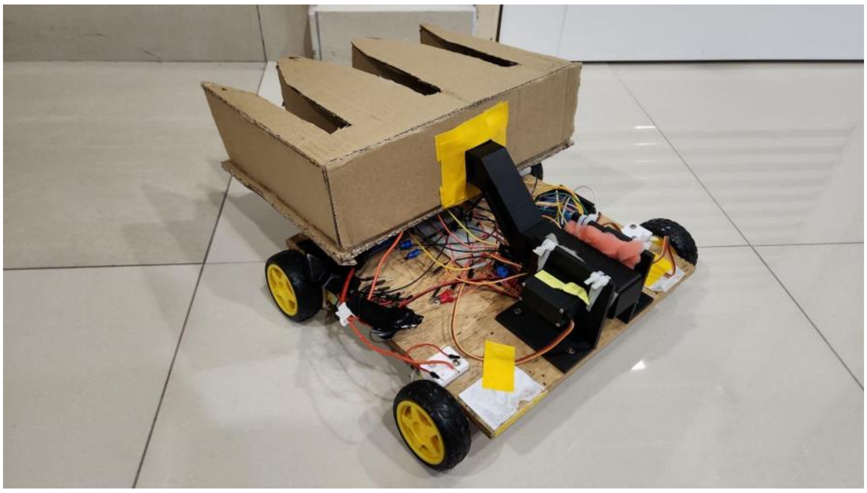
Introduction to the Prototype

MEC 2402: Design Methods

WARMAN Project Report

SWAR 12



Full Name of Member	Kieran Paul Bhasker (34022104)	Lim Yap Khye (34541896)	Chong Zheng You (33520720)	Keziah (34789642)
Headshot of Member				

Table of Contents

Executive Summary

This report outlines the design, development, and performance evaluation of the SWAR 12 prototype for the 2025 Warman Design and Build Competition. The autonomous robot collects and deposits three meteorite balls using a front-mounted, servo-actuated scoop mechanism. Initially conceptualized with a gripper-based system, the final scoop design significantly improved task efficiency and reliability. Key enhancements addressed earlier failures in ball collection and retention. The robot performed all actions within the 120-second limit and navigated complex terrain, including a pivoting seesaw. Final refinements increased mechanical simplicity, task accuracy, and compliance with competition constraints. (106 words)

1.0: Introduction to the Prototype

The prototype developed for the 2025 Warman Design and Build Competition – *Project SEESAW* – is a fully autonomous transport system engineered to collect and deliver three meteorites into a designated storage bunker. Designed to traverse complex terrain, including a pivoting seesaw, the system must complete all tasks within 120 seconds while strictly adhering to competition rules and constraints.

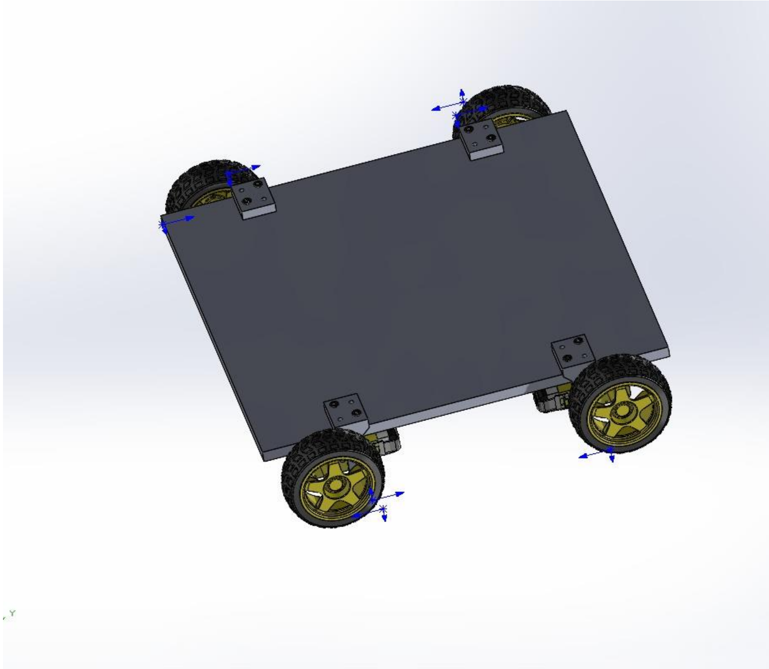


Figure 1: 3D CAD Image of the prototype base

The vehicle is powered by TT gear motors paired with standard 65mm diameter wheels, providing sufficient traction and torque to navigate flat surfaces and cross the seesaw bridge. A key feature of the collection system is its front-mounted scoop mechanism, which collects the balls as the vehicle moves forward. Once aligned with the balls, the scoop is actuated by 2 MG996R high-torque servo motors, which flip the scoop upward, lifting the balls into an integrated storage compartment above the chassis. This flipping action ensures the balls are securely held during movement, especially when crossing the seesaw.

Upon reaching the Ball Deposit Zone after crossing the seesaw, the scoop performs another controlled flip forward using the servo motors to release all collected balls into the target area quickly and accurately.

The entire operation is controlled by an Arduino Mega, which sequences movement, servo activation, and task timing. This is crucial to ensure that every action is executed accurately while remaining within the time limit. The system is triggered by a single manual action, pressing a pushbutton, and operates independently throughout the run without remote control or human interference.

A visible LED serves as a shutdown indicator, lighting up when the system has completed all tasks and ceased all motion. This ensures compliance with the competition requirement for signaling the end of operations. This solution emphasizes mechanical simplicity and effective automation to achieve an optimal and reliable performance.

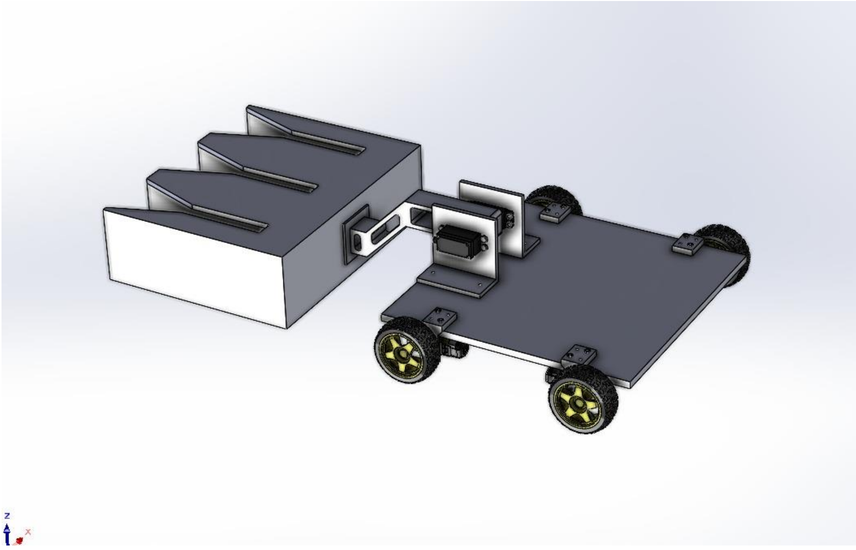


Figure 2: 3D CAD of the final prototype

(293 words)

No.	Item	Price per Quantity (RM)	Quantity	Price (RM)
1	65mm wheels (pair)	20.9	2	41.8
2	3V-6V Dual Axis TT Gear Motor	3.5	4	14
3	3D Printer filament	69	1	69
4	MG996R servo motor	20	2	40
5	Arduino Mega	239	1	239
6	11.1V, 2200 mAh lipo battery	50	1	50
7	10A voltage regulator	22	1	22
8	10A fuse	5	1	5
9	L298N motor driver	4.9	2	9.8
10	Male-to-female jumper wires	2.3	3	6.9
11	M3 25mm nut and bolt	0.9	20	18
12	M3 30mm nut and bolt	1	20	20
13	M4 10mm nut and bolt	0.8	20	16

			Total:	551.50

2.0: Comparison between the Final Prototype and Preliminary Design

2.1: Analysis of Final Prototype and Preliminary Design

The team's preliminary design featured a gripper-based mechanism to collect each ball individually using dual servo-actuated arms. This approach aimed to achieve precision in picking up balls placed in different positions on the grid. However, it introduced significant complexity in mechanical design and control logic, requiring accurate alignment and sequential movements. The time-consuming nature of gripping each ball also posed a major risk under the 120-second time limit.

Figure 3: Image of gripper function in the chosen preliminary design

In contrast, the final design prototype implemented a scoop-based mechanism that flips upward using MG996R servo motors. This design allowed the system to collect all three balls simultaneously during forward motion, then lift them securely into a storage compartment in a single action. The final design greatly simplified the control system, improved execution speed, and reduced failure points. While the gripper concept offered more precision, it lacked efficiency and robustness for the autonomous operation required in the competition. The scoop-flip design, as demonstrated in the full prototype, was more suitable for high-speed, consistent ball collection and enabled full traversal of the course without external control, satisfying both functional and rule compliance requirements.

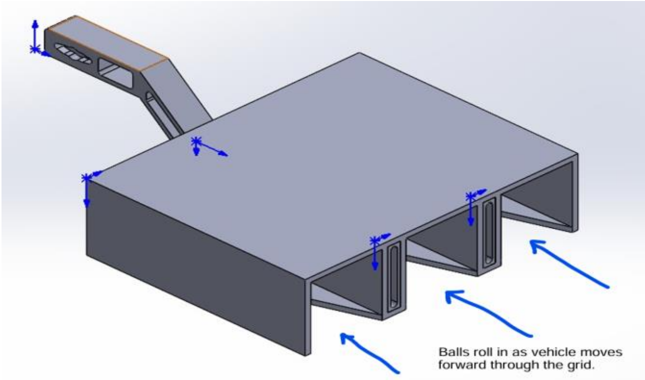


Figure 4: 3D CAD image of scooping mechanism for final prototype

2.2: Key Design Issues and Improvements

The initial scooping mechanism was inspired by an excavator-style bucket, designed to collect the balls through a broad forward motion. However, this design encountered several critical issues during testing. Firstly, the scoop was unable to collect the tennis ball due to its larger diameter. As the scoop pushed against the ball, it often became wedged between the scoop edge and the front chassis, preventing successful collection. Secondly, the scoop failed to retain the balls securely, especially during high-speed movement or when ascending the seesaw. The balls, particularly the table tennis ball, frequently bounced out due to the shallow containment and lack of partitions. To mitigate these problems, the team attempted to modify the scoop by replacing the solid curvature of the scoop with netting, hoping to reduce bounce. However, this caused the scoop to sag under the weight of the balls, compromising structural integrity and lowering the front edge. As a result, the lip of the scoop often got stuck on the front wheels when transitioning onto the seesaw and the balls were rolling on the ground. A buffer layer of toothpicks was also added to push balls deeper into the scoop, but this proved ineffective due to weak contact and misalignment.

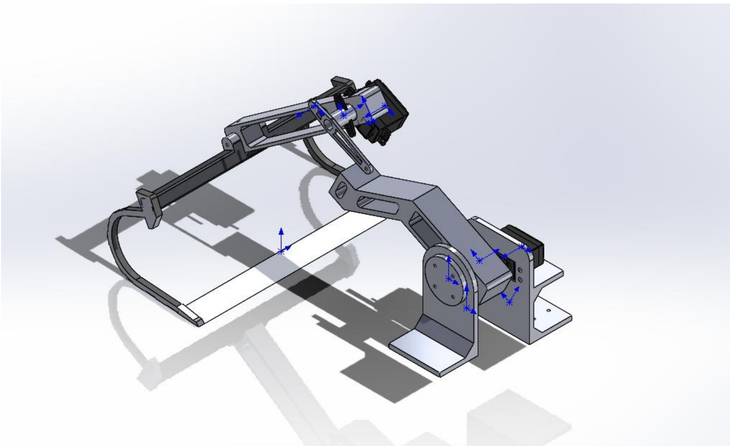


Figure 5: Excavator-style bucket for the initial collecting mechanism

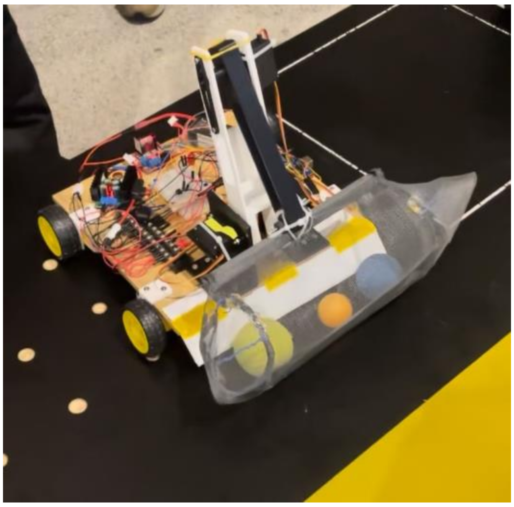


Figure 6: Image of the initial scoop design failing to securely hold the three balls

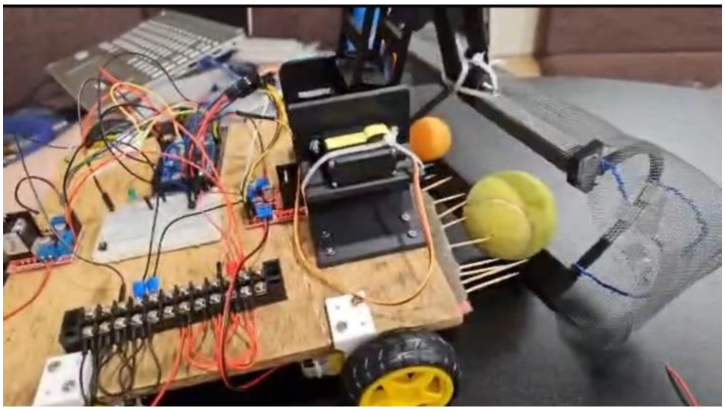


Figure 7: Image of the buffer layer unable to push the balls further into the net, and the lip of the scoop in contact with the ground

In the final design, these issues were resolved with a completely restructured scoop featuring a rigid base, segmented compartments, and guiding edges. Most importantly, the scoop's orientation and actuation were redesigned to lift vertically after collection. This vertical flipping action not only secured the balls within the compartment but also prevented the scoop from obstructing the wheels during ramp traversal. These refinements significantly enhanced the prototype's functionality and competition readiness.

Figure 8: New scooping mechanism travelling forward for balls to roll inside compartments

Figure 9: Scooping mechanism flips upwards to prevent balls from sliding out during movement

2.3: Limitations and Potential Improvements

Despite its improved performance, the final prototype has a few limitations. One issue is that the vehicle travels sidewards when ascending the seesaw, likely due to uneven weight distribution, which causes the wheels to rotate at different speeds and reduce the accuracy of the vehicle's path or even failure to complete the obstacle. Distributing the weight evenly throughout the body of the vehicle may reduce the sidewards movement of the vehicle. Other than that, incorporating feedback sensors such as encoders allows the team to identify the motion of each wheel and adjust the individual speeds accordingly to ensure that all wheels move in sync. Secondly, the scoop occasionally fails to collect balls placed at specific positions, particularly near the corners or edges of the 3×3 grid. While the current scope includes funnel-like dividers to channel balls inward, its reach can be limited. This can be improved by widening the scoop or adding side flares and brush attachments to help redirect off-path balls. Lastly, the scoop remains somewhat vulnerable to bounce, especially for lighter balls. Installing shock-absorbing padding or soft barriers could improve retention. Addressing these targeted issues would further increase the system's reliability and consistency in future iterations.

2.4: Quantitative Performance Summary

	Excavator-style Bucket	Scoop (Final Prototype)
Maximum number of balls it can securely hold	2	3
Maximum number of balls it can deposit into the deposit zone	1	3
Maximum number of balls that fall off during collection	2	1
Maximum number of balls that fall off when climbing the seesaw	3	0

(582 words)

3.0 Conclusion

As a team, this 12-week journey has been both challenging and deeply rewarding. From day one, we were excited to tackle the Warman Design and Build Competition, but we quickly realized that turning ideas into a functional, competition-ready prototype required more than just technical knowledge but it also needed commitment, adaptability, and teamwork.

Through many late nights and sleepless nights of brainstorming, debugging, and testing, we learned to rely on each other's strengths and communicate openly when things didn't go as planned. Our transition from the initial gripper concept to the final scoop-flip design shows our willingness to reflect, learn, and improve. Every member brought a unique perspective, and this diversity made our collaboration strong and creative.

More than just building a robot, we built trust, problem-solving confidence, and a passion for engineering design. We now feel more prepared to take on future projects by learning from our mistakes and are inspired to further explore autonomous systems, control logic, and real-world problem-solving.

To the teaching staff, especially to Dr. Chiew, thank you for your continuous support, constructive feedback, and encouragement. Your advice has pushed us to think critically and stay motivated, even during setbacks. This project has made a lasting impact on our development as engineers, and our team is proud of what we've achieved together, although our final prototype did not manage to complete the track during the run.

Despite that setback, we're walking away from this experience with stronger technical and interpersonal skills and, more importantly, with the drive to keep building, learning, and innovating.