T1 Comms 2

Scoping Requirements Document

I. Table of Contents

II. Division of Labour and Workload Acknowledgement

Table 1. Table outlining the division of labour amongst team members.

Member name	SID	Cohort	Sections responsible
Yuelei (David) Huo	46045376	ENGG3000	Deliverables
Luke Smyth	46422102	ENGG3000	Inclusions & Inclusions, Formatting
Jannatul Munera Jalen	45787972	ENGG3000	Problem Definition (Subsystems), Interface Requirements, Interface Sign-offs
Edoardo Busano	45757100	ENGG3000	Functional Requirements & Performance Requirements
Tasnimul Islam	45697663	ENGG2000	Introduction
Olu Situmini Ekanayake	45560145	ENGG2000	Problem Definition (Assumptions), Constraints
Khatun A Jannat Tabassum	46342036	ENGG2000	Problem Definition (General Statement, Team Specific Statement)

III. Revision History Table

Table 2. Table outlining the changes applied to this document.

Version	Changes Made	Changes Made By	Change Approved By:	Date of Approval
0.1	Document started	Luke Smyth	Everyone	2/8/22
0.2	Added skelton of all sections to document	Everyone	Everyone	9/8/22
0.3	Added tables, relevant labels and details of headings and subheadings	Yuelei (David) Huo	Everyone	10/8/22
0.4	Added Requirements and Constraints	Olu Situmini Ekanayake, Edoardo Busano and Jannatul Munera Jalen	Luke Smyth and Yuelei (David) Huo	14/8/22
0.5	Added Deliverables	Yuelei (David) Huo	Edoardo Busano	16/8/22
0.6	Added Interface Requirements and Sign-offs	Jannatul Munera Jalen	Khatun A Jannat Tabassum	17/8/22
0.7	Added Inclusions and Exclusions	Luke Smyth	Jannatul Munera Jalen	20/8/22
0.8	Added Introduction	Tasnimul Islam	Luke Smyth	20/8/22
0.9	Filling in Deliverable items	Yuelei (David) Huo	Luke Smyth	21/8/22
1.0	Formatted Document for buddy marking submission	Luke Smyth	Everyone	23/8/22
1.1	Revising Subsystem and Assumptions	Jannatul Munera Jalen	Yuelei (David) Huo	3/9/22
1.2	Adding Gnatt Chart	Yuelei (David) Huo	Edoardo Busano	3/9/22
1.3	Final Scoping Document Submission	Everyone	Everyone	3/9/22

IV. Definitions and Abbreviated Terms

Table 3. Table defining all the terms and abbreviations used throughout this document.

Abbreviations	**Definition**
Comms	Communications
FWS	Ferris Wheel Subsystem
LED	Light Emitting Diode
LLS	LEDs Lightshow Subsystem
MQ	Macquarie
MVP	Minimum Viable Product
MM	Marble Machine
PWM	Pulse Width Modulated
T1_C_2	Team 1 Communications Team 2
T1_M_2	Team 1 Motions Team 2
T1_S_2	Team 1 Structures Team 2
UNO	Arduino UNO - A microcontroller board
VCS	Voltage Calibration Subsystem
DC	Direct Current

1. Introduction

1.1 Purpose and Intended Audience

This document gives an outline of T1_C_2's proposal for constructing one cube of the Massive Marvellous Multiple Marble Machine sculpture. This document's purpose is to provide stakeholders with a clear analysis of the software requirements, constraints, and scope of the project. In collaboration with T1_M_2 and T1_S_2, T1_C_2 will be responsible for the design of one of the cubes that will construct the MM. As the Communications team of this cube, we are responsible for the software design, development, and implementation aspects. This document covers all the elements of a preliminary assessment of the problem such as the functional, performance, and interface requirements, constraints, inclusions, exclusions, and the deliverables that are expected from T1_C_2.

1.2 Scope

The project's scope is limited to the design and implementation of one cube of the final sculpture, specifically, its internal design, which will allow marbles to enter the cube, follow a pre-determined path, and then exit the cube. It will be later integrated into a collective, single, and kinetic sculpture that will stand next to the entrance of Macquarie University's School of Engineering building. The structure will handle multiple cubes at the same time which will work together to produce a pleasing kinetic effect such that each cube/series of cubes will follow a standard interface, allowing its elements to be moved and swapped. The MM is split into three major systems: *Communications, Structures, and Motions*. The Communications group is responsible for the software aspects of the cube such as the light show and rotation of the Ferris wheels. The Structures group is in charge of the installation and sourcing of all the components required for the tracks and the Ferris wheels, and finally, the Motions group is in charge of the electronic elements and subsystems that will be included in the track.

2. Problem Definition

2.1 General Statement

The aim of this project is to make a working marble machine where the marbles go through a series of obstacles and in the process turn on LEDs that lights up the box. There are going to be four boxes linked together that make the entire marble machine where each of the boxes has different functionality. The obstacles will be a collection of both movable/operable and non-movable objects.

2.2 Team Specific Statement

As software engineers we are given the task to design and implement the software part of the design that would require us to use a coding language such as C. Specifically we need to design the software for the motors in order to move the obstacles in the machine and also detect marbles passing through by detecting the motion which will turn on LEDs that would light up the box as the marbles go in through and out of the box. We are required to use Arduino UNO which will be mounted onto the box and will control the motors and the LEDs. And lastly, we will also need the software to be able to handle errors and implement stops which we can achieve through our testing phase.

2.3 Subsystems

As there are multiple teams working on the Marble Machine project simultaneously, they are all split into three specific professions, which include **Communications, Motions, and Structural.** The said groups are then split into sub-teams in charge of making plans and implementations of various subsystems of the final MM. Hence the subsystems are:

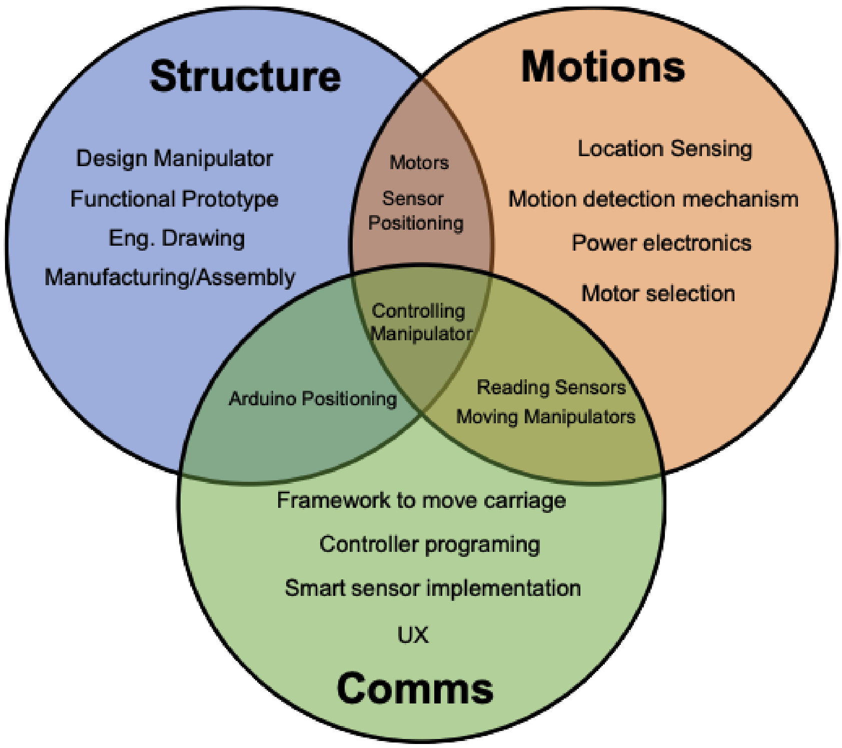


Figure 1: Venn diagram of responsibilities amongst each of the disciplines throughout the project [1].

The main scope of this document would solely cover the Comms aspects to produce subsystems relevant to the software of the MM. Hence, brief explanations of T1_C_2 team subsystems are recorded in this document to provide clarification and recognition of the overall component of the software as well as to prevent any crossover, while a brief explanation of the other team's subsystems has been omitted as it is out of scope of what we are tasked with.

2.3.1 T1_C_2 Subsystems

LED's Subsystem

The system will include (optical) sensors in various parts of the box that **MUST** detect the movement of the ball when it enters, the movement of the Ferris Wheel, and the movement of the ball when it exits the box and through this communication, the LED's attached to the boxes will respond in such a way the lights would turn on to specific colours respectively.

In case of any errors that would occur with the sensors such as failure to detect marbles entering or exiting the box, failure of sensors within the Ferris wheels motors or servos **MUST** start blinking to notify the error.

Ferris Wheel Subsystem

The system will include a specific sensor near the wheel that **MUST** detect marbles that would approach the wheel such that after detection the wheel will start moving the marble to its designated position.

The wheel would include code that allows it to use a rotatory motion at 90° per <=1 second to transport various 16mm solid steel speared marbles from one point to another.

As other system subsystems will require certain parameters to the function, such as motor speed and VCS, it **MUST** function during runtime and be able to handle data efficiently to prevent the system from being slow to respond to the sensor's inputs.

Voltage Calibration Subsystem

The system will include a PWM Buck Convertor- DC/DC Step-down that **MUST** convert a high voltage to a low voltage in an efficient manner (taking in 12V and 2A and converting it to 6V and ~4A respectively). This system will supply power safely for the Ferris Wheel as the wheel will be constantly moving and stopping depending on the inputs from the optical sensors.

As constant fluctuation in current may cause premature failure of the electrical components due to overheating, this may cause a risk of damage in other components within the cube to the point it is cumulative and irreversible. Hence a Buck Converter will be used to prevent short circuit current from rising above the internal peak current limit.

The VCS **MUST** provide the right voltage to each Ferris wheel, which would be 6 Volts of electricity to each Ferris wheel.

2.4 Assumptions

Table 4. Table outlining the assumptions made on the basis of client information provided.

ID	Assumption
A-1	The sensors set off a light show when a marble is detected in the entrance, when entering the Ferris Wheel and exiting.
A-2	The power supply provided will be enough for the process to take place.
A-3	All written code will be compatible with Arduino and will be written in C programming language.
A-4	All subsystems will work in coordination.
A-5	The Ferris Wheel will move and stop according to the communication sent by the sensors.
A-6	Budget plans and cost of all the Hardware along with the construction of the entire cube will be communicated and decided amongst relevant group (Structures and Motions).

3. Deliverables

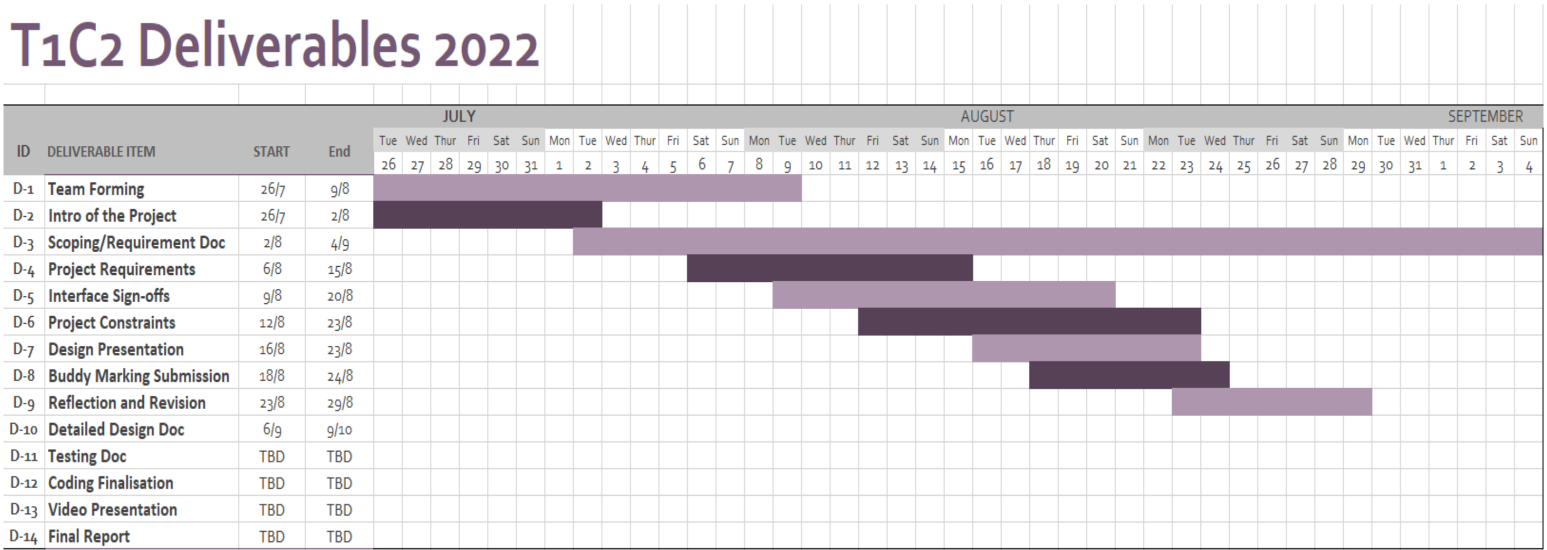
Table 5. Table listing what shall be delivered to the client by the end of the project.

ID	Deliverable Name	Description	Start Date	Due Date
D-1	Team, Forming, Storming and Norming	Getting to know the members. Assigning roles and tasks for each individual. Getting used to the way each other communicates, thinks and works.	26/7/22	9/8/22
D-2	Introduction of the Project	Brief details of the Scope, Problem Definition, Subsystem, Prioritisng Client's requirement.	26/7/22	2/8/22
D-3	Project Requirements	Brief description of the Performance, Interface and Functional Requirements of the project to start the design.	6/8/22	23/8/22
D-4	Interface Sign-offs	Acknowledgement of shared requirements between different teams.	18/8/22	23/8/22
D-5	Project Constraints	Detailing the limitations that are to be checked throughout the project.	18/8/22	23/8/22
D-6	Design Formative Feedback Presentation	Preparing design presentations, giving presentations and receiving formative feedback.	16/8/22	23/8/22
D-7	Buddy Marking Submission	Finalize the initial draft of the scoping document and submit it for feedback.	16/8/22	24/8/22
D-8	Buddy Marking, Reflection and Revision	Buddy marking T1C1's Scoping Documents and providing insightful, analytical feedback. Receiving T1C3's buddy mark and making changes accordingly.	23/8/22	29/8/22
D-9	Scoping/Requirement Document Submission	A simple professional document including the sections Scope, Problem Definition, Assumptions, Requirements, Constraints, Interface Sign-offs, Inclusions and Exclusions.	2/8/22	4/9/22

D-10	Detailed Design Document	A document that addresses the structure of the project and provides details of both the conceptual design as well as a more in-depth through a detailed design.	6/9/22	9/10/22
D-11	Testing Document	A document that will discuss information in regards to the test cases and test results of the project.	TBD	TBD
D-12	Coding Finalization	A repository that will contain all the code that is used for the operation of the MM.	TBD	TBD
D-13	Video Presentation	A short presentation video presenting the final product of the MM project.	TBD	TBD
D-14	Final Report	A document that will hold all the information related to the final product of the project.	TBD	TBD

3.1 Gantt Chart

Figure 2. Gantt chart for the overall project to date.



T1C2 Deliverables 2022

ID	DELIVERABLE ITEM	START	End
D-1	Team Forming	26/7	9/8
D-2	Intro of the Project	26/7	2/8
D-3	Scoping/Requirement Doc	2/8	4/9
D-4	Project Requirements	6/8	15/8
D-5	Interface Sign-offs	9/8	20/8
D-6	Project Constraints	12/8	23/8
D-7	Design Presentation	16/8	23/8
D-8	Buddy Marking Submission	18/8	24/8
D-9	Reflection and Revision	23/8	29/8
D-10	Detailed Design Doc	6/9	9/10
D-11	Testing Doc	TBD	TBD
D-12	Coding Finalisation	TBD	TBD
D-13	Video Presentation	TBD	TBD
D-14	Final Report	TBD	TBD

4. Requirements and Constraints

4.1 Functional Requirements

Table 6. Table outlining the functional requirements for the LLS, the FWS, and the VCS.

ID	Requirement	Priority
FR-1	A setup **MUST** be automatically activated to calibrate all subsystems and their components.	HIGH
FR-2	When the DEBUG flag is set to 1 in the pre-processor, every variable state change and function call **MUST** be displayed on the Arduino IDE console.	MEDIUM
FR-3	If failure occurs for the sensor that detects marbles entering the box, the LEDs placed on the box's ceiling **MUST** start blinking to notify the error.	MEDIUM
FR-4	If failure occurs for the sensor that detects marbles exiting the box, the LEDs placed on the box's sides **MUST** start blinking to notify the error.	MEDIUM
FR-5	If failure occurs for either the Ferris wheels' sensors, motors or servos, the Ferris wheels' LEDs **MUST** start blinking to notify the error.	MEDIUM
FR-6	The sensor placed at the entrance cavity **MUST** detect every marble that drops from it.	MEDIUM
FR-7	The Ferris wheels' sensors **MUST** detect every marble that approaches the Ferris wheels.	HIGH
FR-8	The sensor placed at the exit cavity **MUST** detect every marble that leaves the box.	MEDIUM
FR-9	The LEDs placed on the box's ceiling **MUST** trigger a lightshow every time the entrance sensor detects a marble.	MEDIUM
FR-10	The LEDs placed on the box's sides **MUST** trigger a lightshow every time the exit sensor detects a marble.	MEDIUM

FR-11	The Ferris wheels' LEDs **MUST** turn green when the Ferris wheel is in motion, and red when it stops.	MEDIUM
FR-12	The Ferris wheels **MUST** turn every time the respective sensor is triggered.	HIGH
FR-13	The Voltage Calibration Subsystem **MUST** provide the right voltage to each Ferris wheel.	HIGH

4.2 Performance Requirements

Table 7. Table outlining the performance requirements for the LLS, the FWS, and the VCS.

ID	Requirement	Priority
PR-1	All sensors **MUST** detect passing marbles with a precision of 99%.	HIGH
PR-2	The delay between the detection of a marble and the triggering of an LEDs lightshow **MUST** be less than 0.1 seconds.	MEDIUM
PR-3	The delay between the detection of a marble from a Ferris wheel sensor and the triggering of the wheel rotation **MUST** be exactly 0.5 seconds.	HIGH
PR-4	The rotational speed of the Ferris wheels **MUST** be 90 degrees per second.	HIGH
PR-5	Each time a Ferris wheel rotation is triggered, it **MUST** rotate exactly 90 degrees clockwise.	HIGH
PR-6	The VCS **MUST** redirect 6 Volts of electricity to each Ferris wheel.	HIGH

4.3 Interface Requirements

Table 8. Table outlining the interface requirements applicable to the Motors and State Machine Subsystem.

ID	Requirement	From Team/Subsystem	To Team/Subsystem	Priority
IR-1	The sensor attached in the Entry **MUST** exchange information with the LED's subsystem connected to the Arduino.	T1_C_2 Optical Sensor	T1_C_2 LED subsystem	HIGH
IR-2	The sensors attached in the mid region of 2 tracks **MUST** exchange information with the LED's subsystem connected to the Arduino.	T1_C_2 Optical Sensor	T1_C_2 LED subsystem	HIGH
IR-3	The sensors attached in the Exit **MUST** exchange information with the LED's subsystem connected to the Arduino.	T1_C_2 Optical Sensor	T1_C_2 LED subsystem	HIGH
IR-4	The motor of the Ferris Wheel **MUST** be mounted and wired to designated pins on the Arduino UNO.	T1_S_2 Mounting	T1_C_2 VCS	MEDIUM

4.3.1 Interface Sign-offs

Table 9. Table outlining the interface signoffs by representatives of each subsystem mentioned in the interface requirements.

Requirement ID	Team/Subsystem	Sign-off by	Date
IR-1	T1_C_2	Luke Smyth (SID: 46422102)	20/08/2022
IR-2	T1_C_2	Luke Smyth (SID: 46422102)	20/08/2022
IR-3	T1_C_2	Luke Smyth (SID: 46422102)	20/08/2022
IR-4	T1_S_2	Alex Finnegan (SID: 46414266)	20/08/2022

4.4 Constraints

Table 10. Table outlining the constraints that may be imposed upon the development process of the project.

ID	Constraint	Description
C-1	Time	The project was given to be completed within a time frame of 13-weeks.
C-2	Knowledge	The skills available to complete the project successfully is limited to the skills that each group member brings to the team.
C-3	Cost	All the materials used to make the final cube was said to be kept under AUD $100.
C-4	Code	The programming language must be Arduino-compatible.
C-5	Power Supply	The power supplied to the cube has to be kept under the right voltage range.

5. Inclusions

Table 11. Table listing what shall be included in the project within the Comms scope.

ID	Inclusion
IN-1	Code that provides the right voltage to the cube’s electronic components (VCS).
IN-2	Code for the reading and processing of sensor data.
IN-3	Code that creates a lightshow through the LLS.
IN-4	Code that controls the operation of the FWS.

6. Exclusions

Table 12. Table listing what shall be excluded explicitly from the project from the Comms perspective.

ID	Exclusion
EX-1	Physical construction of components in the box.
EX-2	Physical construction of the board that the box is being inserted onto.
EX-3	Physical implementation of electronic components contained within the box.
EX-4	Maintenance of software after initial implementation and deployment.

7. References

- [1] di Bona, R. 2022. ENGG2000/3000 vPBL SPINE unit. Sydney, Australia: Macquarie University.

8. Appendices

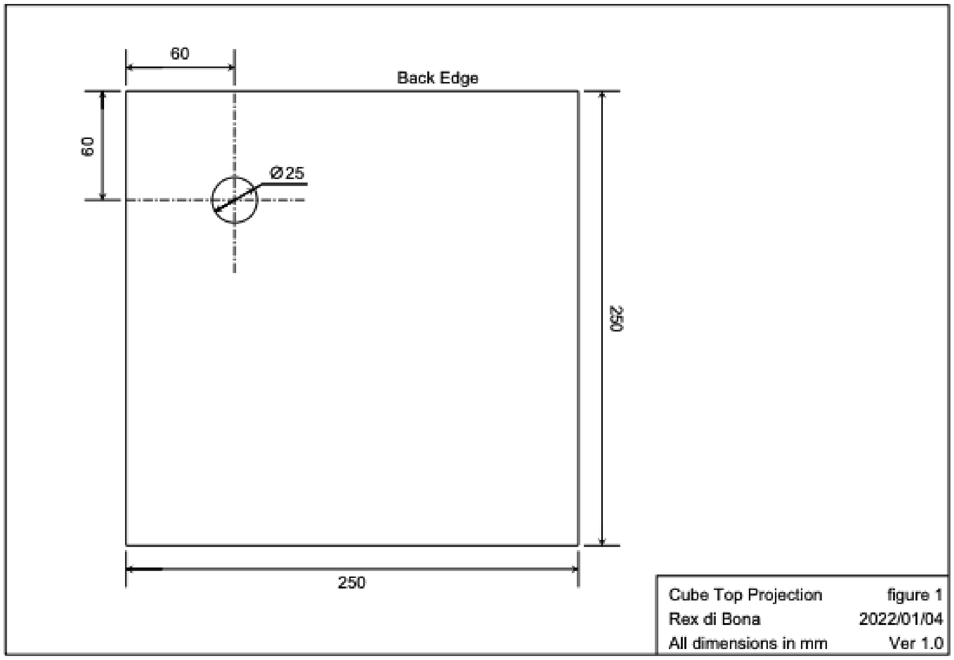


Figure 3. Cube Top Projection

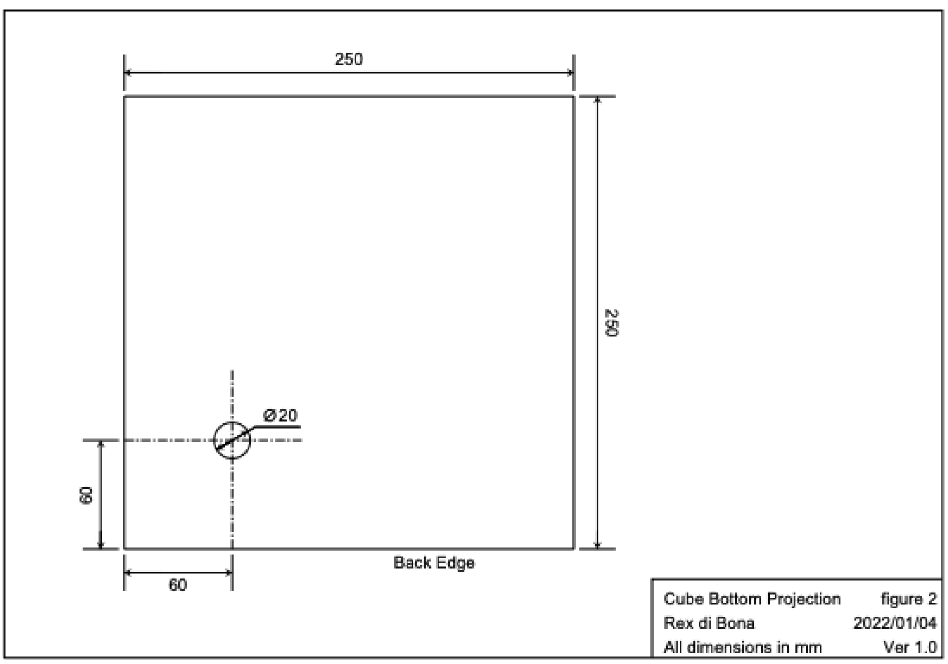


Figure 4. Cube Bottom Projection

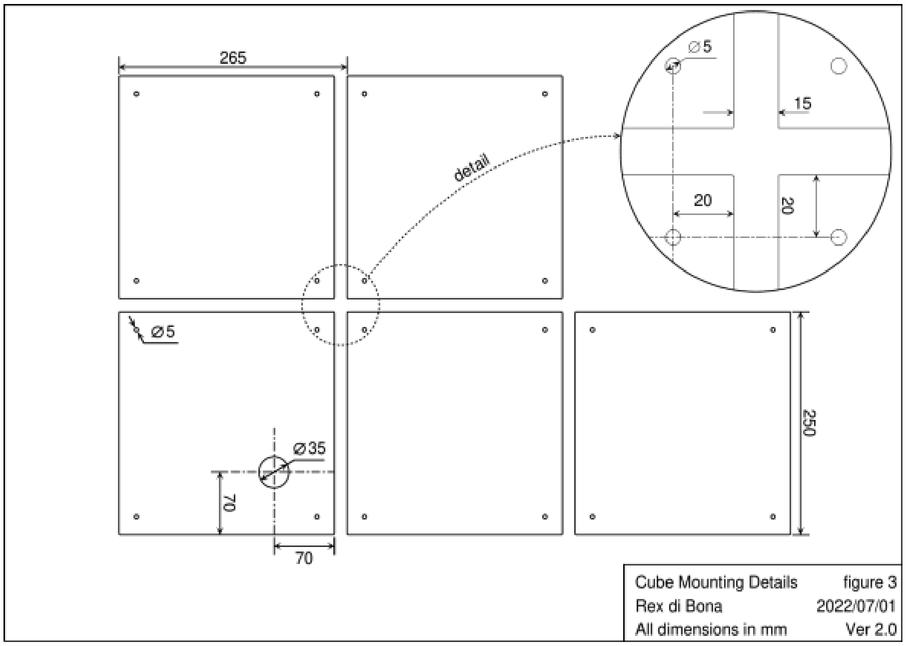


Figure 5. Cube Mounting Locations and Services Hole

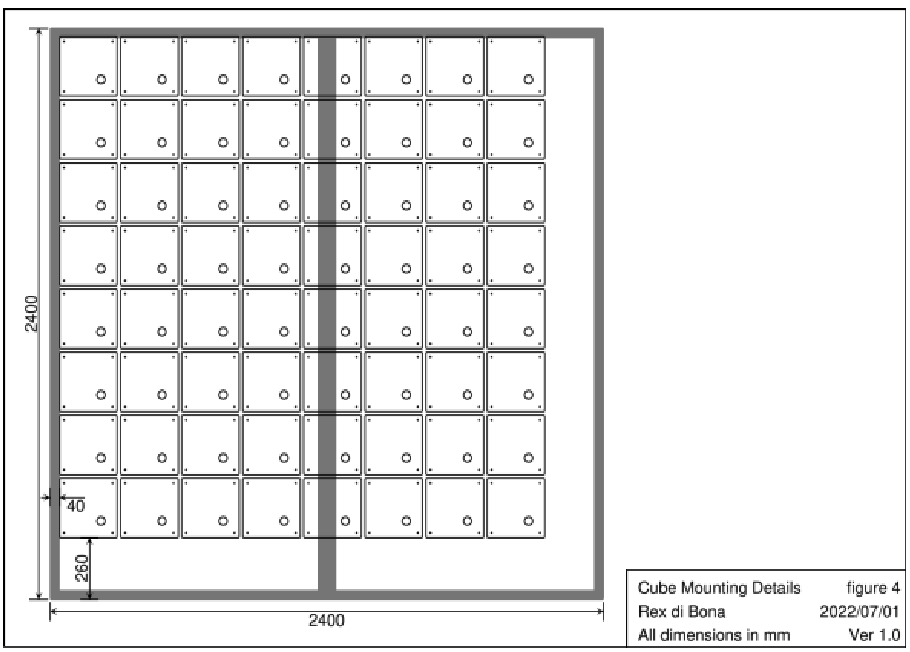


Figure 6. Full Mouting Frame description

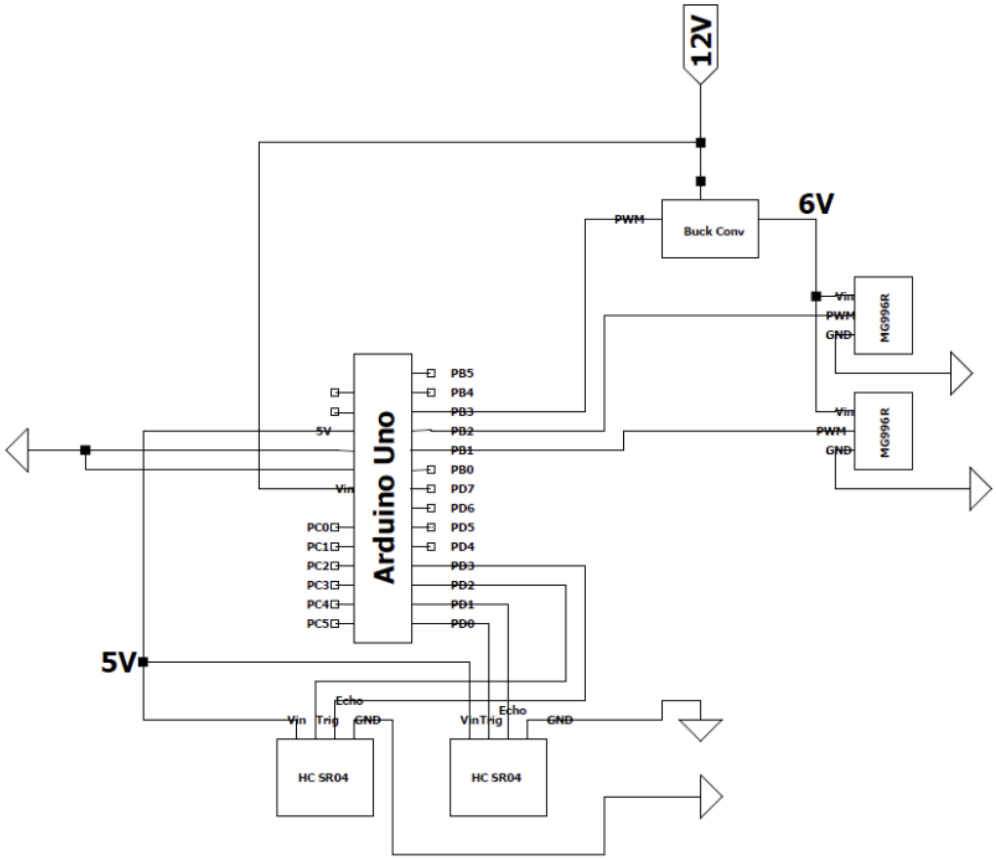


Figure 7. Schematic of the wiring for the UNO.