Deliverable G:

Prototype II & Customer Feedback

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Abstract

This report examines ethical concerns surrounding the implementation of autonomous weapon systems in war. It highlights the risks these systems pose to global stability, safety, and human rights. Mines Action Canada, CRAiEDL, and University of Ottawa students have collaborated to aid in educating people on this topic.

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1. Introduction

2. Summary of Client Feedback

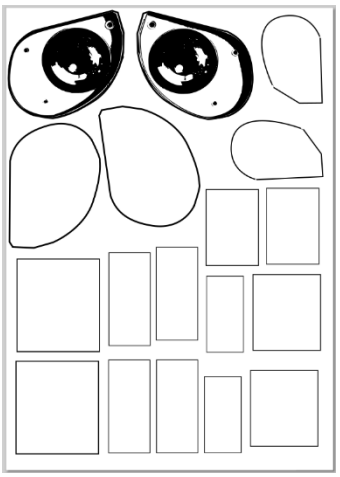
In the third client meeting, our group presented our chosen design concept (the trash-detecting Wall-E bot) to the client. In our presentation, we provided a general outline for our intended changes to the robot's appearance (i.e. the Wall-E resemblance), as well as an overview of how the robot will operate (i.e. the movement and trash detection code). We also informed them of what progress we had made towards our first prototype; at the time, this consisted of a basic laser-cut "Wall-E" plaque that was mounted to the front of the robot, in addition to the code responsible for detecting and distinguish between symbols that will represent trash or recycling. The client had no immediate feedback for our group after the presentation; rather, they mentioned that they liked our idea and that they think we are on the right track to successfully complete our project. When asked if there is anything we could do to improve our design, they mentioned that creating a full Wall-E appearance would be amazing. Our original intention was to only make the signature Wall-E goggles; however, with this piece of feedback we have decided that it is in our interest to also create a cover for the Robomaster S1 chassis so that it further resembles Wall-E. Some other general comments from the client (not specifically towards our team) were noted during the meeting and are summarized below.

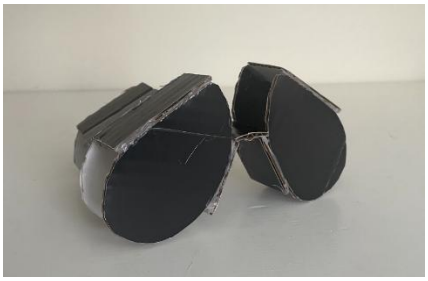
- The video should be formatted similarly to a PSA/advertisement.
- The manifesto should be from the viewpoint of the robot.
- The robot should be tested in person; there are often issues with the real robot that are not present/apparent in the DJI online simulator.

3. Prototype 2 Overview

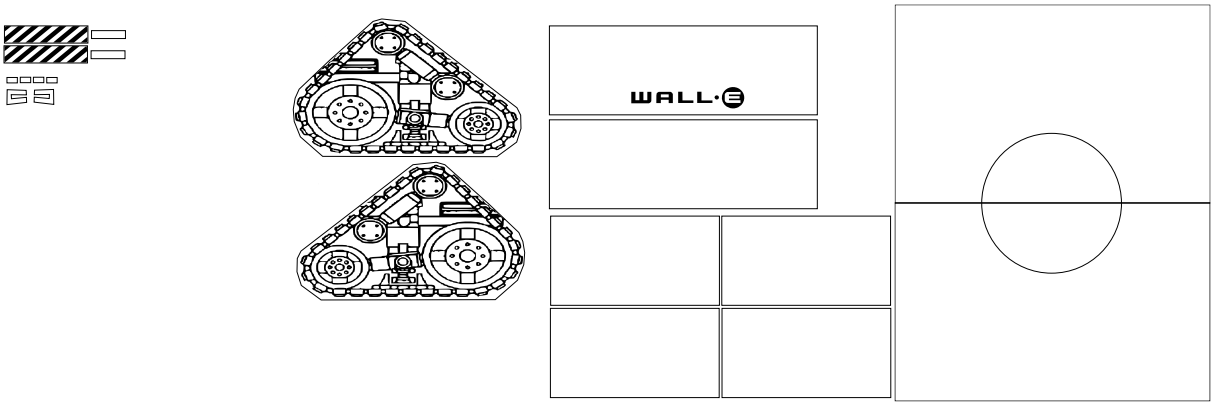
Laser Cut Chassis Cover: Based on the client feedback, it was decided that a cover for the robot chassis will be created. For this prototype, the dimensions of the Robomaster S1 were measured, and a cover was designed in Inkscape; however, since the decision to create the chassis cover was made rather recently, the cover has not yet been laser-cut.

Wall-E Goggles: A design for the Wall-E goggles was also developed in Inkscape. To determine if the dimensions chosen in Inkscape were correct, a cardboard representation of the Wall-E goggles was also constructed. Upon creating the cardboard goggles and discussing with a TA, we decided to extend the back of the goggles for the final design and add holes to lay over the antennas for easy attachment and removal on Design Day.





Wall-E body: The body that is intended to look like wall-Es body was also designed in Inkscape, it is intended to sit directly on top of the chassis, there are two halves of it that slide on and attach with simple clips. This design allows us to add and remove the body modification quickly and easily. There are also arms and wheels that are intended to mimic wall-E's arms and wheels that are attached to the body add on. The lines for cutting are very thin in the design and are therefore hard to see in the pictures below.



Movement code:

For the first prototype, successfully implementing the line-follow function of the movement code proved to be more difficult than anticipated; notably, there were issues with the robot staying on track once it started moving. To solve this issue, we researched online to find a code template that properly used the line-follow function. For our second prototype, we found a reference code that allowed the robot to successfully follow a line and then modified it, using knowledge acquired from our first prototype, to improve the reliability and speed of the robot's movement.

Vision Recognition/Sorting Code:

The vision recognition code was updated to allow the robot to stop moving when it detects the correct symbols representing either trash or recycling. This was a necessary addition, since the vision recognition code will be responsible for stopping and starting the movement of the robot. Now, with this change, when the vision recognition code and the movement code are combined for

prototype 3, they should both work together with minimal issues (so far, they have been treated as separate modules and were tested independently).

4. Analysis of Critical Components and Systems

-Robot movement/detection code- Prototype 2 updates

The software that controls the robot's movement has been fully developed, but as single functions, not yet combined. The main function focuses on making the robot follow a line, and the sub function is for the detection of garbage/recycling (G/R respectively), as well as causing the robot to stop and point when it detects the garbage. Further development will combine these into a full cohesive collection to run the robot.

-Vision Markers- Prototype 2 updates

Vision markers were created with the intent to fix them to objects to act as "Garbage". Further development could lead to the change in size of these markers if they go undetected for any reason.

-Robot Appearance- Prototype 2 updates

A prototype of the headpiece has been developed, as cardboard was coloured and fitted to the top of the headpiece. Dimensions have been noted and sketched and plotted in Inkscape. Further development will include adding a body with the intention of looking like Wall-E, if feasible with the chassis, and laser cutting and printing the Inkscape design as a final appearance, making sure it does not interfere with the robot's functionality and updating dimensions accordingly.

-Litter/prop creation- Prototype 2 updates

The materials were purchased and designs on INKSCAPE have been developed, and cuts/construction of these will continue throughout the next prototype.

-Sound effects- Prototype 2 updates

The sound effects code has been fully developed, and tested with the real RoboMaster-S1, but has yet to be incorporated into the main function, which will commence later in development.

5. Documentation

5.1. Prototype Test Plan

Tests					Prototypes			
N°	**Objective (Why)**	**Test Method (What)**	**Usage of Results (How)**	**Test Duration (When)**	**Type (What)**	**Objective (Why)**	**Fidelity**	**When to realise**
1	Testing robots' movement	The purpose of obstacle-lined path movement is to test and evaluate the robot's capacity to navigate and adapt to different types of terrains. This is important because this	Use the results to modify movement control and traction settings to optimize accuracy in riding, thereby	1-1.5 hours (Feb 28)	Focused physical	Ensure smooth and smooth path following by the robot	low	Feb 26

		robot is supposed to work independently in unpredictable environments, striking a balance between safe and efficient movement. If it does not offer reliable movement, it meets with its first failure.	allowing robot movements with a high degree of energy and safety.			without any errors.		
2	Checking symbol detection	The robot must accurately identify symbols for communication with its environment. Without this ability, we cannot make appropriate judgements based on these decisions, such as stopping at designated points or maneuvering around terrains. This is highly critical in the proper application in practical scenarios.	Optimizing camera settings and enhance detection software to improve reliability, ensuring that the robot's visual data interpretation is consistent.	1-1.5 hours (Feb 28)	Focused analytical	Ensure correct identification and interpretation of symbols by the robot as these are crucial for autonomous decision-making.	medium	Feb 27
3	Evaluating headpiece impact	We will concern ourselves that putting a headpiece would not interfere with the robot's vision system. Otherwise, the robot may later have difficulties in adjusting objects or recognizing certain symbols, which may result in mis navigation. The design should ensure that all components are functioned properly.	If the headpiece obstructs the camera, or the detection accuracy is affected, the design should be modified to the necessary need.	1-1.5 hours (Feb 28)	Focused physical	Ensure that the headpiece does not obstruct the vision of the robot on which it can rely for proper navigation.	low	Feb 27
4	Testing the chassis light pattern	The light of the robot is very important in the communication process of actions to its users. Anything that goes wrong with them could lead to confusion or safety problems in its operating environment, especially in low visibility.	Optimal lighting patterns need to be installed and response timing to ensure clear real-time feedback, when the lights are fulfilling their purpose.	1-1.5 hours (Mar 7)	Focused physical	Make sure the function of the lights is visually available so that the robot knows it has detected an object.	low	Mar 4
5	Testing the response to the litter	To detect and react to objects in the way, such as the litter, the robot should avoid all accidents or incorrect activities. If not, it will effectively undermine its functional safety and stop the operation of the robot.	Enhance the object detection sensitivity and the response time to allow for effective avoidance or braking for the robot.	1-1.5 hours (Mar 7)	Focused physical	The obstacle detection and avoidance capability of the robot must be valid in a way that no unintended	medium	Mar 5

						collision occurs.		
6	Improving movement stability	Variations in robot mobility could render any kind of reliable functioning under given conditions. Testing on different terrains assures adaptability thus keeping it from failing unexpectedly in real-time applications.	Calibrating motion algorithms and sensor feedback to provide the best smooth and predictable motion.	1-1.5 hours (Mar 7)	Focused analytical	Ensure predictability of the robots' behaviours on different terrains, preventing any erratic actions.	medium	Mar 5
7	Optimizing the detection range	To detect the symbols from the right distance so the robot could react instantly. Otherwise, if the distance is too short, it would not be quick enough and might miss essential signs used for navigation.	Adjust camera focus, software settings, and lighting compensations to achieve maximum detection consistency to improve the detection range.	1-1.5 hours (Mar 7)	Focused analytical	Make sure the robot can identify markers at some working distance, preventing any delays.	medium	Mar 5
8	Finalizing the robots' headpiece design	A perfectly designed headpiece must be visually appealing with a proper concept for usefulness. Contrarily, its sensorial duties may be impaired, making the very presence of a robot less effective and less enjoyable.	A particular sensor ensuring the powerful connection of the headpiece design element naturally seem more favourable.	1-2 hours (Mar 21)	Focused physical	Develop a final headpiece that is aesthetically appealing and functionality without interference.	High	Mar 17
9	Improving the robots' movements	In order for a planned maneuver to be executed properly, the robot must follow paths with a high precision. A higher inaccuracy may mean failed operations by having one miss a stop point or turn in the wrong direction.	Make some refinements, tuning, and speed adjustments to our motor control and path-maintain algorithms in order to optimize movement accuracy.	1-2 hours (Mar 21)	Focused physical	Ensure that the robot has smooth movements without turning errors during navigation.	High	Mar 19
10	Validate the whole systems' integration	Alongside, let every piece of the robot component that we incorporated to work perfectly. The malfunction of just one section brings system malfunction about, which results into unpredictable or unsafe behaviours from the robot.	Test that the movement, detection, and response functions are working in conjunction as it would in the real world.	1-2 hours (Mar 21)	Focused physical	Confirm all subsystems of the robot work the way it needs to work.	High	Mar 21

After the completion of Prototype 2, enhancing movement stability and vision recognition through our Wall-E inspired design with client feedback was accomplished. The prototype came out pretty good, showcasing line-following navigation, symbol detection, and interactive sounds effects, all in place to increase both engagement and functionality. However, there is still two red-marked areas in the table shown above that still needs to be completed. These refinements will be included in Prototype 3, for a more polished and fully functional design.

5.2. Prototype Analysis

Wall-E appearance

During the first prototype, we only printed out the wall-E symbol to attach to the front of the chassis, after client meet 3 our team decided it would be better if we created an entire body to make the robomaster really resemble Wall-E. So, during prototype 2 we made it our goal to completely design this. The progress we have made so far is measuring the robomaster and designing the entire body and eyes on Inkscape, which was completed. For results to see if our design is fully functional, we will need to print this body out and test it in our next prototype to see if it is fully functional as intended or if the body design needs further modifications.

Vision Recognition System

For the first prototype, the vision recognition code was tested in the online simulator using the DJI app. Positive results were obtained from these tests, indicating that our code worked; however, physical tests with the real robot were still necessary. For prototype two, we tested the vision recognition system on the actual robot by presenting various letters and symbols to the robot on a laptop screen. For each of the presented symbols, the robot had the correct response (i.e. appropriate chassis colour and sound effect), which indicated that our code was successful.

Robot Movement:

Our code for the first prototype did not work as intended. Therefore, a new code was created using a reference found online. The new code primarily takes advantage of the gimbal-lead movement mode, where the chassis reorients itself in-line with the direction that the gimbal is facing. With our improved code, once the camera detects a line, it will continue to look at it and the robot will start moving. Since the gimbal always adjusts itself to stay centered on the line, the chassis will not deviate from the line as well. Extensive testing with the physical robot was done to ensure this worked properly: a course was set up using red tape, and we made the robot follow it to determine if/when it will deviate from its path. By adjusting several of the variable values within the code, we were able to improve the speed at which the robot follows the line, as well as how accurately it can follow a line (especially through corners). In the end, the robot was able to repeatedly move at an adequate speed without straying from its path, indicating that our code was good.

6. Prototype Feedback (Vanya)

N°	Prototype Feedback	Test Results	Actual Test duration

1	The video should be formatted similarly to a PSA/advertisement.	Begun brainstorming session and planning for a video.	30 mins
2	The manifesto should be from the viewpoint of the robot.	Begun brainstorming session and planning for the manifesto.	1 hr
3	It would be better to create a full Wall-E appearance.	Addition of a box cover and more accurate eye design and arm placement.	2 hrs
4	Robot has limited movement abilities and must be treated accordingly.	Successful implementation of a line-follow function of the movement code.	2 hrs
5	Will not have the robot in advance for design day so any attachments must be easily removed and put together.	Changed design for arms to being attached to box, incorporated changes to original sketches and design.	1 hr

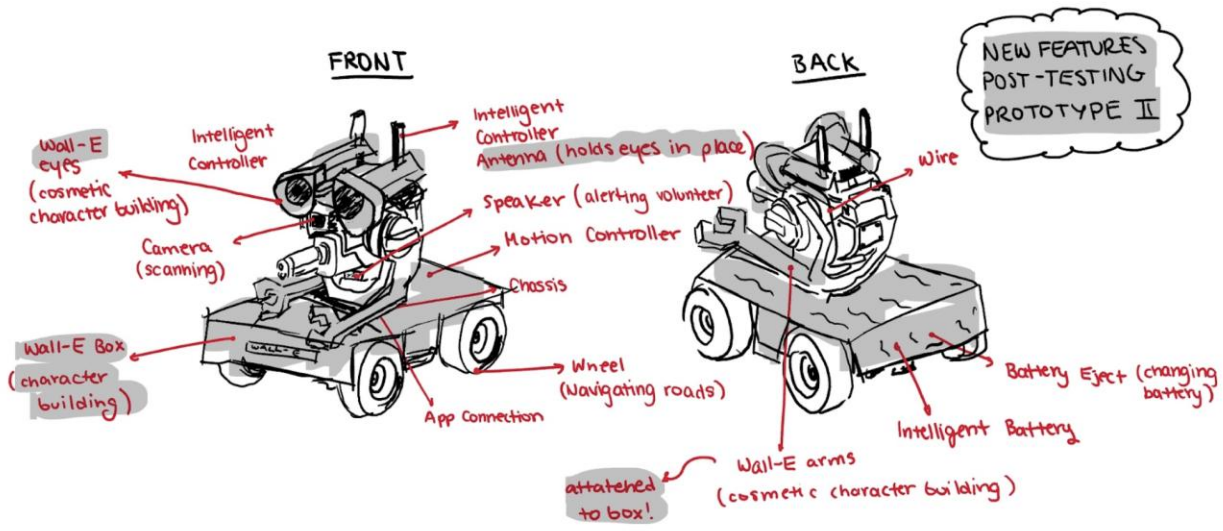
7. Post-Testing Updates

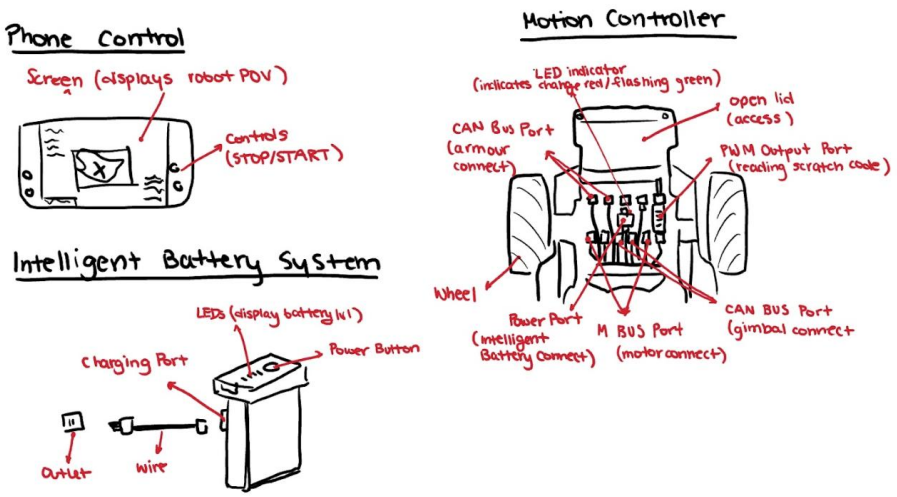
Note: Post-Testing Updates included are those that have been changed/updated since the last deliverable. Some features that remained unchanged were excluded.

7.1. Detailed Design (Vanya)

New Feature Post-Testing Prototype 2:

- Eyes have been extended in the back with holes to fit over the antennas for easy attachment to the robot, and a platform has been added under the goggles for stability.
- Wall-E box to fit over the robot has been added to complete the robot's look and have a more effective and captivating appearance.
- Arms moved from the head of the chassis to the box surface for easy attachment to the robot and higher functionality.





7.2. Bill of Materials (Vanya_)

BOM		
Product	Cost Estimate	Link
Colour printing	$2	uoPrint: Self-service printers | About us
Canva pamphlet	$0	Canva: Visual Suite for Everyone
Icing and cupcake batter for Design Day garbage cupcakes	$6	https://www.instacart.ca/products/17880224-red-velvet-cupcake-mix-465-g?retailerSlug=loblaws (Food dye and cupcake deco previously owned)
Wall-E sound effects	$0	Free sound links from online. Website link: https://www.voicy.network/official-soundboards/movies/wall-e
Wall-E cosmetic features	$0	Laser-Printed and 3-D printed in Makerspace.
Robomaster S1	$0	https://www.dji.com/ca/support/product/robomaster-s1
Robot Décor	$10	Designed and printed in MakerLab or Affordable pre-fab décor
Film Camera	$0	(previously owned) https://www.canon.ca/en/products/Video-Cameras---PRO
CapCut Editing App	$0	(previously owned) https://www.capcut.com/
Green Screen		
Litter Prop	$0	Made from recycled and previously owned materials
OnShape software	$0	(Free with tuition) https://www.onshape.com/en/
DJI Scratch software	$0	(Free with tuition) https://scratch3-tello.app/
Presentation board	$13	https://www.staples.ca/collections/presentation-poster-boards-10217

8. Prototype 3 Test Plan

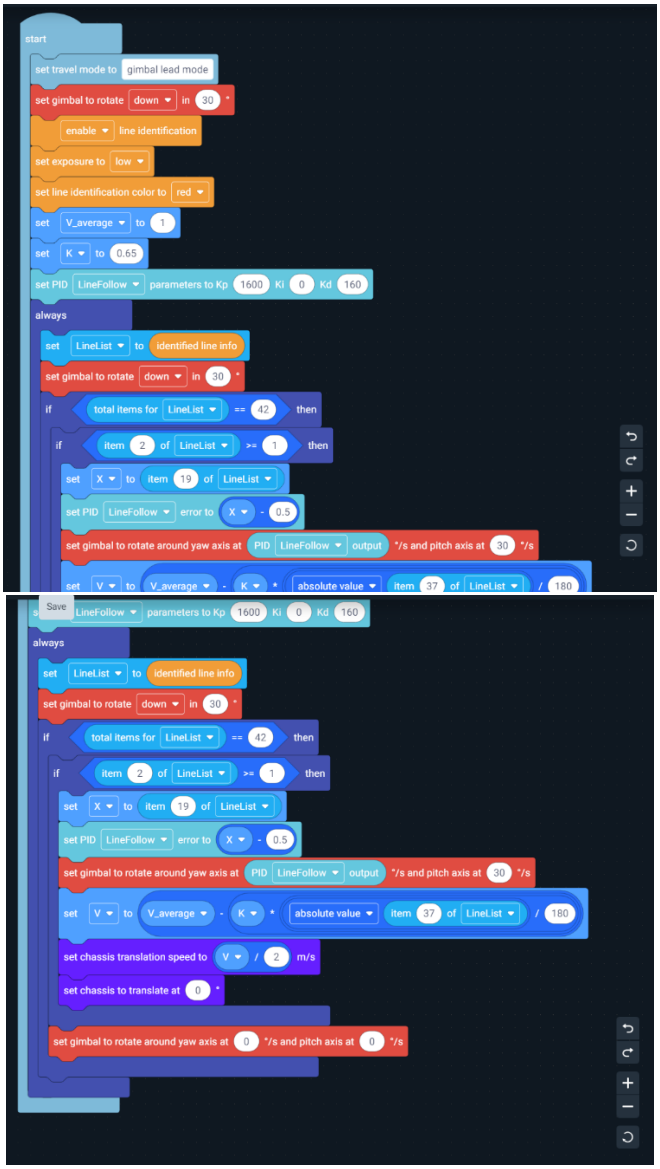
Tests					Prototypes				
No	**Objective (Why)**	**Test Method (What)**	**Usage of Results (How)**	**Test Duration (When)**	**Type (What)**	**Objective (Why)**	**Fidelity**	**When to realise**	**Decision Criteria**
1	Improve navigation accuracy	Identify surface properties about motor control.	Adjust the motor speeds.	2 hours	Focused Physical	The chosen core functionalities, together with their feasibility, shall be validated before their final integration.	High	Week 7	The robot is required to follow a defined course with a percentage of 90 0r more accurate results in three trials.
2	Enhance sensor reliability	Find objects from various distances.	Calibrate detection thresholds	3 hours	Focused analytical	Any possible design flaws shall be identified and rectified in the early stages of development.	medium	Week 7	The robot must effectively detect items within various distances, such as 20 cm to 1m, with a minimum of 85% accuracy.
3	Improve environmental adaptability	A test of robotic performance on different surface types (tiles, carpets, grasses) must be performed.	Traction and movement algorithms need to be tuned to the most stable and responsive settings.	2 hours	Focused physical	The robot should be able to optimize under these certain surface types.	medium	Week 8	The robot must navigate 90% of the test course across all surface types without losing stability or getting stuck.
4	Improve user interaction	Check the results of an LED and sound.	Refine interactive elements.	2 hours	Focused analytical	Feedback should be adopted into the prototype evaluation to meet user requirements.	medium	Week 8	The LED and sound cues must function on 100% of detection without any delay.
5	Optimize battery efficiency	Watch for power consumption.	Optimize power settings.	2.5 hours	Focused analytical	Power consumption should be optimized so that performance and battery life may be balanced.	high	Week 9	The robot should work on a full charge for at least 60 minutes while preforming tasks.
6	Test load bearing capacity	Weight of structure.	Reinforce material selection.	3 hours	Focused Physical	The structural design must achieve durability and reliability.	high	Week 9	The robot should be able to hold a small amount of load without failure of the structure.
7	Improve response to obstacles	Study sensor reaction to random obstacles.	Improve obstacle avoidance algorithms.	1.5 hours	Focused analytical	The system shall be tested against adaptability to any operating environment.	medium	Week 10	The robot should be able to detect and avoid obstacles within 1 second and reroute

									itself successfully 95% of the time.
8	Increase speed consistency	Speed up trials of measurement.	Fine-tun speed settings.	2 hours	Focused Physical	Fine-tuning the speed and direction control with enhance consistency of movement.	high	Week 10	The speed of the robot should maintain a constant speed with ≤ 10% variation through 3 test runs.
9	Evaluate software stability	Run software over long periods.	Ensure software is robust.	4 hours	Focused analytical	Validate that the software performance is by design objectives.	high	Week 11	Software should run for 4 hours without crashing or bugging on major functionalities.
10	Validate DJI educator blocks code	Carry out preprogrammed motion and reaction scenarios.	Ensure that there are no exceptions while running the code.	3 hours	Focused analytical	Final integration of the mechanical, electrical, and software systems.	high	Week 11	The robot shall be able to perform all the programmed motions without error in 3 repeats.

In prototype 3, these separate codes, which control movement, sign detection, and sound recognition, among others, will be put together into a single system to check the full capacity of testing by making sure none of the components are interfering with one another. Besides, all the necessary hardware parts will be laser-printed and assembled, gaining traction to alignment and strength for the design. This assembly will then be tested to make sure none of the additional components interrupt the movement of the robot and the sensor precision and general versatility. All this process falls into general preparation for final testing and validation, which will allow checking whether the prototype works as planned.

9. Conclusion (Vanya)

In conclusion, the team was able to make good progress in the development of our final product for our client. We implemented feedback from Prototype into our updated design, designed and tested our Prototype II to acquire more feedback, measured and designed a complete Wall-E appearance, and successfully coded for the robot's movement and combined it with the sound coding to be functional. Things we must work on in preparation for the final prototype include working on the manifesto and video, improving and finalising the code, and testing the robot's appearance and functionality.


start
set travel mode to gimbal lead mode
set gimbal to rotate down in 30 °
enable line identification
set exposure to low
set line identification color to red
set V_average to 1
set K to 0.65
set PID LineFollow parameters to Kp 1600 Ki 0 Kd 160
always
set LineList to identified line info
set gimbal to rotate down in 30 °
if total items for LineList == 42 then
if item 2 of LineList >= 1 then
set X to item 19 of LineList
set PID LineFollow error to X - 0.5
set gimbal to rotate around yaw axis at PID LineFollow output °/s and pitch axis at 30 °/s
set V to V_average - K * absolute value item 37 of LineList / 180
Save
LineFollow parameters to Kp 1600 Ki 0 Kd 160
always
set LineList to identified line info
set gimbal to rotate down in 30 °
if total items for LineList == 42 then
if item 2 of LineList >= 1 then
set X to item 19 of LineList
set PID LineFollow error to X - 0.5
set gimbal to rotate around yaw axis at PID LineFollow output °/s and pitch axis at 30 °/s
set V to V_average - K * absolute value item 37 of LineList / 180
set chassis translation speed to V / 2 m/s
set chassis to translate at 0 °
set gimbal to rotate around yaw axis at 0 °/s and pitch axis at 0 °/s