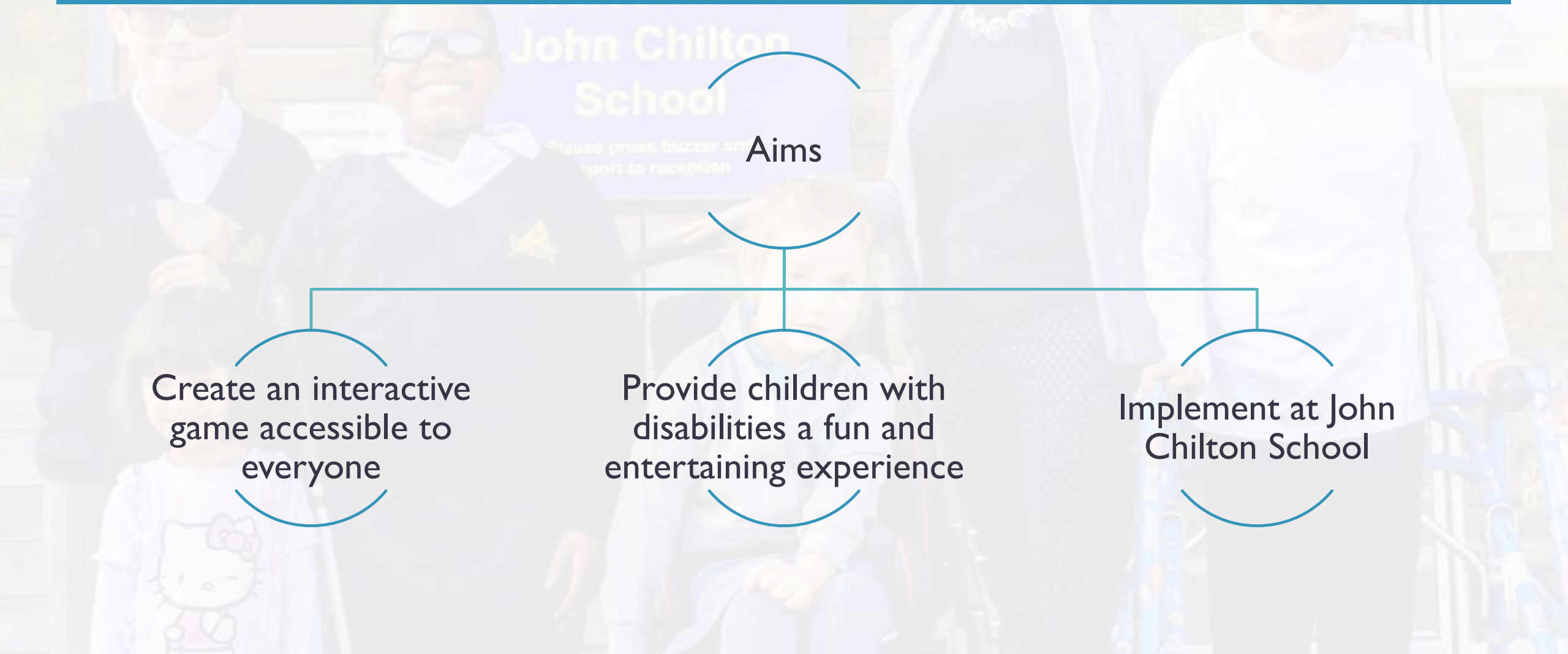
Imperial College London

Assistive Technology Board Game:

Engineering Design Project 2017-2018

Fig. 1: John Chilton School
http://www.john-chilton.ealing.sch.uk

PROJECT BRIEF – THE PROBLEM



USER REQUIREMENTS SPECIFICATIONS

Accessible

Autonomous

Multiplayer

Audio-visual feedback

Easy to play

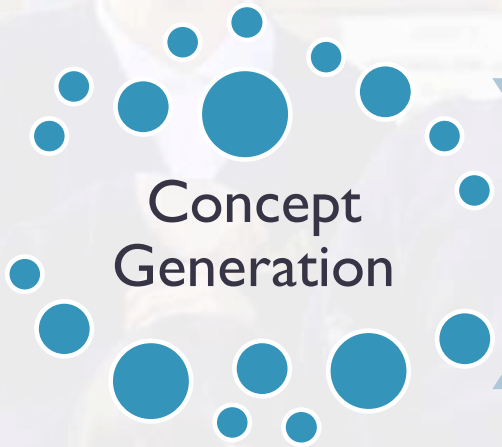
Easy to store

Low maintenance

TECHNICAL REQUIREMENTS SPECIFICATIONS

- **Functionality and Performance**
  - Fast Game Response (30ms - 1s)
  - Variety of Control Technologies
- **Usability, Interface and Ergonomics**
  - High Visibility and Contrast
  - Universal Controls
- **Portability**
  - Short Set-up time (< 5 min)
- **Size and Weight**
  - 700 x 700mm External
  - Light weight (<12 kg)
- **Life, Reliability and Maintenance**
  - Minimum Maintenance Required
- **Safety and Security**
  - Electrical/Children Safety

INITIAL DEVELOPMENT



Concept Generation

Board Game with Adaptable Control Inputs

Specification Definition

- John Chilton School Visit
- Children's Feedback

Background Research

- Input Control Technologies
- Disabilities Involved
- Most Popular Commercial Games

Concept Selection

Flipper Game

BACKGROUND RESEARCH

- **Most common disabilities**
  - Speech impairment
  - Lack of fine motor skills
  - Lower limb paralysis

- **Already used control systems**
  - Puff-control
  - Eye-gaze control
  - Touchscreen

- **Chosen control systems**
  - Push-button
  - Voice Recognition
  - MMG

- **Popular board games**
  - Hungry Hungry Hippos
  - Connect 4
  - Chess

- **Chosen board game**
  - Flipper game (pinball type)
  - 4 players
  - 3 different types of control

DESIGN – THE SOLUTION

- **Game flow** - overview
- **Mechanical Design:**
  i. General game assembly
  ii. Flipper Mechanism
  iii. Ball return Mechanism
- **Electrical Design:**
  i. Controls
  ii. Central Unit
  iii. Goal Counting Mechanism
- **Game flow** - overall

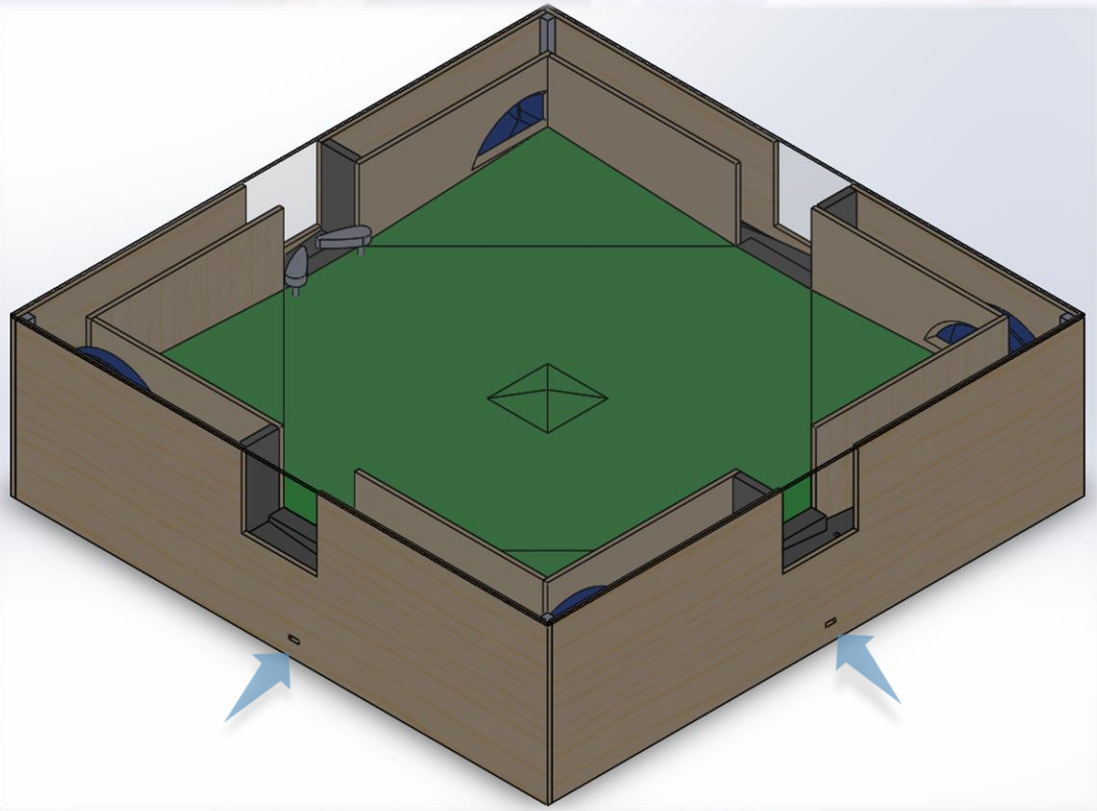


Fig. 2: CAD drawing of game design

GAME FLOW:
GAME OVERVIEW

Action from the player

- Input detected by the control units

Analysis and Processing

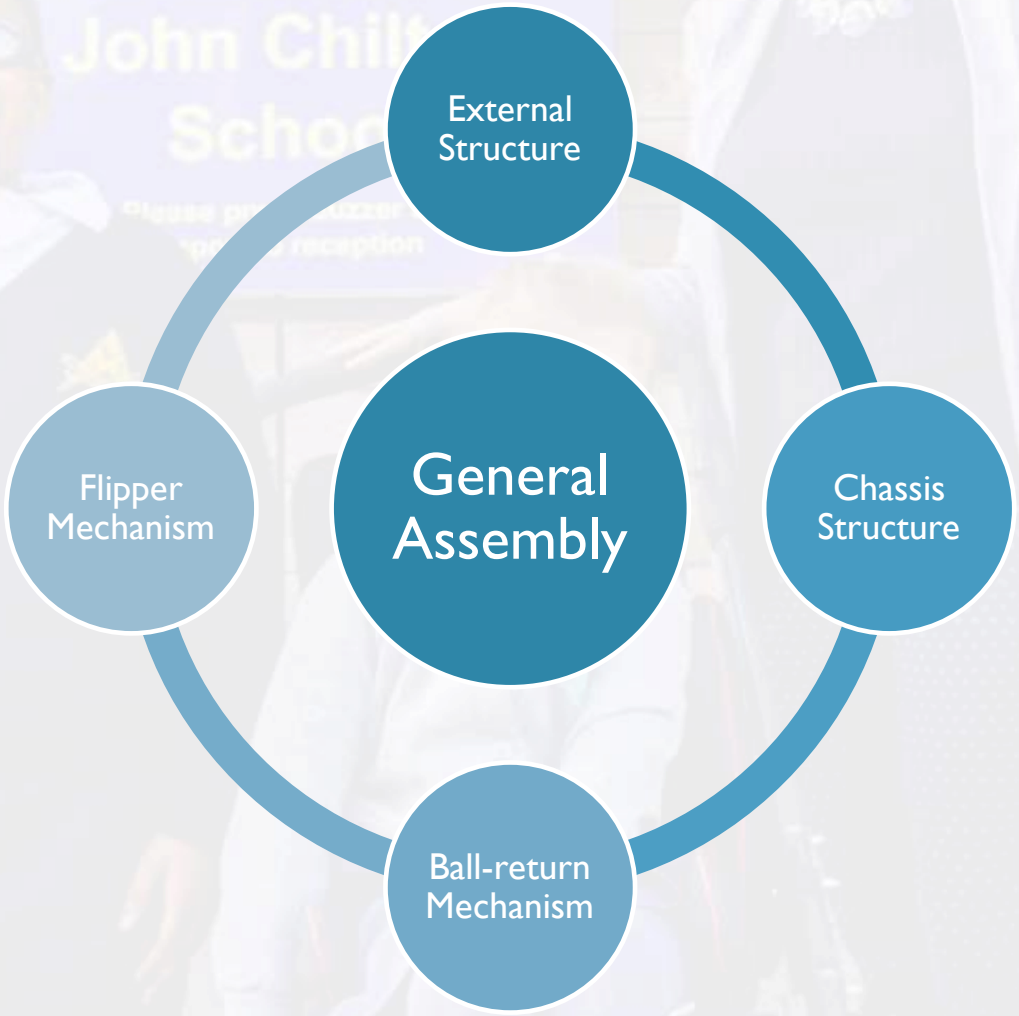
- Signal processed by CPU

Action of the flipper

- Output signal into electrical circuit

Fig. 3: Raspberry Pi, https://www.raspberrypi.org/app/uploads/2017/05/Raspberry-Pi-3-1-1619x1080.jpg

MECHANICAL DESIGN



MECHANICAL DESIGN:

GENERAL GAME ASSEMBLY

M D F
Lightweight
Easy manufacture
Electrical Insulation
Appealing

1 Ball return hole

2 Ball return mechanism

3 Playfield with corner and center slopes

4 Ball return slope

5 Flippers

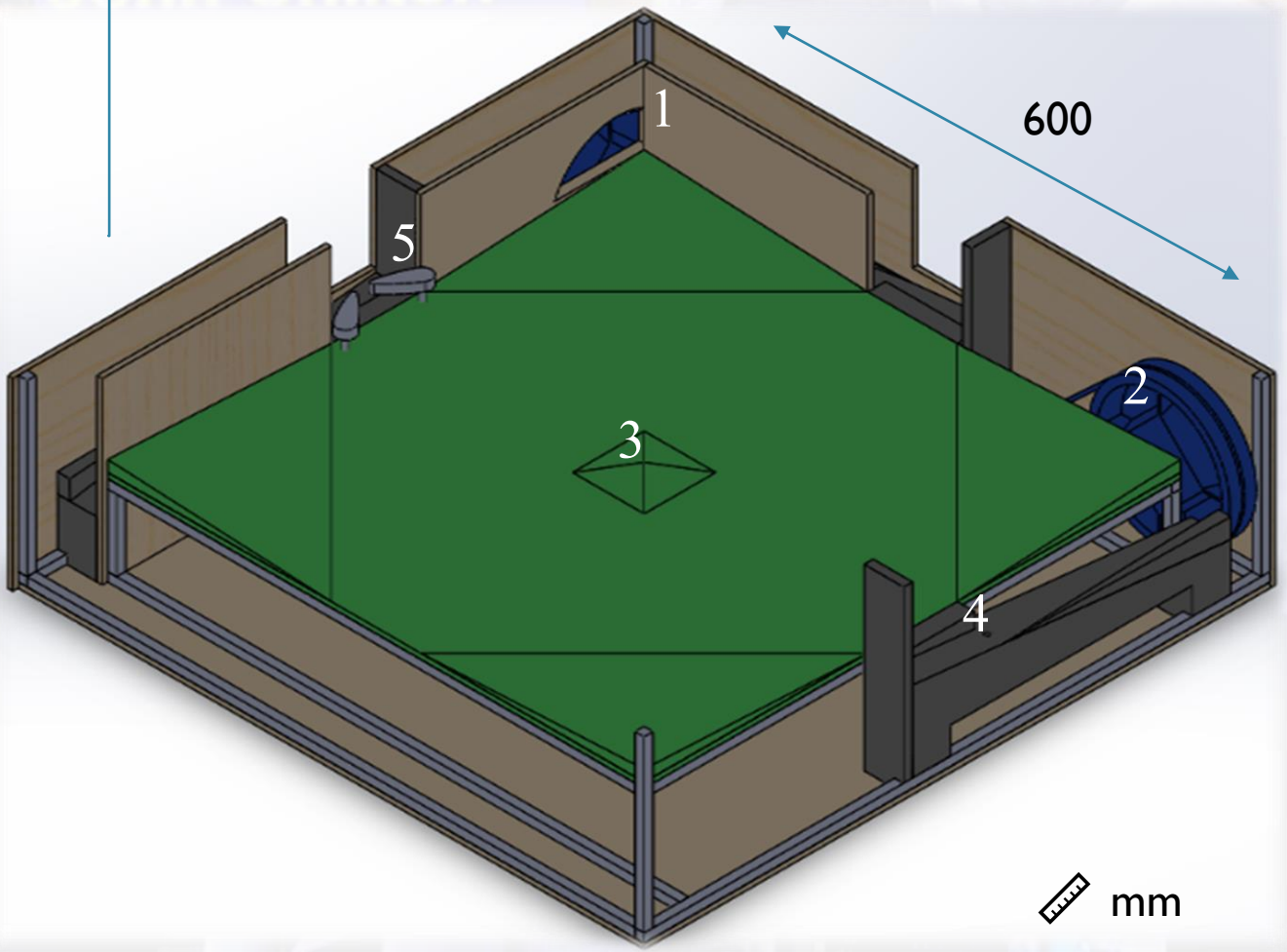


Fig. 4: CAD drawing of game design showing components

MECHANICAL DESIGN:

CHASSIS STRUCTURE

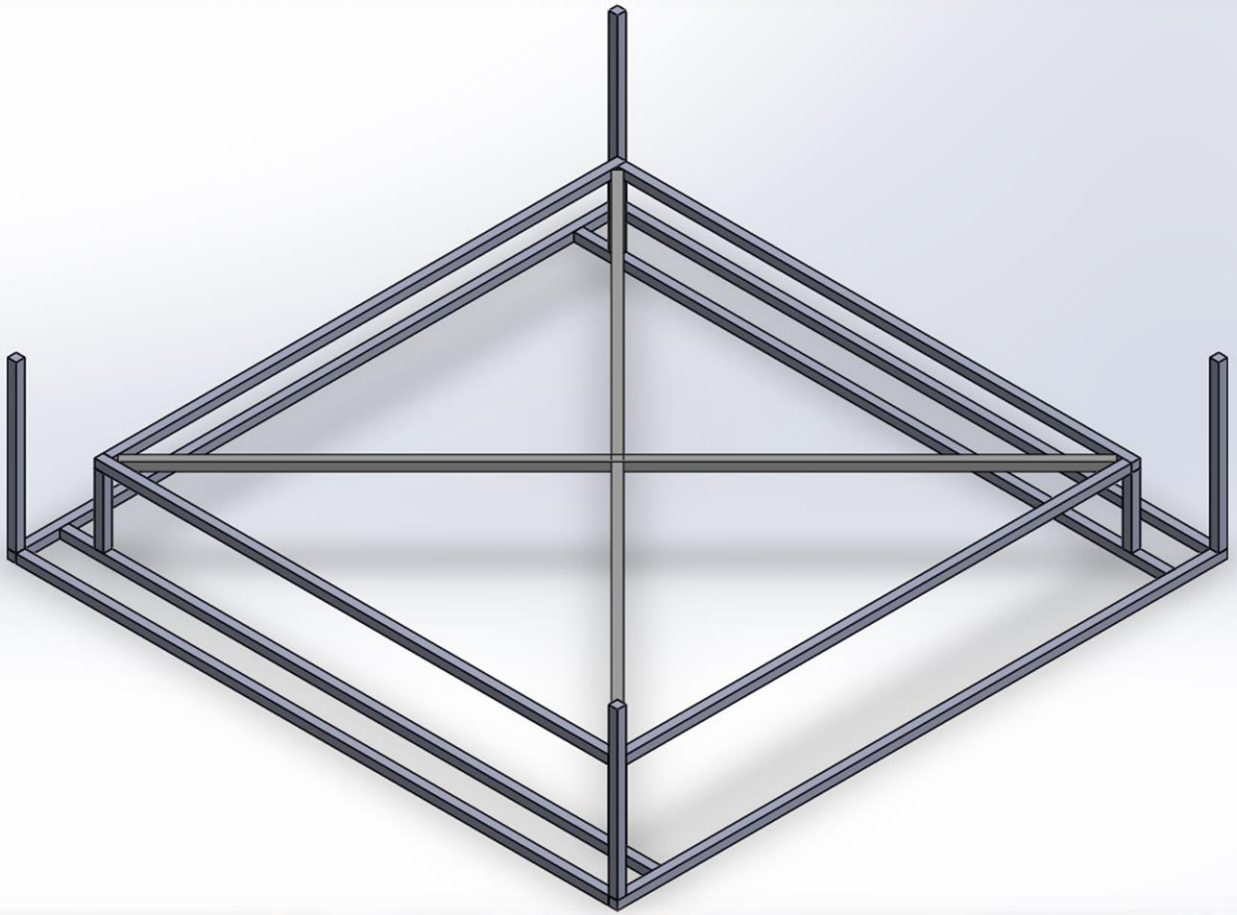


Fig. 5: CAD drawing of metal chassis

MECHANICAL DESIGN:

FLIPPER MECHANISM ASSEMBLY

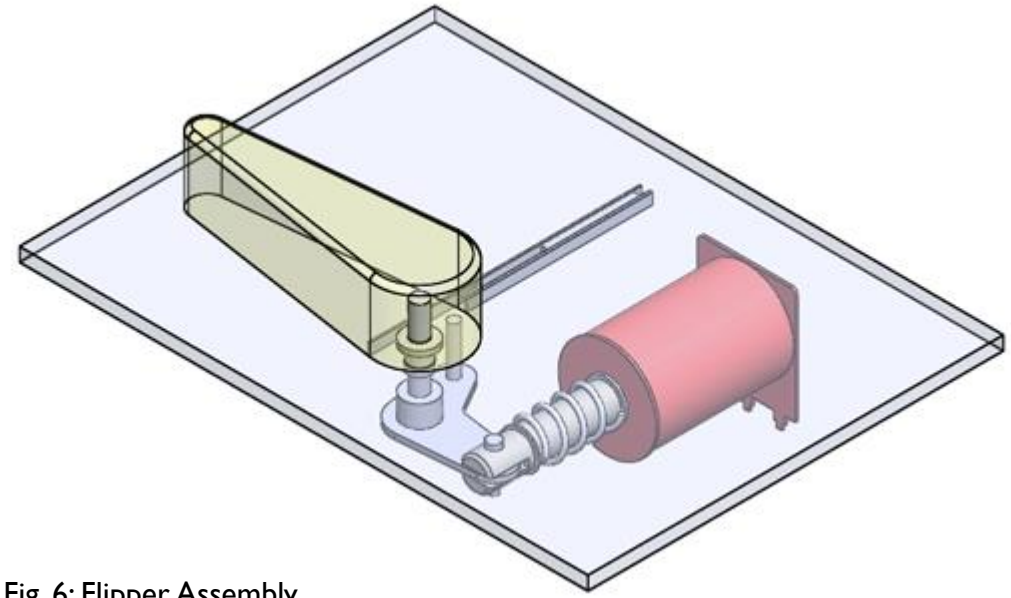


Fig. 6: Flipper Assembly

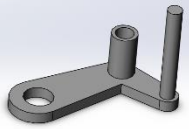


Fig. 7: CAD drawing of Coupling part

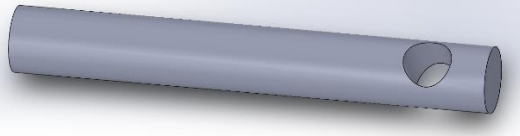


Fig. 8: CAD drawing of Armature part

- **Main features**
  - 50v coils
  - Armature and coupling part with CAD
  - EOS switch prevents overheating
  - Spring returns armature to its initial position

MECHANICAL DESIGN:

BALL-RETURN MECHANISM ASSEMBLY

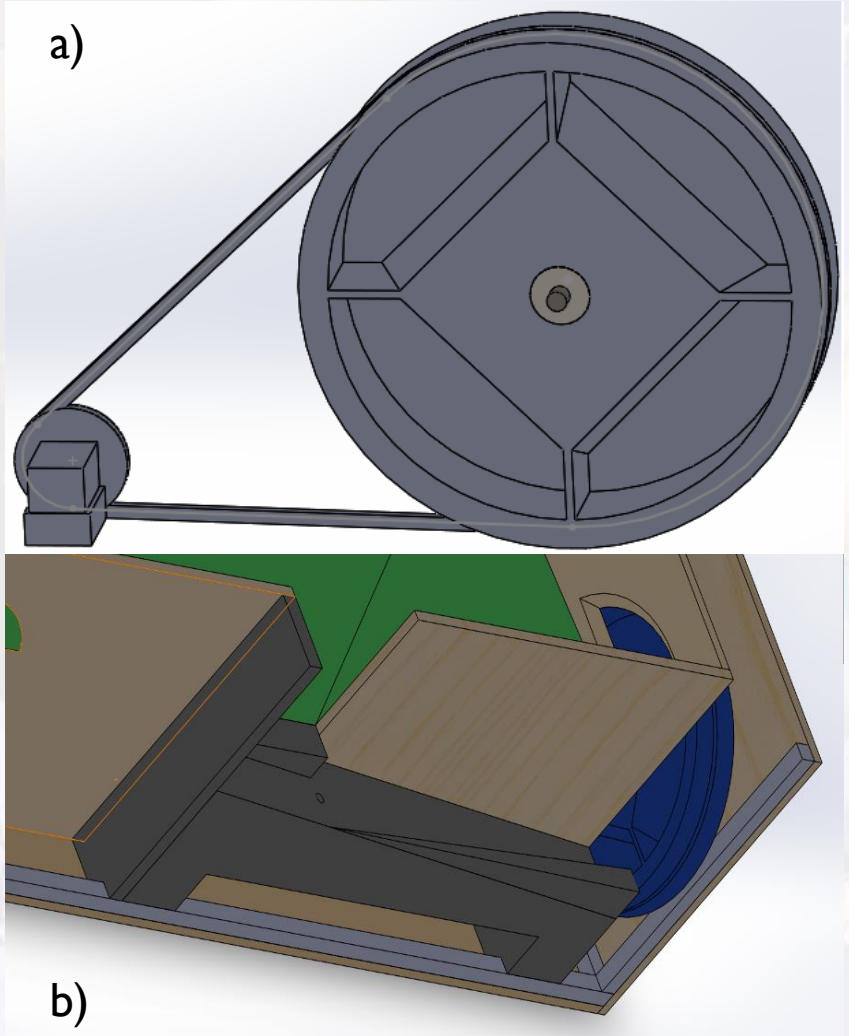


Fig. 8: CAD drawing of return mechanism: a)wheel, belt, pulley and motor; b) corner view showing all components

- **Main features**
  - Components:
    - Collecting slope
    - Return wheel
    - Timing pulley and belt
    - Return hole
  - Designed using SolidWorks
  - 3D printed wheel and pulley
  - Bearing reduces friction in wheel connection
  - DC motor rotating at ~230rpm

MECHANICAL DESIGN:

BALL-RETURN MECHANISM ASSEMBLY

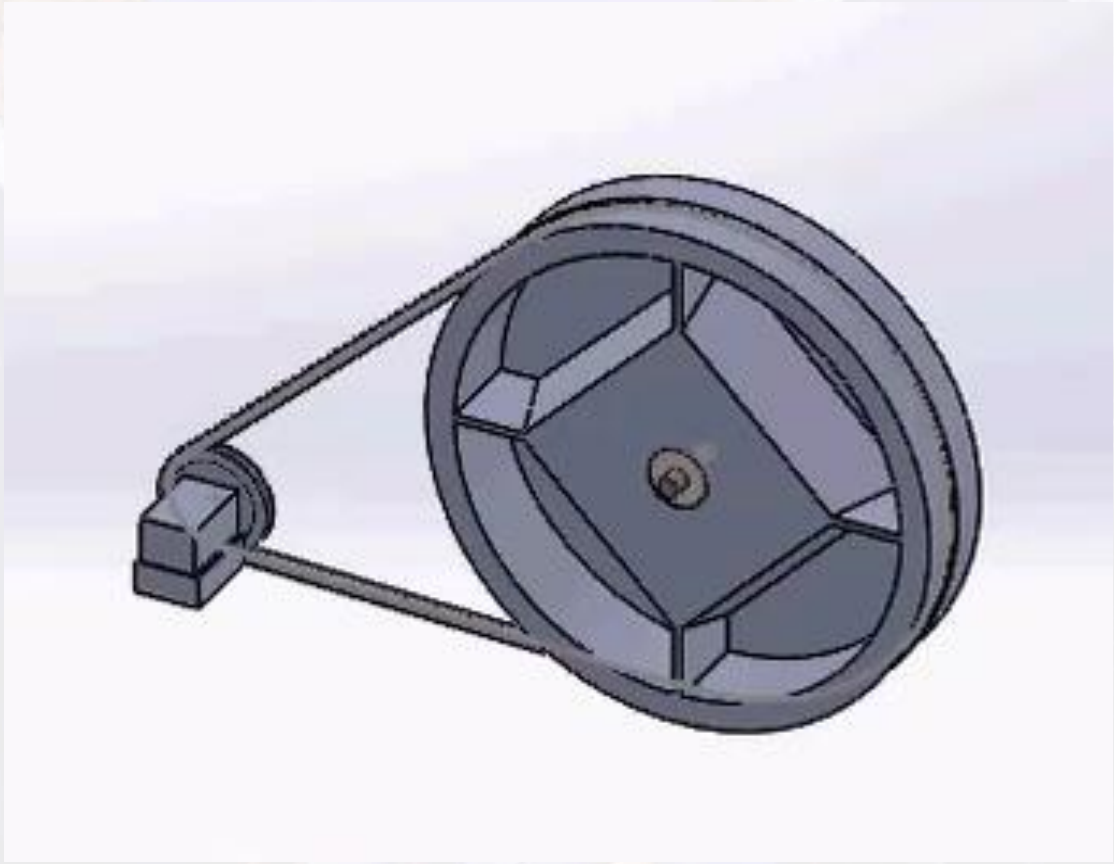
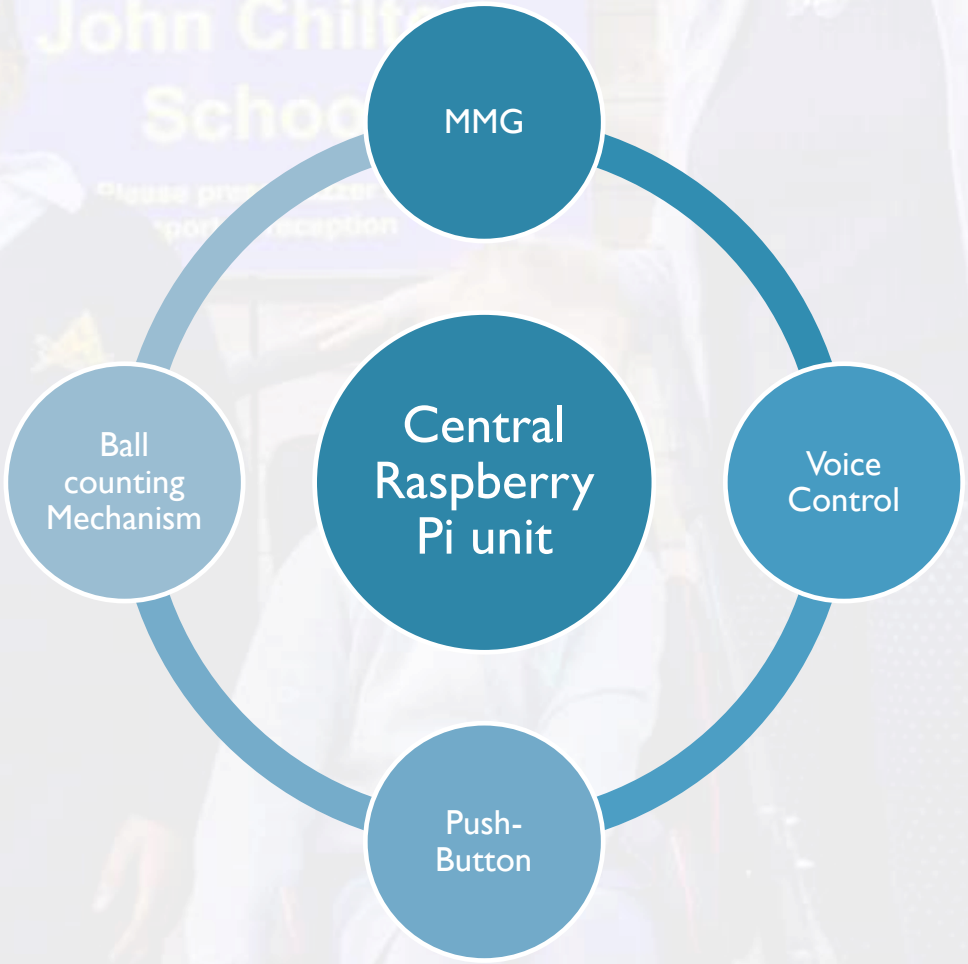


Fig. 9: CAD simulation of mechanism rotating

ELECTRICAL DESIGN



ELECTRICAL DESIGN:

BUTTON CONTROL UNIT

Switch Button

- Signal sent when button is pressed

Jack

- Signal transmission
- Mimics switch buttons available at John Chilton School

Adaptor

- Jack to USB adaptor

Central Raspberry Pi Unit

- Input signal from switch
- Output voltage

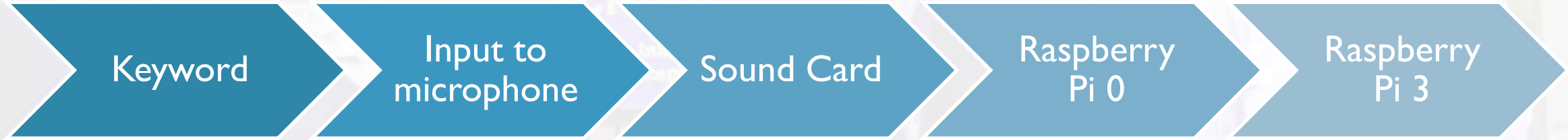
Flippers

- Voltage sent to flippers
- Mechanical activation

Fig. 10: buttons, http://www.inclusive.co.uk/dome-and-disc-switches-p4947

ELECTRICAL DESIGN:

VOICE RECOGNITION CONTROL UNIT



- Hotword : "GO"

- Microphone picks up all audio signals
- All signals sent to Raspberry Pi 0 for processing

- Digitizes audio signals
- Converts jack to USB

- Probes microphone input for audio data
- Compares digital audio input against trained audio model
- Outputs binary signals to RPi 3 CPU

- Probes RPi 0 input
- CPU
- Activates flipper via transistors

snowboy HOTWORD DETECTION

Fig. 11: Snowboy Software, https://snowboy.kitt.ai/

ELECTRICAL DESIGN:

VOICE RECOGNITION CONTROL UNIT

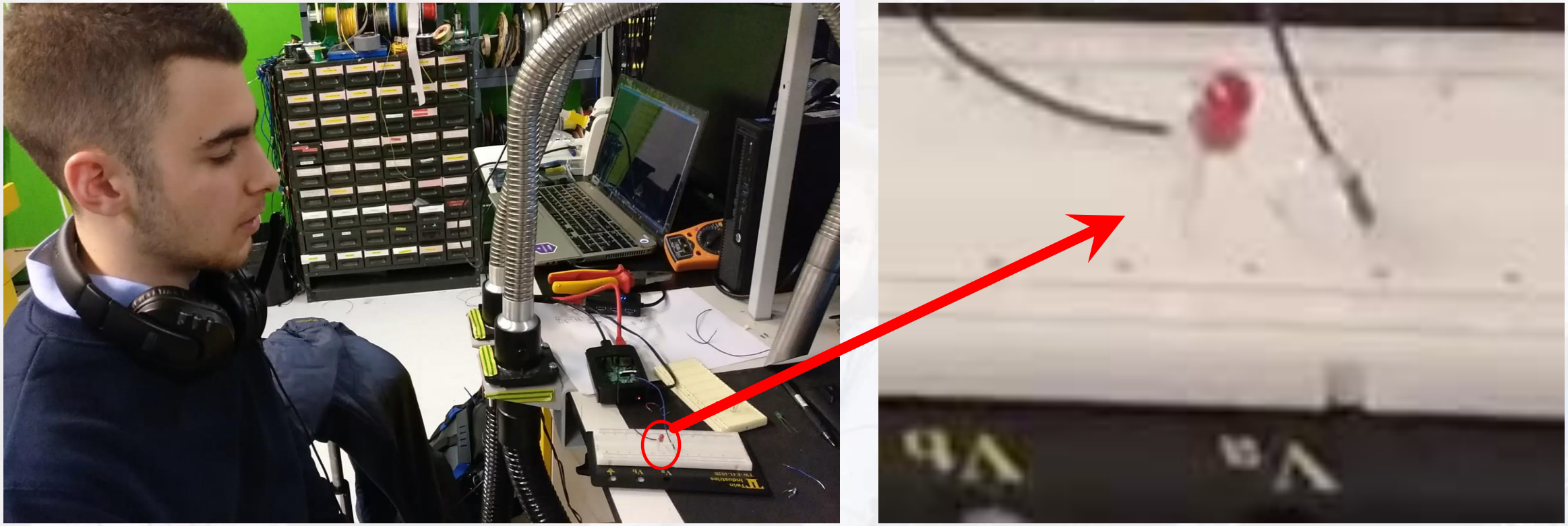


Fig 12:VR Control Unit LED demonstration

ELECTRICAL DESIGN:

MMG CONTROL UNIT

Eyebrow Movement	MMG	Arduino Nano	Central Raspberry Pi Unit	Flippers
• Head movement cancel any output (0)	• Microphone: muscle contraction • IMU: rotation	• Output 1 to activate flippers • Output 0 otherwise	• Input from Arduino • Output voltage	• Voltage sent to flippers • Mechanical activation

ELECTRICAL DESIGN:

MMG CONTROL UNIT

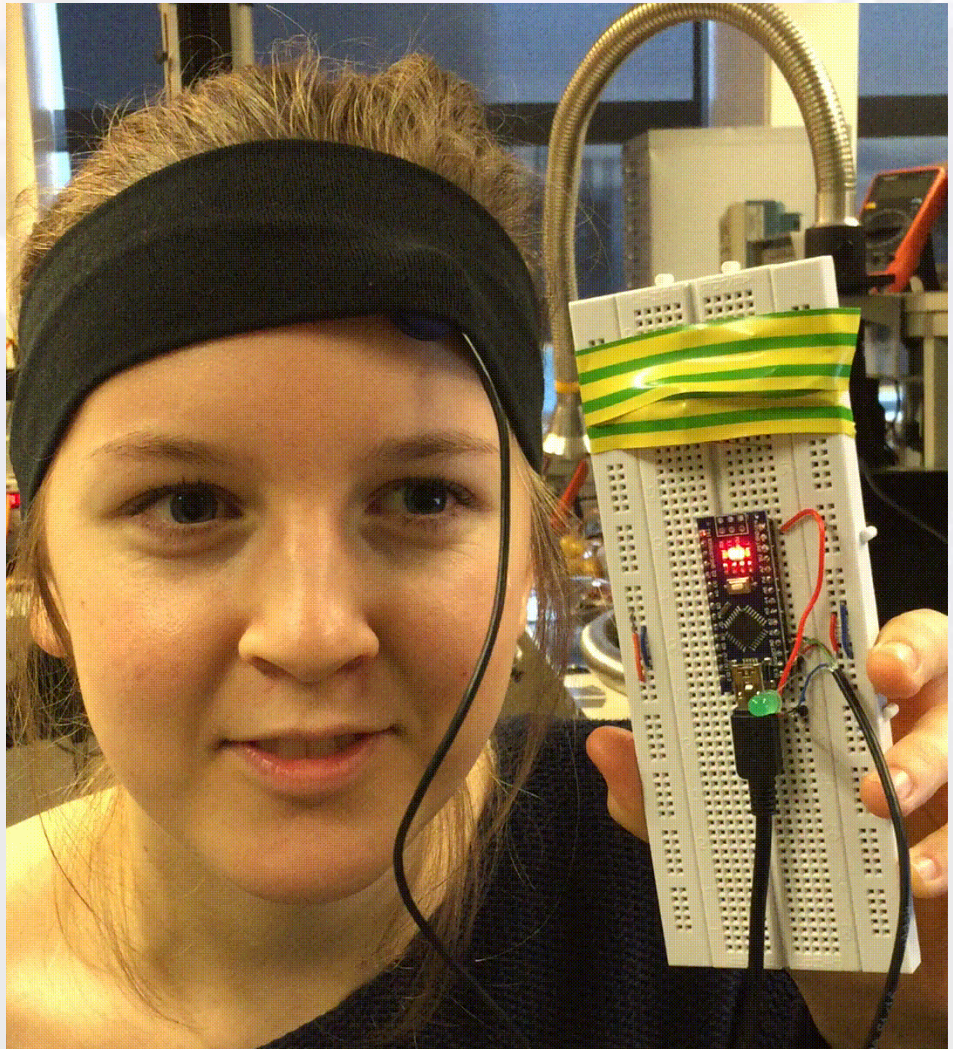


Fig 6: MMG control unit activating an LED

ELECTRICAL DESIGN:

BALL COUNTING MECHANISM

Infrared Light Emitting Diode → Photodiode detects IR light → Signal converted to a digital output (+5V) voltage → Digital Voltage used for activating visual and audio feedback

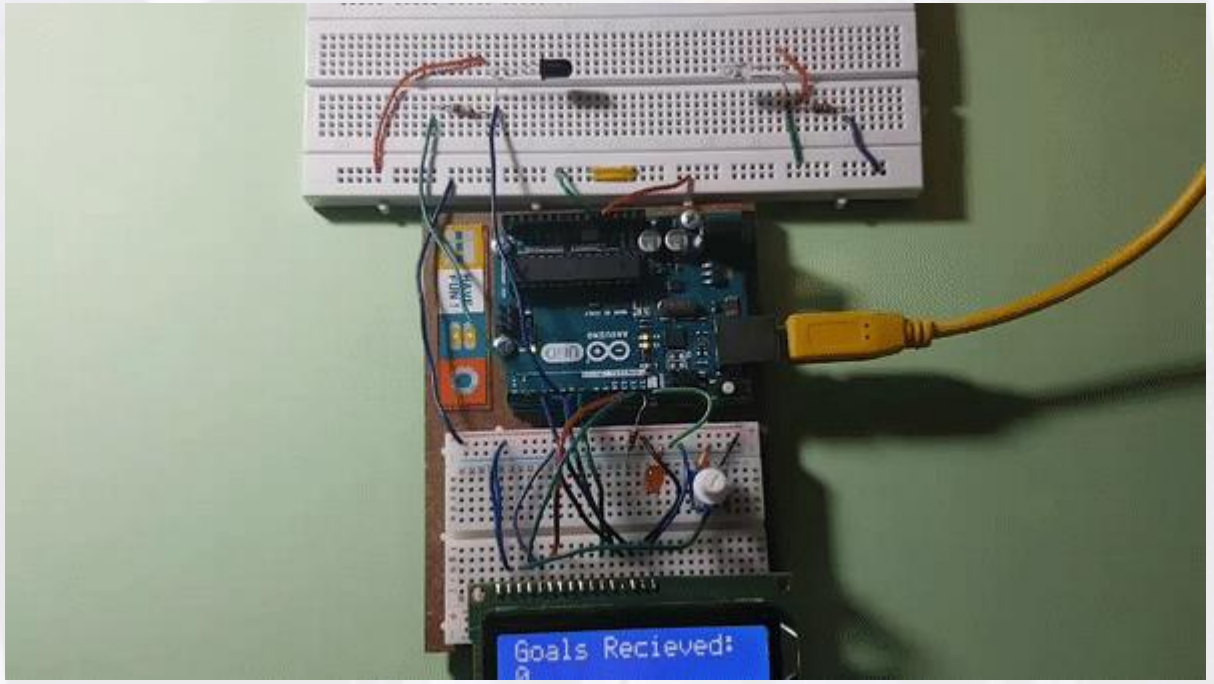


Fig. 6: Video of Operation of Prototype

GAME FLOW:

OVERALL GAMEFLOW

Start of the game

- Start the ball return mechanisms
- Reset all goal counters
- Start the snowboy program

Flippers activated

- Produce the flipper sound
- Move the corresponding flipper pair

Goal scored

- Produce the goal sound
- Increase the corresponding goal counter
- Successfully return the ball

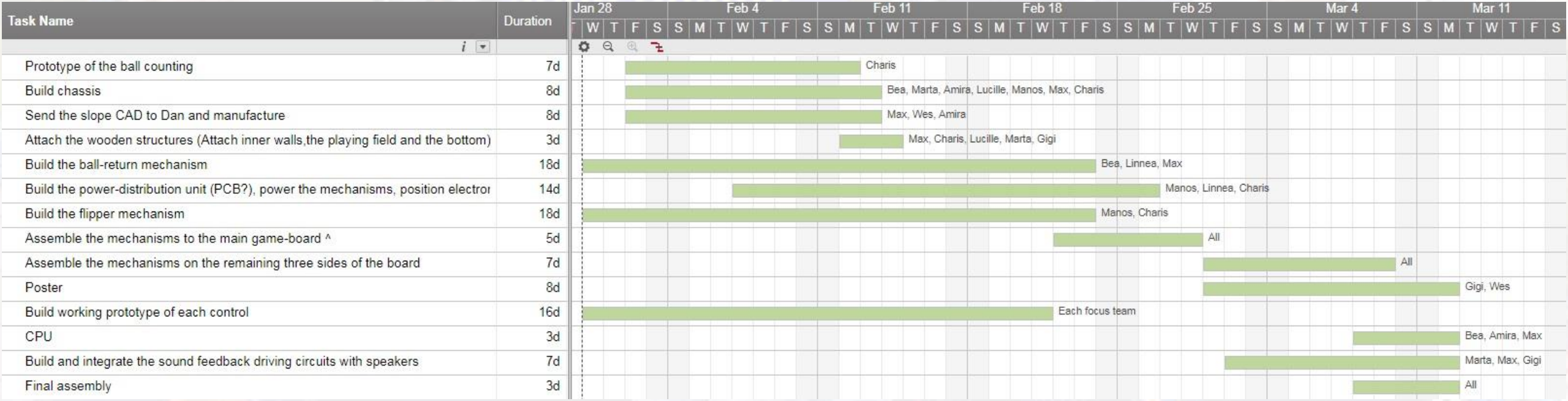
Goal threshold reached

- Stop the ball return wheels
- Produce the end-of-game sound

EVALUATION PLAN

- Structural integrity
- Portability
- Functional mechanisms
- Control systems functioning
- Appealing custom-made look
- Gameplay user evaluation

MANUFACTURING PLAN:
GANTT CHART



RISK EVALUATION

- Children's toys safety[1]
- Electrical risk evaluation according to standards[2]
- Sound level test

1. Regulations from the Health and Safety Executive, http://www.hse.gov.uk/electricity/standards.htm#power
2. Standards for insulating material, California referenced standards codes http://www.bearhfti.ca.gov/laws/insulation_regs.pdf

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