WRO®

SOUTH AFRICA

FUTURE INNOVATORS

AGE GROUP	Elementary

TEAM NAME

KargoVault

South Africa

Project Stability

By Team KargoVault

We believe in stability when it comes to transporting cargo across the Ocean

KargoVault

Future Innovators Category 2023

Table of Content

Team Introduction and Roles 1

Project Summary 2

Presenting the Robotic Solution 3

Impact of Cargo Containers on Marine life 4

Cargo containers lost at sea 4

Construction of the Solution

Electronic components used and cost 6

Designing and building the circuit 7

3D Designing 9

3D printing and Slicing 10

Arduino Code 11

Advantages Of KargoVault 12

Challenges During the Development Process 13

Social Impact and Innovation 14

Reference List 15

Team Introduction and Roles

Veer Mansingh

- Circuit Builder
- Robot Builder
- Programmer
- 3D model Builder and printer
- Decorator
- Circuit Diagram
- Posters

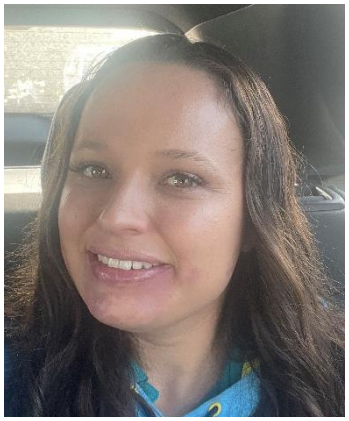
Khanyisile Magangane

- Robot Builder
- Booklet Creator
- Circuit Builder
- 3D model Builder and printer
- Painter and decorations
- Posters
- Circuit diagram

We are Grade 6 learners from Curro

Helderwyk in Brakpan, Gauteng, South Africa.

Our Coach is Ms Kasselman



Project Summary

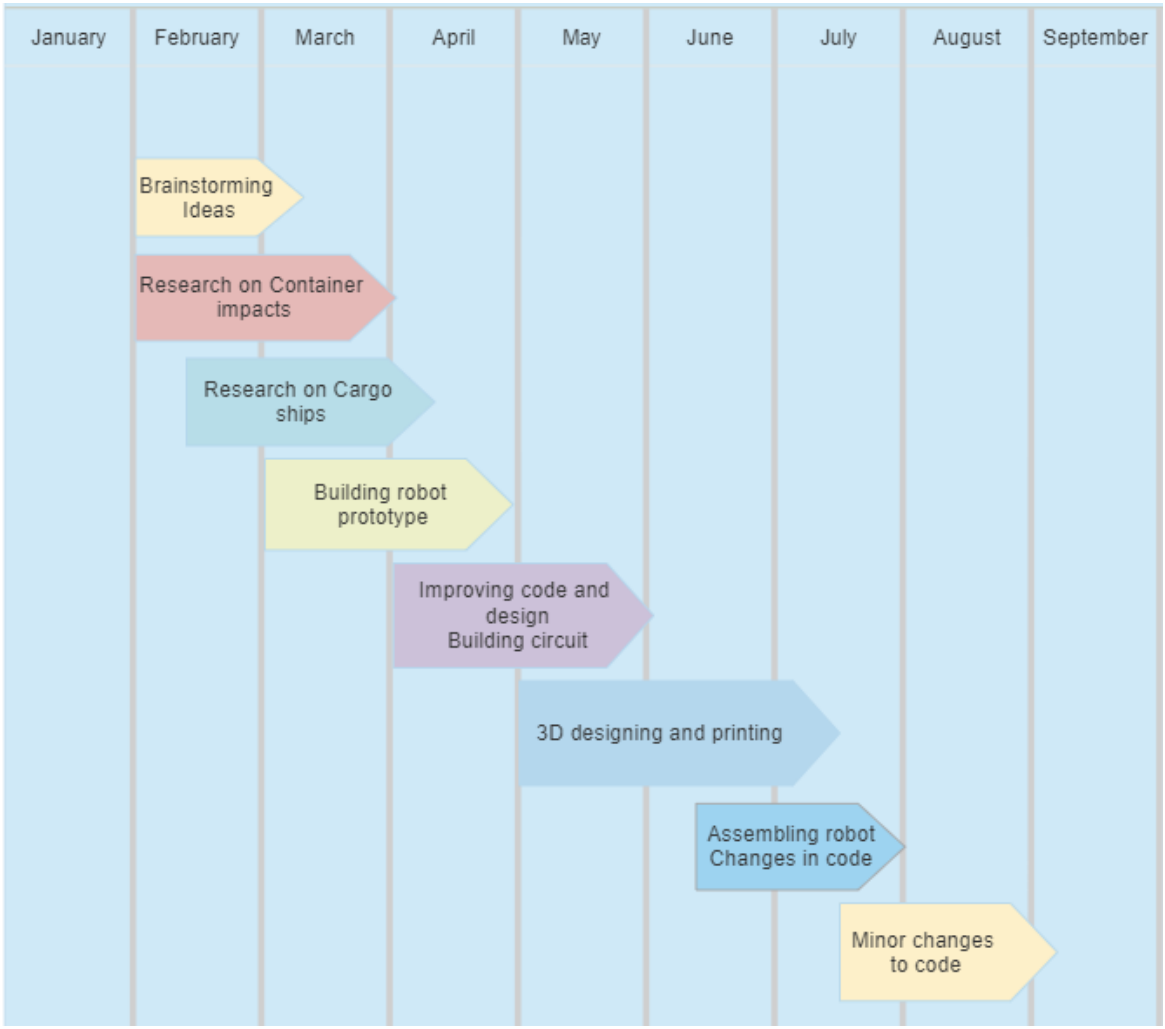
Goal 14 of the UN sustainable development goals is to conserve and sustainably use the oceans, seas and marine resources for sustainable development. Cargo shipping containers that fall in the oceans can cause harm to Marine life. Losing containers at sea also impacts companies and creates a shortage of the product contained.

Additionally, we came across UN Goal 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The robotic solution used on KargoVault can not only be used on cargo ships but can also be used to stabilize platforms on cruise ships and can even be incorporated in the foundation of buildings which can assist support during earthquakes.

Presenting the Robotic Solution

Evolution of the Project idea

Our Project Idea Timeline



Safe shipping at its best with KargoVault. Shipping cargo is one of the most important aspects of shipping. When the waves hit the ship, the ship's buoyancy drops, affecting everything on board including the cargo. This causes the ship to collapse. We need something to stabilize the cargo while the boat is moving. That's why we developed KargoVault, a device that keeps the cargo stable while shipping. The KargoVault keeps the cargo stable by using a platform controlled by two servos. The two servos are connected to the boat while the accelerometer is connected to the servos. The servos are specially positioned to stabilize the cargo buoyancy while the accelerometer provides real time feedback on the state of the ship. With the help of algorithms, the servos continuously change their position to keep the platform balanced. This keeps the cargo stable and not moving around inside the boat.

Impact of cargo containers on Marine life

The loss of shipping containers into the ocean can have negative impacts on marine life in several ways, namely:

1. Habitat Destruction: Falling shipping containers can cause physical damage to the seafloor and other marine habitats, potentially destroying or damaging sensitive ecosystems, such as coral reefs, seagrass beds, or other marine habitats. This can disrupt marine ecosystems, harm marine species, and contribute to loss of biodiversity.

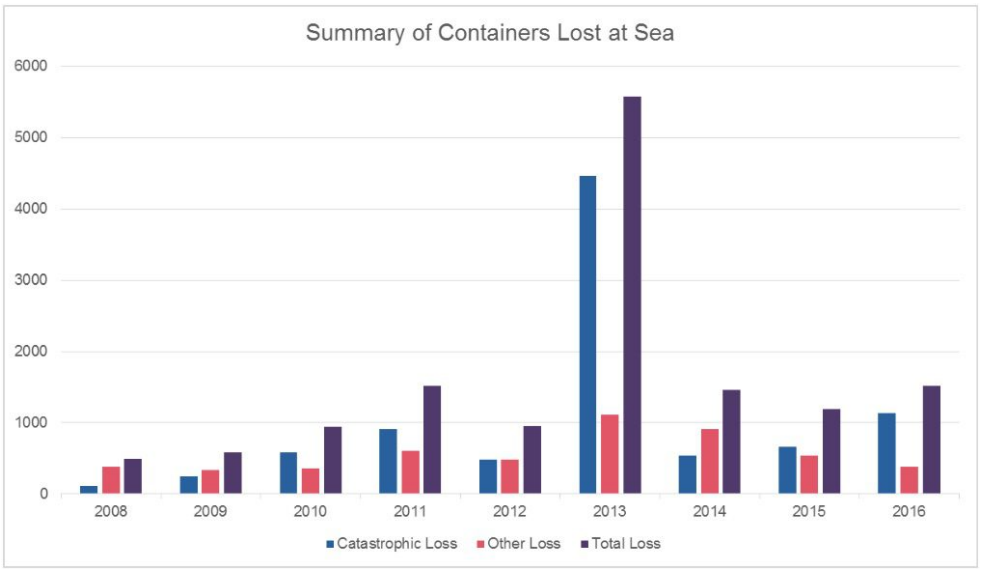
2. Marine Debris: Lost shipping containers and their contents can add to the growing problem of marine debris, which can pose entanglement or ingestion risks to marine animals. Marine debris, including plastic or metal fragments from damaged containers, can entangle or injure marine wildlife, leading to injuries or death, and disrupting marine ecosystems.

3. Chemical Pollution: Shipping containers may contain various types of cargo, including hazardous materials, which could pose a risk of chemical pollution if released into the ocean. For example, containers carrying chemicals, oil, or other toxic substances can leak or spill into the marine environment, which could cause contamination and harm to marine life.

4. Disruption of Fisheries: Falling shipping containers can also pose risks to fishing activities, as they can damage fishing gear, such as nets or traps, and disrupt fishing operations. This can result in economic losses for fishermen and impact local fishing communities.

Containers lost at sea

How many shipping containers go missing at sea each year? It's hard to say with absolute accuracy, as it depends on a variety of factors such as weather, shipping routes and container handling. Industry estimates show that on average several hundred shipping containers go missing every year.



It’s important to note that container loss is a major concern for container shipping companies as well as the relevant authorities. Container loss has both a financial and environmental impact. As a result, efforts are being made to improve container securing procedures and develop technology to reduce the risk of container loss.

How KargoVault helps marine life

The robot we created for cargo ships can indirectly help marine life in many ways:

1. Environmental Protection: By helping to sustain the steadiness of cargo ships, the robot can reduce the chance of cargo spills or accidents that could affect marine habitats and wildlife. This can assist to protect marine ecosystems from potential pollution and damage.

2. Sustainable Shipping: By acing shipping operations and reducing the chance of cargo damage, the robot can lead to more structured shipping practices. This may lead to fewer losses of valuable goods, reducing the need for more resources to replace damaged cargo and reducing waste.

3. Efficient Transportation: The robot's ability to keep the ship stable during wild seas can help reduce delays and disruptions in shipping schedules. This can lead to more efficient transportation of goods, which may result in less fuel consumption and emissions, contributing to reduced air and water pollution and minimizing the impact on marine ecosystems.

4. Improved Safety: Ensuring that cargo ships remain stable can enhance the safety of crew members onboard, reducing the risk of accidents or injuries caused by unstable ship movements. This can help safeguard the well-being of sailors and other maritime workers, contributing to a safer working environment in the marine industry.

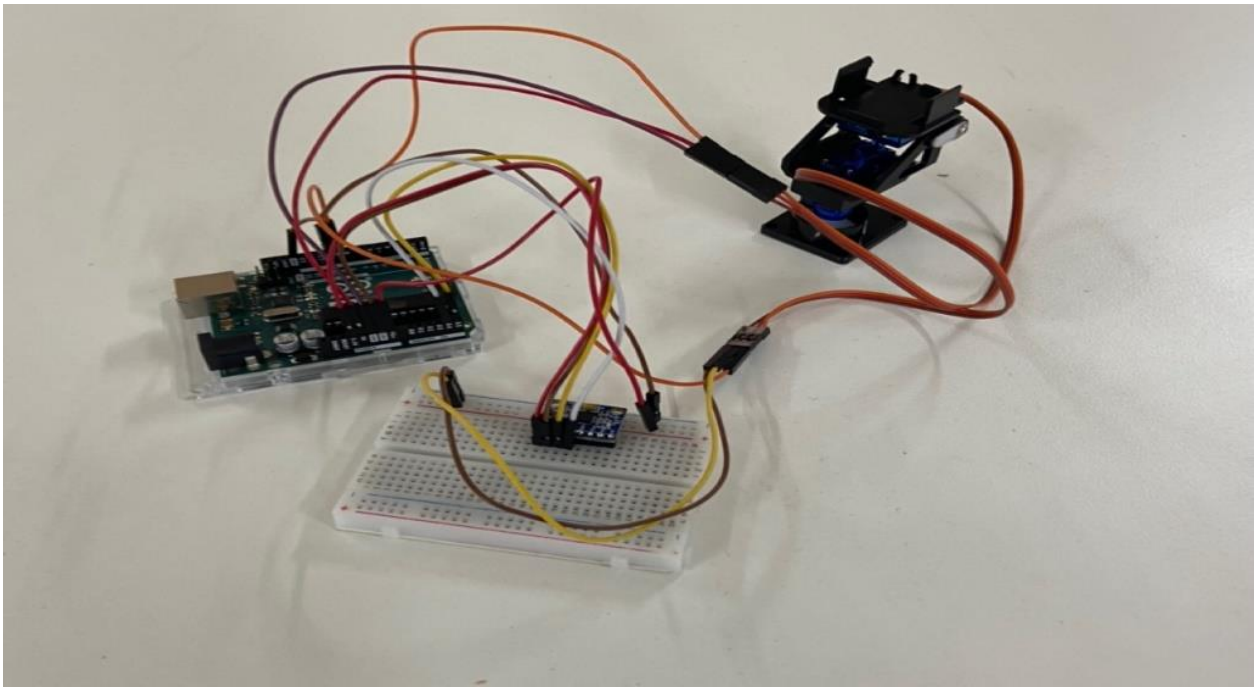
Construction of the solution

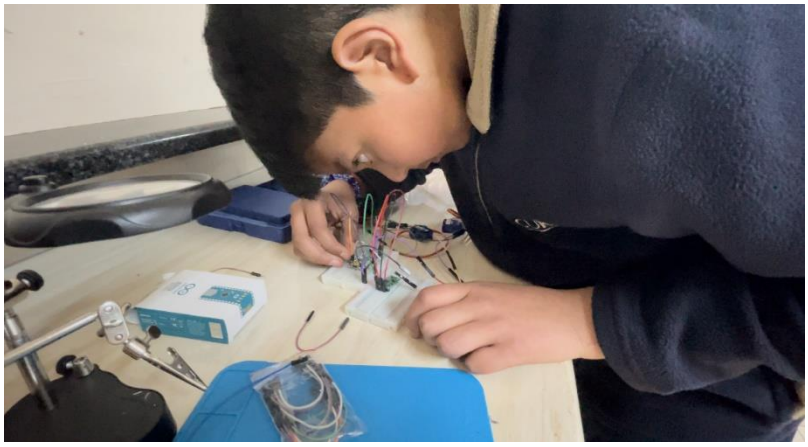
Electronic components used.

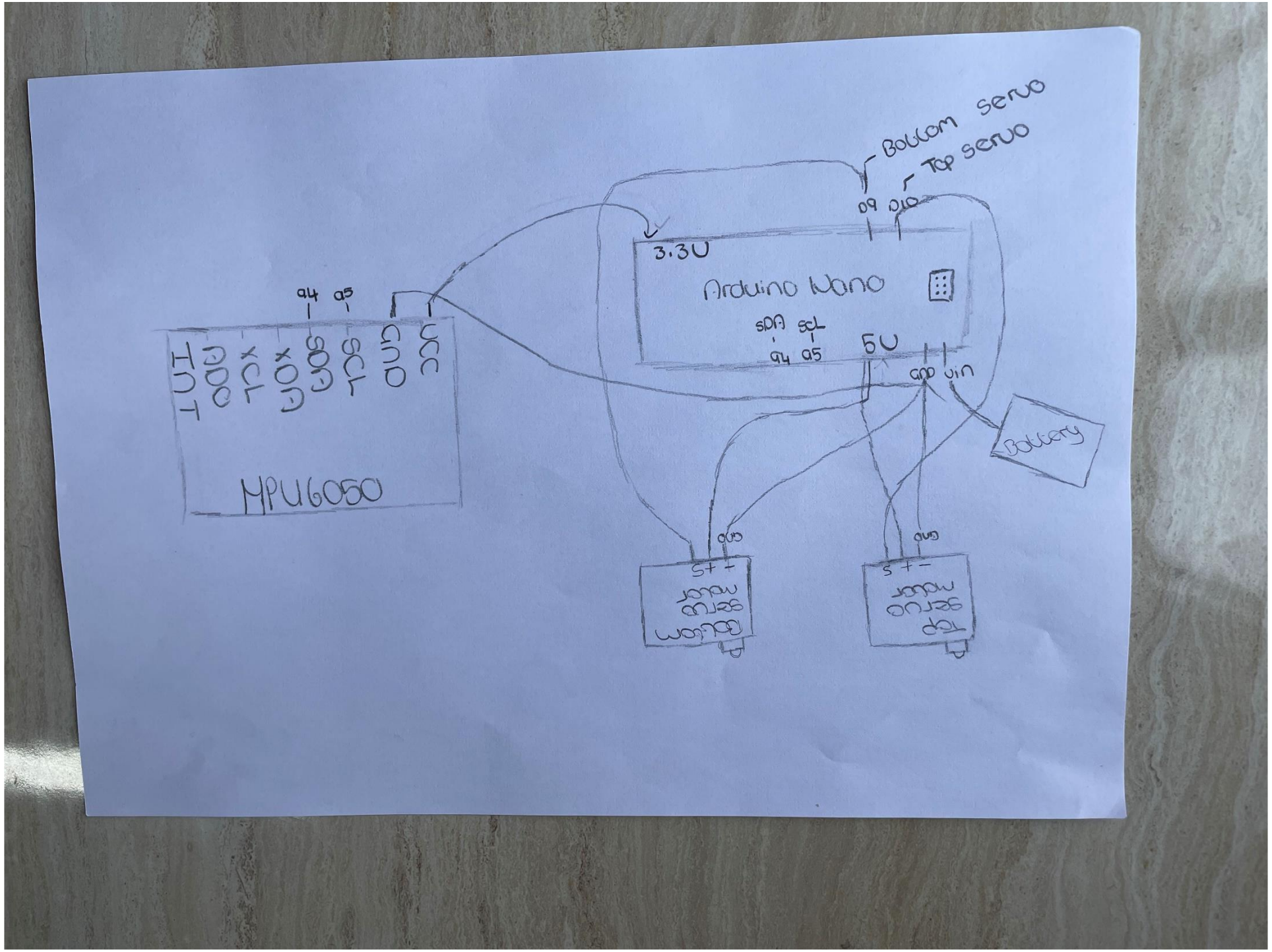
Components	Amount	Cost
Jumper wires 	Male to male (a few)	R76.00
Arduino Nano 	1	R309.00
Servo Motors 	2	(R52.00 x2) R104.00
MPU6050 	1	R49.00
Breadboard 	2	(R9.00X2) R18.00
9V Battery 	1	R97.00
Battry adapter 	1	R5.00
Total cost of circuit		R658.00

Designing and building the circuit

Since we decided to use an Arduino Nano instead of Lego, we had to build the circuit ourselves. The first step was to place the Arduino Nano onto a breadboard to make it easier to connect the electronic components' pins to the board. For the smaller MPU6050 (a compact sensor that houses an accelerometer and gyroscope), we placed on a different small breadboard. We also added two Servo motors to the setup. One servo responds to the boat's movement along x-axis, and the other servo responds to movement along y-axis. The two servo motors work together to stabilize the cargo, keeping it stable. The MPU6050's pins were connected on the same board as the Arduino Nano.

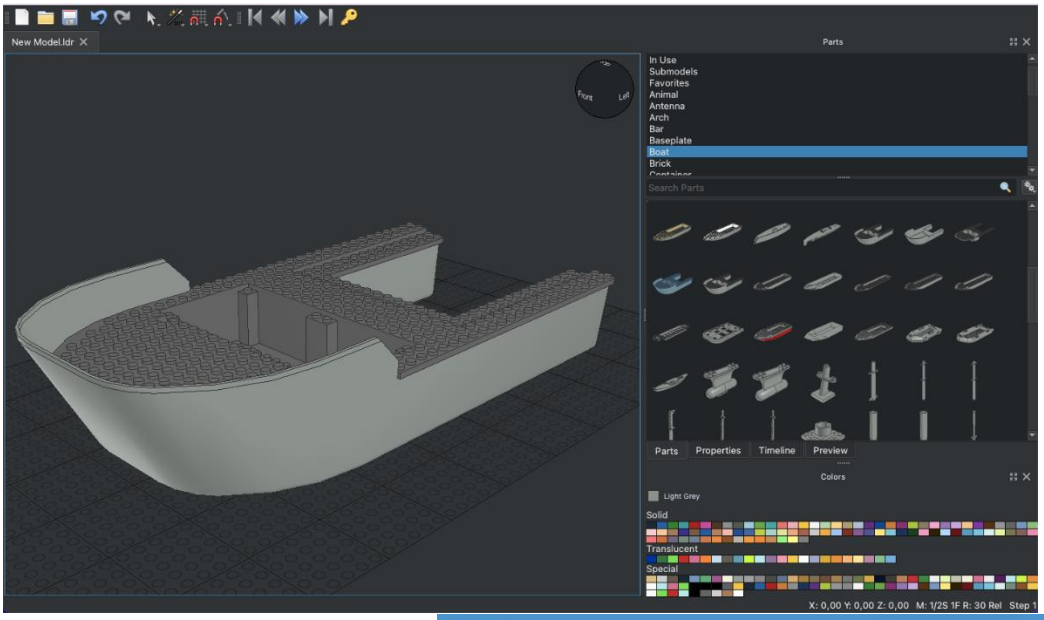


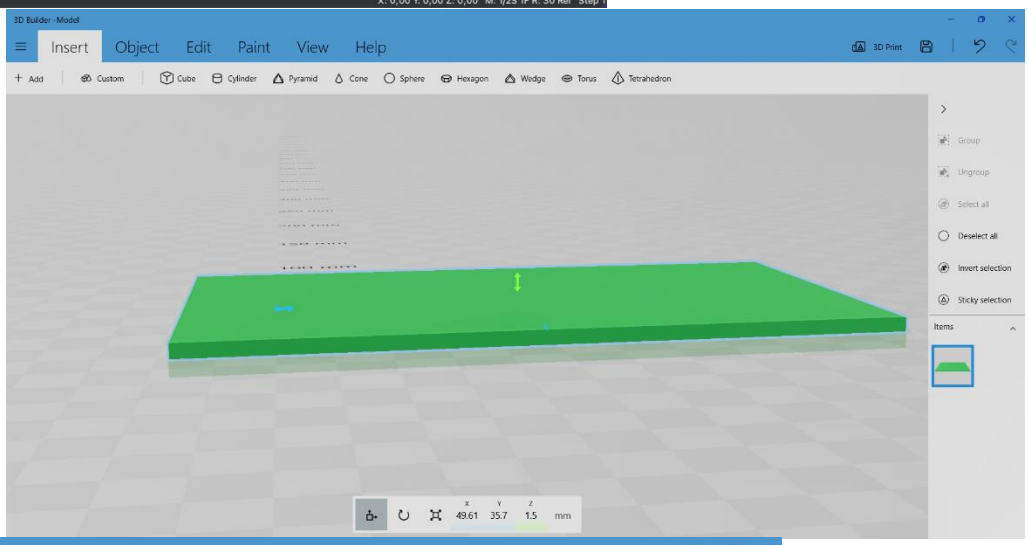


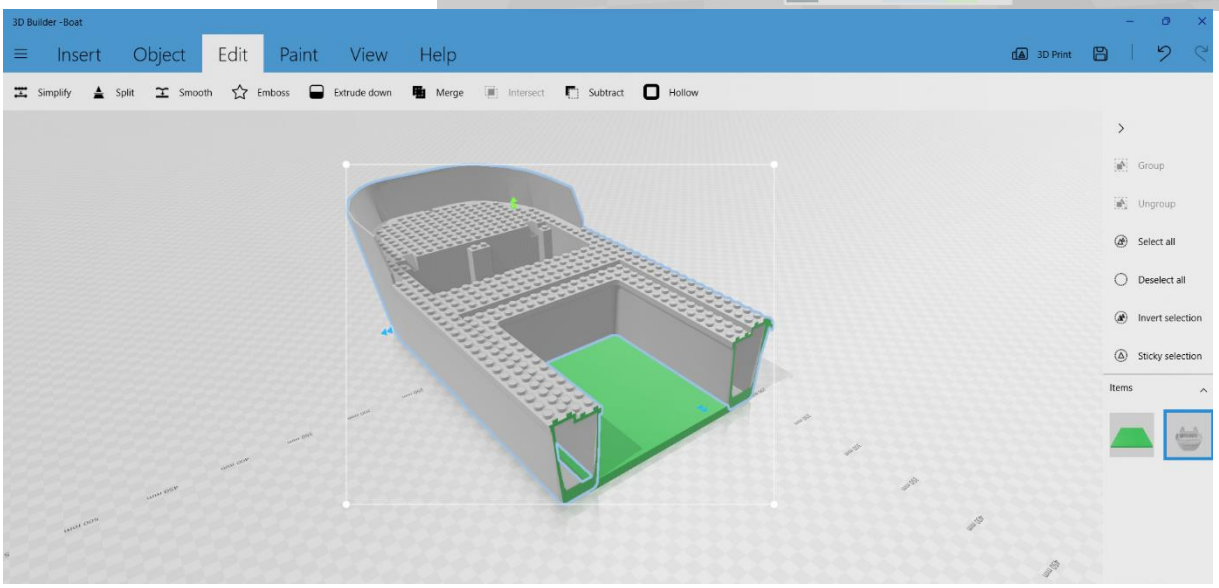

Bottom servo
Top servo
3.3V
Arduino Nano
SDA SCL
A4 A5
5V
GND Vin
Battery
MPU6050
INT
GND
XCL
XDA
SDA
SCL
GND
VCC
A4 A5
Bottom servo motor
Top servo motor
S + -
GND

3D Designing

In order to build our boat, we used two computer programs: LeoCad, and 3D Builder. First, we obtained various components from LeoCad, which we modified in 3D Builder in order to build our robot. The main floor of the cargo ship was designed in 3D Builder, as well as the front section of the boat. We also needed to create a lower section for the boat's bottom, as LeoCad did not have the correct base. Additionally, we had to trim down several sections of the boats's walls to ensure that the two halves of the boat fit together correctly.

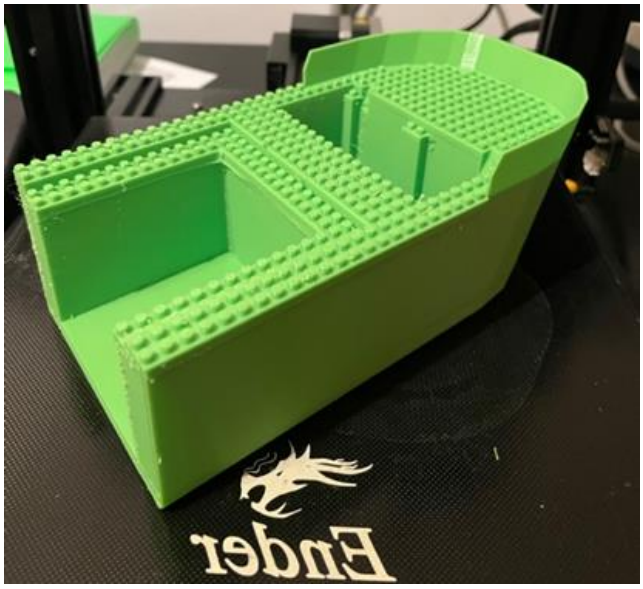


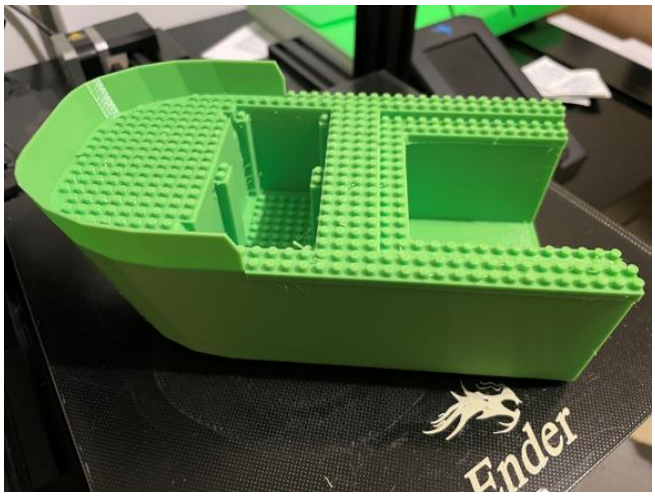


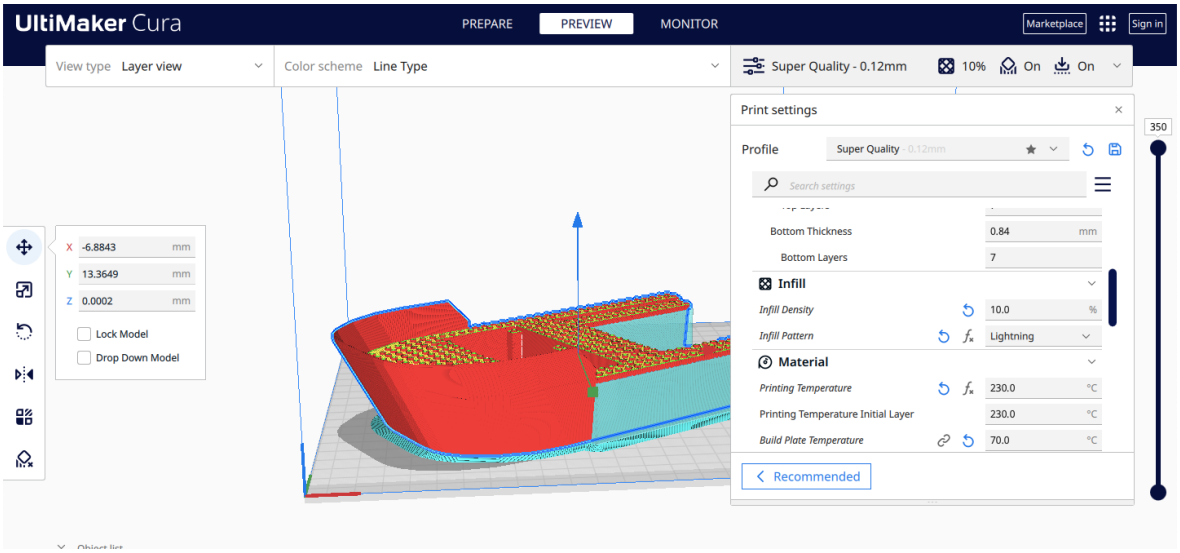


3D Printing and Slicing

Once the boat parts were designed, each model needed to be separated into layers. This allows the 3D Printer to build each piece we designed. To do this, we needed to slice the models. We used UltimakerCure software to do this slicing. We also adjusted some settings in the software to make sure the printed models came out strong and smooth.







Arduino code

```
#include <MPU6050.h> //Libraries(tools) that will help do different things in our project
#include <I2Cdev.h>
#include <Wire.h>
#include <Servo.h>

MPU6050 mpu; // Sensor that measures tilt, pitch and roll

int16_t ax, ay, az; // Accelerometer x-axis, y-axis and z-axis
int16_t gx, gy, gz; //Gyroscope x-axis, y-axis and z-axis

Servo servo1; //Servo connected at the bottom
Servo servo2;//Servo connected at the top

//int is the variable we created to store information like a box
int val1; // Variables that store sensor readings from accelerometer x-axis
int val2; // Variables that store sensor readings from accelerometer y-axis
int pval1;// pval is the position value for x-axis after the calculations
int pval2;// pval is the position value for y-axis after the calculations

const float smoothingFactor = 0.2;//smoothingFactor helps make the movements smoother (Value 0 - 1)

void setup() { //We say hello to our tools and say which pin they are connected to
  Wire.begin();
  Serial.begin(115200);//Communicating with Serial Monitor [data rate in bits per second (baud)]
  mpu.initialize(); // Loads the MPU6050 firmware and configures it
  servo1.attach(10);// Servo1 is connected to pin 10
  servo2.attach(9); // Servo 2 is connected to pin 9
}

void loop() {
  mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);//code from library to get the motion of the MPU6050

  val1 = map(ax, -17000, 17000, 0, 179); //-17000 and 17000 is the minimum and maximum readings of the accelerometor
  val2 = map(ay, -17000, 17000, 0, 179); //0 and 179 is the minimum and maximum reading of the servo motors

  val1 = smoothingFactor * val1 + (1 - smoothingFactor) * pval1;// The formula that continuously runs to calculate val1
  val2 = smoothingFactor * val2 + (1 - smoothingFactor) * pval2;// The formula that continuously runs to calculate val2

  if (val1 != pval1) { // If val1 does not have the same value as pval1 - True
    servo1.write(val1);// If val1 has the same value as pval1 move the servo to val1 position
    pval1 = val1;
  }

  if (val2 != pval2) { // If val2 does not have the same value as pval2 - True
    servo2.write(val2); // If val2 has the same value as pval2 move the servo to val2 position
    pval2 = val2;
  }

  delay(20); //Pause the loop for 20 milliseconds before repeating again
}
```

Advantages of using KargoVault

The device we developed has the following benefits, among others.

1. The algorithms maintain the ship's stability even in rough waters. This lowers the possibility of cargo moving and resulting damage, ensuring the safe transportation of priceless items.

2. The robot constantly modifies the servos using algorithms, which improves the ship's balance and minimizes the need for human interaction. This lessens the workload for ship crew and increases the effectiveness of shipping operations.

3. By delivering swift and efficient stabilization in response to changes in the ship's state, the robot's real-time feedback from the gyroscope boosts the cargo ship's overall safety while at sea.

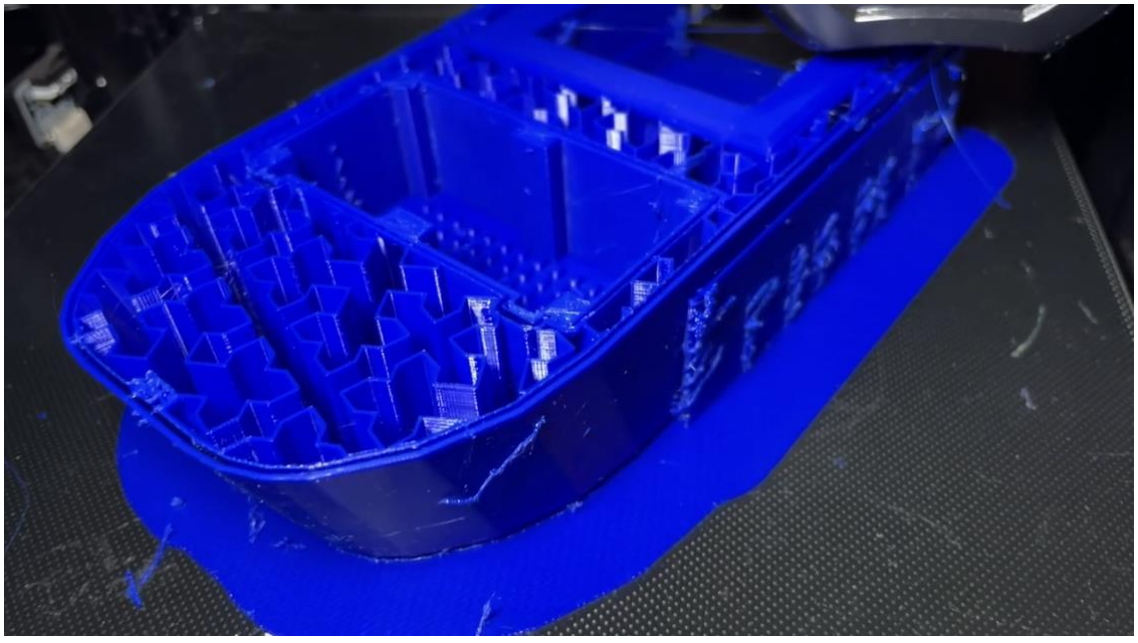
Challenges during the Development process

The 3D printer only had a small surface area to work with, so we had to divide the model into two pieces. However, the size of our initial boat design prevented all of the components from fitting within. Before we got it right, we had to make numerous adjustments to the boat's size in 3D Builder.

We had to adjust the printing temperature in order to improve the quality of our prints. We found that various filament colours performed better at various temperatures. The prints were impacted by changing evening temperatures as well. On occasion, the printing bed's components would lift, making the print entirely uneven. By slightly raising the temperature of the bed and applying hairspray on the glass bed to guarantee good filament adhesion, we were able to fix the issue. It was difficult to print the boat, especially when there was no power. It took about 6 days to print one half of the boat, and if the power went off while printing, the cooled print resulted in layer breaks when printing was resumed. In order to prevent these splits, we had to restart a number of prints.

The Arduino Uno board we were using at first was too big for our model, so we moved to the Arduino Nano. To fit within the boat, we also needed to acquire smaller breadboards.

Our Arduino arrangement required us to learn C++ coding and conduct substantial study on how various components function and are programmed, unlike using EV3 Lego kits with block coding. Writing our own code was a major undertaking. We had trouble locating the appropriate library for our MPU6050, a part we had to use in our Arduino IDE Script. In the end, we discovered a useful library on GitHub, which is now incorporated into our code.



Social Impact and Innovation

Impact of the Solution on Society

KargoVault is a great innovation that could save you money and help the environment. It could help reduce the amount of cargo lost due to shipping instability, which could lead to lower costs and fewer losses. Plus, it could help make the shipping industry more environmentally friendly by protecting cargo and preventing it from being lost at sea. Since it helps keep goods safe and intact, it's a great fit for sustainability and responsible use of resources and could help make a positive change in the shipping industry.

This innovation can help protect marine ecosystems by reducing cargo loss due to instability during shipping. Preventing cargo from spilling and contaminating the ocean can help keep marine habitats healthy and support the many species that live in them. All of this adds up to KargoVault's potential to balance economic growth, protecting the environment, and protecting the ocean in a sustainable way.

How Our Idea could be used

KargoVault's robotic solution has the potential to make a huge difference in the world. Its versatility and ability to work in different environments could help make us safer, more stable, and more resilient.

KargoVault can help keep houses and hospitals stable during an earthquake, which can save lives and prevent a lot of damage. It can help reduce injuries, property damage, and provide a safety net for communities that are prone to natural disasters. KargoVault can help keep hospitals and other important places open during an earthquake by making sure critical infrastructure stays stable. This helps rebuild after a disaster and keeps important services open for people who need them.

KargoVault can help keep cruise ships safe and comfortable by keeping platforms stable during rough seas. It can help prevent accidents, injuries and discomfort caused by too much boat movement.

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Coding MPU6050

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