Robot Sports Team Description Paper 2026

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Abstract. Robot Sports is an open industrial team, meaning that its participants are all employed by, or have retired from, various high-tech companies in the Dutch Eindhoven region, or are active students. This is the last year the team will participate in the MSL league, while it is preparing to enter one of the humanoid leagues. Our new MSL platform, which has been developed over the past years, has been stabilized/optimized to better perform in the last MSL tournament. In this team description paper, we reflect back on our journey and we further develop novel capabilities that we can carry forward into the humanoid league.

Keywords: robotics · machine vision · machine learning · artificial intelligence · motion control · RoboCup · MSL.

1 Introduction

The Robot Sports team is an open industrial team supported by the main sponsor VDL, an internationally operating family-owned industrial business with more than 100 manufacturing companies, headquartered in Eindhoven, The Netherlands. The team shares a dedicated facility with the Falcons team in the city of Veldhoven, near Eindhoven. The team started as the Philips "Cyber Footbal Team" which started participating in 2002 and was renamed to VDL Robot Sports in 2012.

2 Reflection on our journey - MSL RIP

In 2000, a group of colleagues from the Philips mechatronics department visited the Clockwork Orange RoboCup MSL team at University of Amsterdam. One of our team members was contacted by their former supervisor Pieter Jonker from Delft University to gauge our interest. RoboCup was about AI and robotics, and the robotics part could probably benefit from the vast mechatronics expertise at Philips, so it was assumed. In 2002, we played our first World Cup in Fukuoka. Fast forward a quarter of a century and here we are, ready to call it quits with our wheeled robots and continue with humanoid robot platforms. Are we ready? Not really. Do we feel forced? More or less. Does it make sense? Most likely.

With our mechatronics background, we developed a wheeled platform with additions to play soccer. Locomotion, sensing, ball handling and kicking were all improved based on mechatronic principles: a multidisciplinary co-design of mechanics, electronics and embedded software, leading to a robot optimized for its task. At the same time, other teams chose to stick with universally available hardware, instead relying on machine learning to add soccer capabilities such as ball pickup and dribble. With recent accelerations in ML and AI, this seems to be the path forward.

Progress over the past decade in MSL has been less than the first one and a half decade of RoboCup. Comparing the 2024 World Cup MSL final with the one played in 2013, the latter was much more exciting. Since then, the speed of the robots did not increase much, ball passing and powerful and accurate shots on the goal were incrementally improved and (most importantly perhaps) game tactics did not noticeably change.

Mechatronics evolution will make a new start on a new platform.

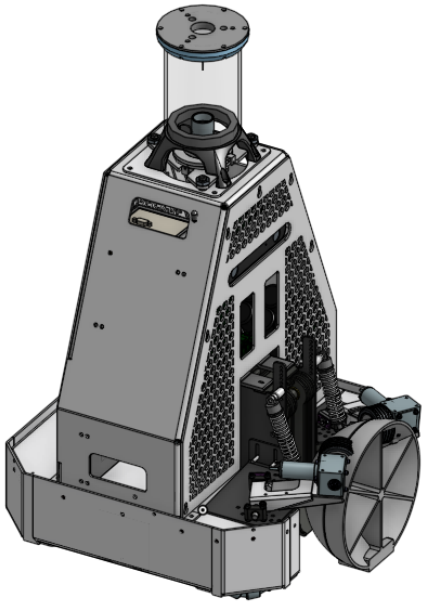
3 Robot Platform 2026

The platform improvements have focused on the completion of the platform, to be ready for the final MSL tournament in South-Korea 2026. The lessons of the 2025 Eindhoven world championship have been incorporated in the platform, focusing on the key improvements needed to play competitive games, especially ball control.

(a) Platform 2026 improvements

3.1 HW improvements

The HW improvements are minor, with a primary focus on improving system reliability. This year's modifications include the integration of more robust steel omniwheels and a metal mounting ring of the omnivision mirror tube.



(b) Platform 2026

In previous iterations, design efforts prioritized serviceability. The current configuration, which allows for quick removal of the front and back panels, demonstrated its use during World Cup in Eindhoven and on a daily basis thereafter.

3.2 Ball control

At the 2025 World Championship in Eindhoven, we secured fourth place, showcasing our capability to play competitive games. However, a significant challenge has been to maintain stable ball possession, causing the team to loose the ball repeatedly. In preparation for the 2026 competition in Seoul, the ball handler system has been reviewed and redesigned. The new design integrates new sensors to detect ball presence/distance and updated motor control laws. Extensive testing has ensured that the robot can maintain ball possession, also during faster turns. We expect these improvements to significantly enhance gameplay robustness and contribute to more consistent and competitive performance.

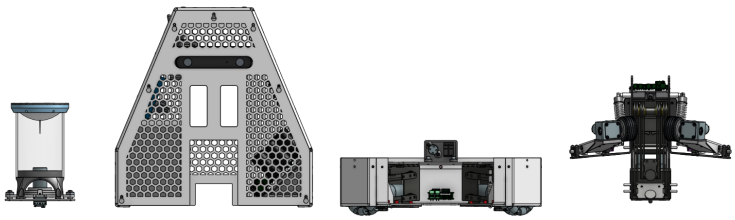
3.3 Vision calibration

One of the lessons learned during the 2025 World Championship was that collisions with opponent robots caused mechanical misalignment of the vision tower. As a result, the tower was no longer perfectly vertical, leading to progressively

increasing localization errors during the tournament. Importantly, this degradation remained unnoticed until after the competition ended. To address this issue, an automated detection mechanism is introduced to identify vision miss-calibration. The approach relies on monitoring deviations from predefined fixed reference points on the robot. In addition, the vision calibration procedure has been further automated, allowing quick recalibration through a single-button operation.

3.4 Transportation

The robot's structural framework is composed of four modules: the Chassis, Tower, Top Vision, and Ball Manipulation. This modular architecture was designed with logistical benefits in mind, facilitating disassembly enabling flexible transportation options. The goal is to allow team members to carry individual components in standard luggage, eliminating the dependency on custom shipping solutions to tournaments. This has become especially relevant traveling to South-Korea. The transport of batteries has received special attention because of generic regulations and airline-specific restrictions.



(c) Platform 2025 sub-parts

3.5 Software improvements

The software improvements have primarily focused on critical bug fixes and stability enhancements. For example, we resolved a bug where power was lost after a shot, causing the robot to momentarily halt. Additionally, we refined ball tracking by prioritizing the nearest ball instead of a distant one. Furthermore, we improved positioning logic so that when ball control is lost, one robot remains close to the ball rather than all moving away. These examples illustrate some important software corrections implemented to ensure readiness for the 2026 world championship.

4 Innovations to carry forward to the humanoid league

Beyond incremental platform improvements, the innovations presented in this paragraph are positioned as stepping stones toward the team's transition to

the humanoid leagues. Rather than optimizing exclusively for the current MSL platform, Robot Sports increasingly focuses on the development of transferable capabilities that remain applicable across robotic embodiments.

4.1 ISAAC SIM/LAB

VDL Robot Sports has implemented a cloud-based Isaac environment, enabling a collaborative development platform for next-generation robotics—particularly for the humanoid league. As a first step, we simulate our current MSL robots within the Isaac environment to gain operational experience and expertise while awaiting the acquisition of humanoid platforms. Our first objective is to incorporate our current robots in Isaac Gym, integrate it with ROS, and leverage Isaac Lab to train a neural network, for example to learn to keep the ball within a defined area like the center circle. This approach ensures we will be well-prepared to transfer learned capabilities to future humanoid systems, aligning with our long-term development goals.

4.2 MSL reference architecture (MRA)

Robot Sports still strongly believes in the concept of a reference architecture to promote re-use and sharing software between teams. The MRA was originally designed for the MSL, but can be updated to use it for the Humanoid League. The updated concept will be based on ROS2 messages instead of using Protobuf as an interface definition language.

As an intermediate step, we will use some components from the MRA with a native C++ interface on our robots. In the future, when the team migrates to the humanoid league an ROS2 message interface will be added to these components.

4.3 Brain inspired self-localization

Robot Sports is currently developing a brain-inspired self-localization method aimed at improving the existing line-detection-based approach, which is prone to localization errors. This development becomes particularly relevant for participation in the humanoid league, where omnidirectional vision is not available and robot positioning must be robustly and reliably estimated using the two cameras located in the robot's head.

Drawing on the free-energy principle from neuroscience, the method treats perception as a dynamic process of making predictions and minimizing discrepancies between expected and actual sensory data. In doing so, it mirrors the human brain, where place cells and grid cells map out spatial environments.

In the field, robot 'place cells' respond to landmarks such as goal posts and distinct line patterns, while odometry and IMU data drive the continuous update of robot's internal state 'grid cells.' Using Bayesian inference, the robot refines its internal model, learning from prediction errors, and adapting its position estimate. It enables robots to function effectively in a variety of environments,

even when field lines are missing and only goalposts are available for orientation, much like humans can play on any makeshift field. This year, we will present this innovation as part of the technical and scientific challenge, with the aim of deploying and evaluating a prototype under real field conditions during the tournament.

4.4 Compact Empirical Sensor Actuator Model (Cesam)

We feel the need to have an artificial model that reflects a number of physical interactions of the robot in its environment. This model could be trained using a neural network. However, we see an opportunity to significantly reduce resources such as CPU power, memory usage and training time. We call this Cesam: Compact Empirical Sensor Actuator Model.

We believe that reducing training time is important in the face of topological changes that naturally occur during development. In addition, biological systems train much more efficiently than neural networks, so we are convinced that improvements must be possible. We will start with ball handling and later include other actuators.

Once we have such an empirical model, we will be in a much better position to accurately evaluate our hand-crafted algorithm in a simulation environment. We could have separate models for the different robots to test the algorithm's robustness. In parallel, we could use the empirical model to train algorithms that compute optimal actuator responses.

Once we have this framework operational, we expect to have a much faster turnaround time in our development cycle.

5 Conclusion

The VDL Robot Sports team would like to express its sincere appreciation to the Middle Size League community for 25+ years of inspiring and highly competitive robot football. Participation in the MSL has provided an exceptional environment for technological innovation, collaboration, and continuous learning.. It has been a remarkable journey, and the team is proud to have contributed to and grown within this international community. As this season marks our final participation in the MSL, we look forward to competing once more at the upcoming World Championship and concluding this chapter with the same spirit of innovation and sportsmanship that has characterized the league throughout the years. The knowledge and experience gained within the MSL will form a strong foundation for our future transition toward humanoid robot competitions.

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