RCJA 2025 Rescue Line, Rescue Maze and Soccer Technical Description Paper

Team Information:

Challenge/Division: Lightweight Soccer

Team Name: Hyperion

School: Brisbane Boys' College

State/Territory: Queensland

Team Member Names:
If any team member had a specific role, please include this below.

Member 1: Matthew Adams (Hardware, Electrical)

Member 2: Sam Garg (Software, Movement & Avoidance)

Member 3: Luke Atherton (Hardware, Structural)

Member 4: Thomas McCabe (Software, Camera Vision)

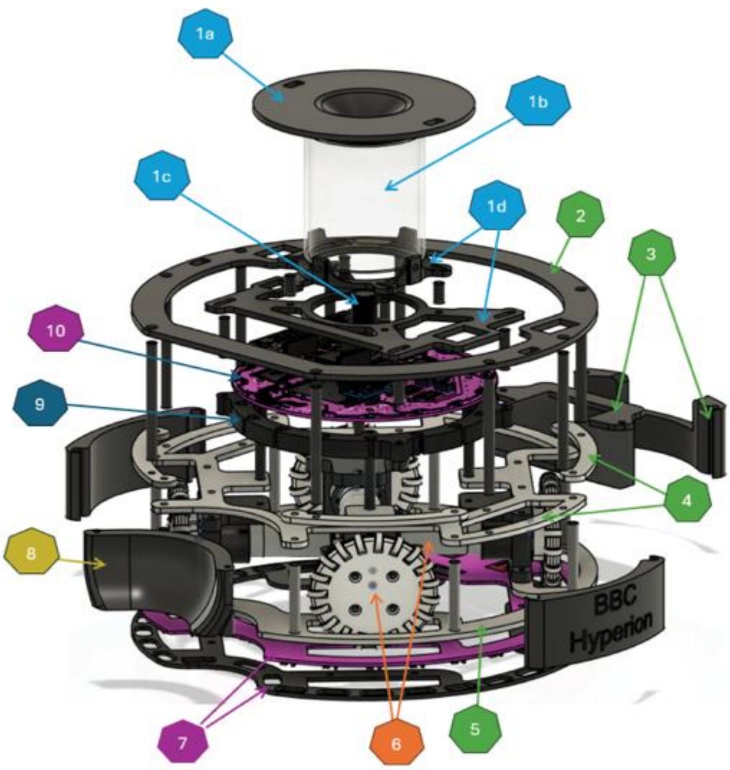
Robot Properties **(200 words recommended maximum, plus components list (if applicable))**
Please describe the software (e.g. EV3 Block Code, Python) and hardware (e.g. Spike Prime, EV3, Raspberry Pi) you have used for your robot.

For each piece of software/hardware used, please give it a star rating out of 5 (1=very bad, would not recommend to other teams, 5=very good, would strongly recommend to other teams).

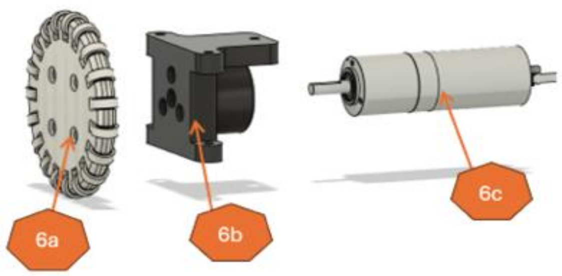
If you have used custom electronics for your robot, please include specific model/part numbers or web links, and a star rating for each.

<u>Hardware:</u>
Both of our robots are built on a shared design. Each robot features four motors, providing power, speed, and precise control for 360-degree movement. The goal of our robot design was to achieve a low centre of mass to improve acceleration, deceleration, and reduce tipping during turns. The frame was structured to compactly house all components without wasted space. We maintained a simple and focused design, prioritising only the components essential for consistent, reliable performance.

Materials:
The main materials used are CNC-machined aluminium 6061 for the core structural plates, 3D-printed PLA for most other components, and 3D-printed ABS for the wheels. Aluminium provides strength and durability, PLA offers ease of printing with good strength and heat resistance, and ABS is chosen for wheels due to its superior heat resistance and durability near the motors.



CAD 3D Exploded view of overall Robot Structure
In AutoDesk Fusion 360



3D Exploded view of Motor Mount
In AutoDesk Fusion 360

Vision System (1):
The vision system allows the robot to track the goal in a full 360° field of view using a reflective mirror and a single upward-facing camera. It is composed of the following components:

- **Cone-Shaped Reflective Mirror (1a):**
  Reflects the surrounding environment into the camera, enabling a complete horizontal field of view without requiring multiple cameras.
- **Clear Acrylic Tube (1b):**
  Connects the mirror and the camera while allowing light to pass through unobstructed. Unlike standoffs, the tube avoids introducing blind spots in the camera's field of view.
- **Upward-Facing OpenMV Camera (1c):**
  Programmed in MicroPython to process the reflected image and determine the angle to the goal.
- **Adjustable PLA Mounting Plates (1d):**
  Allow calibration of the mirror’s position to correct for misalignments introduced during the manufacturing process.

General Frame Design (2, 3, 4, 5)
The robot's structure is built around modular components designed for accessibility, weight distribution, and mechanical strength.

- **Top Plate (2):**
  3D-printed in PLA, the top plate houses key switches and includes a handle for convenient transport and match setup.
- **Battery Containment (3):**
  Comprises a holder and a rear support wall between the mid and base plates. This design secures the battery and minimizes damage caused by movement or impacts.
- **Mid & Base Plates (4 & 5):**
  Made from CNC-machined aluminium to centralize the robot's mass low to the ground, enhancing stability during quick movements and directional changes.

Drive System (6: 6a, 6b, 6c)
The drive system is engineered for multi-directional movement and durability during competitive play. It includes the following elements:

- **Custom Omni-Directional Wheels (6a):**
  Designed with silicon-coated steel rollers for enhanced traction and durability. These rollers are mounted on 3D-printed ABS hubs.
- **Motor Brackets (6b):**
  Custom-made to hold motors in place, ensuring proper alignment and structural integrity.
- **High-Performance Motors (6c):**
  Each wheel is driven by a DCX19 Maxon 9V motor, selected for its compact size and high torque output.

Capture Zone (8)
The ball capture zone is 3D-printed in PLA and designed to increase contact area with the ball. Its curved surface better matches the ball's shape, reducing sudden impacts and improving control during turns and rapid movement.

PCBs (7 & 10)
Custom PCBs are designed in AutoDesk Fusion 360 and manufactured by JLCPCB for fast turnaround and reliable quality.

- **Light Sensor Board (7):**
  Enables boundary line detection. Protected by a sensor cover that prevents damage from field debris.
- **Main Board (10):**
  Integrates the power supply, microcontrollers, motor controllers, Bluetooth module, and the camera interface.

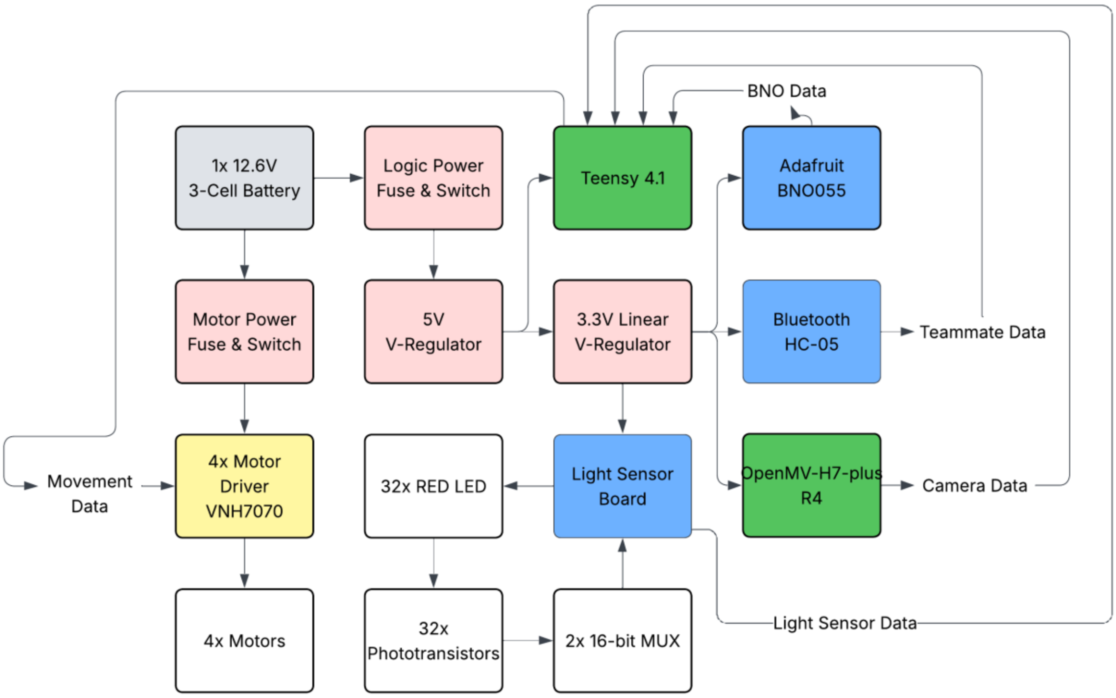
Component Ratings:

Maxon DCX 19 16:1 Motors x4 (Rating: 5/5) https://www.maxongroup.com/enau/drives-and-systems/brushed-dc-motors
OpenMV H7 (Rating: 5/5) https://openmv.io/products/openmv-cam-h7-plus?srsltid=AfmBOopUlx-O5g0kAdq29yPygN9NjdEHzttPajDnhGekYY7qRUs_2A8N
Teensy 4.1 (Rating: 4.5/5) https://core-electronics.com.au/teensy-4-1.html
BNO005 (Rating: 4/5) https://www.amazon.com.au/Precision-Acceleration-GyroscopeGeomagnetic-Smartphones/dp/B0FD8P7FWX
HC-05 (Rating: 4/5) https://www.amazon.com.au/Bluetooth-Pass-Through-WirelessCommunication-Arduino/dp/B01G9KSAF6

TSSP58038 (Rating: 4/5)
https://www.digikey.com.au/en/products/detail/vishaysemiconductor-optodivision/TSSP58038/4695717?srsltid=AfmBOopEVuwf_liw91CwBaYATAahxA23xp6aBPaJavajmFHZMRfkdnSS

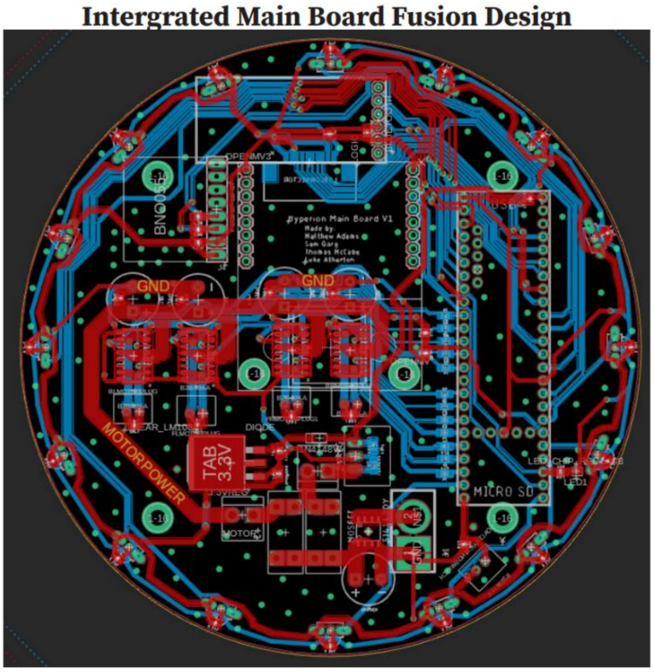
Electrical:

We have 2 custom-made PCBs these are an Integrated main board and a Light sensor Board.



Electrical Logic Flowchart

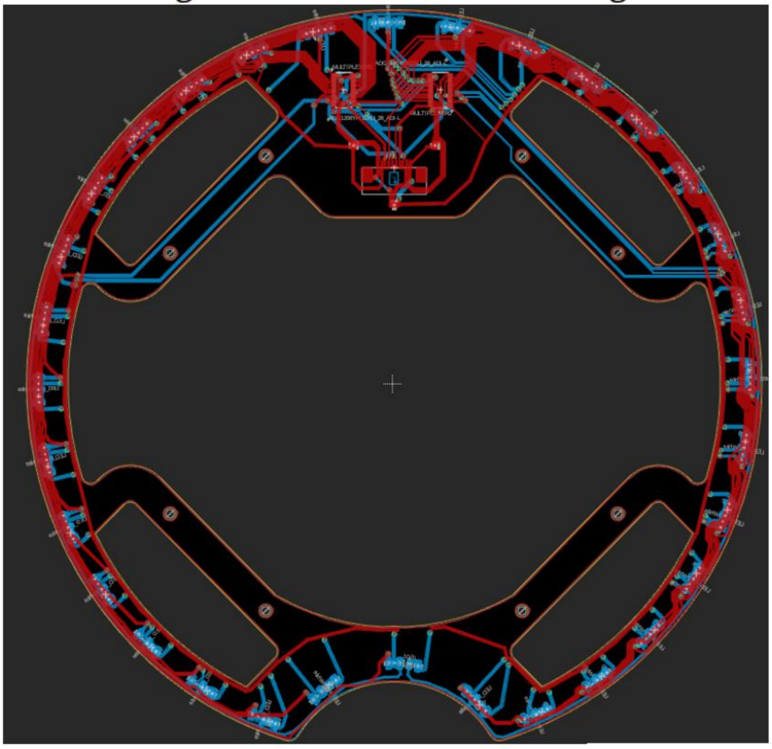
Intergrated Main Board Fusion Design



The Main Board

Our main board holds all our important components and the power supply circuit. Since our robot uses a 12.6V 1300mA battery we use a 5V regulator for the Teensy and a 3.3V regulator for the (Camera) OpenMV-H7, (IR Sensors) TSSP58038, (Bluetooth) HC-05, (Compass) BNO005, and the Light sensor board via a FFC connector.

Light Sensor Board Fusion Design

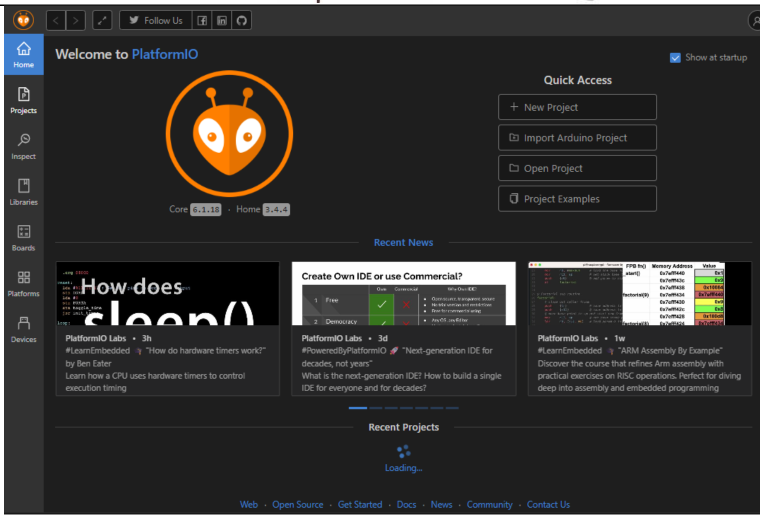


The Light Sensor Board

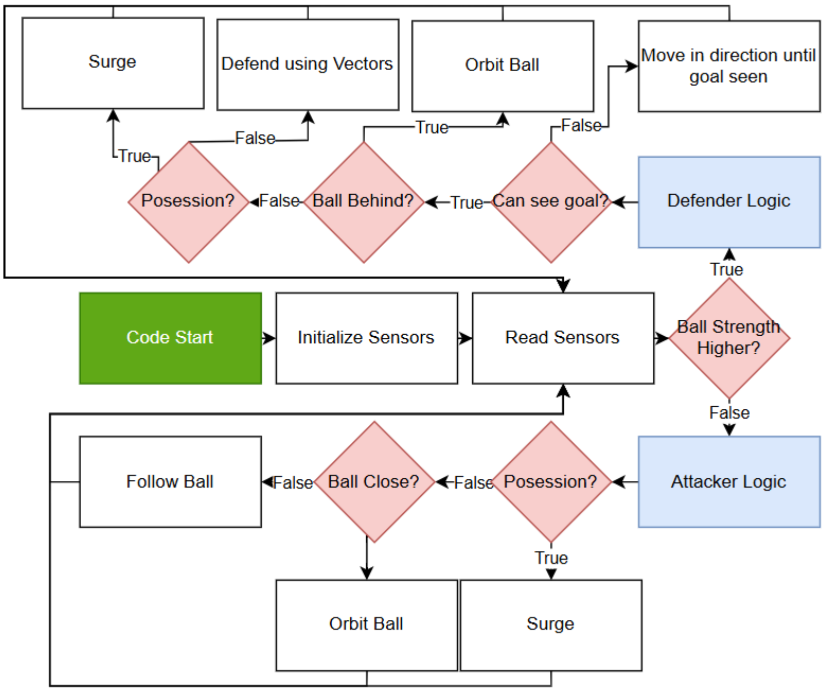
This PCB contains 32 Red LEDs and 32 Photo transistors. Each LED and Photo transistor is accompanied by resistors and 0.1uf caps. The signals are transferred to 2 16-bit Multiplexers (MUX) 1 for the right side of the board and 1 for the left. These Multiplexers are used for easy reading of many sensors. The outputting binary signals from the Multiplexers get transferred through the FFC to the main board, then to the Teensy.

<u>Software:</u>

In terms of software, we use Visual Studio Code as our primary code editor to write, maintain, and manage our projects. Alongside this, we utilise the PlatformIO extension, which provides powerful tools for compiling code, identifying errors efficiently, and uploading firmware seamlessly to our robot. This setup has proven to be both reliable and efficient. We highly recommend this combination (5/5) to other teams—provided they are using a PlatformIO-supported microcontroller, such as the Teensy 4.1, which we currently use in our system.



PlatformIO UI and Features (Visual Studio Code)



Software Logic Flowchart (Both Robots at Same Time – Bluetooth Switching)

Collaboration (100 words recommended maximum)

Please describe if your team has used any methodologies, software or systems to aid collaboration (working together). This could be related to the design, construction or programming of the robot(s).

It is the overall desire of RoboCup Junior events that any technological and curricular developments will be shared with other participants after the event. Any developments including new technology and software examples, may be published on the RoboCup Junior website after the event, furthering the mission of RoboCup Junior as an educational initiative.

To communicate, our team uses Microsoft Teams and WhatsApp. Furthermore, to ensure save backups, we use GitHub and email. This ensures that we have a backup should something go wrong locally on our computers at any time.

Key Achievement & Area for Improvement **(300 words recommended maximum)**
Please describe one aspect of your robot your team is particularly proud of, and one aspect you would like to further improve.

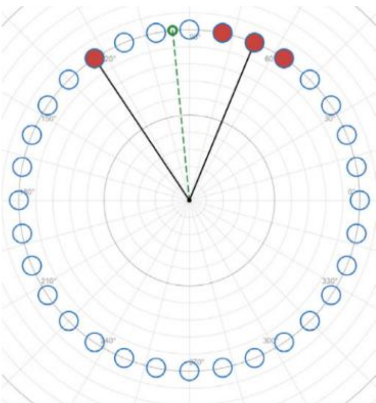
Hardware / Electrical:

Key Achievements:

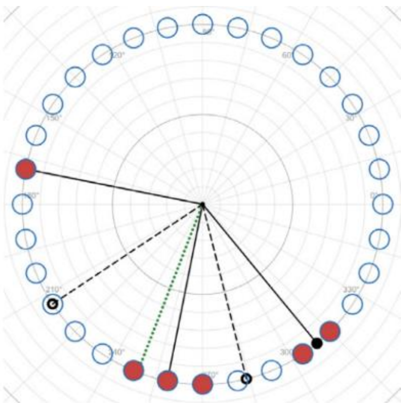
- The omnidirectional vision system was a major achievement. By replacing traditional standoffs with an acrylic tube, we eliminated blind spots and ensured consistent, uninterrupted 360-degree visibility of the goal. The conical mirror, developed through simulation and calculated dimensions, enabled a theoretical 31 metre field of vision. Together, these design choices provided a reliable and efficient vision system that enhanced on-field awareness and performance.
- A further achievement was the transition from PLA to aluminium 6061 for the mid and base plates, significantly improving structural strength and gameplay durability. The new aluminium construction prevented the cracking and failures seen in previous PLA plates during high-speed impacts, while maintaining manageable weight. This change enhanced the robot's stability during turns and acceleration, with a lower centre of mass improving traction and overall control in competitive conditions.
- Another key achievement is the custom PCB design, which required precise routing of wide (100 mil) motor traces to minimise electrical resistance. Careful placement of the motor controllers ensured accessibility for quick repair and maintenance during matches, while maintaining a compact and organised layout that connected effectively to the Teensy microcontroller.

Areas for Improvement:

- One key area for improvement is the addition of more advanced components, such as a kicking mechanism. Although refining the core systems was beneficial this year, the absence of a kicker caused missed scoring opportunities, as the ball often became stuck in the goal box.
- Another area identified is ease of maintenance, particularly relating to the main PCB. Electrical issues frequently required extensive disassembly to access internal components, leading to significant delays. Future iterations will aim to redesign the internal layout to improve accessibility, allowing faster component changes and troubleshooting during matches.

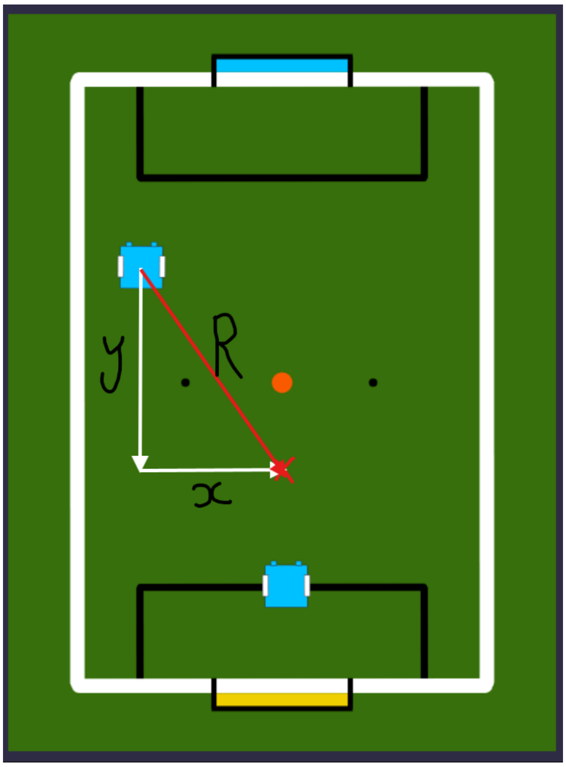


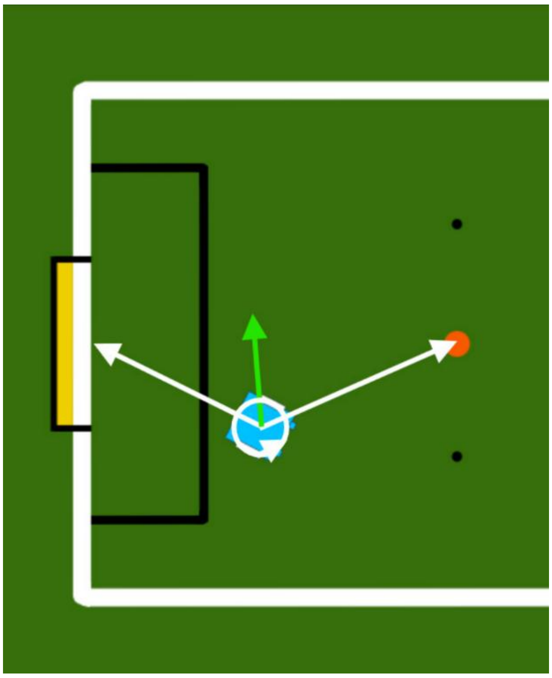
1 Cluster Example



2 Cluster Example

Line Avoidance/Remembrance Cluster Calculation Examples





Attacker Centring Example | Defender Vectors Example

Key Achievements:

- We are particularly proud of our centring and defender logic. Both the attacker and defender are programmed to automatically centre on the field relative to their respective goals when the ball is not detected, allowing for consistent positional awareness and faster reaction times.

Areas for Improvement:

- Improve the reliability and consistency of the out-of-bounds avoidance and line remembrance systems.
- Implement a kicker and dribbler strategy in future versions to enhance offensive capability and goal-scoring efficiency.

Photos and Design Documentation (100 words recommended maximum, plus images)

If there is a design drawing of the robot or if you have photos or notes of the development process, please provide these as proof of your team's learning.

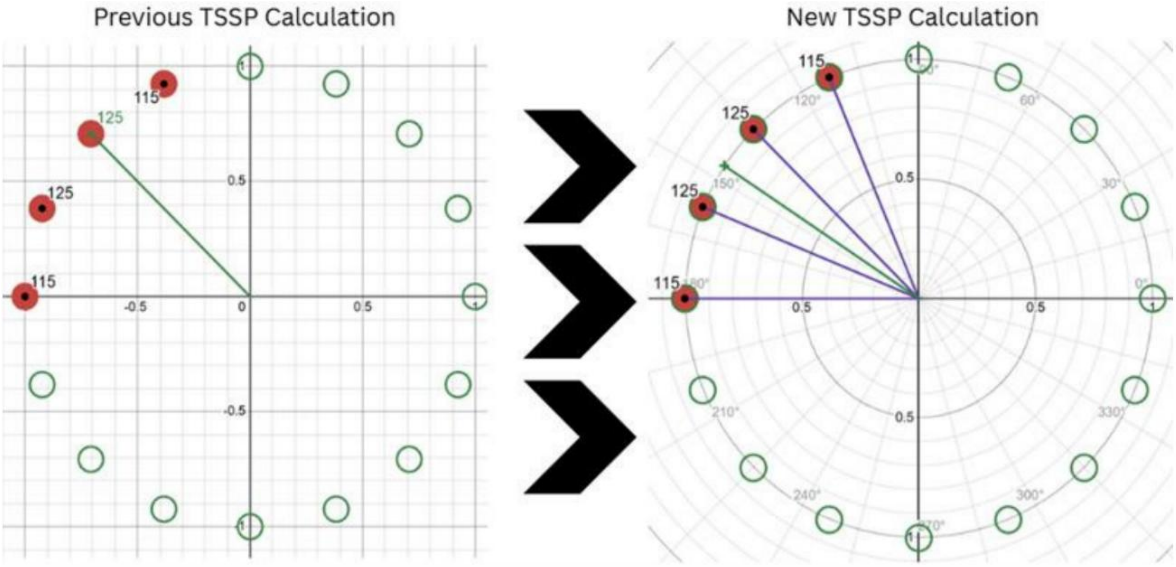
All of our code developments can be seen in our previous commits inside our GitHub here: https://github.com/SamGargRobotics/Hyperion-BBC-Robotics.

Team name:	Hyperion (Brisbane Boys' College)

Name of the Local Currency	Total Cost Local Currency	Total Cost ($) U.S.A. Dollars
Australian Dollar AUD	$ 1,780.96	$1,175.43

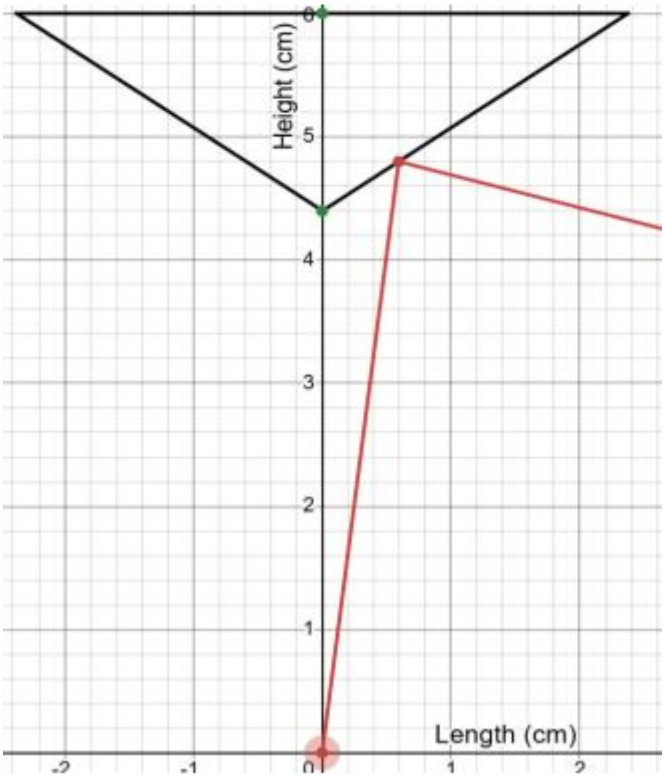
#	Component	Part name	Author	Source	Quantity	Unit cost (Local Currency)	Unit cost (US Dollars)	Total Cost (Local Currency)	Total Cost (U.S.A. Dollars)
1	Custom made Omni-wheels	Wheel Frame (ABS print filament, 9.3 grams)	Team Hyperion (Luke)	3D-Printer	8	$ 0.23	$0.15	$ 1.84	$1.21
2		Silicone-coated steel rollers (custom made)	Team Hyperion (Luke)	Self Made	152	$ 0.01	$0.01	$ 1.52	$1.00
3	Robot Frame (custom made)	Aluminium-6061 plates (mid and base plates) (935g)	Team Hyperion (Matthew)	CNC	2	$ 4.65	$3.07	$ 9.30	$6.14
4		3D printed components (PLA+ print filament, 186g)	Team Hyperion (Luke)	3D-Printer	2	$ 0.93	$0.61	$ 1.86	$1.23
5		Various fasteners (nuts, screws, etc.)	-	aliexpress.com	2	$ 3.48	$2.30	$ 6.96	$4.59
6		Various aluminium standoffs (M3, 10mm to 50mm)	-	aliexpress.com	48	$ 0.80	$0.53	$ 38.40	$25.34
7	Mirror System (custom made)	Reflective mirror foil	Team Hyperion (Matthew)	Self Made	2	$ 0.05	$0.03	$ 0.10	$0.07
8		Acrylic tube (65mm length, Ø55)	Team Hyperion (Luke)	Self Made	2	$ 4.00	$2.64	$ 8.00	$5.28
9	Camera	Open MV Cam H7 Plus	OpenMV	Openmv.io	2	$ 130.00	$85.80	$ 260.00	$171.60
10	Battery	Turnigy 11.1V 1300mAh 3S 45-90C Lipo Pack	HobbyKing	HobbyKing.com	4	$ 17.98	$11.87	$ 71.92	$47.47
11	Drive Motors	DCX19 9V Maxon Motor (second hand)	Maxon Group	maxongroup.com	8	$ 141.04	$93.09	$ 1,128.32	$744.69
12	Microcontroller	Teensy 4.1	Sparkfun Electronics	core-electronics.com.au	2	$ 59.95	$39.57	$ 119.90	$79.13
13	Assorted Wires	22 AWG Wire, jumper wires, FFC	-	aliexpress.com	2	$ 5.00	$3.30	$ 10.00	$6.60
14	Switches	Rocker Switch	-	aliexpress.com	6	$ 1.41	$0.93	$ 8.46	$5.58
15	Bluetooth Module	Bluetooth Module (HC-05)	DSD TECH	core-electronics.com.au	2	$ 14.40	$9.50	$ 28.80	$19.01
16	Compass	9-DOF Absolute Orientation IMU BNO055 AHRS	Bosch Sensortec	aliexpress.com	2	$ 12.99	$8.57	$ 25.98	$17.15
17	Custom made Main PCB with Electrical Components	Main PCB board	Team Hyperion (Matthew) / Jlcpcb	jlcpcb.com	2	$ 1.90	$1.25	$ 3.80	$2.51
18		All Electrical Components for Main PCB	-	digikey.com	2	$ 18.00	$11.88	$ 36.00	$23.76
19	Custom made Light Sensor PCB with Electrical Components	Light Sensor PCB Board	Team Hyperion (Matthew) / Jlcpcb	jlcpcb.com	2	$ 3.90	$2.57	$ 7.80	$5.15
20		All Electrical Components for Light Sensor PCB	-	digikey.com	2	$ 6.00	$3.96	$ 12.00	$7.92

Hyperion Bill of Materials



Improvements to TSSP (IR Sensor) Calculations

Visual Comparison of Robots (July 2025)
Aluminium vs PLA



Mirror Calculations Example

Mirror Dimension Simulation Fixed Parameters: Base diameter (23.75 mm), vertical distance from camera to mirror base Variable: Mirror height — determines reflection angle and field of view

Goal of Task: Find optimal mirror height for full field coverage

Method: Simulated ray reflections (mirror radius 2.375 cm) in Desmos → Adjusted mirror angle so reflected ray enters camera just below horizontal → Extended ray to floor (14 cm below camera) to find max range

Result: 16 mm mirror height → ~31 m viewing range (well beyond field, accounts for tolerance)