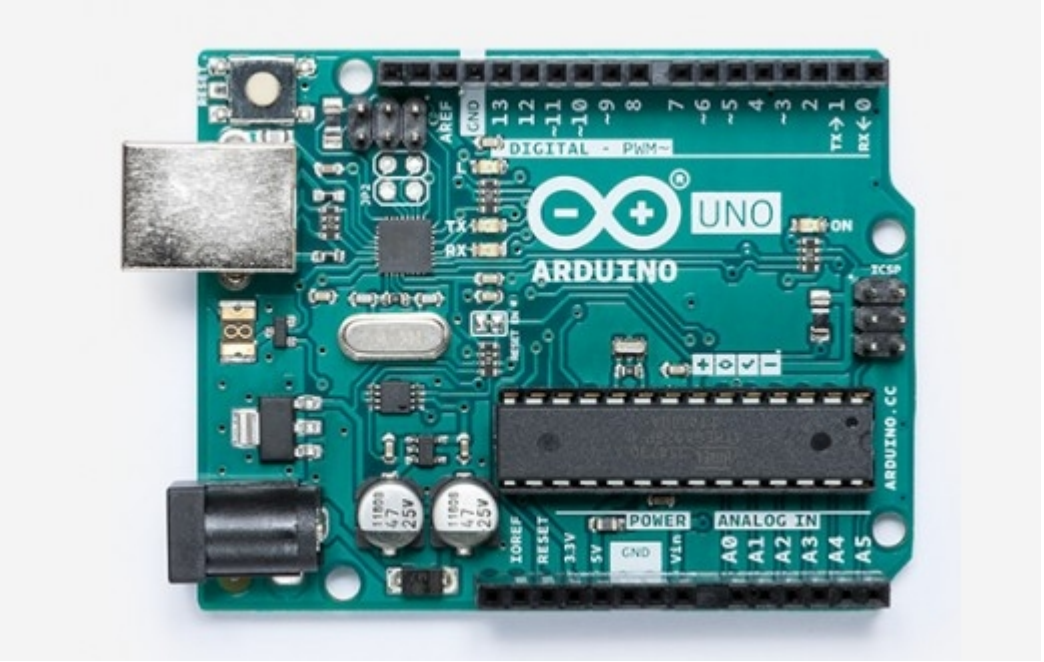
Wait 2s

Play



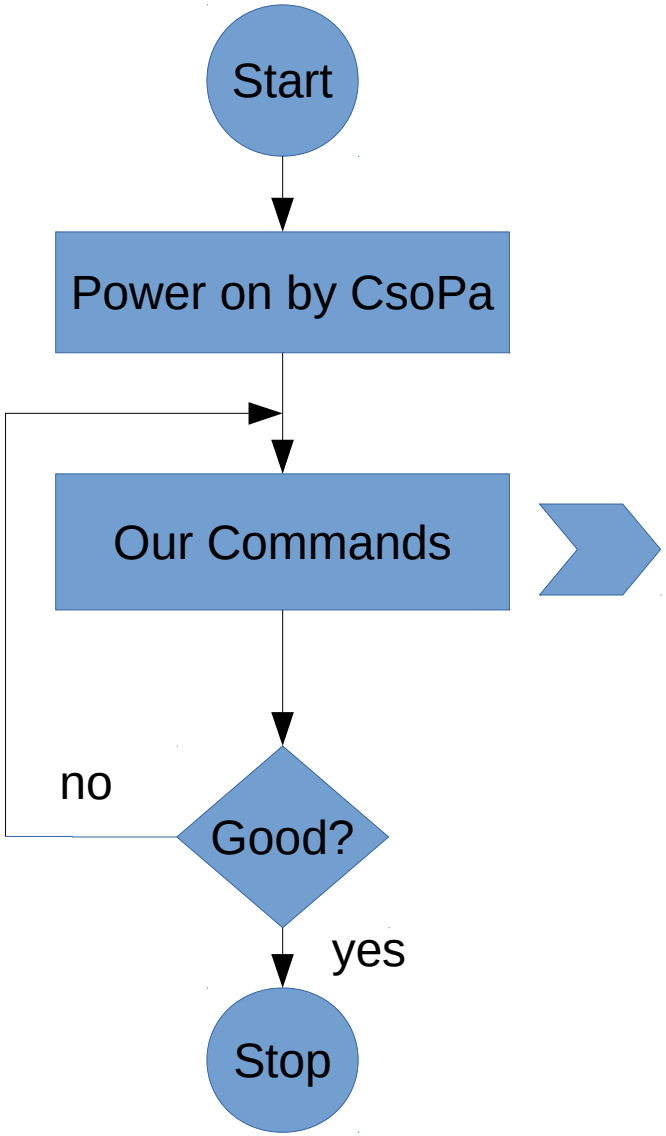
Our solution: Arduino

- Microcontroller
- Small computer on an electric circuit
- Available and recommended for students



[6] Arduino: Arduino UNO Rev 3;
https://store.arduino.cc/usa/arduino-uno-rev3

Flow diagram – Final program



- On/Off (I/O)
- Wait 15s
- Right
- Wait 2s
- Right
- Wait 2s
- OK/Enter
- Wait 2s
- OK/Enter
- Wait 2s
- Play

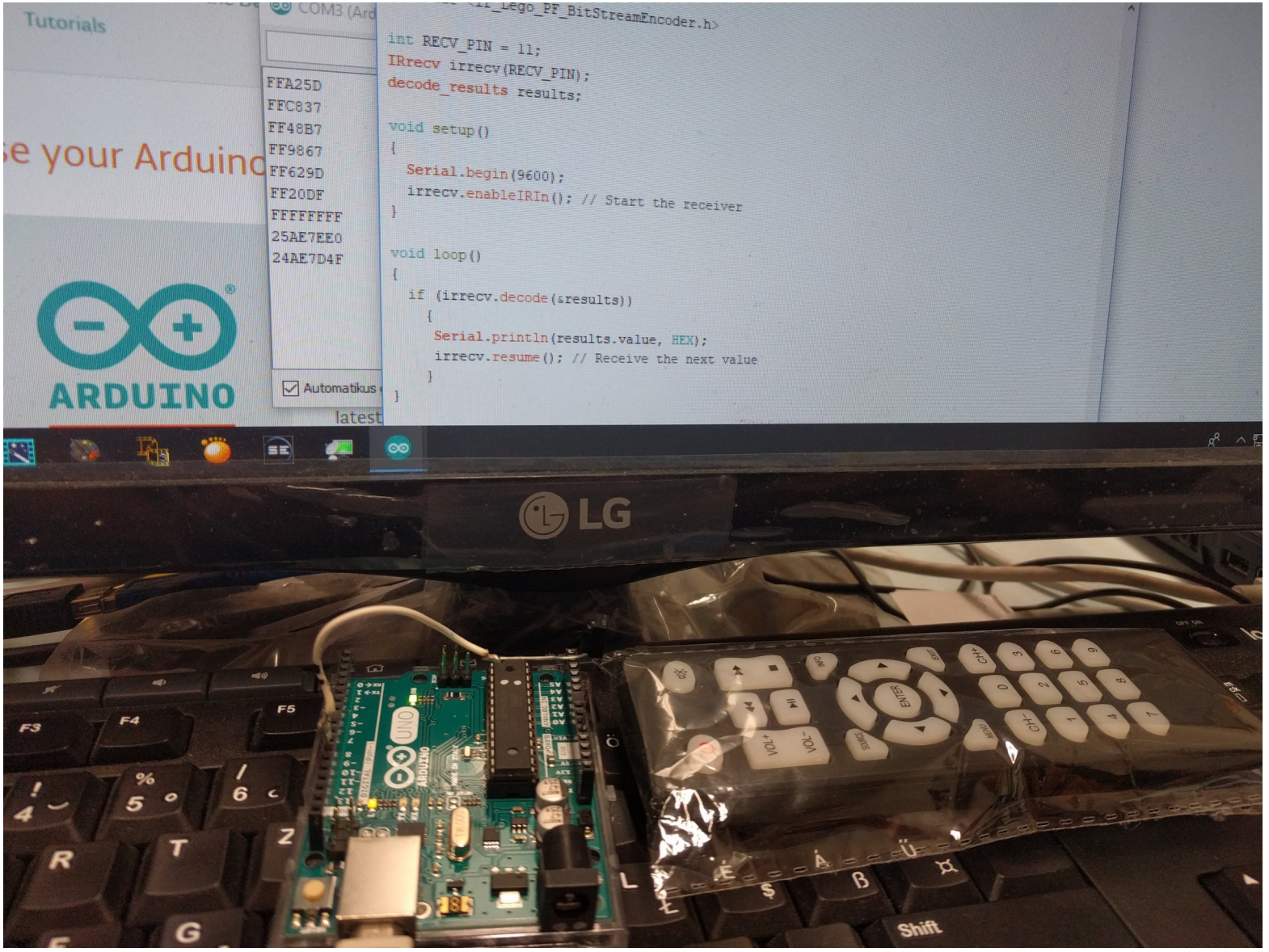
```
/*
 * IRremote: IRsendDemo - demonstrates sending
 * IR codes with IRsend
 * An IR LED must be connected to Arduino PWM pin 3.
 * Version 0.1 July, 2009
 * Copyright 2009 Ken Shirriff
 * http://arcfn.com
 * JVC and NEC protocol added by
 * Kristian Lauszus (Thanks to zenwheel and other
  * people at the original blog post)
 */
#include <IRremote.h>

IRsend irsend;

void setup()
{
}

void loop() {
  delay(5000);
  irsend.sendNEC(0xFFA25D, 32); // This turn on
  delay(15000); //15 second delay
  irsend.sendNEC(0xFFC837, 32); // Right
  delay(2000); //2 second delay
  irsend.sendNEC(0xFFC837, 32); // Right
  delay(2000); //2 second delay
  irsend.sendNEC(0xFF48B7, 32); // OK/Enter
  delay(2000); //2 second delay
  irsend.sendNEC(0xFF48B7, 32); // OK/Enter
  delay(2000); //2 second delay
  irsend.sendNEC(0xFF9867, 32); // Play
  delay(5000); //5 second delay
  irsend.sendNEC(0xFF20DF, 32); // Mute
  delay(86400000);
}
```

Our measurements



Arduino has a library with IR demonstration programs. Our set is visible in the picture.

FFA25D
FFC837
FF48B7
FF9867
FF629D
FF20DF

Product label

- **Tele-command (TC) equipment**
- **Type: Automatic Sequencer for Enceladus Model**
- **Made by: Bíró Zsófia, Tiefenbeck Flórián, 2018**
- **‘Wigner diák kutatótábor Budapest, Hungary’**
- **S/N 2018001**

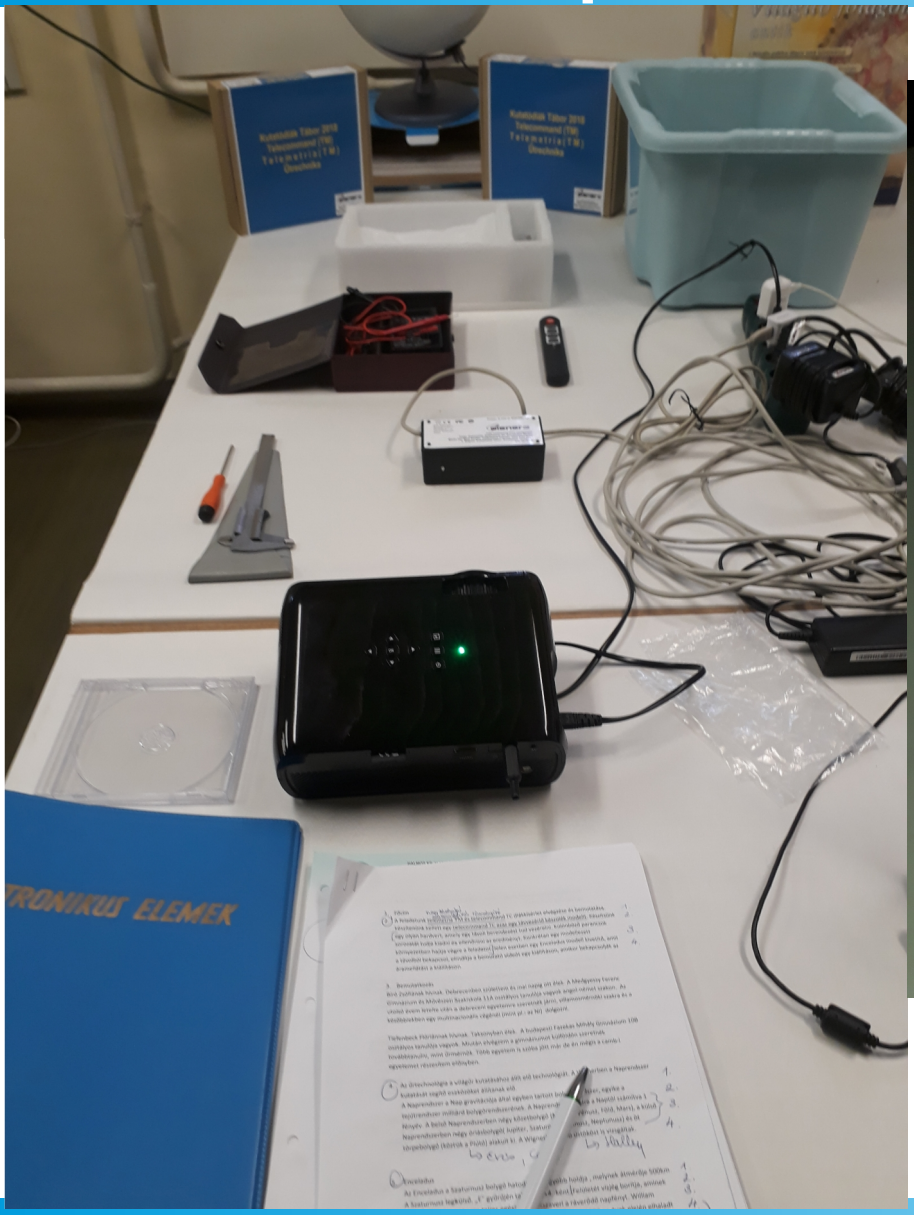
ESA Product Assurance

- 3 years in orbit
- Microgravity compability
- Easy operation
- Easy cleaning
- Operation manuals

[7] ESA: Product Assurance and Safety; 1997. 01.
http://www.esa.int/esapub/sp/sp1201/a12.htm

Handling problems

Final experiment and product view



Thank You for Your attention

- Acknowledgment: Éva OLÁH, Nóra Szathmári, Bebesi Zsófia, Opitz Andrea, Werovszky Veronika, Vizi Pál

- Budget included: 2 Arduinos, Earth globe, IR LEDs, IR Rec IC, Lupe, Screwdrivers, Wires, Connectors etc.

- References: [1] Sistema Solar Wiki:Solar-System-Irg.sp.png http://sistema-solar.wikia.com/wiki/File:Solar-system-lrg.sp.png
- [2] A busy neighborhood: Some of Saturn's larger moons, 3/25/2016, https://arstechnica.com/science/2016/03/saturns-inner-moons-may-have-formed-only-recently-from-a-giant-ring
- [3] [A Cassini űrszonda hamarosan a Szaturnuszba csapódik, NASA, 2017/04/27 http://ecolounge.hu/ur/a-cassini-urszonda-hamarosan-a-szaturnuszba-csapodik]
- [4] [Astronomy Picture of the Day, Enceladus Ice Geysers, 2017/10/13 https://apod.nasa.gov/apod/ap071013.html]
- [5] SB-Projects:NEC protocol; 2018. 01. 01. https://www.sbprojects.net/knowledge/ir/nec.php]
- [6] Arduino: Arduino UNO Rev 3; https://store.arduino.cc/usa/arduino-uno-rev3
- [7] ESA: Product Assurance and Safety; 1997. 01. http://www.esa.int/esapub/sp/sp1201/a12.htm